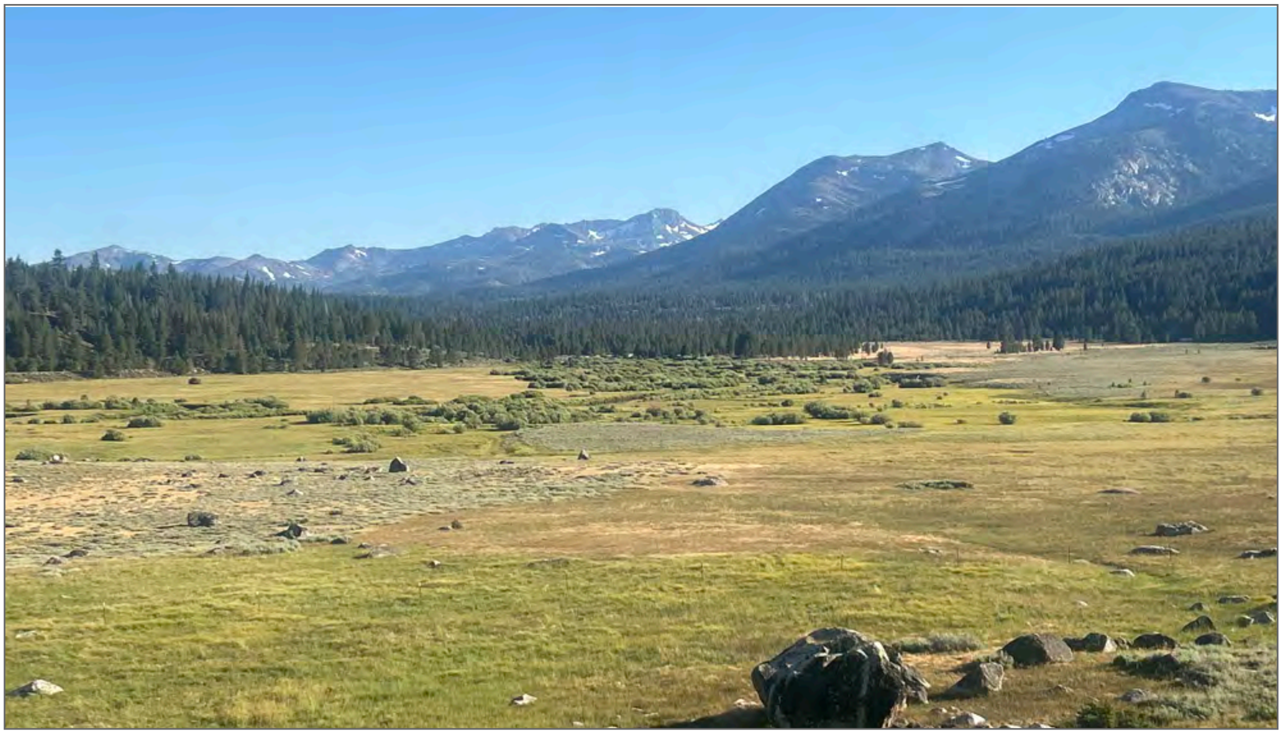
West Fork Carson Prioritization Project

Findings and Planning Report



prepared for

Alpine Watershed Group

prepared by

Waterways Consulting, Inc.

Watershed Resiliency Consulting

Project Manager: Daniel Malmon

1020 SW Taylor St. Suite 380
Portland, Oregon 97205

March, 2026

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Note: *Appendix P-1 and Appendix P-4 are appended to this report; the other Appendices are available at the hyperlinks below*

Geomorphological Appendices

Appendix G-1 Relative Elevation Map Book

Appendix G-2 Bank Erosion Map Books

Appendix G-3 Hydraulic Model Inundation Map Books

Project Prioritization Appendices

Appendix P-1 Project Descriptions and Scoring for 15 Potential Projects (**Appended to This Report**)

Appendix P-2 Stakeholder Feedback and Prioritization

Appendix P-3 Multiple Accounts Analysis and Results

Appendix P-4 Technical Memo: Estimating Pollutant Load Reductions for Prioritized Restoration Projects in West Fork Carson Watershed (**Appended to This Report**)

Hyperlinks above are to Waterways' ftp server, which was active at the time of publication of this report. If the links are no longer functional, please contact AWG or Waterways for an alternate version.

1.0 INTRODUCTION

The West Fork Carson Prioritization Project (WFCPP) is a basin-scale planning effort designed to improve understanding of the sediment and geomorphologic system of the portion of the West Fork Carson River (WFCR) watershed that is in California (**Figure 1**), and to identify and prioritize stream restoration actions that could improve water quality. The project is led by Alpine Watershed Group (AWG) and funded in full, or in part, by the United States Environmental Protection Agency (EPA) and the State Water Resources Control Board (SWRCB) under the Federal Water Quality Management Planning Program (Clean Water Act Section 205[j]), with a matching contribution from the Carson Water Subconservancy District (CWSD).

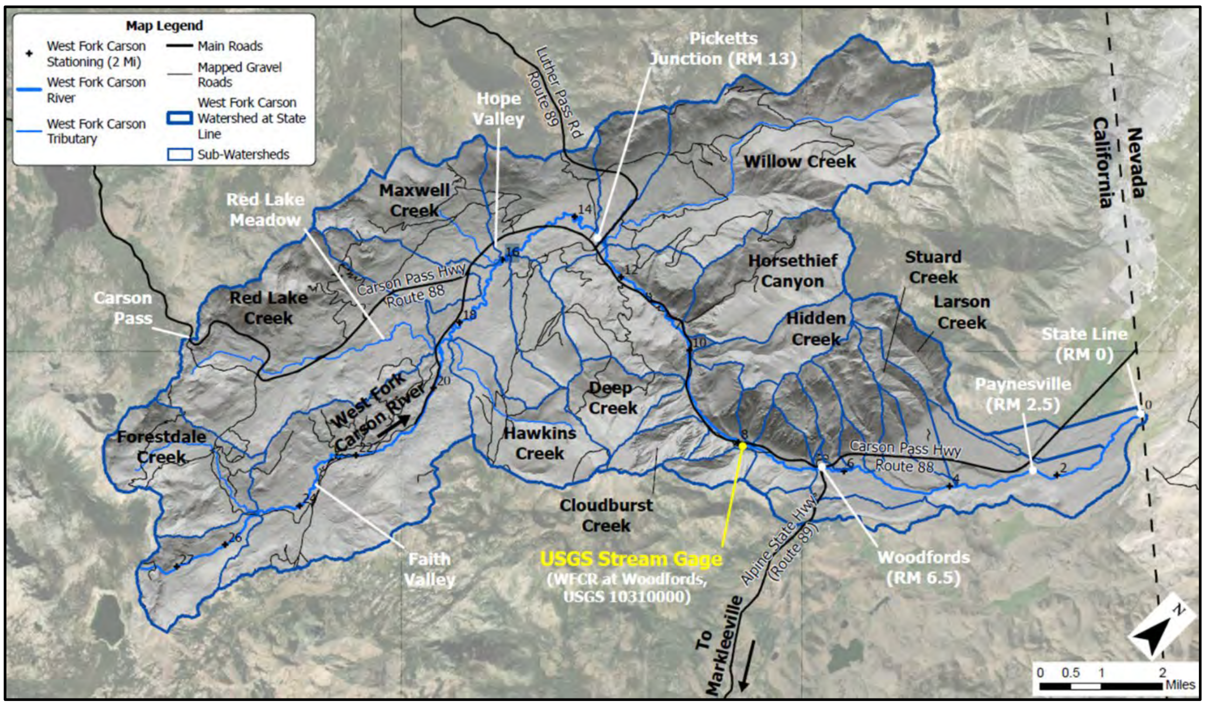


Figure 1. *Map of West Fork Carson River Watershed in Alpine County, California, Showing Subbasins and Some Key Features in the Watershed.*

The WFCR is listed in the 2018 California Integrated Report for Clean Water Act Sections 305(b) and 303(d) as impaired for multiple pollutants, including turbidity and sediment-related constituents such as phosphorus (SWRCB, 2021). In the 2023 West Fork Carson River Vision Plan, the Lahontan Regional Water Quality Control Board (Lahontan) emphasized the need for a "Geomorphologic Model and Prioritization Project" to better understand sediment sources and transport processes in the watershed and to identify which reaches or tributaries would be most beneficial to restore for water quality improvements (Lahontan, 2023).

This project focuses primarily on processes controlling fine sediment and turbidity, sediment-bound constituents, and, to a lesser extent, water temperature. Other water quality impairments, including dissolved nutrients, bacteria, and salts, are largely influenced by non-geomorphic processes and are outside the scope of this project.

1.1 GOALS, OBJECTIVES, AND OVERALL APPROACH TO PROJECT

The overarching goal of the WFCPP, as defined by AWG (2024), is to complete a geomorphological assessment and sediment transport planning model to:

1. Characterize sediment inputs and fluxes within the West Fork Carson River watershed to identify dominant sources and storage areas.
2. Develop a Prioritization Plan that recommends stream restoration and infrastructure projects based on quantified sediment processes, potential benefits to water quality, and feasibility.

Based on these objectives, the project contained two components:

Geomorphologic Model: A synthesis of field observations, topographic analysis, hydraulic modeling, and mapping was used to characterize and understand the physical processes controlling sediment transport in the watershed. This included identifying the key sediment sources, such as upland erosion and streambank erosion, downstream suspended sediment transport, and sediment storage within floodplains. The geomorphologic model includes a basin-scale hydraulic model and a "sediment budget"—a watershed-scale accounting of sediment sources, storage, and export. Results from the sediment budget directly inform project identification and prioritization by highlighting locations where interventions are likely to provide the greatest benefit.

Project Identification and Prioritization: This part of the project identifies potential restoration projects in the basin, guided by the geomorphologic model and sediment budget results. Fifteen potential restoration projects were screened for physical feasibility, predicted water quality improvements, and other ecological and social factors. Projects were then evaluated using a multi-criteria scoring approach and stakeholder-informed weighting system called Multiple Accounts Analysis (MAA) to generate a prioritized set of potential restoration sites.

1.2 SCOPE OF REPORT

This report, and accompanying Appendices, document the methods and outcomes of the project and include:

- A discussion of watershed and reach-scale geomorphology and sediment processes,
- An explanation of the methods and findings of the sediment budget, including conclusions relevant to management and restoration,
- Identification of potential restoration projects to reduce fine sediment and provide other environmental and social benefits,
- Detailed descriptions and feasibility level evaluations of 15 potential projects,
- Landowner engagement and stakeholder input,
- The results of the prioritization and rankings of potential projects, and
- Discussion of the results of the rankings and recommendations for watershed-scale restoration planning.
- Estimate of the potential reduction in fine sediment export as a result of prioritized projects.

To allow readers to review methods, analyses, and detailed results, much of the supporting information, including maps, hydraulic analyses, and detailed descriptions of potential projects, is provided in the Appendices. The Appendices are subdivided into two sections, corresponding to the two main components of the report:

Geomorphologic Model:

- **Appendix G-1:** A 21-page map book of the main stem WFCR and tributaries that shows the geomorphology of the streams in detail.
- **Appendix G-2:** Two, 21-page map books showing the extent and intensity of bank erosion along the WFCR and tributaries using two separate methods: the Bank Erosion Hazard Index (BEHI) (Rosgen, 2001), and a more subjective Bank Erosion Severity Index based on field observations from summer 2024.
- **Appendix G-3:** A 21-page map book showing the modeled inundation extents of the 2-year, 10-year, and 100-year recurrence interval floods along the mainstem WFCR and key tributaries.

Prioritization Plan:

- **Appendix P-1:** Detailed descriptions, information, evaluations, and scoring for each of the 15 potential projects, including a watershed map of potential projects that shows land ownership.
- **Appendix P-2**: Results of a stakeholder engagement process to understand the relative importance of different societal values (costs, benefits, risks, feasibility, recreational, and aesthetic impacts) of restoration projects to key stakeholders in the watershed.
- **Appendix P-3**: An annotated slideshow presenting and explaining the MAA process, along with the results.
- **Appendix P**-4: A Technical Memorandum regarding “Estimating Sediment Pollutant Load Reductions for Prioritized Restoration Projects in the West Fork Carson River Watershed” is included as an appendix to support future implementation funding grant requests for the 10 highest-priority restoration projects.

2.0 GEOMORPHOLOGIC MODEL

The geomorphologic model developed for the WFCR watershed is not a single, quantitative computer model, but rather an integrated synthesis of past work, new observations, measurements, analyses, and interpretations designed to explain how sediment is generated, transported, stored, and exported from the watershed.

MACTEC (2004) previously evaluated the geomorphology of the upper West Fork and East Fork Carson River at a watershed scale in the context of potential stream restoration. That study performed a reach-by-reach characterization of stream channels in both the East Fork and West Fork – including measurements of pool frequencies, habitat complexity, and substrate characteristics – and provided interpretations of the geomorphology and general recommendations about active channel restoration techniques and priority reaches. They concluded that the most significant disruptions and negative impacts to the system were those associated with grazing and resource extraction in the 1800s, rather than recently. MACTEC et al. (2004) recommended against highly engineered solutions to stream restoration. Instead, they recommended site-scale, low intensity channel restoration treatments in specific reaches (especially Faith and Hope Valleys) to reinforce natural trends of channel recovery.

Based on field observations, previous work, new data, and geological inference, a working hypothesis behind the geomorphologic model is that natural erosional and depositional processes that predominated in the upper WFCR basin have been modified by land use and/or geological changes, leading to changed patterns of erosion and deposition, and a major shift in the importance of different fine sediment sources in the watershed-scale sediment budget. The prevalence of thick deposits of fine sediment in the large glacial and structural valleys, such as Hope Valley, Faith Valley, Red Lake Creek, and other meadows, indicate that they were once major sediment sinks on the landscape. Presently, given the widespread prevalence of bank erosion in these valleys today, it seems clear that there was some kind of a shift from depositional to erosional conditions in these valleys.

The geomorphologic model aims to understand the current sources of fine sediment in the basin and combines several lines of evidence, including geologic mapping, topographic analysis, hydraulic modeling, field-based erosion assessments, historical aerial imagery, and long-term streamflow and sediment data. These lines of evidence are brought together to identify dominant geomorphic processes, understand the relative importance of different sediment sources and sinks, and explain observed patterns of erosion, deposition, and channel change throughout the basin—the central questions underlying whether and where stream restoration actions could be used to benefit water quality. A central element of this framework is the sediment budget (Section 2.3), which provides a quantitative accounting of the primary sediment sources, transport rates, and storage elements, and serves as the primary bridge between geomorphic understanding and restoration planning.

In addition to the analyses presented in the main body of this report, several components of the geomorphologic model are provided as standalone appendices intended to support future planning, design, and implementation efforts in the WFCR watershed (**Appendices G-1** through **G-3**).

2.1 GEOLOGIC OVERVIEW OF THE BASIN

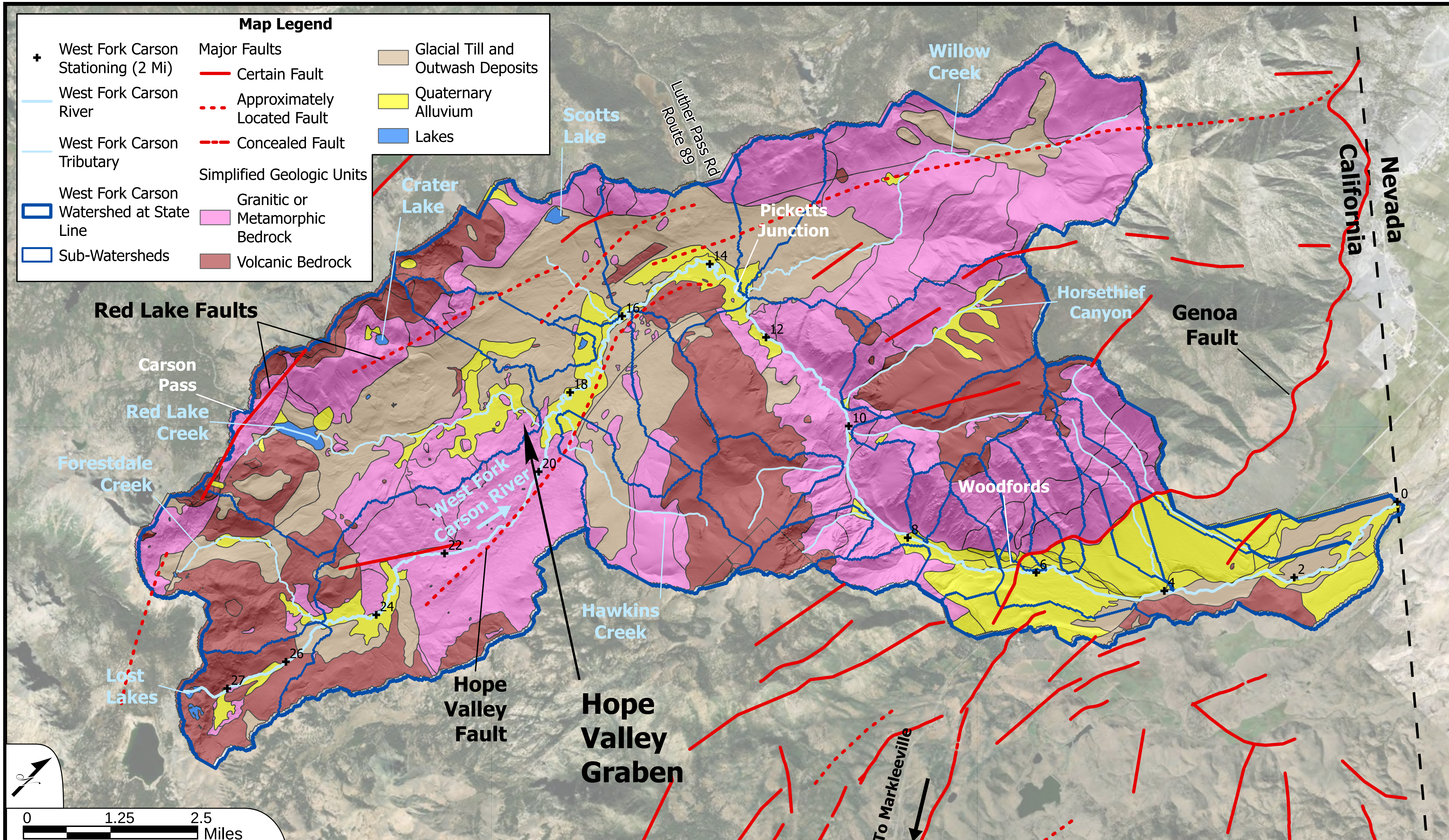
The geomorphic processes operating in the WFCR watershed, as well as the sediment budget, are fundamentally controlled by its geologic framework. **Figure 2** presents a modified geologic map of the basin based on mapping by Armin and John (1983) and Armin et al. (1984). For the purposes of this study, the numerous mapped geologic units were consolidated into four generalized categories, listed below in order of relative age (oldest first):

1. **Granitic and metamorphic rocks**
2. **Volcanic rocks**
3. **Glacial till and outwash deposits**
4. **Alluvial deposits**

The oldest rocks in the basin are crystalline **Mesozoic metasedimentary and granitic rocks**, primarily Cretaceous granitic rocks of the Sierra Nevada batholith. These crystalline rocks are relatively resistant to erosion and tend to produce coarse sediment (sand and gravel) where exposed. **Volcanic rocks**, including Miocene (10–15-million-year-old) volcanic flows and associated deposits, are also present in upland portions of the watershed, including high peaks such as Red Lake Peak, Stevens Peak, Round Top, and Little Round Top, which are all part of the Carson Pass volcanic center (Armin and John, 1983). These rocks have a range of erodibility depending on lithology and can weather to produce both coarse (gravel and larger) and fine grained sediment (silt and clay).

Overlying and inset into these bedrock units in the upper basin are extensive Quaternary **glacial till and outwash deposits**, particularly within Hope Valley and other broad valley bottoms. These deposits consist of poorly sorted material ranging from clay and silt to boulders, derived from glacial transport and deposition primarily during the Tioga and Tahoe glaciations (170,000 to 14,000 years old). Glacial till is generally more erodible than the underlying bedrock and contains abundant fine sediment that can be mobilized through gullying and bank erosion; whereas glacial outwash in the lower basin contains large boulders that line the channel bed and banks and prevent bank erosion. Therefore, the distribution of glacial till and outwash deposits is an important control on sediment supply in the basin.

The youngest geologic units are Holocene **alluvial deposits**, consisting of fluvial sand, gravel, and fine overbank sediments that form modern channels, floodplains, and terraces. These deposits are directly associated with active channel processes, mostly since the last glacial retreat, and represent both potential sources as well as long-term storage reservoirs for fine sediment.



Simplified Geologic Map of the West Fork Carson River Watershed

(modified from Armin and John, 1983; Armin et. al, 1984)

West Fork Carson River Prioritization Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE 2

2.1.1 Tectonic Setting and Structural Controls

The WFCR watershed lies within the eastern Sierra Nevada–western Basin and Range transition zone, an area influenced by extensional tectonics. Hope Valley occupies a structurally controlled depression interpreted as a **graben**, bounded by normal faults (Hagan et al., 2009). Down-dropping of this structural block created accommodation space that was later modified by glaciers and filled with glacial and fluvial sediments. The graben structure helps explain both the broad valley morphology and the thick accumulation of unconsolidated sediment that now forms the eroding meadow banks.

Structural controls also influence channel gradient and base level. Downstream of Hope Valley, the river transitions into narrower, confined reaches that locally coincide with resistant bedrock or boulder-controlled valley constrictions. These controls limit lateral migration, prevent significant sediment storage, and influence upstream channel adjustments.

2.1.2 Paleocanyon Features

Hagan et al. (2009) describe evidence for an ancestral paleocanyon system within the region, carved into bedrock prior to glaciation and later partially filled with volcanic and sedimentary deposits. Portions of the modern WFCR occupy segments of this paleocanyon system. The presence of paleocanyon topography influences valley alignment, gradient transitions, and the distribution of unconsolidated deposits.

The bedrock framework, tectonic setting, paleocanyon development, and glacial history provide the geologic template upon which modern geomorphic processes operate. Differences in erodibility among granitic bedrock, volcanic units, glacial till, and alluvium directly influence patterns of bank erosion, sediment supply, and floodplain storage evaluated in the sediment budget (Section 2.3).

2.2 HYDROLOGY AND HYDRAULIC ANALYSIS

For the purposes of this report, *hydraulic analysis* includes two closely related components. The first is <u>hydrology</u>, which describes how much water enters the river system and when—ranging from large flood events to lower flows during dry periods. The second component is <u>two-dimensional (2D) hydraulic modeling,</u> which is used to understand where that water goes on the landscape, including the extent of flooding, water depths, and flow velocities within the channel and across floodplains. The 2D model is confined to the channels and adjacent floodplain areas and helps identify existing flow patterns in the WFCR watershed, where floodplain topography allows overbank flooding and sediment storage, and where it may be possible to influence these conditions to provide potential benefits.

This section begins with a summary of the high flow hydrology of the WFCR based on presently available data, followed by a description of the development and results of the basin-scale 2D hydraulic model.

2.2.1 Hydrology

For this assessment, the hydrology analysis mainly focused on higher flows in the WFCR watershed. Large flood events are particularly important in the geomorphic and sediment context of the WFCR.

High-magnitude flows mobilize large volumes of suspended sediment, drive bank erosion, allow floodplain sedimentation, and can produce significant channel adjustments. Flood events contribute disproportionately to long-term sediment export and channel changes.

Information on historic floods are available from long-term records at the U.S. Geological Survey (USGS) stream gage 10310000 – West Fork Carson River at Woodfords, CA. The gage is located approximately 8 miles upstream of the California–Nevada state line (**Figure 1**) and captures runoff and sediment contributions from the upper basin, including Hope Valley. The period of record includes the following active years: 1890–1891, 1901–1920, and 1937 to present, providing more than a century of peak flow data (**Figure 3**). This long record allows for a reliable analysis of flood magnitude, variability, and recurrence intervals relevant to sediment transport and floodplain inundation.

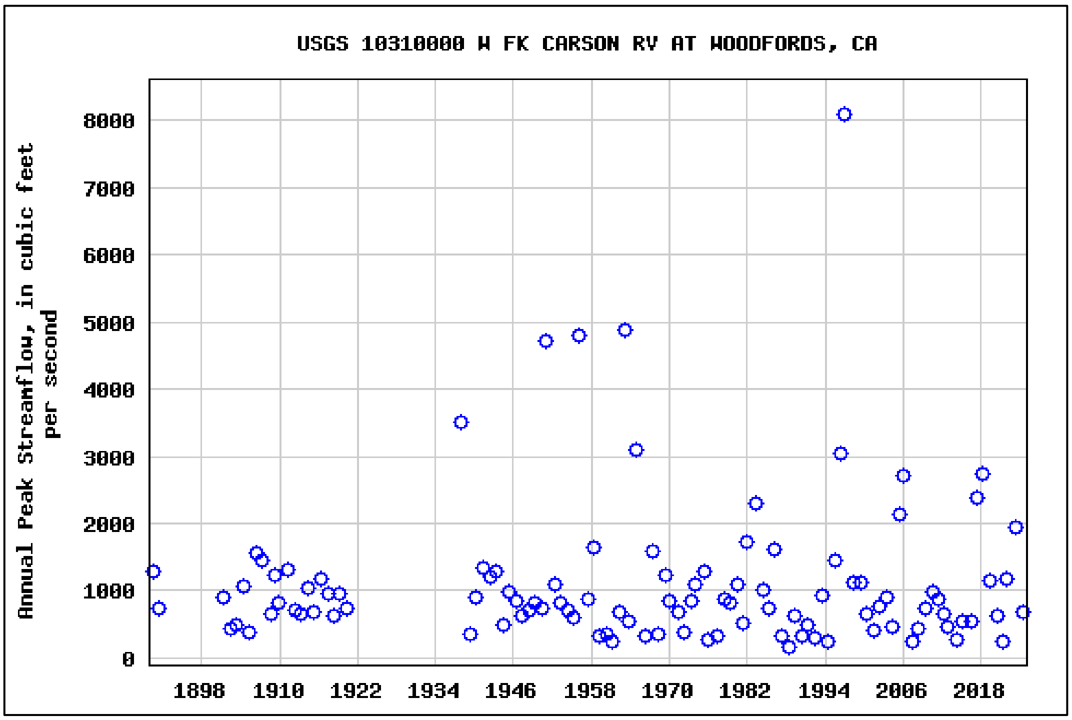


Figure 3. *Historic Water Year Peak Flows at the West Fork Carson River at Woodfords Gage (from USGS website [USGS, 2026]).*

Table 1 lists the highest recorded peak flows during the period of record. The largest flood on record occurred on December 31, 1996, with a peak discharge of 8,100 cubic feet per second (cfs). This event was almost twice as large as the second-highest recorded flood (4,890 cfs in 1963). Notably, the seventh-largest flood in the record occurred earlier that same year, in May 1996, making calendar year 1996 an unusually extreme hydrologic year in the context of the full period of record.

Table 1. *Highest Historic Flow Peaks at USGS Gage on West Fork Carson at Woodfords (Active Years: 1890 – 1891, 1901 – 1920, 1937 – present)*

Date	Peak Flow (cfs)
12/31/1996	8,100
1/31/1963	4,890
12/22/1955	4,810
11/19/1950	4,730
12/10/1937	3,500
12/22/1964	3,100
5/15/1996	3,040
4/7/2018	2,750
12/30/2005	2,720
5/5/2017	2,380
5/28/1983	2,290

Peak flow frequency analysis was conducted using the U.S. Army Corps of Engineers Hydrologic Engineering Center Statistical Software Package (HEC-SSP). Results are presented in **Table 2**. Based on this analysis the estimated 100-year recurrence interval peak flow is close to 6,000 cfs, and the 2-year recurrence interval flow is around 800 cfs. The 2-year discharge was used in this study to delineate floodplain inundation areas for hydraulic modeling and sediment storage analyses (**Appendix G-3**).

Table 2. *Estimated Peak Flow Frequency in West Fork Carson River at Woodfords Gage*

Recurrence Interval	Peak Flow at USGS Gage
1.25-yr	450
1.5-yr	550
2-yr	790
5-yr	1,510
10-yr	2,190
20-yr	3,030
50-yr	4,460
100-yr	5,840

Peak flows in the primary tributaries were evaluated using two methods (**Table 3**). The first method, referred to as the basin transfer method, uses the peak flows at the Woodfords gage, and applies a simple drainage area ratio adjustment to estimate peak flows on tributaries. The second method used regional regression equations developed by the USGS (Gotvald et al., 2012) in the StreamStats program (Ries et al., 2024). StreamStats estimates peak flood discharges based on watershed characteristics, with drainage area and mean annual precipitation serving as key input parameters.

Table 3 compares peak flow estimates generated using StreamStats with flows generated using the drainage-area-scaled flows derived from the Woodfords gage. The comparison shows the StreamStats estimates are significantly higher, typically by a factor of two, compared with those developed from the basin transfer method. StreamStats regression equations are based on statistical analyses of multiple gaged basins and represent average hydrologic behavior across a broad region. As such, they may not fully reflect local watershed conditions. The study area is primarily snowmelt-driven and includes meadow and floodplain storage that can attenuate peak flows. In contrast, the regional regression datasets used by StreamStats often include basins influenced by rainfall-driven runoff, which typically produce sharper and higher peak discharges. Consequently, StreamStats may overestimate peak flows for this type of watershed. Because the Woodfords gage is located within the basin and represents similar watershed conditions and local hydrology, and has a long period of record, the basin transfer method was used for this planning-level hydraulic model.

Table 3. *Estimated Tributary Flows for Hydraulic Model Input*

		Percent Chance Exceedance	80	50	10	2	1
		Return Int.	1.25	2	10	50	100
Location	Drainage Area (Sq-Mi)	Analysis	Flow (cfs)				
West Fork Carson at Woodfords, CA (USGS 10310000)	65.4	Bulletin 17B	449	789	2186	4459	5841
Headwaters to Below Willow Creek							
Upper West Fork Carson River	1.91	DA Ratio	13	23	64	130	171
		StreamStats	39	68.6	206	405	501
Forestdale Creek	3.6	DA Ratio	25	43	120	245	322
		StreamStats	64	112	336	660	816
Red Lake Creek	9.09	DA Ratio	62	110	304	620	812
		StreamStats	120	210	628	1230	1520
Hawkins Creek	2.94	DA Ratio	20	35	98	200	263
		StreamStats	46	81.4	244	480	595
Unnamed 1L	1.68	DA Ratio	12	20	56	115	150
		StreamStats	26	46.5	140	275	342
Maxwell Creek	3.63	DA Ratio	25	44	121	247	324
		StreamStats	57	101	303	596	738
Willow Creek	10.87	DA Ratio	75	131	363	741	971
		StreamStats	89	157	470	925	1150
Willow Creek to Woodfords Gage							
Horsethief Canyon	3.76	DA Ratio	26	45	126	256	336
		StreamStats	45	78.3	235	462	574
Hidden Creek	1.77	DA Ratio	12	21	59	121	158
		StreamStats	25	44.8	134	265	330
Deep Creek	1.68	DA Ratio	12	20	56	115	150
		StreamStats	28	49.4	148	292	363

2.2.2 Hydraulic Model Set Up

A two-dimensional (2D) hydraulic model was developed to simulate floodplain inundation patterns and flow dynamics throughout the WFCR watershed. The model domain and boundary conditions are shown in **Figure 4**. The model extends from the upper basin past the California-Nevada state line and includes the mainstem WFCR and major tributaries.

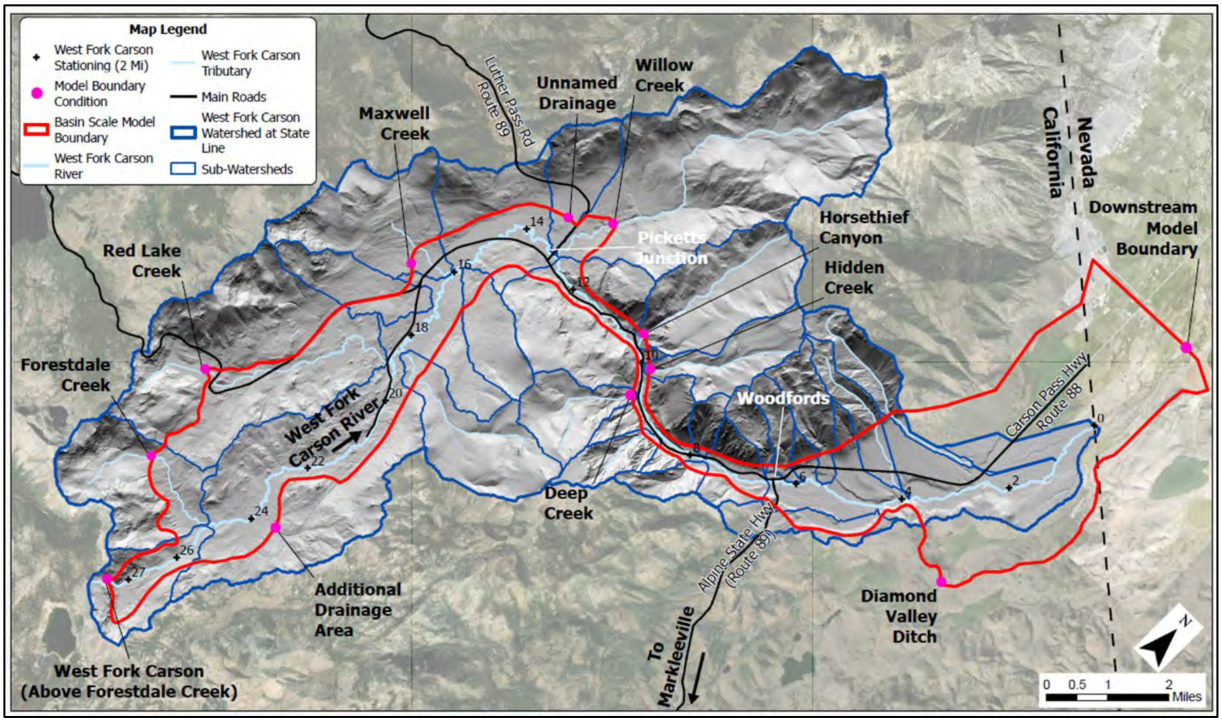


Figure 4. *Basin-Scale Hydraulic Model Extent and Boundary Conditions*

Topographic input for the hydraulic model was obtained from Sierra Nevada Work Unit 8 LiDAR data collected by NV5 Geospatial for the USGS. LiDAR acquisition occurred over two days in November 2021 and during multiple collection periods from June through August 2022. The 2022 dataset was used as the primary basis for terrain development. Minor terrain modifications were performed at select roadway crossings to hydraulically connect upstream and downstream flow paths where culvert information was unavailable. These edits were limited in scope and intended solely to prevent artificial flow obstructions in the model. Given the scope of the current project and the scale of the watershed, no supplemental ground survey data were incorporated into the modeling terrain. While this is appropriate for a planning-scale model, it is anticipated that site-scale modeling to support design work will require collection of ground-based survey data.

A two-dimensional computational mesh was developed with breaklines along channel banks to improve representation of channel geometry and hydraulic gradients. Finer mesh elements were applied within the active channel where hydraulic variability is greatest, while coarser elements were used across the overbank and floodplain areas to enhance computational efficiency without materially affecting model accuracy.

Boundary conditions consisted of flow hydrographs applied at the upstream limits of the mainstem and principal tributaries. Peak discharges for tributary inflows were estimated using a basin transfer method (**Table 3**). This approach assumes similar hydrologic response characteristics among subwatersheds and is considered appropriate for basin-scale planning analyses of this nature.

2.2.3 Hydraulic Model Results

Results of the basin-wide 2D hydraulic model are presented in **Appendix G-3** as a map book showing inundation extents for the 1-year, 2-year, and 10-year recurrence interval peak flows. These maps provide a spatial representation of where water spreads across the valley bottom under progressively larger flood events and were used to evaluate floodplain connectivity and restoration potential throughout the watershed.

Figure 5 presents two examples from the hydraulic modeling results map book. In this first example (**Figure 5A**), between Diamond Valley Road and the California-Nevada State Line, the modeled 1-year and 2-year flows are relatively confined to the existing channel and adjacent low surfaces. The 10-year flow does not spread extensively across the valley bottom as is common on fans; instead, the flood flow mostly remains within the main channel (except within a fan channel at the lower end of the reach). This pattern indicates that the reach is very incised relative to the adjacent floodplain, and/or wider. Efforts to reconnect the floodplain will require substantial "lift," raising the grade of the channel by 8 to 10 feet using boulders. In the second example (**Figure 5B**), Forestdale Creek and the West Fork Carson River converge in a narrow, bedrock-confined reach. Here, the channel is geologically confined and there is no floodplain. The model shows that the most upstream significant floodplain storage area in the watershed is at this location, where the valley opens to upper Faith Valley. In these areas, with a rise in the base level of 2 to 3 feet, the floodplain would be more frequently inundated, capture more fine sediment, temporarily store floodwater, and promote groundwater recharge.

Areas such as those identified with green arrows in **Figure 5** immediately identify potential restoration opportunities. Where the 10-year flood inundates large portions of the valley bottom, but smaller refloods do not, relatively modest increases in channel bed elevation (e.g., on the order of 2–3 feet) could increase the frequency of overbank flow from once per decade to annual or near-annual events. Such changes would be expected to increase floodplain sedimentation, improve hydrologic connectivity with the floodplain, and reduce bank erosion.

At the basin scale, these modeling results provided a screening-level tool for identifying reaches with the potential for increasing floodplain connectivity.

In addition to the basin-scale model, the hydraulic model was applied at a finer, site-specific scale to evaluate initial feasibility of specific restoration concepts. Smaller models were developed focusing on several areas of interest where multiple existing and proposed model runs were used to evaluate potential project opportunities. These site-specific models have higher resolution and shorter run times than the basin scale model, allowing multiple scenarios to be evaluated. These site-scale hydraulic analyses were used to estimate the amount of channel bed aggradation that might be required to reconnect floodplains and to assess potential interactions with infrastructure or other constraints. The results of those site-scale evaluations are included in **Appendix P-1**.

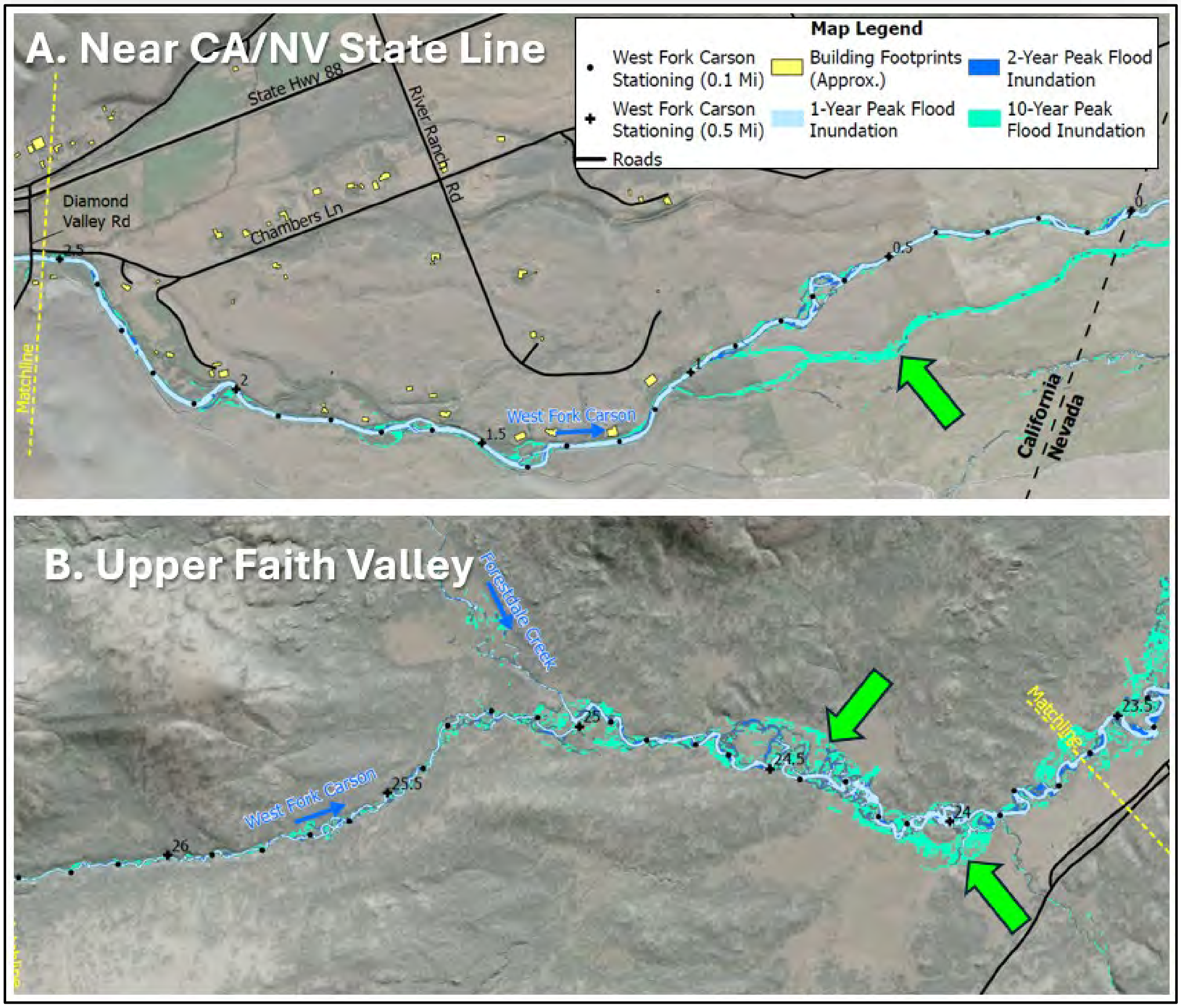


Figure 5. *Hydraulic Model Results Showing Extent of the 1-Year, 2-Year, and 10-Year Recurrence Interval Flows. (A) Near the California/Nevada State Line (B) Below the Confluence of Forestdale Creek and West Fork Carson River. Green arrows identify accessible floodplains that are inundated by the 10-year but not the 2-year floods.*

2.3 SEDIMENT BUDGET

A ***sediment budget*** is a quantitative accounting of sediment sources, storage, and transport within a defined spatial domain (like a watershed) over a specified time period (Dietrich and Dunne, 1978). A sediment budget provides a framework for evaluating how sediment is supplied to, stored within, and removed from a landscape, and for identifying which processes dominate sediment dynamics (Reid and Dunne, 2016). Sediment budgets can be useful as comparative and diagnostic tools, allowing managers to distinguish between dominant and secondary sediment sources of sediment, even if individual components of the sediment budget are not precisely known (Reid and Dunne, 1996).

A sediment budget for fine sediment was developed for the portion of the WFCR watershed in California. The sediment budget quantifies the sources, transport, and storage of fine sediment in the system (**Figure 6**). For this project, the purpose of the sediment budget is to provide a process-based foundation for identifying and prioritizing restoration actions that would reduce fine sediment delivery to the WFCR, and in turn, benefit water quality.

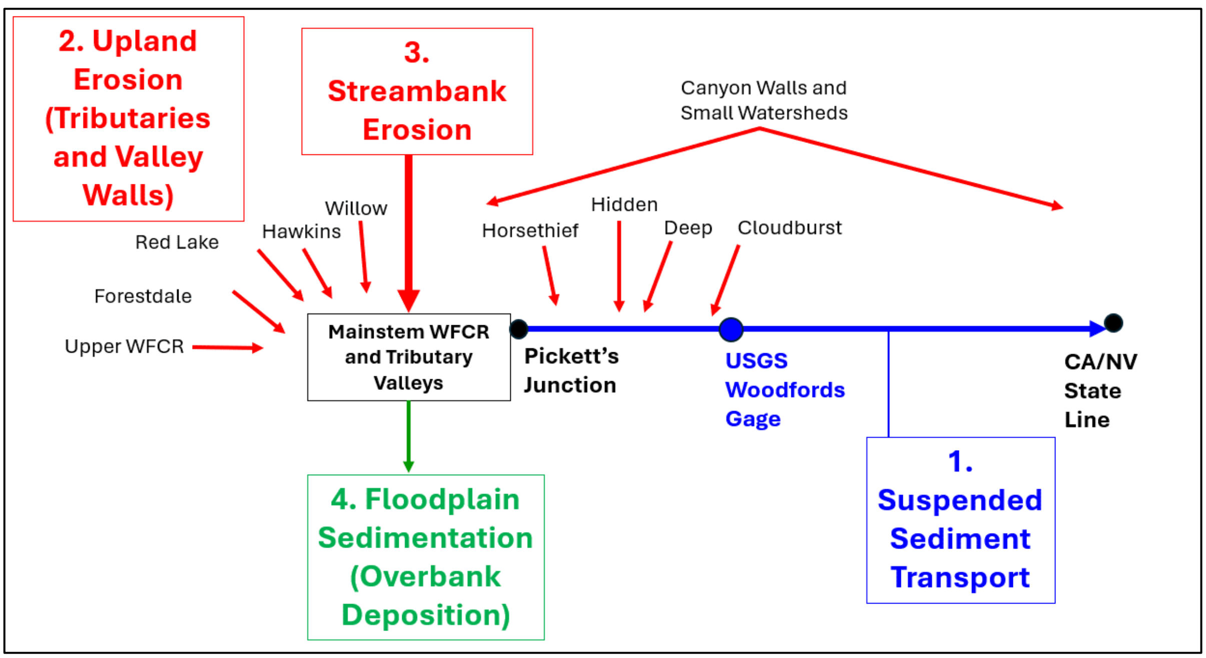


Figure 6*. Sediment Budget Schematic for Fine Sediment in the West Fork Carson River. Red arrows are sediment sources, green arrow is sediment storage, and blue arrow represents sediment export from the basin via suspended load transport.*

The sediment budget in this study addresses fine sediment (fine sand, silt, and clay) in the WFCR above the California/Nevada State Line and integrates four primary components (**Figure 6**):

(1) instream suspended sediment transport,
(2) upland erosion,
(3) streambank erosion, and

(4) overbank floodplain sedimentation[1].

Each of these components was estimated using methods appropriate for a basin-scale assessment, including regional empirical studies, local field observations, hydraulic modeling, historical aerial imagery, and long-term stream gaging records.

Uncertainties in the Sediment Budget. The objective of the sediment budget is not to produce a precise annual mass balance, but to constrain the relative magnitude and spatial distribution of sediment sources and sinks. Consistent with the guidance of Dietrich and Dunne (1978) and Reid and Dunne (1996), high levels of uncertainty are explicitly acknowledged for the sediment budget. For this project, the main purpose is to identify dominant processes rather than quantify exact fluxes.

2.3.1 Suspended Sediment Transport

The long-term suspended sediment transport in the WFCR was estimated using flow and sediment sampling data from the USGS gage at Woodfords (USGS Gage 10310000), supplemented with water quality monitoring from the Surface Water Ambient Monitoring Program (SWAMP), a program administered by the California State Water Resources Control Board to track trends in surface water health (SWRCB, 2023). The Woodfords gage provides a continuous record of streamflow and sediment downstream of Hope Valley, with data extending back to the late 1800s (see **Figure 3**). As is normally the case, suspended sediment concentrations (SSC) increase with increasing flows, although considerable scatter exists, particularly during high-flow events (**Figure 7**).

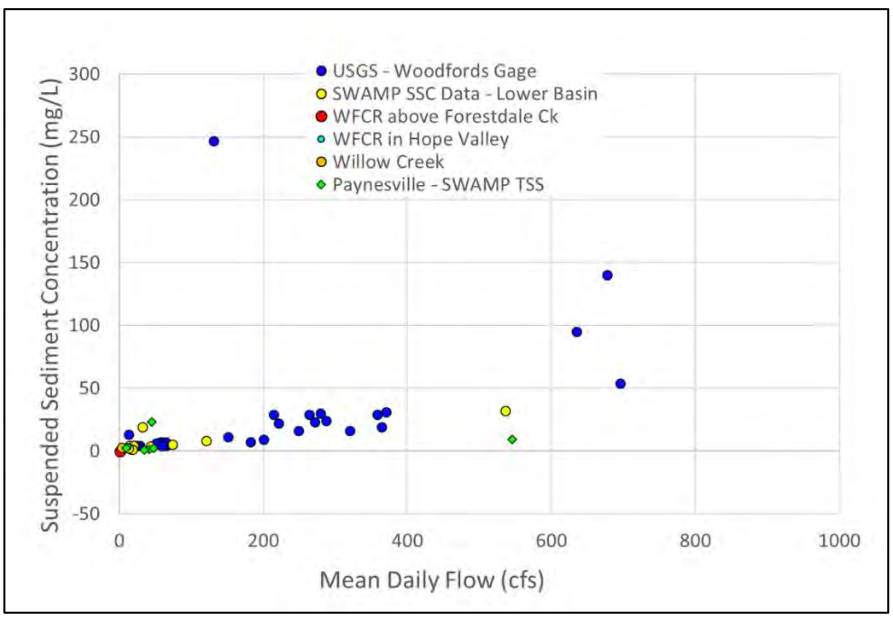


Figure 7*. Suspended Sediment Concentration Data from Different Locations Around the WFCR Watershed*

[1] Component #4 (floodplain sedimentation or overbank deposition) was the most uncertain of the four components and the most time consuming to estimate in practice. Therefore, overbank deposition was not estimated independently but instead was solved from the other three components and reality checked with a simple calculation.

To estimate the long-term suspended sediment flux, we combined the USGS SSC data along with SWAMP SSC data from the lower basin (**Figure 8**). These data show a clear steep increasing trend with discharge. This strong trend reflects that there must be a non-linear increase in the intensity in the processes supplying the fine sediment during higher flows.

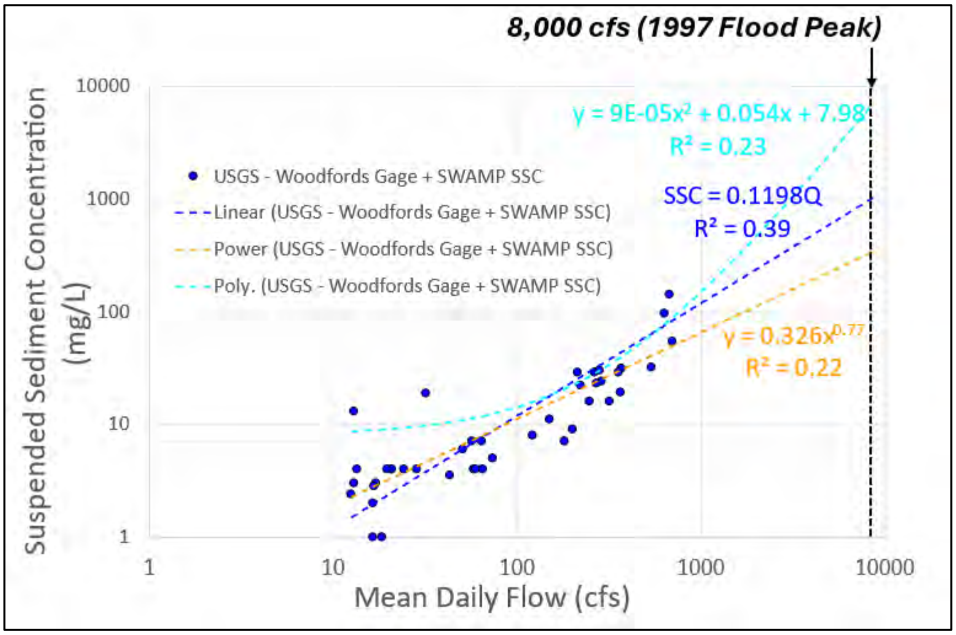


***Figure 8**. Suspended Sediment Rating Curves Versus Mean Daily Flow (data points are the combined data from USGS Woodfords gage and SWAMP SSC data from the Lower Basin)*

Several regression approaches were evaluated to quantify the SSC–flow relationship for estimating sediment flux. Power-law regressions are commonly used for rating curves, but this regression appears to underestimate the limited SSC data available for high flows (orange line, **Figure 8**). A second order polynomial regression (cyan line, **Figure 8**) increases more steeply with discharge and goes through the data at moderately high flows, but likely overestimates SSC during extreme events for which we have no data. The best fit (R^2 = 0.39) was found to be a linear regression with the intercept set to zero (blue line, **Figure 8**). The resulting equation (SSC [mg/L] = 0.1198 × Q [cfs]) appears to provide a more reasonable fit to the available data across the range of flow.

The three equations were applied to the mean daily streamflow data for the Woodfords gage, and the daily sediment fluxes were aggregated into Water Year sediment fluxes (October 1 to September 30) for the period of record, which covers more than 100 years. Computed this way, the range of estimates for the long-term fine sediment flux at Woodfords spans approximately 3,000 to 6,000 tons per year (**Figure 9**). The power-law model yields the lowest estimate (~3,000 T/yr) and, as explained in the previous paragraph, likely underestimates transport during high flows. For example, with that model the water year with by far the largest flood (WY 1997) only ranks as the fourth-largest water year in terms of sediment flux (**Figure 9A**), which is not realistic based on the expectation that sediment mobilizes disproportionately during the highest flows. In contrast, the polynomial model

(~5,715 T/yr) may overestimate flux during extreme floods, resulting in a sediment flux for WY 1997 that is far outside the scale of the graph (**Figure 9C**). The linear model provides an intermediate estimate of 4,554 T/yr (**Figure 9B**). Based on these comparisons, **a reasonable round-number estimate for the long-term average fine sediment flux is approximately 5,000 tons per year**, recognizing substantial uncertainty.

This estimate is considered more reliable than upland and bank erosion predictions because it is based on direct, long-term, local measurements of sediment transport, rather than the more indirect empirical models as discussed in the following sections. Thus, the estimate of 5,000 tons per year provides a reasonable, well-grounded estimate of the amount of sediment leaving the watershed, capturing the integrated effects of all upstream sources and storage reservoirs.

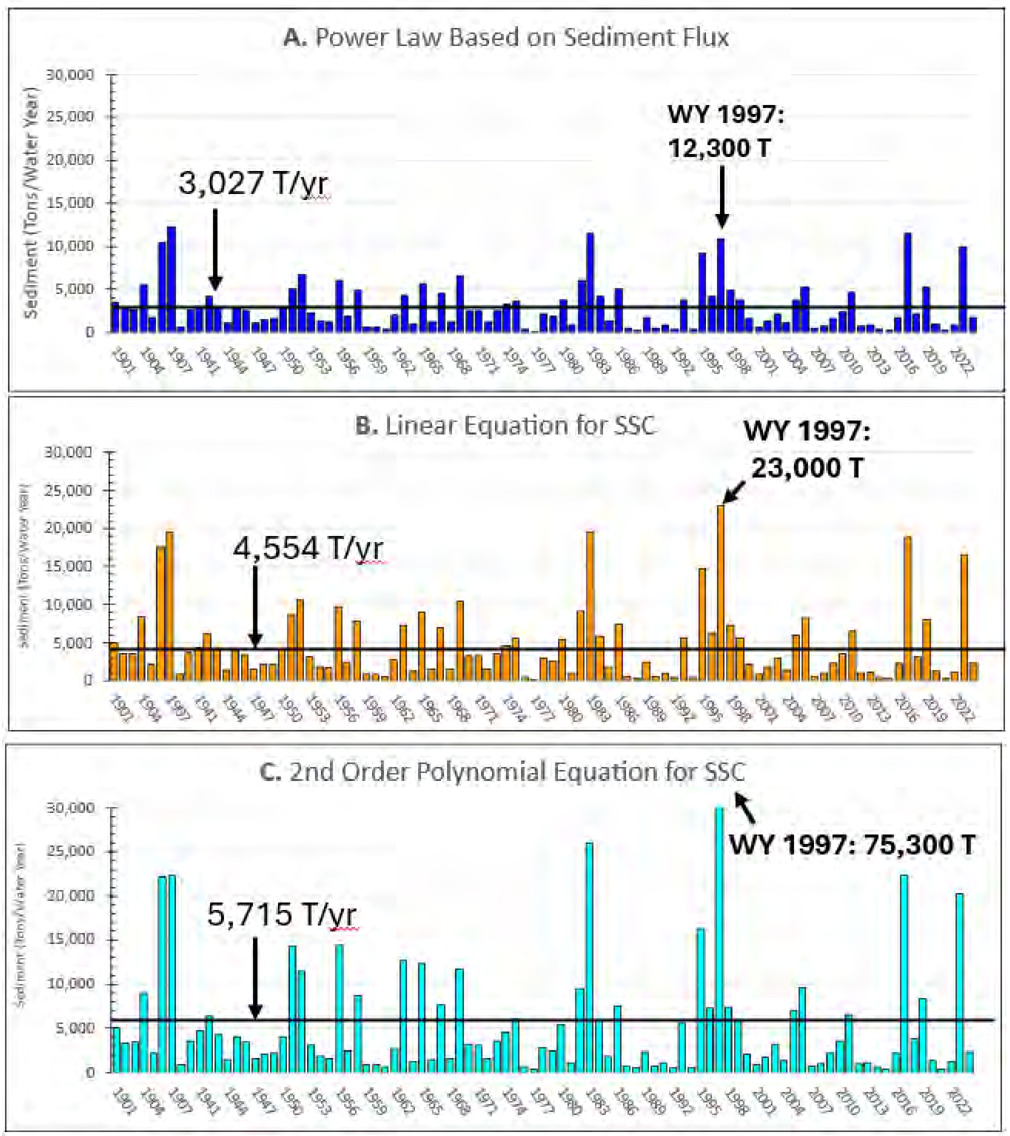


***Figure 9**. Annual Sediment Fluxes Computed Using Three Different Rating Equations: (A) Power Law Regression of Discharge Versus Sediment Flux; (B) Linear Regression Through 0,0 of Discharge Versus Suspended Sediment Concentration; (C) Second Order Polynomial for Discharge Versus Suspended Sediment Concentration*

2.3.2 Upland Erosion

Upland erosion represents the portion of the sediment budget derived from hillslopes, unchannelized drainage features, and headwater areas upstream of the actively incising and eroding stream network. Upland erosion consists of hillslope processes like gullying, landslides, rainsplash, rill erosion, wind erosion, and other processes (**Figure 10**). The upland erosion component of the sediment budget would be the primary part of the sediment budget affected by human and other perturbations, including logging, road building, and increased wildfire frequency. The upland-sourced sediment is transported downstream and delivered to the WFCR as tributary inflows and direct erosion from canyon walls (**Figure 6**).

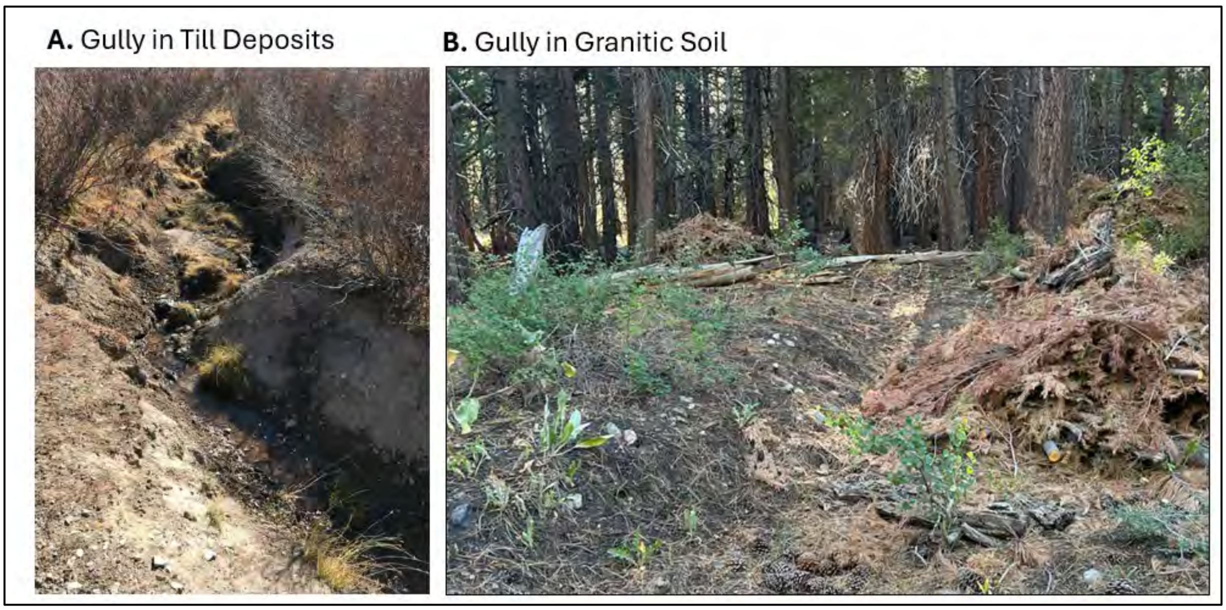


***Figure 10**. Photos of Upland Erosion in the West Fork Carson River Watershed*

Estimates of upland erosion are based on an extensive study by Simon et al. (2004), which estimated fine sediment yields for watersheds in the Lake Tahoe region (**Figure 11**). In that study, long-term streamflow and suspended sediment concentration data from a set of "index basins" were used to compute annual sediment yields, expressed as mass of suspended sediment (tons/yr). These basins span a range of basin sizes, but experience broadly similar climate, geology, precipitation regime, and relief as in the WFCR basin, making them suitable analogs for the current study.

Waterways conducted additional analyses of the Simon et al. (2004) dataset to better understand the factors controlling differences in upland sediment yield among the index basins. The index basins were grouped into three categories—high, medium, and low erosion—based on their reported sediment yields (**Table 4;** also see **Figure 2**). Comparison of basin characteristics suggested that geology may be a dominant control on erosion rates among these watersheds, given the relatively uniform climate and relatively similar topographic relief across the Lake Tahoe region (with exceptions).

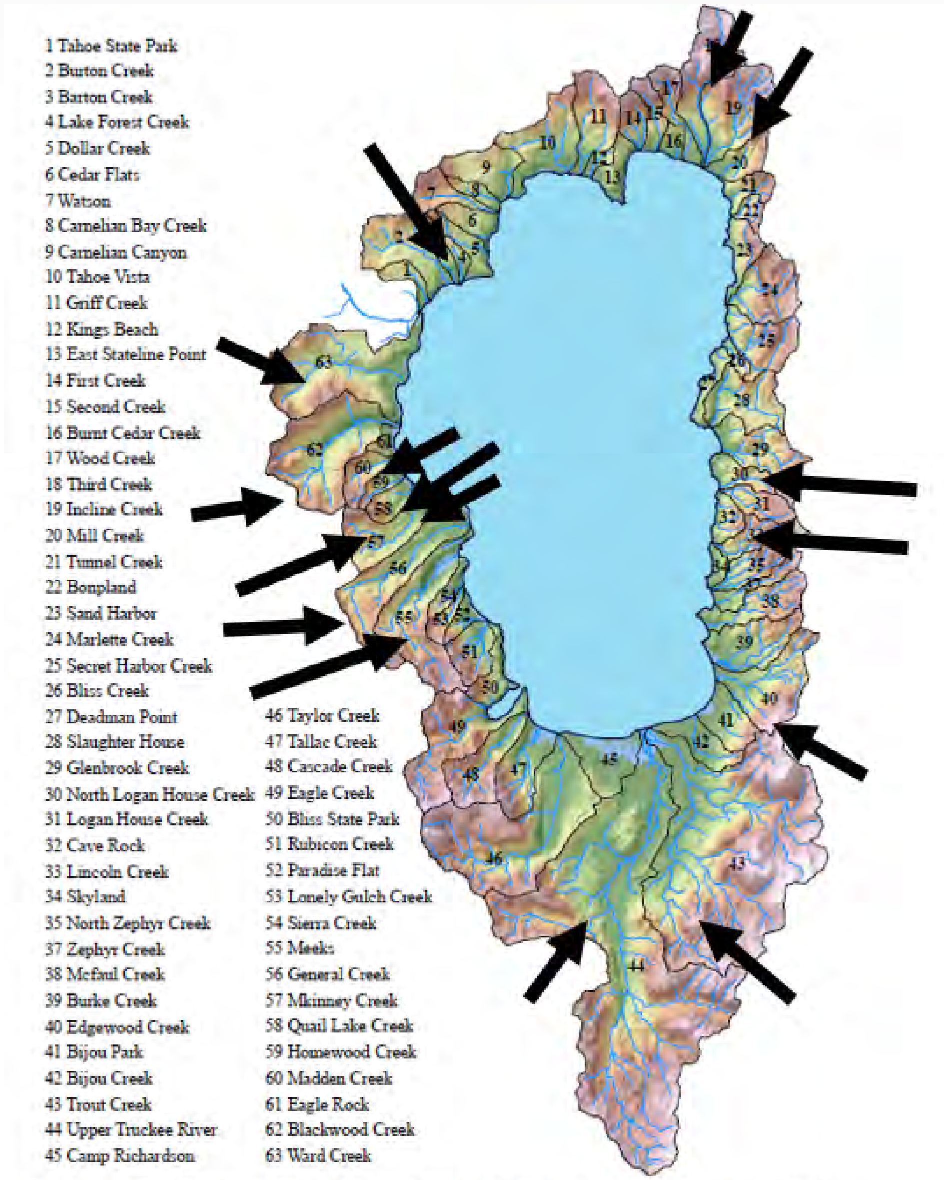


Figure 1. Map of the Lake Tahoe Basin showing the 63 watersheds draining to the lake.

***Figure 11**. Tahoe Basin Watersheds from Simon et al. (2004). Black arrows added by Waterways identify the "index watersheds" in **Table 4**.*

To test this hypothesis, Waterways performed a GIS-based analysis of the geology of the index watersheds using the digital geology compilation of the Lake Tahoe basin (Saucedo, 2005; **Table 5**). The analysis grouped mapped units into four generalized categories: granitic rocks, volcanic rocks, glacial till, and alluvium. The relative proportion of these geologic units was calculated for each index basin and compared to the estimated sediment yields. Basins with a higher percentage of glacial till typically had higher sediment yields, while basins dominated by granitic or volcanic lithologies had lower sediment yields (**Table 4**). There were some exceptions and variations, typically related to land use and topographic features of the index basins. The index basins were grouped into three categories—high, medium, and lower eroding basins.

A parallel analysis was conducted for subwatersheds within the WFCR basin using the same geologic groupings. Based on the similarity of geologic composition, basin size, and topography between WFCR subwatersheds and the Lake Tahoe index basins, sediment yield values were assigned to each WFCR subwatershed by analogy (**Table 5**). These assigned yields, shown in **Figure 12**, represent long-term average upland sediment inputs and are intended to capture relative differences among subwatersheds, rather than precise annual loads. The resulting upland erosion estimates amount to **a long-term average upland fine sediment yield of about 1,400 tons/yr at the CA/NV State Line**. Importantly, **80 percent of this amount originates in the upper basin** (**Table 5**). These estimates provide a basin-scale characterization of sediment sources derived from hillslopes and headwater areas. While these estimates are subject to uncertainty, they use regional empirical data and provide a consistent framework for comparing upland sediment contributions across the WFCR watershed.

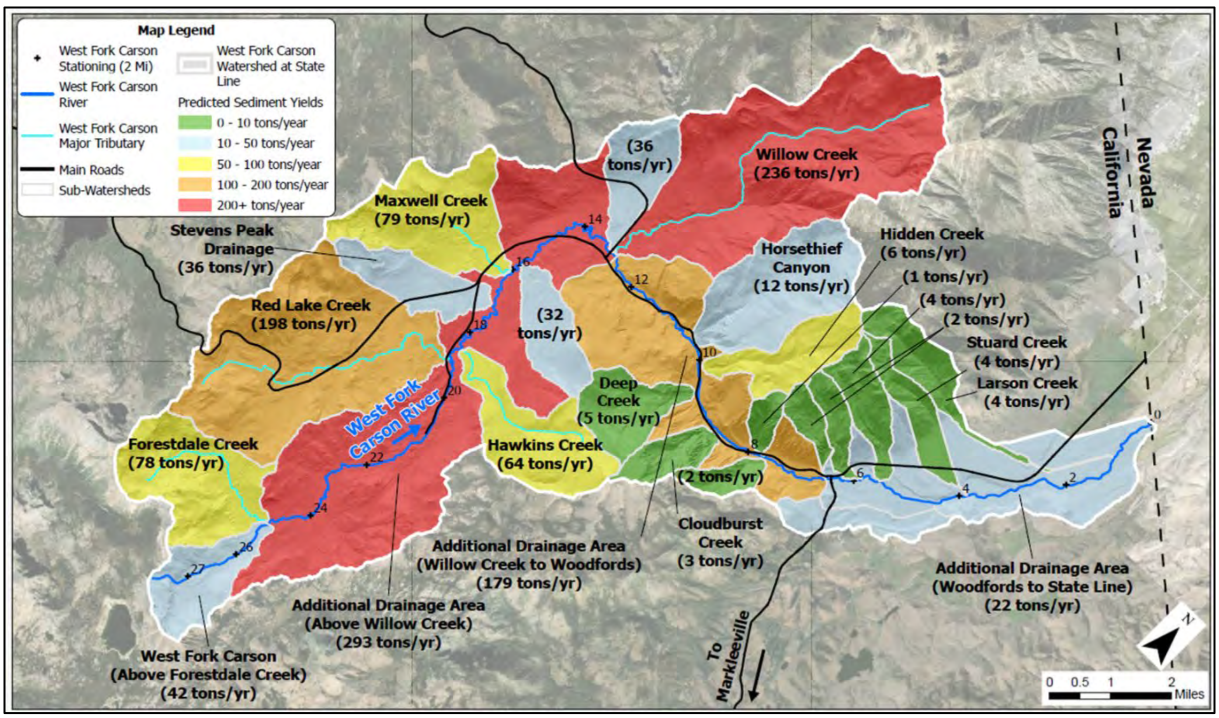


Figure 12*. West Carson Watershed Map Showing Upland Erosion Amounts*

Table 4. *Geology and Sediment Yields in Tahoe Basin Index Watersheds (Simons et al., 2004)*

Index Watersheds	Generalized Geology by Watershed Area (computed by Waterways using geologic compilation by Saucedo, 2005)							Sediment yields reported by Simon et al. (2004)					Computed by Waterways				
	Drainage Area (mi2)	**Drainage Area (km2)**	**Granitic and Meta-morphic**	**Volcanic**	**Till**	**Alluvium**	**Dominant Lithologies (G = granitic, V=volcanic, T=till, A=alluvium)**	**Median Annual Total Suspended Load**	**Median Annual Fines Load**	**Total Suspended Sediment Yield**	**Total Fines Yield**	**Contributions from Streambanks to Fines Yield**	**Fines as a % of Sediment Yield**	**Upland Fines Yield (Total minus Banks)**	**Upland Sand Yield (Computed from % Fines in Total Load)**	**Upland Total Sediment Yield (Fines + Sand)**	**Notes on Sediment Sources**
(Sorted by Total Suspended Sediment Yield)								metric tons/yr	metric tons/yr	T/km2-yr	T/km2-yr	%	%	T/km2-yr	T/km2-yr	T/km2-yr	
Group A - Very High Upland Sediment Yields - Extensive Till and Gullying in Volcanics, Heavy Logging and Roads																	
Blackwood Creek	11.3	29.19	8%	57%	28%	7%	V, T	1930	846	66.55	29.17	51%	44%	**14.31**	**18.34**	**32.65**	Bank erosion and gullying in volcanic lithology
Third Creek	6.1	15.85	35%	13%	44%	7%	T, G	880	318	56.05	20.25	10%	36%	**18.23**	**32.22**	**50.45**	Extensive till deposits in lower watershed
Ward Creek	9.5	24.70	2%	39%	52%	7%	T, V	855	412	34.06	16.41	25%	48%	**12.31**	**13.24**	**25.55**	Extensive till deposits in lower watershed
Group A Average	*9.0*	23.25	15%	37%	41%	7%	T and V	*1,222*	*525*	*52*	*21.95*	*29%*	*43%*	***14.95***	***21.26***	***36.21***	
Group B - Moderately High Upland Sediment Yields - Extensive Till in Granitic Watersheds, Generally Larger Drainage Basins																	
Upper Truckee River	53.8	139.34	49%	9%	28%	13%	G, T	2200	1010	15.49	7.11	63%	46%	**2.61**	**3.08**	**5.69**	Major bank erosion, lots of till and alluvial deposits
Trout Creek	36.7	95.09	67%	0%	28%	5%	G, T	1190	462	12.51	4.86	2%	39%	**4.74**	**7.47**	**12.22**	Lot of till deposits
Incline Creek	6.6	17.17	61%	23%	8%	8%	G, V	217	129	11.99	7.13	4%	59%	**6.87**	**4.68**	**11.55**	Lot of till deposits
General Creek	7.6	19.68	54%	0%	37%	8%	G, T	176	53.3	9.12	2.76	45%	30%	**1.52**	**3.51**	**5.03**	Major bank erosion, lots of till and alluvial deposits
Meeks Creek*	8.2	21.36	76%	0%	21%	0%	G	79.8	19.1	3.59	0.86	0%	24%	**0.86**	**2.73**	**3.59**	Short data set - maybe should have a higher yield
Group B Average	*22.6*	58.53	61%	7%	25%	7%	G and T	*773*	*335*	*11*	*4.54*	*23%*	*40%*	***3.32***	***4.30***	***7.62***	
Group C - Low Upland Sediment Yields - Granitic Watersheds, Relatively Little Till																	
Eagle Creek*	7.0	18.05	93%	0%	2%	1%	G	69.9	21.8	3.43	1.07	69%	31%	**0.34**	**0.74**	**1.08**	Very low sed yield (granite)
Edgewood Creek	3.1	7.92	95%	0%	0%	5%	G	21.3	11.4	2.63	1.41	18%	54%	**1.15**	**1.00**	**2.15**	Very low sed yield (granite), relatively high % bank erosion
Quail Lake*	1.2	3.19	14%	29%	52%	3%	T	6.4	3.2	1.52	0.76	0%	50%	**0.76**	**0.76**	**1.52**	Small watershed domninated by till, but low yield
Dollar Creek*	1.1	2.96	0%	100%	0%	0%	V	4.6	2.6	0.98	0.55	4%	57%	**0.53**	**0.41**	**0.94**	None
Glenbrook Creek	4.3	11.07	47%	49%	0%	4%	G/V	8.9	7	0.85	0.67	46%	79%	**0.36**	**0.10**	**0.46**	Very low sed yield, high % bank erosion
Logan House	2.1	5.42	99%	0%	0%	1%	G	3	2.3	0.56	0.43	1%	77%	**0.42**	**0.13**	**0.55**	None
Group C Average	*3.1*	8.10	58%	30%	9%	2%	G and V	*19*	*8*	*2*	*0.81*	*23%*	*58%*	***0.59***	***0.52***	***1.12***	

* denotes watersheds with only 3 years of data (the rest are all > 11 years of data)

Table 5. Sediment Yields from Upper West Fork Carson River Watershed

Watershed	Drainage Area	Drainage Area	Granitic/ Metamorphic	Volcanic	Till	Alluvium	Water	Dominant Lithologies	Index Watershed(s) with Similar Geology	Index Upland Fines Yield	Index Upland Sand Yield	Index Upland Total Yield	Upland Fines Loading	Upland Sand Loading	Total Upland Suspended Sediment Supply	Total Upland Suspended Sediment Supply	Percent of Overall Upland Fine Sediment Supply at State Line
	(mi^2)	(km^2)	*Percentage of Drainage Basin*							T/(km^2-yr)	T/(km^2-yr)	T/(km^2-yr)	T/yr	T/yr	T/yr (1,000 kg)	tons/yr (2,000 lb)	
Headwaters to Below Willow Creek																	
West Fork Carson River above Forestdale	1.91	4.94	4%	77%	8%	9%	2.3%	V	Group B average	3.32	4.30	7.62	16.42	21.23	37.65	**42**	3%
Forestdale	3.60	9.31	21%	55%	20%	4%	0.2%	V	Group B average	3.32	4.30	7.62	30.93	40.00	70.93	**78**	6%
Red Lake Creek	9.09	23.54	37%	20%	33%	9%	1.6%	G,T	Group B average	3.32	4.30	7.62	78.17	101.09	179.25	**198**	14%
Hawkins Creek	2.94	7.62	42%	28%	26%	3%	0.0%	G,V,T	Group B average	3.32	4.30	7.62	25.31	32.73	58.04	**64**	5%
Stevens Creek	1.64	4.26	16%	13%	58%	12%	0.6%	T	Group B average	3.32	4.30	7.62	14.14	18.29	32.44	**36**	3%
Unnamed 1L	1.68	4.34	61%	1%	34%	4%	0.0%	G, T	Group B average	3.32	4.30	7.62	14.43	18.66	33.08	**36**	3%
Maxwell	3.63	9.40	25%	22%	47%	6%	1.1%	T,G,V	Group B average	3.32	4.30	7.62	31.21	40.36	71.57	**79**	6%
Unnamed 2R	1.49	3.86	10%	37%	53%	0%	0.0%	T,V	Group B average	3.32	4.30	7.62	12.83	16.59	29.42	**32**	2%
Willow	10.87	28.14	78%	0%	21%	1%	0.0%	G,T	Group B average	3.32	4.30	7.62	93.48	120.88	214.36	**236**	17%
Additional Drainage Area	13.50	34.96						G, T	Group B average	3.32	4.30	7.62	116.10	150.14	266.24	**293**	22%
	50.34	130.38	45%	20%	28%	6%	0.5%	G, T	**Headwaters to Below Mouth of Willow Creek**				**433**	**560**	**993**	**1,095**	**80%**
Willow Creek to Woodfords Gage																	
Horsethief	3.76	9.75	38%	53%	0%	8%	0.0%	V,G	Group C average	0.59	0.52	1.12	5.78	5.09	10.87	**12**	0.9%
Hidden	1.77	4.60	28%	72%	0%	0%	0.0%	V,G	Group C average	0.59	0.52	1.12	2.73	2.40	5.13	**6**	0.4%
Deep	1.68	4.35	14%	86%	0%	0%	0.0%	V,G	Group C average	0.59	0.52	1.12	2.58	2.27	4.85	**5**	0.4%
Cloudburst	0.90	2.34	45%	52%	0%	3%	0.0%	V,G	Group C average	0.59	0.52	1.12	1.39	1.22	2.61	**3**	0.2%
Unnamed 3R	0.58	1.51	84%	9%	0%	7%	0.0%	G	Group C average	0.59	0.52	1.12	0.90	0.79	1.69	**2**	0.1%
Unnamed 4L	0.43	1.11	93%	5%	0%	1%	0.0%	G	Group C average	0.59	0.52	1.12	0.66	0.58	1.24	**1**	0.1%
Additional Drainage Area	6.01	145.95						V, G	Group C average	0.59	0.52	1.12	86.57	76.20	162.77	**179**	13.2%
	65.48	169.61	46%	26%	22%	6%	0.4%	V,G	**Willow Creek to Woodfords**				**101**	**89**	**189**	**209**	**15%**
Woodfords to Paynesville																	
Unnamed 5L	0.53	1.36	75%	24%	0%	1%	0.0%	G	Group C average	0.59	0.52	1.12	0.81	0.71	1.52	**2**	0.1%
Unnamed 6L	0.68	1.75	84%	8%	0%	8%	0.0%	G	Group C average	0.59	0.52	1.12	1.04	0.91	1.95	**2**	0.2%
Unnamed 7L	1.20	3.11	82%	9%	0%	9%	0.0%	G	Group C average	0.59	0.52	1.12	1.84	1.62	3.47	**4**	0.3%
Unnamed 8R	1.09	2.81	7%	6%	17%	70%	0.0%	Alluvium	Group B average	3.32	4.30	7.62	9.34	12.08	21.42	**24**	1.7%
Stuard	1.13	2.94	62%	6%	0%	33%	0.0%	G	Group C average	0.59	0.52	1.12	1.74	1.53	3.27	**4**	0.3%
Additional Drainage Area	4.15	10.76						V, G	Group C average	0.59	0.52	1.12	6.38	5.62	12.00	**13**	1.0%
	74.26	192.33	45%	24%	20%	11%	0.3%	G	**Woodfords to Paynesville**				**21**	**22**	**44**	**48**	**4%**
Paynesville to State Line																	
Larson	1.13	2.93	76%	12%	1%	11%	0%	G	Group C average	0.59	0.52	1.12	1.74	1.53	3.27	**4**	0.3%
Additional Drainage Area	2.79	7.23						V, G	Group C average	0.59	0.52	1.12	4.29	3.77	8.06	**9**	0.7%
	78.18	202.49	44%	23%	20%	12%	0.3%		**Paynesville to State Line**				**6**	**5**	**11**	**12**	**1%**
													Fines	**Sand**	**Total**		
									Entire Watershed above State Line				**561**	**676**	**1,237**	**1,364**	**100%**
													T/yr	**T/yr**	**T/yr**	**tons/yr**	

2.3.3 Streambank Erosion

Streambank erosion represents a major source of fine sediment to the WFCR, as can be seen in the field (**Figure 13**). For the purposes of the sediment budget, estimating the amount of fine sediment contributed by bank erosion was done using a combination of field-based indices, empirical relationships, and analysis of historical channel change. Because of the importance of streambank erosion to the sediment budget and to restoration objectives in the WFCR basin, multiple complementary methods were used to constrain reasonable estimates of the approximate magnitude and spatial pattern of bank erosion in the watershed.

***Figure 13**. Bank Erosion Along WFCR in Hope Valley*

BEHI-Based Estimates of Bank Erosion

One method used to estimate bank erosion rates was a field-based assessment developed by Rosgen (2001), known as the Bank Erosion Hazard Index. The first part of the calculation consists of estimating the Bank Erosion Hazard Index (BEHI), which describes the susceptibility to erosion of bank sections based on combining field data from the WFCR with a set of curves provided by Rosgen (2001). BEHI integrates measurements of bank height, bank angle, root density, surface protection, bank material, and other field evidence into a single index score that is classified into hazard categories ranging from "Very Low" to "Extreme" (**Figure 14**). The field data to compute BEHI were collected along the WFCR mainstem and selected tributaries during summer 2024 by Waterways, Alpine Watershed Group, and Watershed Resiliency Consulting. A full basin map book with BEHI ratings is provided in **Appendix G-2**.

Rosgen (2001) developed empirical relationships linking BEHI ratings to linear bank erosion rates based on datasets from streams in Yellowstone National Park, Montana, and the Front Range in Colorado. Applying these relationships to the WFCR resulted in estimated bank erosion rates for each bank segment. These estimates can be compiled and shown as a plot of cumulative erosion versus river mile to highlight areas along streams where erosion is concentrated (**Figure 15**).

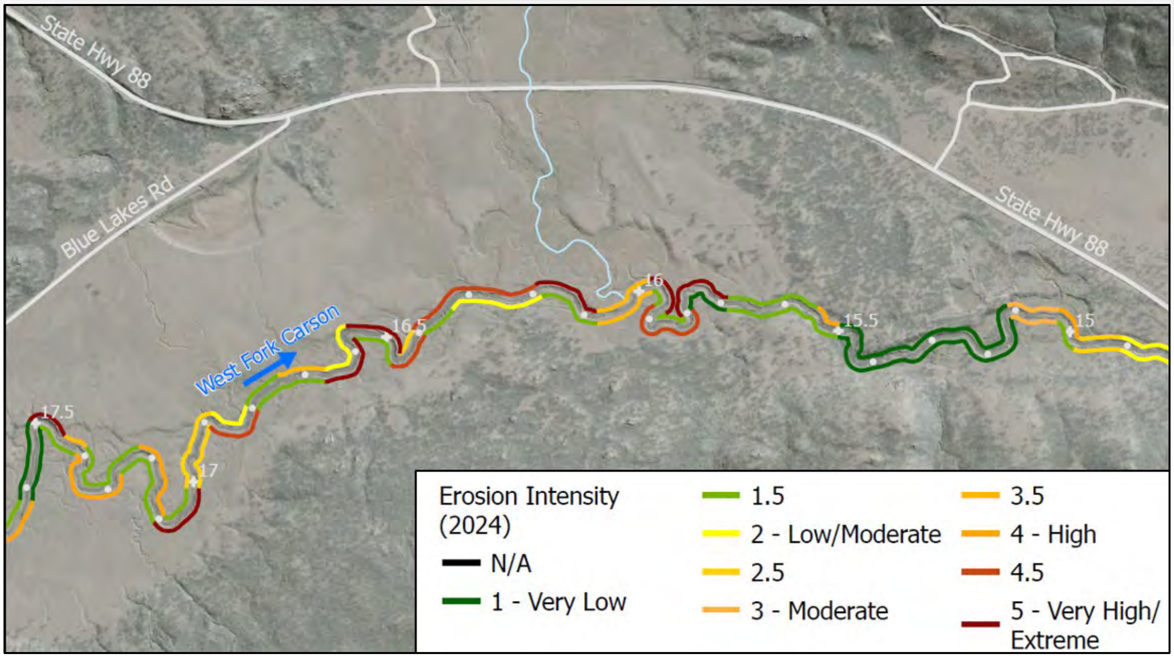


Figure 14*. Example of Bank Erosion Mapping in Lower Hope Valley*

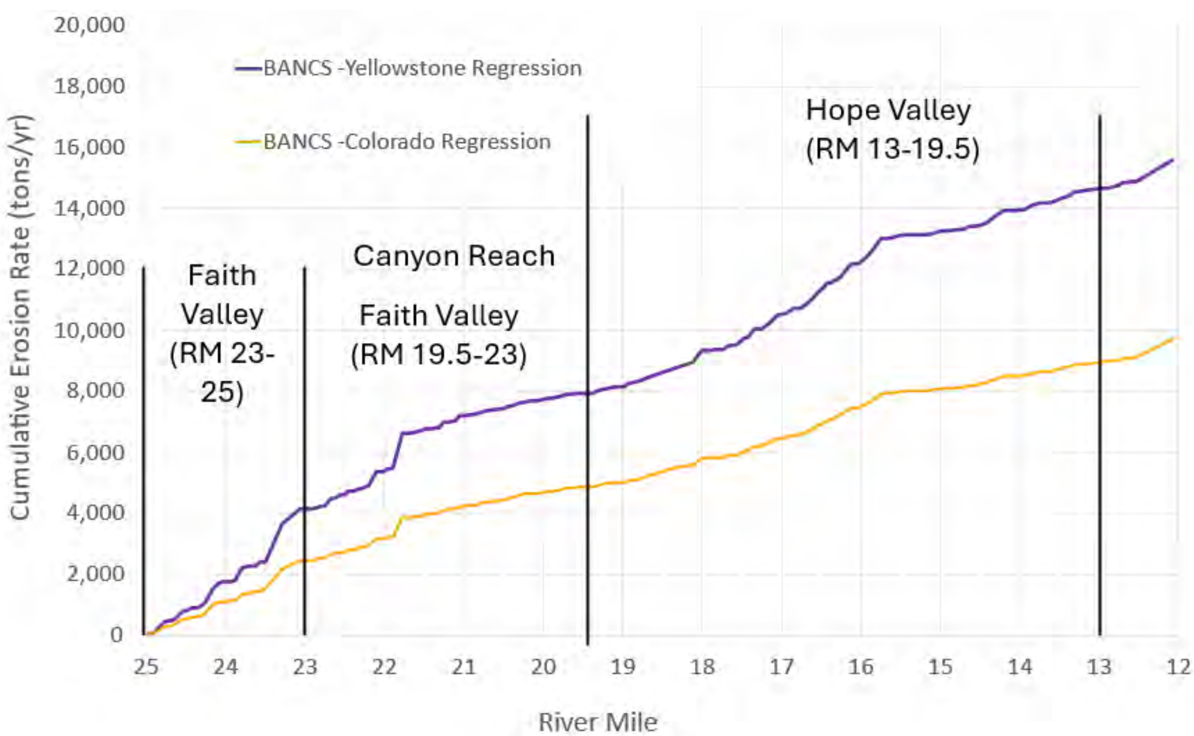


Figure 15*. Amount of Bank Erosion Estimated Using Rosgen's (2001) Methods on Mainstem WFCR. Data plotted as a cumulative amount of bank erosion moving from upstream to downstream. No bank erosion occurs downstream of RM 12 due to boulder-lined banks. Tributary bank erosion is not included in this graph.*

Based on the Rosgen (2001) method, bank erosion in the WFCR basin is estimated at 18,000 tons per year using the Yellowstone curve, and 12,000 tons per year using the Colorado curve (**Table 6**).

These estimates appear unrealistically high when compared to independent estimates of suspended sediment flux. The estimated fine sediment load passing the Woodfords gage is on the order of 3,000 to 6,000 tons per year (see **Figure 9**), much lower than the BEHI-predicted bank erosion rates. Although bank erosion is clearly a major sediment source, it is not physically reasonable for bank erosion to be 2- to 4-times greater than the annual sediment load leaving the basin. Because the sediment transport estimates are derived from long-term, site-specific gaging and sampling data, they are considered more reliable than the bank erosion rates derived from empirical relationships developed in other regions. This discrepancy motivated the development of an alternative approach to estimating bank erosion using local data.

Table 6. *Bank Erosion Rates Computed Using the Rosgen (2001) Method*

Stream	Stream Length	BEHI/BANCS Yellowstone Equation	BEHI/BANCS Colorado Equation
	mi	tons/yr	tons/yr
West Fork Carson[1]	13.35	15,600	9,739
Forestdale Creek	2.3	412	346
Red Lake Creek	2.91	1,603	1,203
Willow Creek	2	610	475
West Fork Carson River Basin		**18,225**	**11,763**
Notes:			
1. West Fork Carson River below Woodfords Canyon does not contribute to basinwide bank erosion because the banks are continuously lined with glacial outwash boulders.			

Bank Retreat Rates from Historical Aerial Photography

To develop a more realistic estimate of bank erosion, historical aerial imagery was combined with field-based erosion observations. Historic air photos showing the WFCR channel in Hope Valley are available on Google Earth dating back more than 80 years. Changes in channel position in sequential air photos provide a direct record of bank retreat rates. We selected two representative reaches (lower Hope Valley and lower Red Lake Creek) and digitized the location of stream banks on both sides of the channel from four sets of aerial photographs (approximately 1940, 1992, 2010, and 2024/2025) (**Figure 16**).

To develop a relationship for estimating bank retreat rates applicable across the basin, bank positions from 1992 to 2024/2025 were compared—a 33-year interval that included the largest flood of record in the WFCR. Linear bank retreat rates were calculated at intervals of approximately 0.05 miles (264 feet) by comparing the positions of the left and right bank lines in the sequential photos, providing average bank retreat rates in feet per year for a sample of approximately 20 locations within each of the two, one-mile-long analysis reaches.

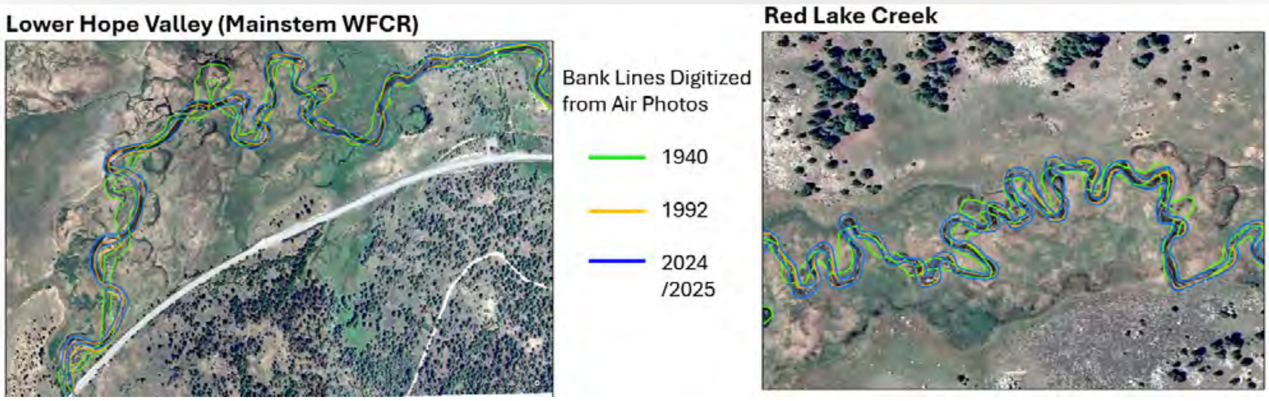


***Figure 16**. Channel Migration in Lower Hope Valley and Red Lake Creek Lower Meadow*

To develop an empirical model with the ability to predict sediment contributions from bank erosion around the basin, the long-term bank retreat rates were compared with both BEHI and a subjective field-based Erosion Severity score collected during field work. The Erosion Severity score ranges from 1 to 5, with 5 representing the most heavily eroding banks, such as those shown in **Figure 13**. There is a clear relationship between measured bank retreat rates and both BEHI and Erosion Severity (**Figure 17**); however, the data exhibit substantial scatter. Most regression forms (linear, power law, polynomial) produced relatively weak predictive relationships. The best-performing regression was a linear equation with the intercept forced to zero, yielding an R^2 value of approximately 0.6 (**Figure 17**). The degree of scatter suggests that regression-based predictions could substantially overpredict or underpredict erosion rates at individual locations, and that it is possible that these errors could compound when applied basin-wide.

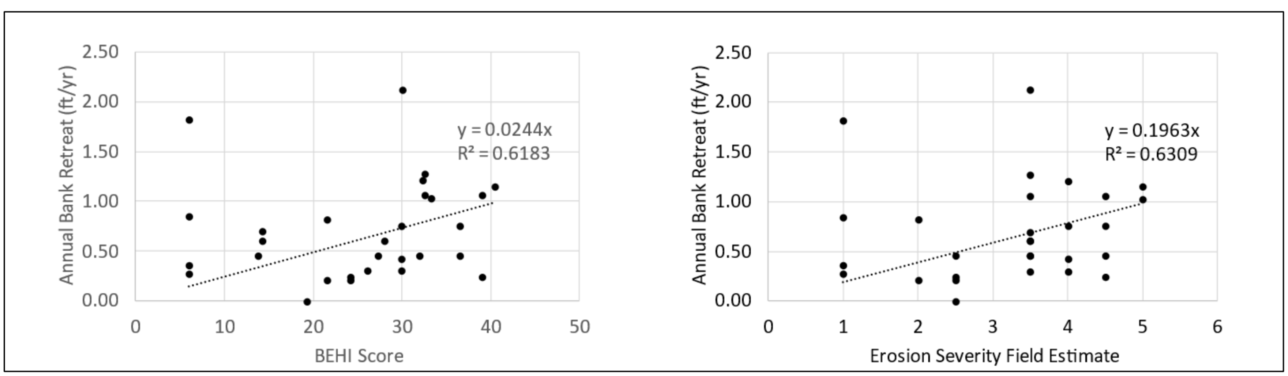


***Figure 17**. Data Relating Bank Retreat Rate in Feet Per Year to BEHI and Erosion Severity*

As an alternative to a continuous regression model, an ordinal classification approach was developed in which representative bank retreat rates were assigned to bank sections based on mapped Erosion Severity values. **Figure 18** presents histograms of measured retreat rates grouped by Erosion Severity in lower Hope Valley. These data indicate that severity scores between 1 and 3 generally correspond to little or no measurable long-term erosion, although exceptions exist. Scores between approximately 3 and 4.5 correspond to moderate erosion, with retreat rates typically ranging from 0 to 1 ft/yr (estimated representative value of approximately 0.5 ft/yr). A score of 5 corresponds to severe erosion, with estimated retreat rates typically exceeding 1.0 ft/yr. Based on these relationships, a simple model was developed to estimate bank erosion from Erosion Severity values across the basin (**Table 7**). This approach emphasizes the contribution of a relatively small number of highly eroding banks, accounts for moderately eroding areas, and does not assign erosion to banks with low severity values, such as those commonly observed along the insides of bends.

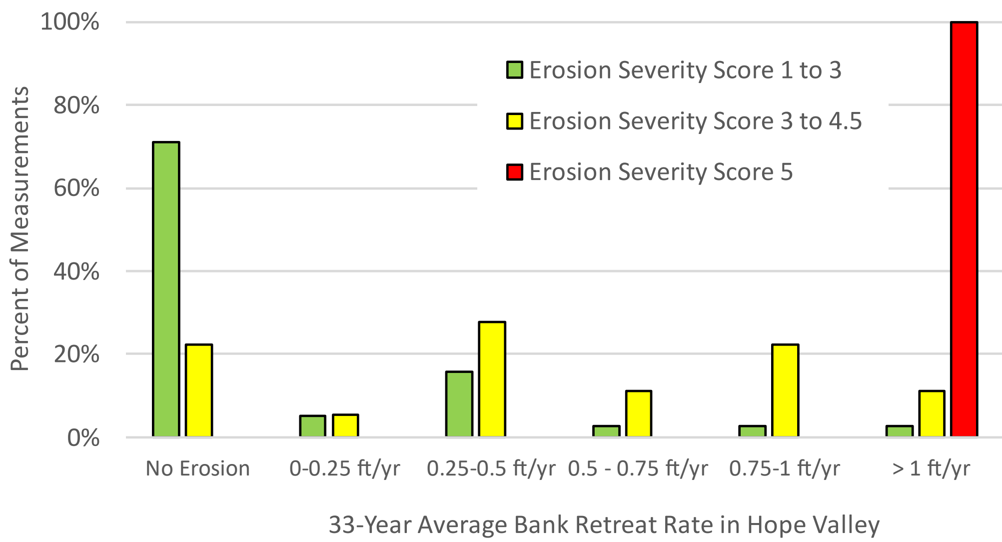


***Figure 18**. Histogram Showing Measured Bank Retreat Rates for Different Erosion Severity Values*

***Table 7.** Bank Retreat Rates Assigned to Erosion Severity Scores*

Erosion Severity Value	Assumed Bank Retreat Rate
	(ft/yr)
1 to 3	0
3 to 4.5	0.5
5	1

Bank Erosion Estimates using Air Photos and Field Data

Figure 19 compares cumulative bank erosion estimates derived from multiple methods, including the Rosgen (2001) methods (Yellowstone and Colorado), the two air-photo-based regression models shown in **Figure 17**, and the ordinal method summarized in **Table 6**. The comparison shows that the air-photo-based regressions predict substantially lower bank erosion rates than the Rosgen methods; however, these estimates are still much higher than the independently estimated suspended sediment flux from the basin. **Figure 19** includes only erosion along the mainstem WFCR; if tributary erosion were included, these values would be higher.

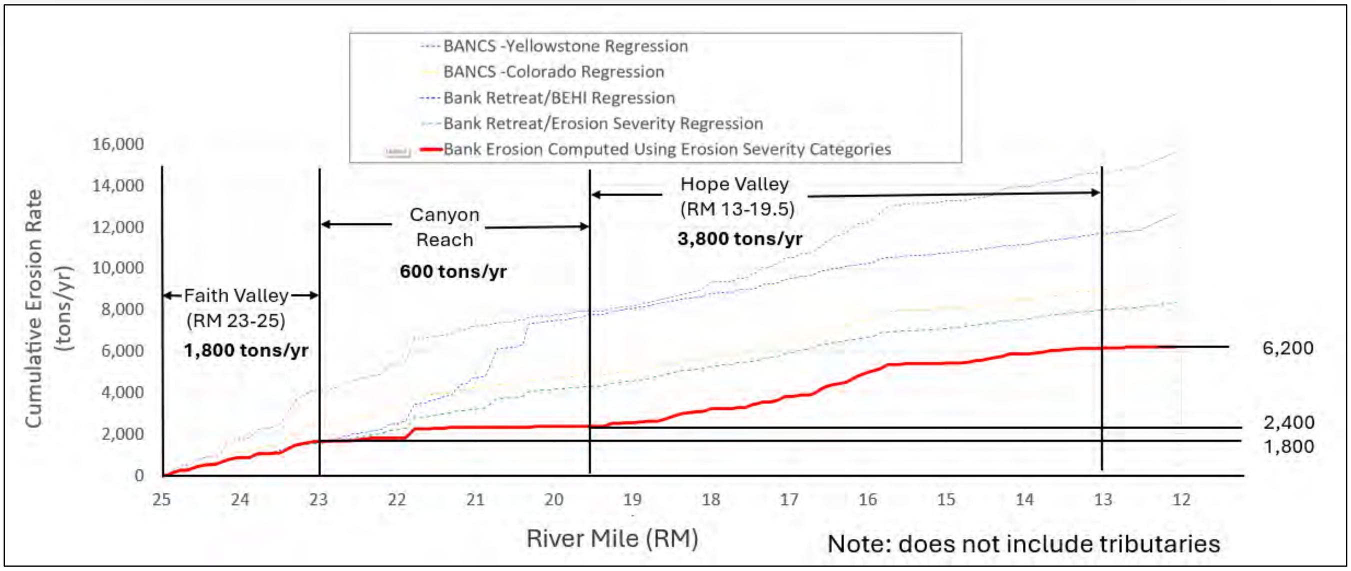


***Figure 19**. Comparison of Cumulative Bank Erosion Estimates Using Multiple Methods. Red line represents the results of the final bank erosion analysis.*

The method using the subjective Bank Erosion Severity scores and the air-photo-measured bank retreat rates predicts **approximately 6,200 tons per year of sediment derived from bank erosion** along the WFCR mainstem. This value was selected for use in the sediment budget because it is grounded in locally observed erosion severity and long-term channel change and produces estimates that are more consistent with measured sediment transport.

Bank erosion contributions from tributaries were not included in the estimate of 6,200 tons/year used in the sediment budget. BEHI and Erosion Severity were mapped in several tributaries of the WFCR, and showed that bank erosion in tributaries is present, but less prevalent, compared with the WFCR. In Red Lake Creek, channel migration rates are much less than in the main stem (**Figure 16**), and it is unclear whether the retreat rates in **Figure 18** and **Table 7** apply to tributaries. At the basin scale, tributary contributions to bank erosion are expected to be small relative to the mainstem WFCR due to their shorter cumulative bank length, lower bank heights, and generally lower observed erosion severity (using the Rosgen method, tributaries accounted for approximately 15 percent of total estimated basin-wide bank erosion [**Table 6**]). This relatively small contribution of hundreds of tons per year was considered negligible compared to the magnitude of the uncertainty in other elements of the sediment budget and was not included.

Bank erosion in the basin is spatially concentrated: approximately 60 percent of bank erosion along the 25-mile mainstem WFCR occurs within the roughly 7-mile reach of Hope Valley (**Figure 19**). This spatial concentration directly supports a restoration strategy focused on reconnecting floodplains and reducing bank erosion in Hope Valley as a means of achieving watershed-scale reductions in fine sediment.

2.3.4 Floodplain Deposition

In unconfined, alluvial reaches of the WFCR—most notably in Hope Valley—a portion of fine sediment is stored on floodplains during overbank flooding. Fine sediment (sand-, silt-, and clay-sized material) is transported primarily in suspension and can be deposited on floodplain surfaces when flows exceed channel capacity and spread laterally across the floodplain. Floodplain deposition occurs predominantly during high-flow events, when water carrying sediment overtops the channel banks and inundates adjacent floodplains. The amount of fine sediment deposited on floodplains is controlled by three primary factors:

(1) the magnitude and frequency of flows that access the floodplain,
(2) the fine sediment concentration of those flows, and
(3) the trap efficiency of the floodplain, defined as the fraction of incoming suspended sediment that settles out before water returns to the channel.

In principle, floodplain deposition could be estimated directly using a basin-scale model that explicitly represents overbank hydraulics, sediment concentrations, and spatially variable trap efficiency. While such approaches have been applied in detailed research studies, implementing them for the WFCR at the basin scale would require a substantial amount of additional data and modeling effort, while still yielding results with high uncertainty, due to a lack of calibration data. For the purposes of this project, floodplain deposition was estimated indirectly as the residual term in the sediment budget, and "reality checked" by making an order-of-magnitude calculation of the average deposition rate predicted from this method and comparing that with field observations. Specifically, floodplain deposition in the WFCR was computed by combining the estimated upland erosion (1,400 tons per year) and bank erosion (6,200 tons per year) inputs and subtracting the estimated long-term suspended sediment export from the basin (5,000 tons per year). Using this mass balance approach, floodplain deposition in the WFCR watershed is estimated to **average approximately 2,600 tons per year**. By comparison with the other components of the sediment budget, this value exceeds the estimated contribution from upland erosion and amounts to roughly half of the sediment exported from the basin. This scale of contribution to the sediment budget seems reasonable, given the presence of large, glacially carved valleys in the upper watershed that provide substantial potential storage space for fine sediment.

To evaluate whether this estimate is physically reasonable at a site scale, the implied vertical accretion rate was calculated and compared with field observations. We used the basin-scale hydraulic model to estimate the total area of active floodplain for the seven largest floodplain units in the upper basin (**Table 8**). For this calculation, floodplain area was defined as the area inundated by the modeled 2-year recurrence interval flow, excluding the active channel. This resulted in an estimated floodplain area of approximately 210 acres. Converting 2,600 tons per year of sediment to a volumetric rate (using a typical fine sediment bulk density of 80 lb/ft^3) yields an average vertical accretion rate of approximately **0.007 ft/yr, or about 0.1 inch per year**.

Table 8. *Discrete Floodplain Units in the Upper West Fork Carson River Basin*

Floodplain Unit	2-Year Peak Flow Inundation Area (not including channel)
	Acres
Forestdale Creek	2.3
Willow Creek	6.2
Red Lake Creek	39.6
Upper Faith Valley	7.6
Lower Faith Valley	13.5
Upper Hope Valley	88.6
Lower Hope Valley	53.2

At this rate, it would take on the order of 140 years to accumulate one foot of sediment, averaged across the entire floodplain under current, incised conditions. This magnitude is broadly consistent with field observations, including the thickness of fine-grained deposits exposed in eroding banks (e.g., **Figure 13**), which likely accumulated over timescales of centuries to millennia. Accretion rates were likely higher in the past, prior to channel incision, when floodplain connectivity was greater and overbank deposition occurred more frequently.

These results suggest that increasing floodplain connectivity and overbank sedimentation represents a viable strategy for reducing fine sediment export from the WFCR watershed. Restoration actions that increase the frequency and extent of floodplain inundation have the potential to shift sediment from being exported downstream to being stored within upper-basin floodplains, particularly in large valley settings such as Hope Valley.

2.3.5 Sediment Budget Findings and Interpretations

Sediment Budget Results

Figure 20 presents a schematic summary of the WFCR sediment budget developed in this study. The widths of the arrows are scaled approximately to the magnitude of sediment flux associated with each process. This diagram integrates the four primary components evaluated in Sections 2.3.1 through 2.3.4—upland erosion, streambank erosion, floodplain deposition, and suspended sediment export—and highlights their relative importance at the watershed scale.

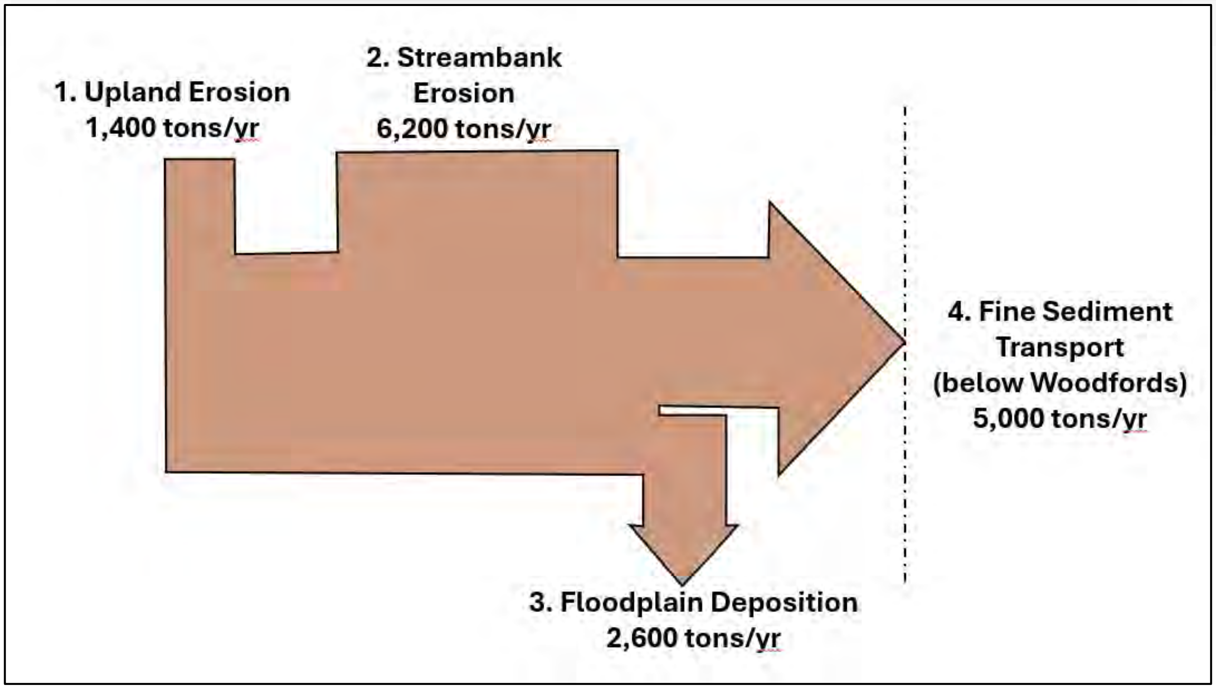


***Figure 20**. Schematic Diagram of Sediment Budget for the West Fork Carson River Basin in California. Widths of arrows are approximately proportional to the size of the sediment fluxes associated with the four geomorphic processes.*

Interpretations - Current and Historical Sediment Budgets

The sediment budget indicates that, at present, **streambank erosion** (**2,** in **Figure 20**) is the dominant source of fine sediment in the WFCR watershed. Estimated bank erosion rates are comparable to, and likely exceed, the long-term average **suspended sediment flux** exiting the basin (4). In contrast, **upland erosion** (1) contributes a smaller, secondary component of fine sediment input. **Floodplain deposition** (3) represents a substantial sink for sediment within the upper basin, storing roughly half of the sediment that would otherwise be exported downstream. Under current geomorphic conditions, the basin exports on the order of 5,000 tons per year of fine sediment, indicating that the large glacial meadows that had once been sediment storage reservoirs are now the largest sources of sediment in the basin. The direct cause of this change in the sediment budget would have been channel incision and/or widening. The geomorphic processes of channel incision (a.k.a. channel bed lowering relative to the adjacent floodplain elevation) and channel widening can both contribute to an increase in channel capacity and a decrease in the stability of the banks, which in turn result in less overbank sedimentation and more bank erosion.

Human Impacts on Sediment Budget. The most significant human-induced changes to the sediment budget were probably historic logging and intensive cattle grazing in the mid- to late-19th century. The rapid conversion of watershed-scale vegetation beginning in the 1860s likely increased upland fine sediment production and may have also heightened the frequency and magnitude of stochastic sediment-generating events such as wildfire, debris flows, and shallow landslides. Impacts within the valley bottoms, particularly in Hope Valley and Faith Valley, were even more important. Early clearing and grazing drastically reduced woody riparian vegetation (e.g., willow and aspen) in the floodplain and diminished beaver activity, reducing channel complexity and overbank flow dispersion. Loss of these stabilizing factors likely triggered channel incision, followed by bank widening as banks became higher and more unstable, and this would have been accelerated by livestock trampling. As channels deepened and widened, flood flows became increasingly confined to a single-thread channel rather than dispersing flow and sediment across multiple channels and floodplain surfaces. **This transition—from a depositional, multi-thread, low-energy, densely vegetated system to the present single-thread, erosional morphology—most likely occurred during the peak grazing period of the 1860s and 1870s and has persisted to the present day**. Compared with the sudden drastic changes of the middle-1800s, more recent land use impacts have a relatively small impact (MACTEC, 2004).

Figure 21 presents a conceptual reconstruction of how the WFCR sediment budget likely functioned following the last glacial retreat but prior to the drastic channel incision and/or widening discussed above. Following the last glacial retreat, **upland erosion** (1, in **Figure 21**) supplied some fine sediment, though this has historically been somewhat limited due to the lack of soil development on glaciated slopes. Most of the fine sediment that was produced in the basin was stored within the large glacial valleys, forming the large floodplain meadow deposits observed today. **Streambank erosion** (2) would have been substantially lower, as channels were closer to floodplain grade, with less erosion of tall, vertical exposed banks. At the same time, **floodplain sedimentation** (3) would have been much greater, with frequent overbank flows depositing fine sediment across valley bottoms rather than exporting it downstream. As a result, **sediment export from the basin** (4) would have been correspondingly lower.

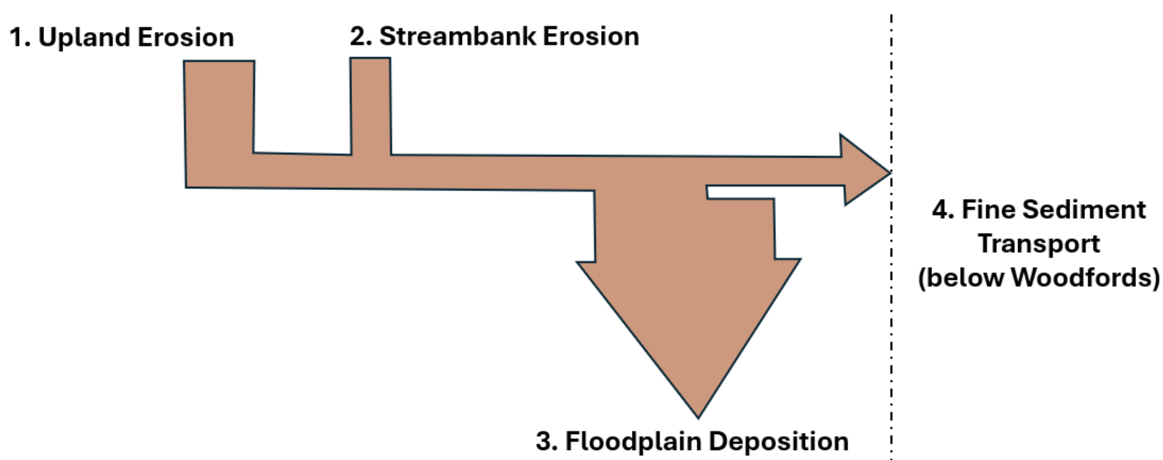


Figure 21*. Schematic Diagram of Post-Glacial Sediment Budget Prior to Channel Incision.*

Causes of Changes in the Sediment Budget. The contrast between the present-day and conceptual historical sediment budgets raises an important question: What caused channel incision and/or widening in the WFCR, and when did it occur? The precise timing and drivers are not known with certainty; however, several plausible mechanisms exist. One likely factor is the historical reduction of beaver populations and associated riparian vegetation, which may have reduced natural flow dispersion across valley bottoms, increased channel confinement, and promoted incision. Another is channel widening and bank destabilization due to loss of stabilizing vegetation, possibly due to sheep and cattle grazing. A third possible driver could be long-term geologic lowering of downstream base level, particularly through gradual erosion of glacial moraines or boulder-controlled valley constrictions, initiating upstream-propagating channel downcutting. Incision and channel widening may reflect a combination of these mechanisms, or additional processes not evaluated here, such as post-glacial tectonic influences within the Hope Valley Graben (Hagan, et al., 2009). Although unresolved, this question could be addressed through focused geomorphic, stratigraphic, and dating studies.

2.3.6 Bedload and Stream Restoration in the WFCR

Although this sediment budget focuses on fine sediment (washload and suspended load), it is important to acknowledge **bedload**—the coarser material that moves by rolling, sliding, and bouncing near the streambed rather than in suspension. Bedload is not a direct driver of water quality impairment (turbidity and fine sediment) and thus was outside the scope of this study, but it plays a crucial role in channel morphology and interacts with the fine sediment budget, particularly in the contexts of floodplain connectivity. A primary goal of restoration is to aggrade the bed and reconnect floodplains, which can be best accomplished through the deposition of bedload. In many natural rivers, bedload comprises only a small fraction of the total sediment flux. For example, empirical data and geologic theory (Turowski et al., 2010) suggest some “rules of thumb”: bedload typically comprises between 1% and 30% of annual total sediment load in alluvial streams, with smaller percentages (< 2–5%) in larger systems, larger percentages (30-60%) in sand dominated lowland streams. There is a wide range of variability in the ratio of bedload to suspended load in steep and glaciated landscapes, where geology plays a key factor. Within the WFCR basin, granitic rocks tend to weather to produce more sand size material, and other geologic units (volcanics, glacial till) weather into more fine-grained sediment (silt and clay).

Even if one assumes an upper-end bedload proportion of roughly 20% of the total load for the WFCR—at the high end of typical observations—then with an estimated long-term suspended load of ~5,000 tons per year, the corresponding bedload would be on the order of 1,000 tons per year. Using a typical bulk density for gravel and coarse sand (~1.6 tons per cubic yard), this equates to only ~625 cubic yards per year of bed material (or 60–70 large 10-yard dump truck loads annually). This amount of gravel is unlikely to provide sufficient material, by itself, to significantly aggrade the channel bed over broad reaches of the WFCR. Observations in Faith Valley indicate that much of the available bedload was trapped upstream of the uppermost beaver dam analog (BDA), and after about 3 to 4 years only a small amount of gravel has reached the pond behind the second BDA. For larger reach-scale restoration interventions—especially those that aim to raise channel bed elevations and sustain grade control—bedload availability and continuity may be limiting factors. Consideration of sediment supplementation (e.g., importing coarse material from downstream reaches) could be warranted in long-term restoration planning, especially in Hope Valley (discussed further in Section 3.5).

2.3.7 Management Implications of the Fine Sediment Budget

From a management perspective, the cause of the interpreted change in the sediment budget is not critical. Instead, the modern sediment budget, along with our field-based interpretations, suggest that the most effective long-term strategy for reducing fine sediment loads is not to attempt to eliminate sediment sources entirely, but instead to restore processes that favor floodplain storage and reduce bank erosion. Restoration actions that reconnect floodplains, raise channel beds, and reduce bank heights have the potential to move the system incrementally back toward a sediment balance more characteristic of pre-incision conditions (**Figure 21**). It is unlikely that the sediment budget can be fully restored to immediate post-glacial conditions, particularly in large valley settings such as Hope Valley. However, a realistic restoration objective is to move the balance in meadow reaches toward greater sediment storage and reduced bank erosion.

Another key finding of the sediment budget is the strong spatial concentration of both sediment sources and storage potential. Bank erosion is focused within incised floodplain sections of the WFCR, especially in Hope Valley, and meaningful floodplain storage opportunities are similarly concentrated in these large, unconfined valley bottoms. In contrast, downstream canyon reaches lack significant sediment sources and storage potential and function primarily as efficient sediment transport corridors. This spatial pattern has direct implications for restoration planning: Actions aimed at reducing sediment export must focus on the floodplains in the upper basin, especially Hope Valley, where both sediment generation and storage potential are greatest.

The sediment budget clarifies where sediment reduction efforts are most likely to be effective: in upper-basin meadow reaches where bank erosion is concentrated, and where floodplain storage potential exists. Guided by this geomorphic framework, the next phase of work identified and prioritized restoration actions capable of influencing these processes. Section 3 presents the methodology and results of that prioritization effort.

3.0 PRIORITIZATION PLAN

Based on fieldwork and the results of the geomorphological model, Waterways identified a suite of potential stream restoration projects in the West Fork Carson River (WFCR) watershed that could reduce fine sediment loading while also providing additional environmental and societal benefits. Desktop analyses and field visits were used to identify, evaluate, and score potential projects. Project scores were then evaluated using a multi-objective decision-making framework known as Multiple Accounts Analysis (MAA) (Robertson and Shaw, 1998; 2004), which combines technical scoring with stakeholder-informed weighting. This section describes the project identification, evaluation, and prioritization process and concludes with recommendations for a long-term stream restoration strategy.

3.1 PROJECT IDENTIFICATION AND EVALUATION

3.1.1 Project Identification

The initial project identification process focused on physical and geomorphic conditions, using topographic analysis, hydraulic modeling, and field visits along stream reaches within the project area defined by Alpine Watershed Group (AWG, 2024). The primary objective at this stage was to identify locations where restoration actions could increase fine sediment storage and/or reduce streambank erosion. Practical considerations such as land ownership, equipment access, and detailed technical feasibility were not evaluated during this initial screening phase.

One of the primary tools used in project identification were **Relative Elevation Model's (REM**) of the streams in the WFCR watershed. An REM map book for the entire basin is included in **Appendix G-1**. As described in Section 2, a REM is a stream-centered representation of the landscape that shows elevations relative to the adjacent streambed rather than relative to sea level, as in conventional topographic maps. This allows for easy identification of areas where the floodplain is close enough to the channel to be reconnected, as well as locations where steep banks are actively eroding (**Figure 22**). The REM maps provide a rapid visual guide to locations where interventions could store sediment and stabilize banks, and clearly identify former channels in the floodplain that might be reconnected as part of restoration projects. The maps were used as a base for field mapping and project IDs.

A complementary tool was **two-dimensional (2D) hydraulic modeling,** conducted at both watershed and reach scales. The watershed-scale model simulated the inundation extents of the 2-year and 10-year recurrence interval floods. These results highlight areas where floodplain inundation expands substantially between smaller and larger floods, such as in lower Hope Valley (**Figure 23**). Locations exhibiting large differences in inundation extent between the 2-year and 10-year floods were identified as candidates for restoration interventions, since relatively modest changes in channel bed elevation, roughness, or flow dispersion could increase the frequency and extent of overbank inundation and thereby enhance sediment deposition on the floodplain. A basin-wide map book of hydraulic model results is included in **Appendix G-3**. Project areas identified using these desktop analyses were field-verified by Waterways to confirm that the REM and hydraulic model outputs accurately represented site conditions.

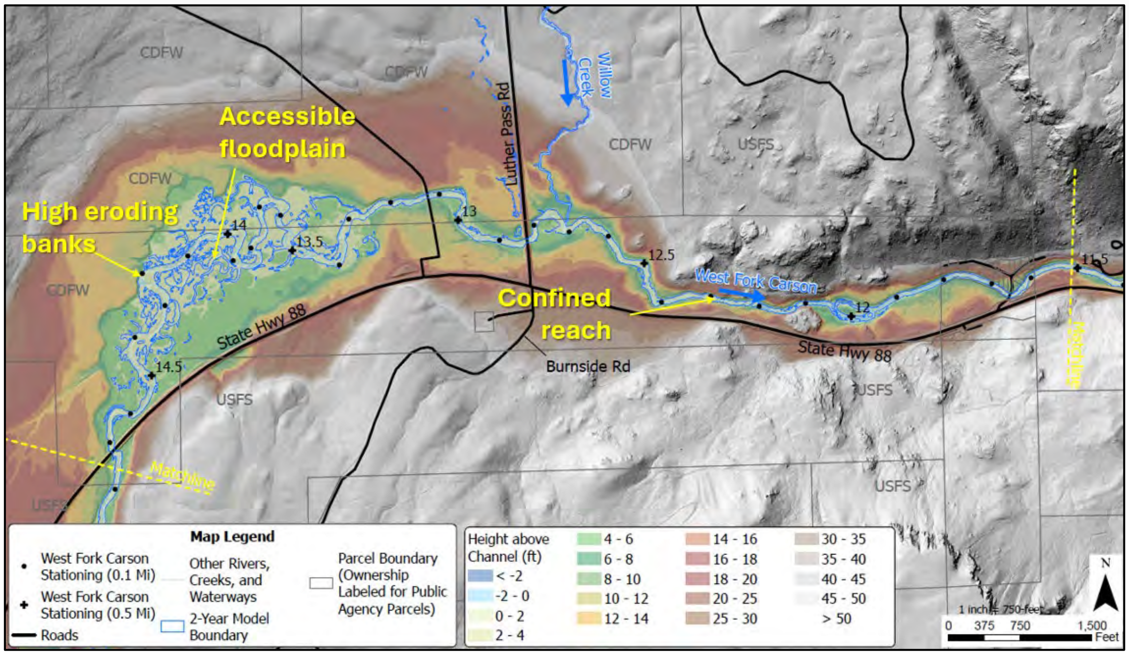


Figure 22. *Example of Use of the Relative Elevation Model (REM) for Identifying Potential Project Areas*

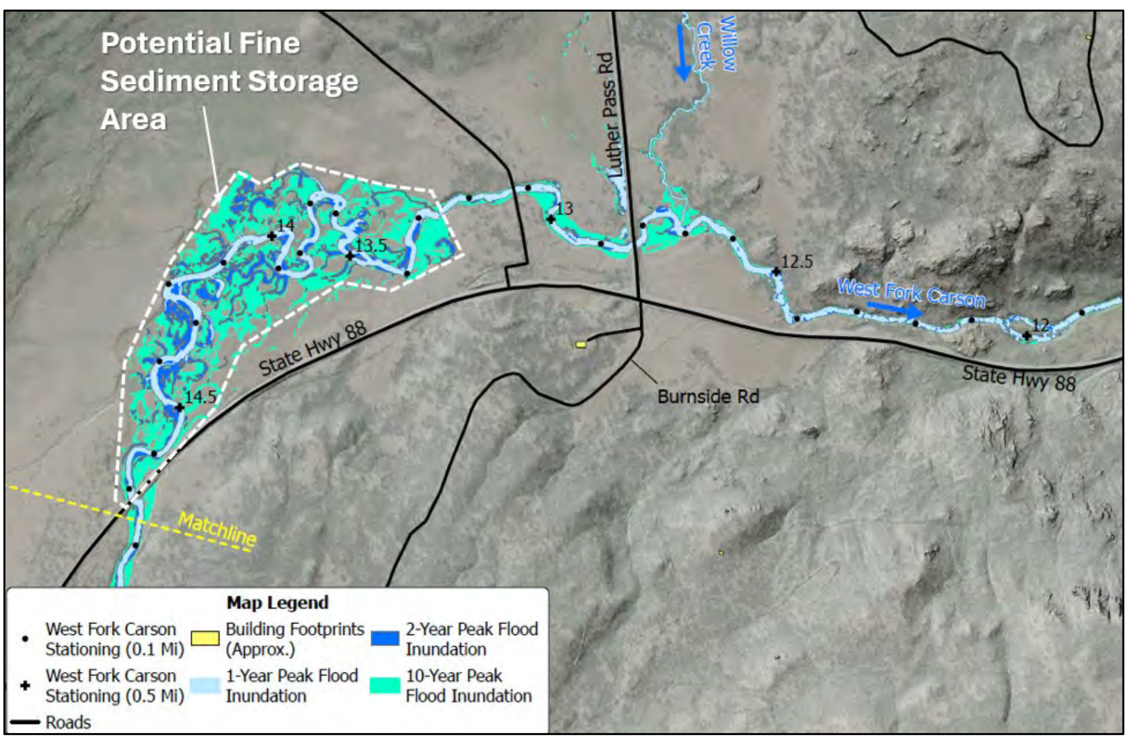


Figure 23. *Example of Use of the Hydraulic Model Results in Identifying Potential Project Areas*

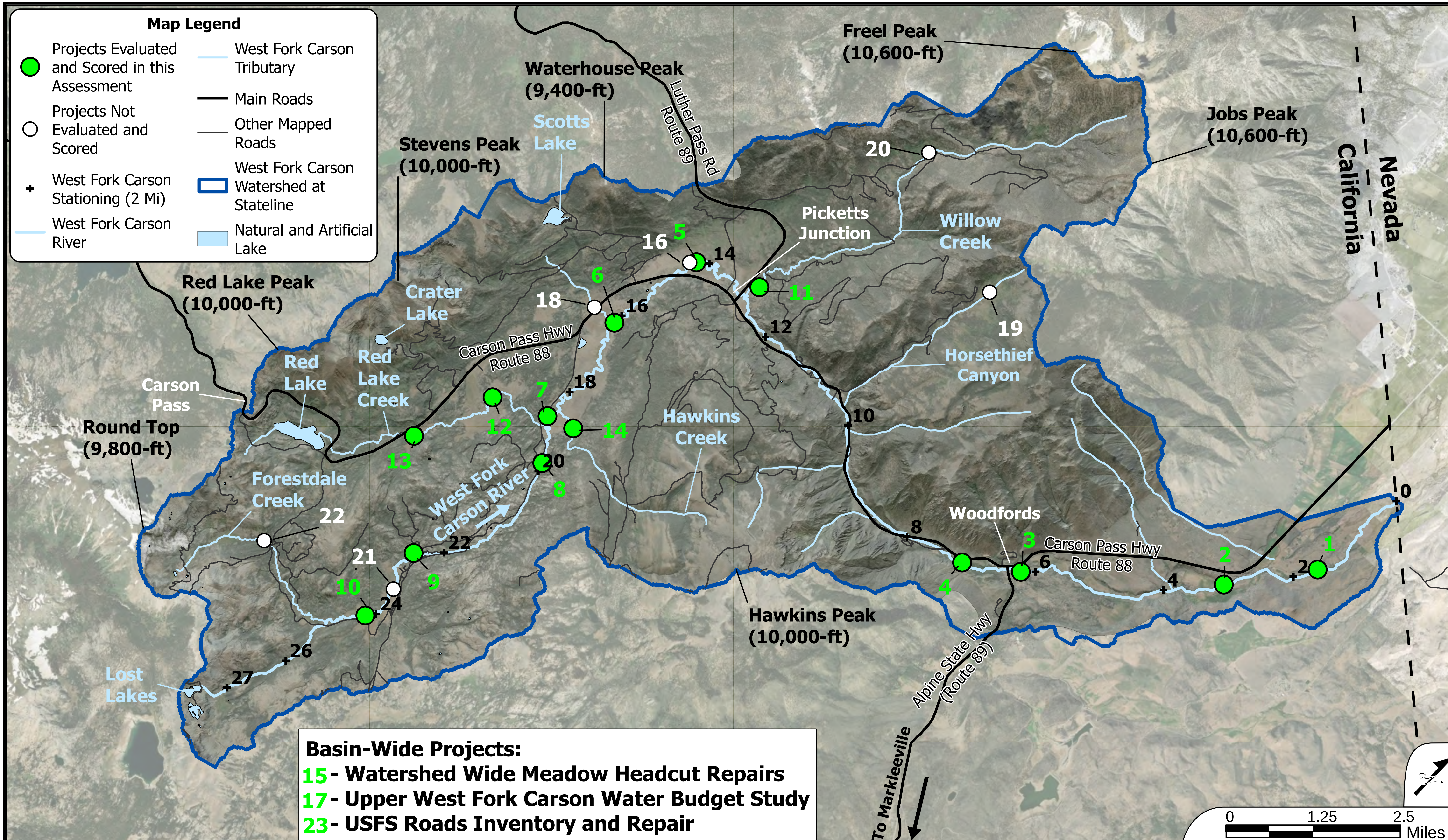
Using a combination of fieldwork, desktop analyses, review of past work, and conversations with local stakeholders and agency staff, a total of 23 potential projects were identified in the basin (**Figure 24)**. These projects included not only in-stream restoration opportunities targeting fine sediment retention, but also activities that could reduce turbidity, improve meadow and/or riparian health, or provide information to facilitate future restoration efforts. A comprehensive list and brief description of all 23 potential projects is provided in **Table 9**.

3.1.2 Development and Evaluation of 15 Projects

Of the 23 potential projects, **15 were selected for further development** to better define project extent, project elements, implementation challenges, and anticipated benefits. Projects advanced at this stage focused primarily on in-stream interventions with the potential to reduce fine sediment loading. The remaining eight projects, while not evaluated in detail, remain relevant and worthwhile. These include several headwater meadow restoration projects identified by American Rivers (2018) that may improve meadow health but are unlikely to significantly reduce fine sediment; road assessment and repair projects managed by the U.S. Forest Service, which are outside the scope of the WFCPP but could contribute to sediment reduction; and a proposed water balance study to help quantify the downstream effects of restoration actions.

Most of the **15** advanced projects were visited in the field, some multiple times. Two projects were not visited due to property access constraints but were evaluated using aerial imagery, LiDAR, and hydraulic modeling. Each project was developed to a level sufficient to allow an initial feasibility assessment, including evaluation of geomorphic setting, hydraulic conditions, potential benefits, anticipated costs, and logistical considerations.

For brevity, detailed descriptions of the 15 projects are not included in the main body of this report. Instead, **Appendix P-1** provides detailed, three-page descriptions and evaluations for each project. These project descriptions include maps, photos, summaries of relevant modeling results, and discussion of key design considerations and constraints. **Figure 25** presents an example project description for a relatively small project in the lower portion of Willow Creek, illustrating the format and level of detail provided for all projects evaluated in the prioritization process.



Watershed Map with Locations of Potential Projects

West Fork Carson River Prioritization Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE 24

Table 9. *West Fork Carson Watershed - Explanation of Project Opportunities*

Project #	Project Name	Stream Name	RM (Down-stream End)	RM (Up-stream End)	Project Objectives	Potential Project Elements	Key Considerations and Constraints
					Projects on West Fork Carson River		
1	River Ranch Road Floodplain Reconnection	West Fork Carson	0	2	Spill more floodwater into old fan channels to deposit sediment, recharge groundwater, and expand riparian/wetland habitat.	Fish-passable boulder grade control riffle; large wood installations; willow planting	Project could potentially offer significant flood benefit downstream and deposit of fine sediment on a broad fan close to the CA/NV state line. Multiple private properties would be affected. Unknown landowner interest. Not clear if project would be compatible with current land uses. The project would likely require modifying irrigation infrastructure. Only flood flows should be affected, base flows must be unaffected by project. Project must avoid interfering with flows or causing erosion in irrigation ditch. Higher risk project.
2	Ace Hereford Ranch Floodplain Reconnection	West Fork Carson	2.6	3.3	Increase overbank flow during floods, deposit sediment, recharge groundwater	Fish-passable boulder grade control riffle; wetland enhancements, willow planting, possible livestock exclusion fencing	Only one landowner property. Landowner would be open to potential project. Big lift (~6-10') to reconnect the floodplain. Multiple opportunities to enhance springs and wetlands in conjunction with an in channel project. Compatibility wth current land uses is not known. Project may have relatively small impact on flood flows and sediment storage relative to the scale of effort.
3	Woodfords Fan Reconnection	West Fork Carson	4.5	6.5	Increase flow into alluvial fan, deposit sand and fines, recharge groundwater, expand wetland, improve wetland vegetation.	Boulder Grade Control, ELJs, Willow Planting, Fencing, Off-Channel Wetland Enhancements	Project could potentially offer significant water quality and flood benefit, recharge groundwater, and deposit of fine sediment on a broad fan. Not clear if project would be compatible with current land uses. Multiple private properties would be affected. Unknown landowner interest. Project must avoid interfering with flows or causing erosion in irrigation ditch. Higher risk project.
4	Crystal Springs Floodplain Reconnection	West Fork Carson	6.8	7.5	Increase overbank flow, deposit sediment, reduce bank erosion, recharge groundwater	Boulder Grade Control, Willow Planting, Possible Off-Channel PBRs	Among the only locations in canyon reach where floodplain could be reconnected. Smaller benefit project; high lift to reconnect side channels; boulder structure and/or excavation at side channel inlets would be needed.
5	Lower Hope Valley Restoration	West Fork Carson	12.9	14.7	Raise base level, increase overbank flow, deposit fine sediment, reduce bank erosion, add channel habitat complexity, recharge groundwater; improve scenery, education and collaboration opportunities	Rock Grade Control, BDAs, ELJs, Floodplain Channel Excavation, Willow Planting, Log Weirs	Large scale project in high visibility location. Would reduce bank erosion in heavily eroding area, and shift the balance to retaining sediment in a large basin in a strategic location. High visibility area so project must carefully consider visual effects, recreation impacts, and public perception. Likely to require multi-year outreach and design effort and a phased implementation. Could apply lessons learned from the 2022-2024 Faith Valley Restoration project, as it has similar geomorphology. Bedload management will be important.
6	Middle Hope Valley Restoration	West Fork Carson	15.5	16.6	Raise base level to increase overbank flow, deposit sediment, and reduce erosion, and recharge groundwater; expand wet meadow, attract beaver (Similar to the Faith Valley project)	Managed Avulsions, Boulder Grade Control, BDAs, PALS, ELJs, Bank Layback, Tree Felling, Willow Planting.	Similar project type, geomorphic setting, and potential benefit as project #5 above, but may be slightly smaller in scale and less visible to the public. Very heavily eroding reach, big contributor of fine sediment. There could be opportunities to manage meander cutoffs to circumvent some of the most heavily eroding bank line.
7	Upper Hope Valley Reconnection	West Fork Carson	17.8	19.5	Increase overbank flow during floods; deposit fine sediment in floodplain; reduce bank erosion; recharge groundwater	Boulder Grade Control, Floodplain Channel Excavation, Managed Avusion; Engineered Log Jams, Willow Planting	Largest and potentially the highest disturbance project on the list. In a frequently visited area at the head of Hope Valley. Not clear how well it would work because of the amount of lift needed to spill water into the floodplain.
8	Blue Lakes Road Restoration	West Fork Carson	19.7	20.6	Protect and expand beaver influence in a confined reach	BDAs and Large Wood; Reinforce Existing Beaver Dams	Habitat improvement with minor benefits related to sediment storage/reduction; relatively minor and localized habitat uplift compared with meadow projects, but would be a much smaller project to design and build.
9	Faith Valley Dispersed Camping Area Restoration and Repairs	West Fork Carson	22	22.9	Stabilize eroding reach near a USFS campground	Bank Erosion Protection, Grade Control, BDAs, Large Wood, Reinforce Beaver Dam	Combined habitat/minor infrastructure improvement project at eroding campsites adjacent to WFCR. Minor sediment benefit. Project would stabilize and recover recently breached beaver complexes. Project would need interest and funding from USFS.
10	Upper Faith Valley Restoration	West Fork Carson	24.1	25	Reconnect floodplain, reduce bank erosion, improve vegetation, attract beaver	Felled Trees, BDAs, Large Wood	Project would reconnect large disconnected floodplain area and improve instream complexity in upper portion of Faith Valley. Remote site and unclear if equipment access will be allowed. Relatively large benefit for being so high up in the watershed.
					Projects on Willow Creek		
11	Willow Creek Meadow Restoration	Willow Creek	0	1.7	Reconnect floodplain, reduce bank erosion, improve vegetation, attract beaver	BDAs, PALs, Tree Felling, Willow Planting, Reinforce Existing Beaver Dams	Relatively small scale and low risk project with potential for sediment reduction and floodplain reconnection in a sediment-producing tributary. Project area contains both remote and high visibility areas, with opportunities for education and public outreach.
					Projects on Red Lake Creek		
12	Red Lake Creek Lower Meadow Restoration	Red Lake Creek	0.9	2	Reconnect floodplain, reduce bank erosion, improve vegetation, attract beaver	BDAs, Tree Felling, Willow Planting	Very large meadow that in incised and eroding and could easily be reconnected to its floodplain. Bed load limited, relatively difficult access; few other concerns. American Rivers (2018) assessed meadow and determined future assessments to determine if project potential would be worthwhile.
13	Restoration	Red Lake Creek	0.9	2	Reconnect floodplain, reduce bank erosion, improve vegetation, attract beaver	BDAs and Willow Planting	Smaller project in two meadows, one on public land and the other in private property. Abandoned beaver dam locations could be reoccupied and stabilized. Extensive willow planting could attract and sustain beaver. American Rivers visited this meadow and did not include it in first set of sites but planned to revisit.
					Projects on Hawkins Creek		
14	Hawkins Creek Fan Reconnection	Hawkins Creek	0	0.5	Reconnect fan channel, increase habitat complexity	BDAs, ELJs, Grade Control Structure to Reactivate Fan Channel	Project would spill flood water into a former fan channel in an incised fan, increasing sediment storage and groundwater recharge. Difficult equipment access. There may not be enough of a benefit to justify project cost and effort.

Project #	Project Name	Stream Name	RM (Down-stream End)	RM (Up-stream End)	Project Objectives	Potential Project Elements	Key Considerations and Constraints
Basin Wide Treatments							
15	Watershed Wide Meadow Headcut Repairs	NA	NA	NA	Prevent future damage and loss of wet meadows by finding and treating headcuts basin-wide	Site by site basis	Protection of existing resources; high benefit with relatively little effort; may be unusual to permit given the multiple small sites rather than a single work location.
Additional Potential Projects in the Basin (these projects were not scored with Multiple Accounts Analysis)							
16	Lower Hope Valley Adaptive Management	West Fork Carson	14.2	14.5	Complete ongoing adaptive management program using willow trenches and micro benching	Micro-benching, willow planting, willow trenches on outsides of bends; possibly other small scale treatments	There is a small currently funded project in progress by AWG to adaptively manage previous efforts in lower Hope Valley, in the area of proposed project #5. This smaller ongoing effort would be a part of the larger scale, high-scoring reach scale restoration project. Current effort will begin to establish willow now to benefit a potential future larger scale project in the same area.
17	Upper West Fork Carson Water Budget	Basin wide			Better quantify the overall water balance of the WFCR; answer questions about the impact that expanding wet meadow and willow would have on water deliveries and water rights; predict effect of climatic change and restoration projects on water deliveries at different times of the year	Measurements, modeling, analysis, and public outreach	One of the concerns raised by stakeholders during the WFCPP outreach process is the impact that restoration projects like the ones proposed here will have on water deliveries and water rights. American Rivers collected some data on water flows into and out of the Faith Valley Restoration project and found no measurable impact. More analyses, data, and likely modeling would be useful for answering these questions and addressing concerns in different ways.
18	Highway 88 West Meadow Restoration	Unnamed tributary	NA	NA	Improve meadow conditions, repair headcuts (per American Rivers)	Did not develop concepts for project	This unnamed tributary was not part of the project area of the current project. However, this meadow was prioritized by American Rivers Carson basin meadows assessment (2018) as a degraded meadow below Highway 88. This tributary is not a major contributor of fine sediment to WFCR; however, project here could improvements to a degraded meadow.
19	Horsethief Canyon Meadow Restoration	Horsetheif Canyon	NA	NA	Reduce gully erosion, headcuts, treat bare ground	Did not develop concepts for project	This meadow was not part of the current project area, but was prioritized in the middle of the list of Carson meadows by American Rivers (2018) meadow assessment. The meadow is high up in a tributary of WFCR, and is not a major contributor to fine sediment in WFCR. However, there appear to be opportunities for a small scale meadow restoration, especially repairing headcuts and reducing gully erosion of the meadow.
20	Middle Willow Creek Meadow Restoration	Unnamed tributary	NA	NA	Repair headcuts	Did not develop concepts for project	This meadow was not part of the current project area, but was prioritized by American Rivers (2018) meadow assessment. Small tributary is not a major contributor to fine sediment in WFCR. Project was listed as the lowest priority meadow among those in the assessment.
21	Faith Valley Adaptive Management	West Fork Carson	23.8	23.5	Improve function of past restoration project, understand benefits, identify lessons learned where project did not meet objectives.	Maintain some BDAs, possibly reducing the number or height of some of the BDAs to improve bedload sediment continuity; continue to monitor groundwater, survey post-project conditions after several years, develop document on lessons learned	The Faith Valley Restoration Project was a recent, largely successful project on the upper WFCR that included a valley-spanning rock grade control structure, roadway improvements, and numerous BDAs built and repaired over several years. The project has raised the water table, improved meadow health, and reduced bank erosion, and appears to be depositing fine sediment in the floodplain. These objectives and methods are similar to many of the potential projects described above, and therefore provides a opportunity to learn from past similar work and help stakeholders visualize potential project outcomes. One area where the project did not meet objectives was in aggrading the bed, because most bedload is being trapped above the upstream-most BDA. While it appears that bed aggradation above the uppermost BDA is achieving project goals of reducing bank height and aggrading the bed, most bedload does not get past it. The BDAs may have been built higher and more numerous than was optimal. Continuing to monitor and adaptively manage that project could enhance long term outcome and provide lessons learned that can be applied to other projects in the basin and elsewhere.
22	Forestdale Meadow Headcut Repairs	Forestdale Creek	2.3	2.8	Reinforce beaver dams, stabilize headcuts, avoid possible future degradation	Stabilize headcuts with posts; no other treatments are necessary	Forestdale Meadow was listed as a priority restoration area in American Rivers meadow assessment (2018). In 2018, the technical advisory team for the Faith Valley and Forestdale Meadow restoration project opted to not include Forestdale Meadow as part of that project because it is remote from main project area and the technical advisory group determined that its condition was mostly good compared to Faith Valley. The project would have negligible impact to sediment or water quality due to its location at the top of the WFCR watershed. We recommend including Forestdale Meadow as part of Project #15 above, basin wide heacut treatments, as the main impairment is headcuts.
23	Willow Creek/Forestdale Creek/ Upper West Fork Carson Watershed Roads Inventory and Repair	NA	NA	NA	Reduce fine sediment, improve recreation, reduce upland impacts	Roads and trails inventory and assessment; map and rank repairs	Official and unofficial ATV roads are a source of human-caused fine sediment in the watershed. The current effort focuses on opportunities to address stream geomorphology, and it was not part of the scope of the current project to map and assess road conditions throughout the watershed. A watershed scale assessment effort, especially in Willow, Forestdale, and Upper West Carson watersheds, to inventory eroding roads and unofficial trails, would help identify opportunities and prioritize treatments.

Project 11: Willow Creek Meadow Restoration

Willow Creek, River Mile 0.0 to 1.7

Existing Conditions:

The potential project area is along Willow Creek from its confluence with the West Fork Carson River to approximately 2 miles upstream. The upper section is in a geologically confined basin with a floodplain 100 to 250 feet wide, and the lower section encompasses the Willow Creek fan as it enters the West Fork Carson River. In the upper area, the channel is about 2 to 4 feet below the meadow surface (see Figure 11-A). In the lower part of Willow Creek the channel is mostly disconnected from its floodplain (see Figure 11-B). Beaver are extensive in Willow Creek, but their influence is confined to areas where there are healthy willow stands. The channel has incised about two to three feet, leading to a drop in the water table in the meadow, a loss of connectivity, and loss of willow in some meadow areas.

The upper and middle portions of the project area are rarely visited but the lower portion near the West Carson River is close to Pickett's Junction and gets significant foot traffic.

Project Concept:

The project would employ "low-tech process based restoration" (LTPBR) techniques to reconnect the floodplain, expand and enhance wetland, store sediment, and support beaver in lower Willow Creek. The scale of the channel and the relatively moderate amount of incision makes this area a good candidate for a low cost, low risk, beaver-focused restoration effort. Hand crews would build beaver dam analogs and post-assisted log structures, fell trees, and install willow in strategic locations to accomplish the project objectives of raising the water table, storing fine sediment, improving in-channel habitat, and expanding beaver influence. There is a small fen in the confined section that could be protected with additional BDAs and fencing. There are opportunities for public education and outreach in the frequently visited lower portion of Willow Creek.

Potential Project Elements:

Beaver dam analogs (BDAs), tree felling, post-reinforced beaver dams, post assisted log structures (PALS), willow plantings, fencing to protect fen.

Design Considerations and Potential Constraints:

The primary constraint is proximity to busy intersection and popular recreational area. The main constraint in the upper section is the relatively difficult access. No roads or infrastructure that would be impacted, and there would be little impacts to recreational uses during construction. Opportunities for signage, education, and tours. The upper project area could be built using hand crews and materials could be harvested on site or brought in by pack animals or ATVs.

Multiple Accounts Analysis Scores:

Technical: 4.31

Economic: 3.50

Environmental: 3.48

Social and Cultural: 4.28

Overall MAA Score: 3.84

MAA Rank: #2 of 15

Summary:

Relatively small, low risk project would reconnect small meadow and store sediment, plus provide opportunities for education and signage in a high visibility area.

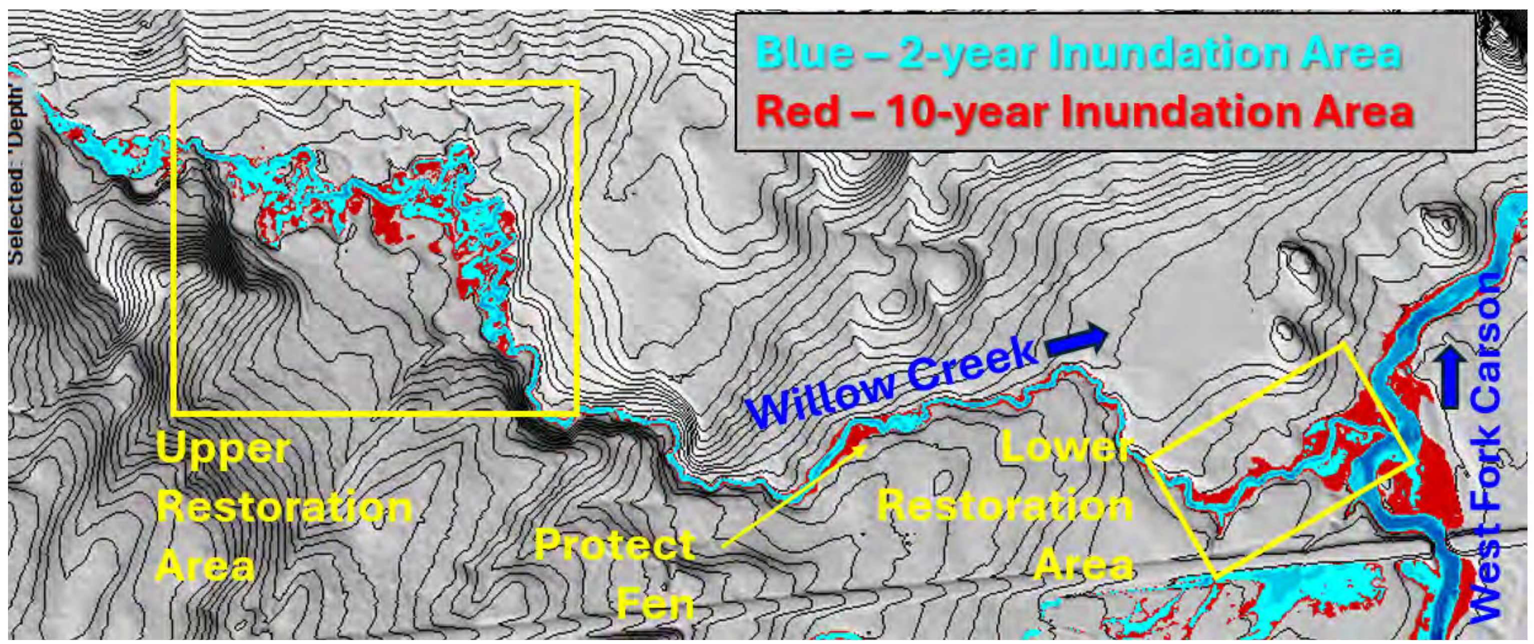


Figure 11-A. Topography and hydraulic model results showing flood extent during 2-year and 10-year events in the lower portion of Willow Creek (existing conditions).

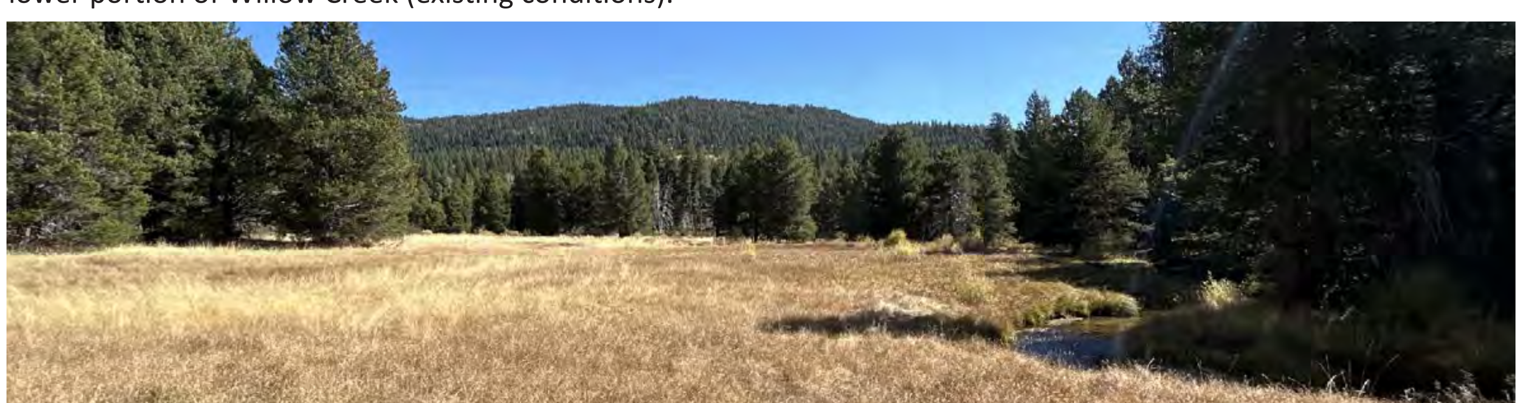


Figure 11-B. Photo of Willow Creek channel and floodplain in the upper area, which could be easily reconnected with LTPBR.

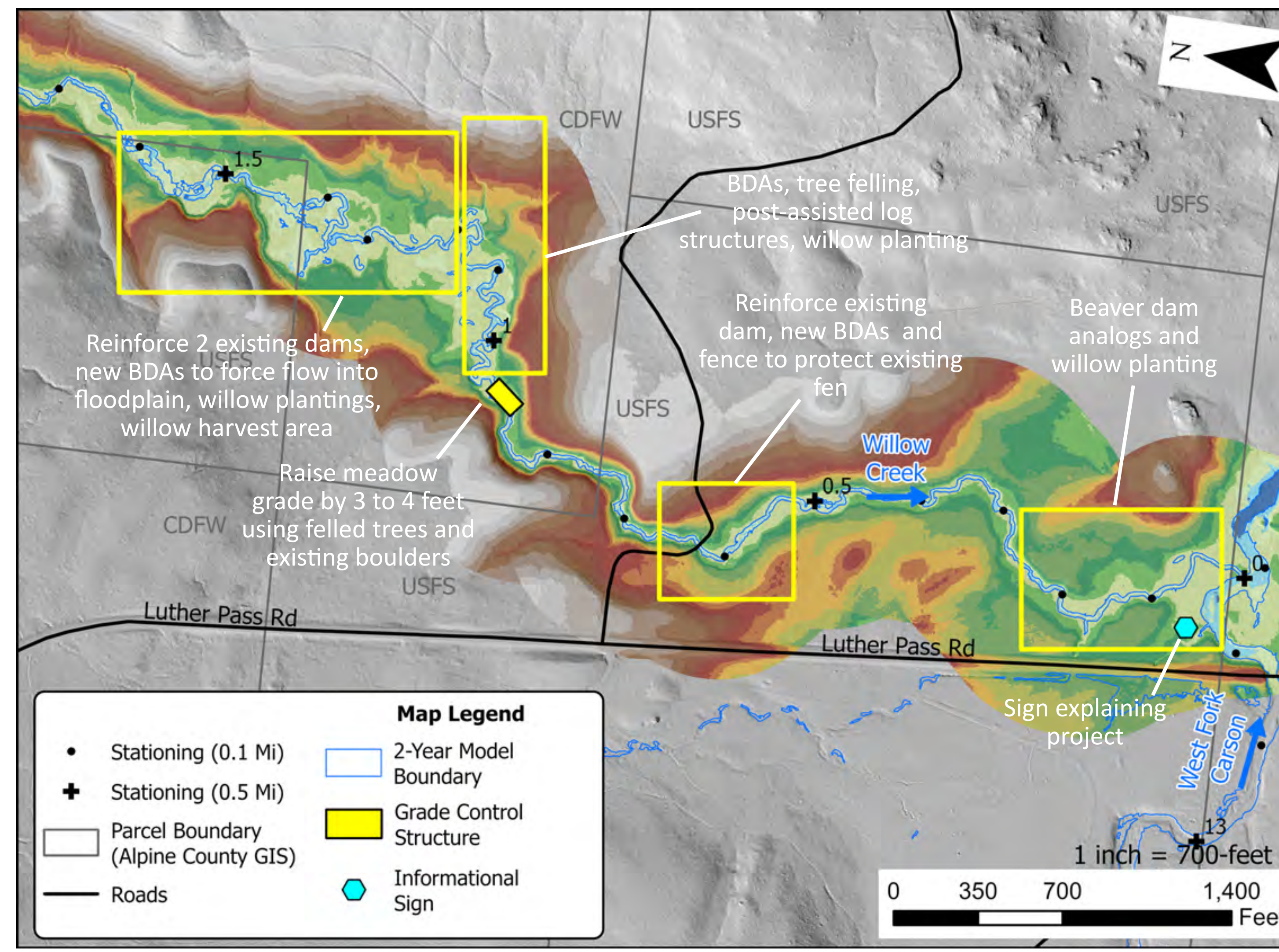


***Figure 11.** Example Project Description for Willow Creek Meadow Restoration (Project 11)*

3.2 PROJECT SCORING

To enable a transparent and consistent comparison among projects with very different settings, objectives, and levels of complexity, each of the 15 projects advanced for evaluation were scored using a standardized set of 20 evaluation factors, referred to as **Indicators** (**Table 10**). The Indicators include technical, environmental, economic, and social/cultural considerations and are organized into primary accounts and sub-accounts (**Table 10**), consistent with the Multiple Accounts Analysis (MAA) framework described below (Section 3.3).

Table 10. *Project Indicators and Scoring Criteria*

Account	Sub-Account	Indicator
Technical	Engineering Feasibility	Geomorphic Difficulty
		Access
		Constructability
	Risks	Risk of Failure to Perform/Likelihood of Success
		Potential Risks to Infrastructure or Existing Natural Resource Values
Economic	Cost	Design and Construction Costs
		Ongoing Maintenance Cost
Environ-mental	Water Quality	Fine Sediment Reduction
		Water Temperature or Pollutant Reduction
	Habitat	In-Channel Habitat Improvement
		Riparian Habitat Improvement
	Geomorphic Process	Prevents or Reverses Degradation
		Improves Channel-Floodplain Connectivity
		Increases Channel Complexity
	Groundwater	Increases Groundwater Recharge and Meadow Recovery
Social and Cultural	Social	Property Ownership
		Flood Benefit
		Ease of Permitting, Water Rights, and Right of Way
	Cultural	Recreational Impact
		Will be viewed as a successful project by stakeholders and the public

Initial scores were independently assigned to each of the Indicators by two experienced restoration practitioners (Daniel Malmon and Loren Roach), both of whom visited the project sites in the field. Each Indicator was scored on a 1 to 5 ordinal scale, where a score of 1 represents relatively low potential or high concern, and a score of 5 represents high potential or favorable conditions. Independent scoring was used to reduce individual bias and to ensure that differing professional judgments were identified and resolved prior to scoring the projects.

Following initial field-based scoring, the two sets of scores were reviewed and reconciled using desktop analyses, hydraulic modeling, LiDAR and aerial photo interpretation, and review of constraints. This produced a single set of 20 Indicator scores for each project. The scores are intended to support relative comparison among projects, rather than to predict absolute outcomes.

A detailed example of the scoring process is provided in **Table 11** which presents the full set of Indicator scores for **Project 11** (Willow Creek), along with a brief justification for each score. Similar evaluations were completed for all 15 projects and form the basis for the weighting and prioritization process described in Section 3.3.

Table 11. Example Project Scoring Table for Willow Creek Meadow Restoration (Project 11)

Project 11 - Willow Creek Beaver Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[2] (1-5)	Notes
Technical	**Engineering Feasibility**	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Not severely incised, small lift to reconnect floodplain.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	4	Hand crews only; could bring materials to upper work area with livestock.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	5	Low tech methods with hand crews.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	High chance of achieving positive response for relatively small effort.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	CDFW property, rarely used. Cattle grazing could be affected.
Economic	**Cost**	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	4	Envision a small low tech, low risk project with some engagement and permitting required. Design cost will be high compared with construction.
		Ongoing Maintenance Cost	Project will not require only monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Monitoring and adaptive maintenance typical for LTPBR projects.
Environ-mental	**Water Quality**	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	Willow Creek watershed produces a lot of sediment. Could deposit a relatively large portion of this in the lower meadow. Would also reduce bank erosion.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	2	Slight water temp reduction through more groundwater recharge.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in West Fork Carson River or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Opportunities to expand the amount of beaver-influenced channel, which will improve in-channel habitat for aquatic organisms.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area.	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Relatively large area of floodplain can be reconnected with somewhat little effort.

Project 11 - Willow Creek Beaver Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[2] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	This is a primary project objective, with high probability of success. Moderate to small area of impact (on the order of 5-10 acres).
		Improves Channel-Floodplain Connectivity[3]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	5	Improves floodplain connectivity in two separate incised meadows.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Adds felled trees, PALS and BDAs to the channel.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	3	Several acres of enhanced wetlands. BDAs will protect existing spring and fen from headcut and dewatering.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	CDFW property.
		Flood Benefit[3]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	2	Hardly any impact on flood attenuation at the CA/NV state line.
		Ease of Permitting, Water Rights, and Right of Way[4]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	4	Probably will be easy to permit if kept to a LTPBR project. Reasonably high likelihood of cultural resources in the area but these would not be disturbed.
	Cultural[4]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Opportunities for education in high visibility area. Upper part of project is rarely visited, which may be a benefit. Could improve fishing.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	5	Lower part is next to Pickett's Junction, easy access, lots of visitors. Could incorporate signage to explain the project and do field tours.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

4. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

3.3 STAKEHOLDER WEIGHTING AND MULTIPLE ACCOUNTS ANALYSIS

While the Indicator scores described in Section 3.2 provide a consistent technical evaluation of project attributes, not all Indicators are equally important in determining which projects should be prioritized. To incorporate stakeholder values into the prioritization process, the project used a Multiple Accounts Analysis (MAA) framework (Robertson and Shaw, 1998; 2004). MAA is a multi-objective decision-making approach designed to compare alternatives that differ across multiple, often competing, objectives by making tradeoffs explicit and transparent. A key advantage of MAA is that it separates technical scoring from value-based weighting, allowing scientific evaluations and stakeholder preferences to be examined independently and then combined in a clear and reproducible manner (Robertson and Shaw, 2004).

Stakeholder input on indicator importance was coordinated by Alpine Watershed Group and obtained from 18 participants representing federal and state agencies, non-governmental organizations, and other entities with an interest in restoration and water quality outcomes in the West Fork Carson River watershed. Participants were asked to assign relative weightings to the primary accounts, associated sub-accounts, and indicators defined in **Table 10**, reflecting the importance of different categories of outcomes (e.g., environmental benefits, technical feasibility, economic considerations, and social or implementation factors). Individual responses were aggregated to produce a single set of representative weightings used in the analysis.

The resulting stakeholder weightings showed a high degree of consistency across respondents (**Figure 26**). Environmental outcomes received the greatest overall weight, followed by technical feasibility, with economic and social considerations receiving comparatively lower but still meaningful weightings. This pattern indicates broad alignment among stakeholders regarding the primary objectives in the watershed, and supports the use of a single, aggregated weighting scheme for project prioritization. The final weightings used in the MAA were the modified stakeholder averages in the first column in **Table 12**.

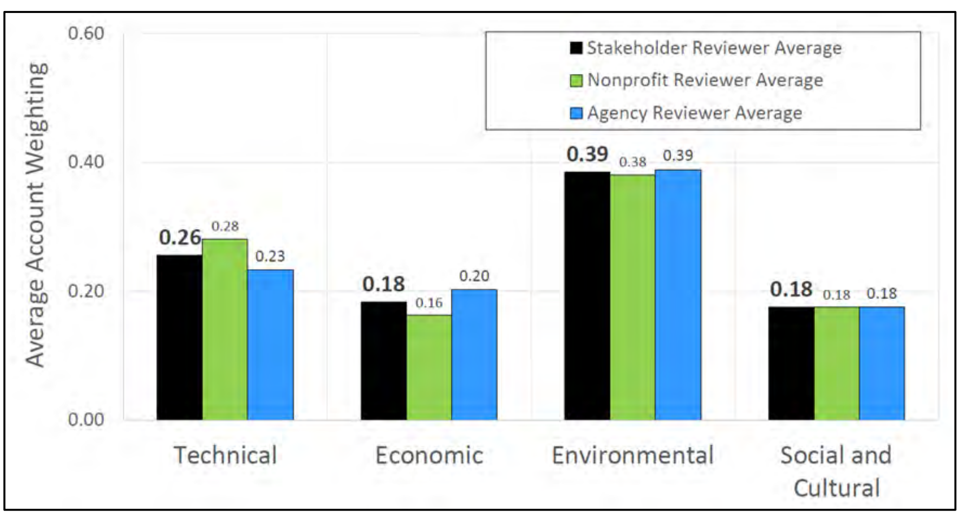


***Figure 26**. Summary of Results of Stakeholder Weightings for Primary Accounts*

PLACEHOLDER PAGE – STAKEHOLDER RESULTS TABLE

Table 12. *Stakeholder Prioritization Results for Account, Subaccount, and Indicator Weightings*

Table X. *Stakeholder Prioritization Results for Account, Subaccount, and Indicator Weightings*

	Modified Stakeholder Average[1]	Stakeholder Average (n=13)	Nonprofit Reviewer Average[2]	Agency Reviewer Average[3]	Alpine Watershed Group: AWG Average	AWG-KM	AWG-BK	AWG-NM	AWGB-JT	AWGB-CR	AWGB-MY	AWGB-ZW	Carson Water Sub-Conservancy District: CWSD-BH	CWSD-KN	Lahontan Regional Water Quality Control Board (Water Board) Reviewers: LRWQCB Average	Re-viewer-1	Re-viewer-2	Re-viewer-3	Re-viewer-4	Re-viewer-5	US Forest Service: USFS-DK	American Rivers: AR-GH	Ca. Dept. Fish and Wildlife: CDFW-AC	Desolation Hotel: DH-ZS
Accounts																								
Technical	0.26	0.26	0.28	0.23	0.29	0.20	0.30	0.10	0.40	0.40	0.10	0.50	0.30	0.20	0.26	0.25	0.25	0.30	0.30	0.20	0.10	0.25	0.20	0.00
Economic	0.18	0.18	0.16	0.20	0.16	0.35	0.20	0.10	0.20	0.10	0.10	0.10	0.30	0.30	0.20	0.02	0.25	0.25	0.30	0.20	0.10	0.15	0.10	0.00
Environmental	0.39	0.39	0.38	0.39	0.38	0.35	0.30	0.50	0.30	0.40	0.50	0.30	0.30	0.30	0.35	0.50	0.25	0.30	0.30	0.40	0.70	0.40	0.45	1.00
Social and Cultural	0.18	0.18	0.18	0.18	0.17	0.10	0.20	0.30	0.10	0.10	0.30	0.10	0.10	0.20	0.19	0.23	0.25	0.15	0.10	0.20	0.10	0.20	0.25	0.00
Sub Accounts																								
Technical																								
Engineering Feasibility	0.55	0.55	0.59	0.52	0.59	0.50	0.40	0.60	0.60	0.70	0.50	0.80	0.60	0.40	0.57	0.65	0.50	0.60	0.50	0.60	0.50	0.60	0.30	1.00
Risk	0.45	0.45	0.41	0.48	0.41	0.50	0.60	0.40	0.40	0.30	0.50	0.20	0.40	0.60	0.43	0.35	0.50	0.40	0.50	0.40	0.50	0.40	0.70	0.00
Economic																								
Cost	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Environmental																								
Water Quality	0.30	0.27	0.28	0.26	0.30	0.25	0.30	0.20	0.40	0.30	0.50	0.30	0.40	0.50	0.32	0.50	0.25	0.25	0.20	0.40	0.10	0.25	0.10	0.00
Habitat	0.20	0.21	0.22	0.21	0.21	0.25	0.30	NA[4]	NA[4]	0.20	NA[4]	0.10	NA[4]	NA[4]	0.14	0.13	0.25	0.10	0.10	0.10	0.20	0.25	0.60	1.00
Geomorphic Process	0.30	0.26	0.24	0.27	0.25	0.25	0.20	0.20	0.30	0.20	0.30	0.30	0.30	0.20	0.26	0.13	0.25	0.40	0.30	0.20	0.40	0.25	0.20	0.00
Groundwater	0.20	0.19	0.22	0.18	0.20	0.25	0.20	0.50	0.30	0.20	0.20	0.20	0.30	0.30	0.21	0.13	0.25	0.15	0.30	0.20	0.10	0.25	0.10	0.00
Social and Cultural																								
Social	0.60	0.59	0.56	0.61	0.56	0.75	0.50	0.40	0.60	0.60	0.60	0.50	0.50	0.60	0.63	0.50	0.80	0.55	0.80	0.50	0.75	0.50	0.50	1.00
Cultural	0.40	0.41	0.44	0.39	0.44	0.25	0.50	0.60	0.40	0.40	0.40	0.50	0.50	0.40	0.37	0.50	0.20	0.45	0.20	0.50	0.25	0.50	0.50	1.00
Indicators																								
Technical																								
Geomorphic Difficulty	0.40	0.40	0.36	0.43	0.35	0.33	0.20		0.40	0.50		0.30			0.47	0.50	0.34	0.50	0.40	0.60	0.60	0.60	0.30	1.00
Access	0.30	0.30	0.33	0.28	0.36	0.33	0.40		0.50	0.25		0.30			0.24	0.30	0.33	0.25	0.20	0.10	0.25	0.20	0.50	0.00
Constructability	0.30	0.30	0.31	0.29	0.30	0.33	0.40		0.10	0.25		0.40			0.30	0.20	0.33	0.25	0.40	0.30	0.35	0.40	0.20	0.00
Risk of Failure to Perform/Likelihood of Success	0.67	0.63	0.62	0.64	0.60	0.50	0.70	NA[4]	0.30	0.80	NA[4]	0.70	NA[4]	NA[4]	0.64	0.75	0.50	0.60	0.70	0.60	0.65	0.70	0.60	1.00
Potential Risks to Infrastructure or Existing Natural Resource Values	0.33	0.37	0.39	0.36	0.40	0.50	0.30		0.70	0.20		0.30			0.36	0.25	0.50	0.35	0.30	0.40	0.35	0.30	0.40	0.00
Economic																								
Design and Construction Costs	0.50	0.48	0.46	0.49	0.50	0.40	0.60		0.40	0.80		0.50			0.50	0.60	0.50	0.40	0.70	0.30	0.45	0.25	0.80	1.00
Ongoing Maintenance Efforts	0.50	0.52	0.54	0.51	0.50	0.60	0.40		0.60	0.60		0.50			0.50	0.40	0.50	0.60	0.30	0.70	0.55	0.75	0.80	0.00
Environmental																								
Fine Sediment Reduction[5]	0.80	0.49	0.45	0.53	0.44	0.50	0.50		0.60	0.60		0.20			0.54	0.40	0.50	0.50	0.50	0.80	0.50	0.50	0.50	0.00
Water Temperature Reduction[5]	0.20	0.51	0.55	0.47	0.56	0.50	0.50	NA[4]	0.40	0.60	NA[4]	0.80	NA[4]	NA[4]	0.46	0.60	0.50	0.50	0.50	0.20	0.50	0.50	0.50	1.00
In-stream Habitat Improvement	0.50	0.52	0.55	0.49	0.56	0.50	0.50		0.50	0.60		0.70			0.53	0.40	0.50	0.50	0.40	0.70	0.50	0.50	0.40	1.00
Riparian Habitat Improvement	0.50	0.48	0.45	0.51	0.44	0.50	0.50		0.50	0.40		0.30			0.50	0.60	0.50	0.50	0.60	0.30	0.50	0.50	0.60	0.00
Reverse Degradation	0.40	0.58	0.48	0.68	0.46	0.60	0.50		0.60	0.50		0.30			0.90	0.60	0.50	0.60	0.70	0.80	0.60	0.60	0.80	1.00
Increases Channel-Floodplain Connectivity[6]	0.30	INDICATOR ADDED AFTER STAKEHOLDER REVIEW																						
Increases Channel Complexity	0.30	0.44	0.52	0.37	0.56	0.40	0.50	NA[4]	0.60	0.50	NA[4]	0.70	NA[4]	NA[4]	0.40	0.40	0.50	0.60	0.30	0.20	0.40	0.40	0.20	0.00
Groundwater Recharge	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Social and Cultural																								
Property Ownership	0.50	0.50	0.46	0.53	0.40	0.50	0.60	NA[4]	0.20	0.60		0.30	NA[4]	NA[4]	0.44	0.60	0.20	0.40	0.50	0.50	0.60	0.75	0.80	0.00
Flood Benefit[6]	0.25	INDICATOR ADDED AFTER STAKEHOLDER REVIEW																						
Permitting, Water Rights, and Right of Way	0.25	0.50	0.54	0.47	0.60	0.50	0.40	NA[4]	0.80	0.60	NA[4]	0.70	NA[4]	NA[4]	0.56	0.40	0.80	0.60	0.50	0.50	0.40	0.25	0.10	1.00
Recreation Impacts	0.30	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Public Perception[6]	0.70	INDICATOR ADDED AFTER STAKEHOLDER REVIEW																						

Notes:

1. Modified Stakeholder Average are values used in the main analysis. Small modifications in the average value were made to approximate and account for differences between the final scoring criteria and the set of criteria that was sent to stakeholders for input.
2. Nonprofit Reviewer Average reflects the average of responses from reviewers from Alpine Watershed Group and American Rivers.
3. Agency Reviewer Average reflects the average of responses from reviewers from CWSD, LRWQCB, USFS, and CDFW
4. Cells with "NA" are those in which stakeholders either did not respond, or responded to an early version of the questionnaire that did not include these specific criteria. Averages do not include responses where missing values would affect the scores.
5. Weighting for the water quality indicators does not use the stakeholders preferences. Instead, relative importance of fine sediment versus water temperature and other benefits is relative to the scope of the West Fork Carson River Prioritization Plan project.
6. For indicators that were added in response to stakeholder suggestions, the weighting was assigned by Waterways based on our understanding of stakeholder values and technical criteria.

3.4 PROJECT RANKING RESULTS AND INTERPRETATION

The MAA analysis combines the stakeholder-informed weightings in **Table 12** with the Indicator scoring for each of the projects (e.g., **Table 11**) to produce prioritization scores for the 15 projects (**Table 13**). **Table 13** is a summary of the project rankings in prioritized order. **Table 14** shows the details of the MAA scoring, and includes the overall scores for each project, along with detailed scores for each of the accounts, subaccounts, and indicators.

3.4.1 Overall Project Rankings and Account-Level Performance

The overall project rankings in **Table 13** reflect the weighted combination of scores across the primary accounts, including Technical Feasibility, Costs, Environmental Benefits, and Social and Cultural accounts. High-ranking projects consistently score strongly (above 3.5) in the Environmental account, reflecting their potential to reduce fine sediment, reconnect floodplains, and improve instream and riparian habitat. Differences in overall ranking are sometimes driven by technical and logistical considerations rather than environmental benefits alone. For example, projects with the highest Environmental scores (e.g., Projects 5 and 6) are ranked slightly lower overall (ranked #4 and #5) due to anticipated challenges such as scale, cost, permitting, or constructability. Conversely, smaller projects with moderate environmental potential (e.g., Projects 11 and 12) rank highly overall because they combine some benefits with low technical and logistical risk.

For planning purposes, we recommend that the top seven highest ranked projects, with overall scores much higher than 3, be strongly considered for implementation as part of a long-term program, while projects ranked 8 to 10 (scores close to 3) should be revisited to see if they are worthwhile in the context of other efforts. Projects ranked 11 through 15 are lower priority, because they provide comparatively limited value under the stakeholder-weighted objectives, and/or face substantial feasibility or implementation constraints.

Table 13. *Summary of MAA Prioritization Results.*

Ranked by Overall MAA Score

	Project #	MAA Rank	Projects	Creek	Project Size	Overall Score	Technical	Economic	Environ-mental	Social and Cultural
Strongly Consider	Project 12	1	Red Lake Creek Lower Meadow Restoration	Red Lake Creek	Small-Medium	**4.07**	4.37	3.50	4.08	4.18
	Project 11	2	Willow Creek Beaver Restoration	Willow Creek	Small	**3.84**	4.31	3.50	3.48	4.28
	Project 15	3	Basinwide Headcut Repairs	Basinwide	Small-Medium	**3.72**	4.37	3.50	3.54	3.40
	Project 5	4	Lower Hope Valley Restoration	West Fork Carson	Large	**3.60**	3.36	2.00	4.24	4.15
	Project 6	5	Middle Hope Valley Restoration	West Fork Carson	Large	**3.57**	3.34	2.00	4.24	4.00
	Project 13	6	Red Lake Creek Upper Meadows Restoration	Red Lake Creek	Small	**3.49**	3.84	4.00	3.04	3.43
	Project 10	7	Upper Faith Valley Floodplain Reconnection	West Fork Carson	Medium	**3.26**	3.65	2.50	3.34	3.30
Maybe	Project 8	8	Blue Lakes Road Restoration	West Fork Carson	Small	**3.01**	4.15	4.00	1.60	3.45
	Project 9	9	Faith Valley Dispersed Camping Repairs	West Fork Carson	Medium	**2.97**	3.55	2.50	2.54	3.55
	Project 7	10	Upper Hope Valley Restoration	West Fork Carson	Large	**2.77**	2.47	2.00	3.24	2.97
Low Priority	Project 14	11	Hawkins Fan Reconnection	Hawkins Creek	Small	**2.74**	2.45	3.00	2.68	3.02
	Project 4	12	Crystal Springs Road Floodplain Reconnection	West Fork Carson	Medium-Large	**2.41**	2.31	2.50	2.30	2.70
	Project 2	13	Ace Hereford Ranch Floodplain Reconnection	West Fork Carson	Large	**2.28**	2.11	2.50	2.14	2.60
	Project 1	14	River Ranch Road Fan Reconnection	West Fork Carson	Large	**2.27**	2.15	1.50	2.84	1.97
	Project 3	15	Woodfords Fan Reconnection	West Fork Carson	Large	**2.13**	2.13	1.50	2.56	1.82

The MAA results synthesize the geomorphologic analysis, project-level evaluation, and stakeholder input to provide a comprehensive understanding of where restoration actions are likely to be most effective in reducing fine sediment loads and achieving additional environmental and societal benefits. The results provide both spatial guidance—identifying the reaches where interventions are most promising—and strategic guidance—informing the type, scale, and phasing of restoration actions across the watershed.

Table 14. *Results of Multiple Accounts Analysis for All Projects*

Account	Account Weight	Sub-Account	Sub-Account Weight	Indicator	Indicator Weight	Project 1 River Ranch Road Fan Reconnection	Project 2 Ace Hereford Ranch Floodplain Reconnection	Project 3 Woodfords Fan Reconnection	Project 4 Crystal Springs Road Floodplain Reconnection	Project 5 Lower Hope Valley Restoration	Project 6 Middle Hope Valley Restoration	Project 7 Upper Hope Valley Restoration	Project 8 Blue Lakes Road Restoration	Project 9 Faith Valley Dispersed Camping Area Restoration and Repairs	Project 10 Upper Faith Valley Floodplain Reconnection	Project 11 Willow Creek Beaver Restoration	Project 12 Red Lake Creek Lower Meadow Restoration	Project 13 Red Lake Creek Upper Meadows Restoration	Project 14 Hawkins Fan Reconnection	Project 15 Basinwide Headcut Repairs
Tech-nical	0.26	Engineer-ing Feasibility	0.55	Geomorphic Difficulty	0.4	2	1	4	2	4	4	2	4	4	4	4	5	4	2	5
				Access	0.3	3	4	2	3	3	2	3	3	5	2	4	3	3	2	4
				Constructability	0.3	1	2	1	2	2	2	2	5	3	3	5	5	4	2	4
				Subaccount Rating		*2.00*	*2.20*	*2.50*	*2.30*	*3.10*	*2.80*	*2.30*	*4.00*	*4.00*	*3.10*	*4.30*	*4.40*	*3.70*	*2.00*	*4.40*
				Weighted Subaccount Value		*1.10*	*1.21*	*1.38*	*1.27*	*1.71*	*1.54*	*1.27*	*2.20*	*2.20*	*1.71*	*2.37*	*2.42*	*2.04*	*1.10*	*2.42*
		Risks	0.45	Risk of Failure to Perform/Likelihood of Success	0.67	3	2	2	2	4	4	3	4	3	4	4	4	4	2	4
				Potential Risk to Infrastructure or Natural Resources	0.33	1	2	1	3	3	4	2	5	3	5	5	5	4	5	5
				Subaccount Rating		*2.34*	*2.00*	*1.67*	*2.33*	*3.67*	*4.00*	*2.67*	*4.33*	*3.00*	*4.33*	*4.33*	*4.33*	*4.00*	*2.99*	*4.33*
				Weighted Subaccount Value		*1.05*	*0.90*	*0.75*	*1.05*	*1.65*	*1.80*	*1.20*	*1.95*	*1.35*	*1.95*	*1.95*	*1.95*	*1.80*	*1.35*	*1.95*
				Account Rating		*2.15*	*2.11*	*2.13*	*2.31*	*3.36*	*3.34*	*2.47*	*4.15*	*3.55*	*3.65*	*4.31*	*4.37*	*3.84*	*2.45*	*4.37*
				Account Value Weight		*0.55*	*0.54*	*0.55*	*0.60*	*0.86*	*0.86*	*0.63*	*1.07*	*0.91*	*0.94*	*1.11*	*1.12*	*0.99*	*0.63*	*1.12*
Eco-nomic	0.18	Cost	1	Design and Construction Cost	0.5	1	2	1	2	1	1	1	5	2	2	4	4	5	3	4
				Ongoing Maintenance Effort	0.5	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3
				Subaccount Rating		*1.50*	*2.50*	*1.50*	*2.50*	*2.00*	*2.00*	*2.00*	*4.00*	*2.50*	*2.50*	*3.50*	*3.50*	*4.00*	*3.00*	*3.50*
				Weighted Subaccount Value		*1.50*	*2.50*	*1.50*	*2.50*	*2.00*	*2.00*	*2.00*	*4.00*	*2.50*	*2.50*	*3.50*	*3.50*	*4.00*	*3.00*	*3.50*
				Account Rating		*1.50*	*2.50*	*1.50*	*2.50*	*2.00*	*2.00*	*2.00*	*4.00*	*2.50*	*2.50*	*3.50*	*3.50*	*4.00*	*3.00*	*3.50*
				Account Value Weight		*0.27*	*0.45*	*0.27*	*0.45*	*0.36*	*0.36*	*0.36*	*0.71*	*0.45*	*0.45*	*0.62*	*0.62*	*0.71*	*0.53*	*0.62*
Environ-mental	0.39	Water Quality	0.3	Fine Sediment Reduction	0.8	4	3	3	1	5	5	4	1	2	4	4	5	3	4	5
				Water Temperature or Pollutant Reduction	0.2	3	2	4	1	4	4	3	1	1	3	2	3	2	2	4
				Subaccount Rating		*3.80*	*2.80*	*3.20*	*1.00*	*4.80*	*4.80*	*3.80*	*1.00*	*1.80*	*3.80*	*3.60*	*4.60*	*2.80*	*3.60*	*4.80*
				Weighted Subaccount Value		*1.14*	*0.84*	*0.96*	*0.30*	*1.44*	*1.44*	*1.14*	*0.30*	*0.54*	*1.14*	*1.08*	*1.38*	*0.84*	*1.08*	*1.44*
		Habitat	0.2	In-Channel Habitat Improvement	0.5	2	1	3	4	4	4	3	4	3	3	4	4	3	2	2
				Riparian Habitat Improvement	0.5	3	4	4	3	5	5	4	2	4	4	4	5	4	3	4
				Subaccount Rating		*2.50*	*2.50*	*3.50*	*3.50*	*4.50*	*4.50*	*3.50*	*3.00*	*3.50*	*3.50*	*4.00*	*4.50*	*3.50*	*2.50*	*3.00*
				Weighted Subaccount Value		*0.50*	*0.50*	*0.70*	*0.70*	*0.90*	*0.90*	*0.70*	*0.60*	*0.70*	*0.70*	*0.80*	*0.90*	*0.70*	*0.50*	*0.60*
		Geo-morphic	0.3	Prevents or Reverses Degradation	0.33	2	2	2	3	5	5	4	1	4	4	4	4	4	3	5
				Improves Channel-Floodplain Connectivity	0.34	4	2	3	4	5	5	4	3	4	4	5	5	4	4	4
				Increases Channel Complexity	0.33	3	1	2	4	4	4	3	2	3	4	4	4	3	3	2
				Subaccount Rating		*3.01*	*1.67*	*2.34*	*3.67*	*4.67*	*4.67*	*3.67*	*2.01*	*3.67*	*4.00*	*4.34*	*4.34*	*3.67*	*3.34*	*3.67*
				Weighted Subaccount Value		*0.90*	*0.50*	*0.70*	*1.10*	*1.40*	*1.40*	*1.10*	*0.60*	*1.10*	*1.20*	*1.30*	*1.30*	*1.10*	*1.00*	*1.10*
		Ground-water	0.2	Increases Groundwater Recharge	1	3	3	2	2	5	5	3	1	2	3	3	5	4	1	4
				Subaccount Rating		*1.50*	*1.50*	*1.00*	*1.00*	*2.50*	*2.50*	*1.50*	*0.50*	*1.00*	*1.50*	*1.50*	*2.50*	*2.00*	*0.50*	*2.00*
				Weighted Subaccount Value		*0.30*	*0.30*	*0.20*	*0.20*	*0.50*	*0.50*	*0.30*	*0.10*	*0.20*	*0.30*	*0.30*	*0.50*	*0.40*	*0.10*	*0.40*
				Account Rating		*2.84*	*2.14*	*2.56*	*2.30*	*4.24*	*4.24*	*3.24*	*1.60*	*2.54*	*3.34*	*3.48*	*4.08*	*3.04*	*2.68*	*3.54*
				Account Value Weight		*1.10*	*0.83*	*0.99*	*0.89*	*1.64*	*1.64*	*1.25*	*0.62*	*0.98*	*1.29*	*1.34*	*1.58*	*1.17*	*1.04*	*1.37*
Social and Cultural	0.18	Social	0.6	Property Ownership	0.5	1	4	1	2	5	5	3	5	5	5	5	5	3	5	4
				Flood Benefit	0.25	4	2	3	3	5	4	3	1	1	2	2	4	3	1	1
				Permitting, Water Rights, and Right of Way	0.25	1	2	1	3	2	2	2	4	2	2	4	4	4	3	3
				Subaccount Rating		*1.75*	*3.00*	*1.50*	*2.50*	*4.25*	*4.00*	*2.75*	*3.75*	*3.25*	*3.50*	*4.00*	*4.50*	*3.25*	*3.50*	*3.00*
				Weighted Subaccount Value		*1.05*	*1.80*	*0.90*	*1.50*	*2.55*	*2.40*	*1.65*	*2.25*	*1.95*	*2.10*	*2.40*	*2.70*	*1.95*	*2.10*	*1.80*
		Cultural	0.4	Recreation Impacts	0.3	3	2	3	3	4	4	4	3	4	3	4	3	3	3	4
				Public Perception of Project	0.7	2	2	2	3	4	4	3	3	4	3	5	4	4	2	4
				Subaccount Rating		*2.30*	*2.00*	*2.30*	*3.00*	*4.00*	*4.00*	*3.30*	*3.00*	*4.00*	*3.00*	*4.70*	*3.70*	*3.70*	*2.30*	*4.00*
				Weighted Subaccount Value		*0.92*	*0.80*	*0.92*	*1.20*	*1.60*	*1.60*	*1.32*	*1.20*	*1.60*	*1.20*	*1.88*	*1.48*	*1.48*	*0.92*	*1.60*
				Account Rating		*1.97*	*2.60*	*1.82*	*2.70*	*4.15*	*4.00*	*2.97*	*3.45*	*3.55*	*3.30*	*4.28*	*4.18*	*3.43*	*3.02*	*3.40*
				Account Value Weight		*0.35*	*0.46*	*0.32*	*0.48*	*0.74*	*0.71*	*0.53*	*0.61*	*0.63*	*0.59*	*0.76*	*0.74*	*0.61*	*0.54*	*0.61*
TOTAL MATRIX SCORE						**2.27**	**2.28**	**2.13**	**2.41**	**3.60**	**3.57**	**2.77**	**3.01**	**2.97**	**3.26**	**3.84**	**4.07**	**3.49**	**2.74**	**3.72**

Total Score	**2.27**	**2.28**	**2.13**	**2.41**	**3.60**	**3.57**	**2.77**	**3.01**	**2.97**	**3.26**	**3.84**	**4.07**	**3.49**	**2.74**	**3.72**
Technical Score	2.15	2.11	2.13	2.31	3.36	3.34	2.47	4.15	3.55	3.65	4.31	4.37	3.84	2.45	4.37
Economic Score	1.50	2.50	1.50	2.50	2.00	2.00	2.00	4.00	2.50	2.50	3.50	3.50	4.00	3.00	3.50
Environmental Score	2.84	2.14	2.56	2.30	4.24	4.24	3.24	1.60	2.54	3.34	3.48	4.08	3.04	2.68	3.54
Social and Cultural Score	1.97	2.60	1.82	2.70	4.15	4.00	2.97	3.45	3.55	3.30	4.28	4.18	3.43	3.02	3.40

3.4.2 Spatial Patterns of Prioritized Projects

The map of project rankings in **Figure 27** reveals a clear spatial trend: The highest-ranking projects are all located in the upper, glaciated portion of the watershed, including both the mainstem West Fork Carson River and its tributaries. This pattern aligns with the findings from the geomorphologic model and sediment budget, which indicate that nearly all fine sediment originates from streambank erosion in the upper basin, particularly in Hope Valley.

The upper basin contains broad, glacially-formed valleys where sediment can be stored, providing geomorphic capacity for interventions to increase floodplain connectivity and sediment retention. In contrast, the lower basin is characterized by deeply incised channels, limited opportunities for improved floodplain connectivity, and minimal active bank erosion due to the boulder-lined channels. These physical constraints, coupled with predominantly private ownership and land uses that may be incompatible with floodplain restoration, reduce both the environmental potential and feasibility of restoration projects in the lower basin. The low geomorphic potential and practical barriers contribute to the lower rankings of projects in the lower basin.

The high-ranking projects in the upper basin are on public lands owned by U.S. Forest Service (USFS) and California Department of Fish and Wildlife (CDFW). Public ownership reduces access constraints and land use conflicts, facilitates permitting, and allows project proponents to work more easily with regulatory agencies and other stakeholders. These factors point clearly to the upper basin as the logical focus for restoration efforts targeting fine sediment reduction in the basin.

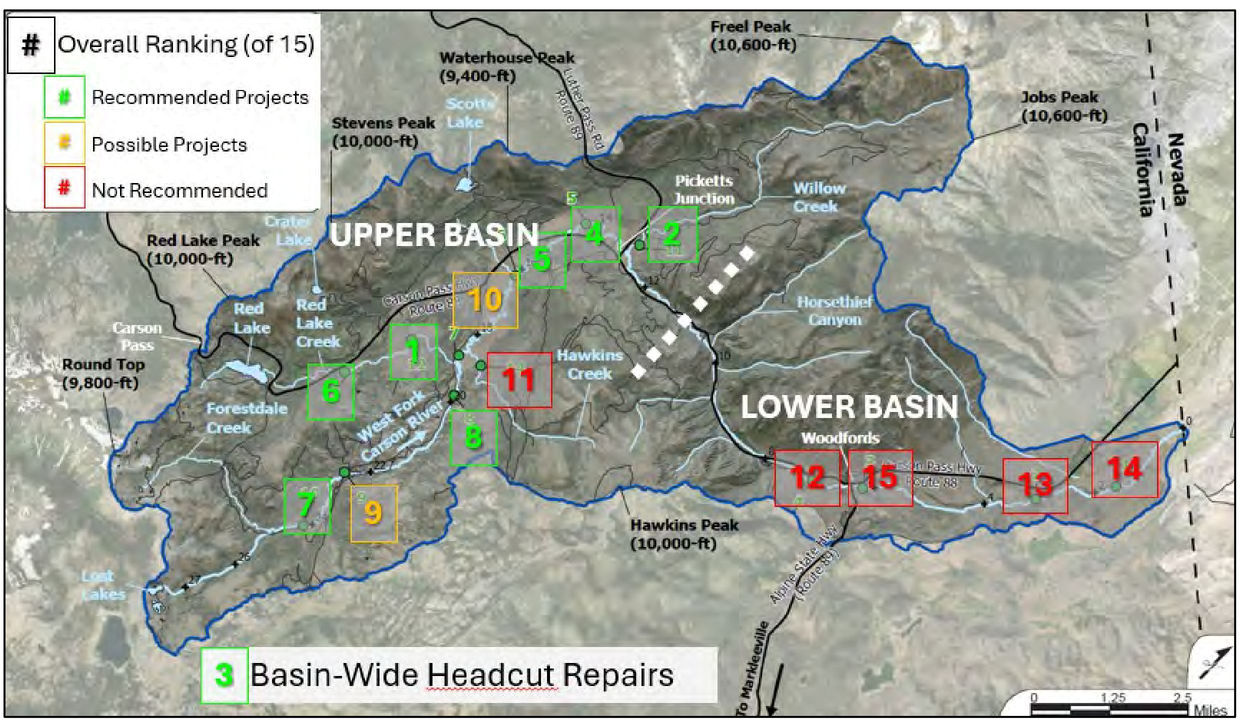


Figure 27. Spatial Pattern of 15 Potential Projects Identified by MAA Ranking

3.4.3 "Low-Hanging Fruit" Restoration Opportunities

Among the 15 projects advanced for detailed evaluation, a subset can be categorized as "low-hanging fruit." (**Table 15**). These projects are generally small in scale, low-risk, and involve actions that enhance sediment retention and floodplain connectivity through simple in-stream or floodplain features. Many mimic or support natural processes, such as beaver dam activity, which slows water, raises local channel bed elevations, reduces bank erosion, and traps sediment, among other beneficial outcomes. These projects can often be constructed with hand labor and minimal equipment, making them suitable for implementation using volunteers, stewardship crews, or small local contractors. Their low cost, low risk, and modular nature allow for phased implementation, monitoring, and adaptive management. These types of projects are valuable for generating near-term environmental benefits, building local experience and support, providing education and outreach opportunities, and informing subsequent, larger-scale restoration interventions. The methods used in these projects have been referred to collectively as Low-Tech Process Based Restoration (LTPBR) (Wheaton, et al., 2019) techniques.

The highest ranked projects in the study are LTPBR meadow restoration projects in Lower Red Lake Creek (**Project 12**) and Willow Creek (**Project 11**), two tributaries to the WFCR in Hope Valley. Another highly ranked project would be a basin-wide effort to identify, stabilize, and monitor meadow headcuts to protect intact meadows across the upper basin (**Project 15**). These projects are recommended as clear low-hanging fruit in the basin. The concepts for each of these projects are described in more detail in **Appendix P-1**.

Table 15. *Summary Table of "Low-Hanging Fruit" Projects*

Projects scored with Multiple Accounts Analysis

Project #	Projects	Creek	Project Size	Overall Score	Technical	Economic	Environ-mental	Social and Cultural
Project 12	Red Lake Creek Lower Meadow Restoration	Red Lake Creek	Small-Medium	4.07	4.37	3.50	4.08	4.18
Project 11	Willow Creek Beaver Restoration	Willow Creek	Small	3.84	4.31	3.50	3.48	4.28
Project 15	Basinwide Headcut Repairs	Basinwide	Small-Medium	3.72	4.37	3.50	3.54	3.40
Project 13	Red Lake Creek Upper Meadows Restoration	Red Lake Creek	Small	3.49	3.84	4.00	3.04	3.43
Project 10	Upper Faith Valley Floodplain Reconnection	West Fork Carson	Small-Medium	3.26	3.65	2.50	3.34	3.30
Project 8	Blue Lakes Road Restoration	West Fork Carson	Small	3.01	4.15	4.00	1.60	3.45

Additional Projects not scored with MAA

Project 19	Highway 88 West Meadow Restoration	Unnamed tributary	Unknown	Meadow restoration projects prioritized by American Rivers (2018); projects that offer benefits but that may not offer significant sediment storage or water quality benefit at the watershed scale.
Project 20	Horsethief Canyon Meadow Restoration	Horsethief Canyon	Unknown	
Project 21	Middle Willow Creek Meadow Restoration	Unnamed tributary	Small	
Project 16	Lower Hope Valley Adaptive Management	West Fork Carson	Small	Currently funded and should be moved forward as an early phase of Project #5.

Projects 8 and **10**, two LTPBR projects along the mainstem WFCR, have moderately high MAA scores (**Table 15**), indicating they could be worth including as part of a long-term, basin-scale restoration program. These two reaches are identified as places where relatively low risk and low cost projects could have a positive impact on habitat within the mainstem WFCR. **Project 8**, in the upper part of Faith Valley, just below the confluence with Forestdale Creek, is an opportunity to increase

connectivity with a large area of floodplain on river right. **Project 10**, along Blue Lakes Road, would help enhance conditions for an existing beaver population in a confined reach by increasing the stability of dams and adding large wood to the floodplain.

In addition to the projects evaluated through the MAA, other low-hanging fruit opportunities include restoration of headwater meadows identified as impaired by American Rivers (2018) (**Projects 19** through **21** in **Table 15**), which could improve meadow health and habitat but are unlikely to substantially affect the basin-scale sediment budget.

3.4.4 Higher Impact, Complex Restoration Projects

The projects that offer the greatest environmental benefits are the large, reach-scale interventions on the mainstem West Fork Carson River, especially in Hope Valley (**Table 16**). These projects address the dominant sources of fine sediment and target the largest areas of geomorphic potential for sediment storage. In addition to water quality benefits, the projects in **Table 16** also offer the greatest potential for improvements to habitat, groundwater recharge, and geomorphic function, while potentially offering some flood attenuation benefits. For these reasons, they consistently receive the highest Environmental account scores in **Table 13**. These high-impact projects are more complex, have higher costs, and present more risks than the "low-hanging fruit" projects, leading to lower Economic and Technical account scores. The larger projects are more complex for many reasons: they require heavy equipment and possible import of unknown quantities of rock; they are in iconic, highly visible areas, where visual impacts to the landscape are important; the projects will be interrelated, in that upstream projects will affect downstream projects; and they will have higher costs, technical demands, and permitting requirements.

Several of these higher-impact projects seem to offer enough benefits to justify the high costs and risks, particularly in Hope Valley (**Table 16**). Because of the higher costs and risks, these should be approached differently from the low-hanging fruit projects. Implementation of these more complex projects will require careful phasing, detailed design, and extensive stakeholder engagement. For many of these projects, monitoring and adaptive management will be essential to ensure that the projects achieve the intended outcomes and to allow for course corrections as the system responds to the interventions.

Table 16. *Larger Scale Restoration Opportunities*

Project #	Projects	Creek	Project Size	Overall Score	Technical	Economic	Environ-mental	Social and Cultural
Project 5	Lower Hope Valley Restoration	West Fork Carson	Large	3.60	3.36	2.00	4.24	4.15
Project 6	Middle Hope Valley Restoration	West Fork Carson	Large	3.57	3.34	2.00	4.24	4.00
Project 9	Faith Valley Dispersed Camping Restoration	West Fork Carson	Medium	2.97	3.55	2.50	2.54	3.55
Project 7	Upper Hope Valley Restoration	West Fork Carson	Large	2.77	2.47	2.00	3.24	2.97

3.4.5 Water Budget for the WFCR and Impacts of Restoration on Water Delivery

In addition to the physical interventions listed here, restoration efforts in the basin could benefit from a water budget focused on quantifying the impacts of restoration actions on downstream water deliveries. Downstream water users have expressed concern that upstream restoration actions—such as willow planting, floodplain reconnection, and the use of beaver dam analogs (BDAs)—could affect water deliveries by increasing evapotranspiration or otherwise altering the timing and magnitude of downstream flows. These concerns are reasonable given the importance of irrigation water in the lower basin and the visibility of restoration techniques that intentionally retain water on the landscape. At the same time, restoration approaches that increase floodplain inundation may alternatively have the potential to improve late-season water availability by enhancing groundwater recharge during high-flow periods, when excess water is available and irrigation deliveries are typically unaffected. This stored floodwater may subsequently return to the channel as baseflow during drier periods, when water demand is higher. Thus, the effect of restoration actions on downstream water deliveries to irrigators could be either beneficial, detrimental, or neutral. Evaluating these potentially offsetting effects requires a quantitative water budget capable of resolving seasonal storage, evapotranspiration, and groundwater–surface water interactions.

Developing such a water budget is outside the scope of this project, and no attempt is made here to predict changes in downstream water delivery due to the restoration actions being proposed. However, a basin-scale water budget focused on restoration-related flow timing is recommended as part of a long-term restoration management program and is identified as a potential action in Section 3. American Rivers has collected some data at the Faith Valley Meadow Restoration Project that could be leveraged for this effort. While this is outside the scope of work of the current project, which focuses on sediment transport and geomorphology, answering those questions could answer stakeholder questions and help secure funding and ongoing community support for a long-term restoration program in the upper WFCR basin.

3.5 HOPE VALLEY: RESTORATION POTENTIAL AND LONG-TERM APPROACH

3.5.1 Restoration Potential and Challenges in Hope Valley

Hope Valley, a glacially carved, fault bounded basin along seven miles of the mainstem WFCR and its tributaries, emerged from the prioritization analysis as the most important landscape for achieving meaningful, long-term geomorphic and water quality improvements in the WFCR watershed. Hope Valley is a broad, glacially carved meadow complex that includes multiple distinct sub-basins and tributaries. Hope Valley is highly visible, frequently visited, and deeply valued for its scenic, recreational, and ecological importance (**Figure 28**). It is also the location where the watershed's largest sources of bank erosion coincide with the greatest opportunities for floodplain reconnection and fine sediment storage. As shown in **Figure 15**, multiple high-ranking projects are clustered within Hope Valley along both the mainstem West Fork Carson River and key tributaries, forming a contiguous zone of restoration opportunity on public land where there is extensive public inter

***Figure 28**. Photo of Lower Hope Valley and Upper West Carson River Watershed Looking Upstream*

Beneficial Geologic/Geomorphic Settings for Restoration. The best opportunities for reversing degradation and reconnecting the floodplain are in Lower Hope Valley (**Project 5**) and Middle Hope Valley (**Project 6**). As shown in **Figure 29**, these projects benefit from a geomorphic configuration similar to Faith Valley, where a project has recently been completed. These reaches share a configuration in which a wide alluvial meadow reach with active bank erosion is situated immediately upstream of a narrow, confined reach with boulder or bedrock constraints. These transitions occur throughout the upper basin where streams cross boulder-rich glacial end moraines, or where streams enter narrow bedrock canyons. This type of geomorphic transition in the WFCR and tributaries provides an advantageous geomorphic setting for restoration because it allows the base level to be raised or stabilized without a high risk of the river laterally bypassing, or "flanking," the constructed base level control. Similar geomorphic transitions can be found in tributaries as well, including in Willow Creek (**Project 11**), and in Upper and Lower Red Lake Creek (**Projects 12** and **13**).

Overall Geomorphic Approach. If channel incision and floodplain disconnection are considered drivers of degradation in Hope Valley, then the most effective long-term solution is to raise the channel bed closer to the floodplain elevation in order to increase the magnitude, frequency, and spatial extent of overbank flooding. The most reliable way to accomplish this is through the installation of stable grade control structures at the downstream end of the eroding meadow reaches, where the channel transitions into confined bedrock or boulder-controlled segments. These structures can remain stable through high flows and establish a higher base level that promotes floodplain inundation and sediment deposition for hundreds to thousands of feet upstream. Upstream of these grade control locations, a wide range of complementary restoration treatments could be applied to further enhance sediment retention, reduce bank erosion, and improve riparian and meadow function. These may include non-channel-spanning large wood structures, engineered rock riffles, beaver dam analogs (BDAs), willow trenching, floodplain roughening, and other established or experimental techniques. The specific mix of treatments would depend on site conditions, project objectives, and stakeholder priorities, but the overarching intent would be to work with natural processes rather than impose a rigid channel form.

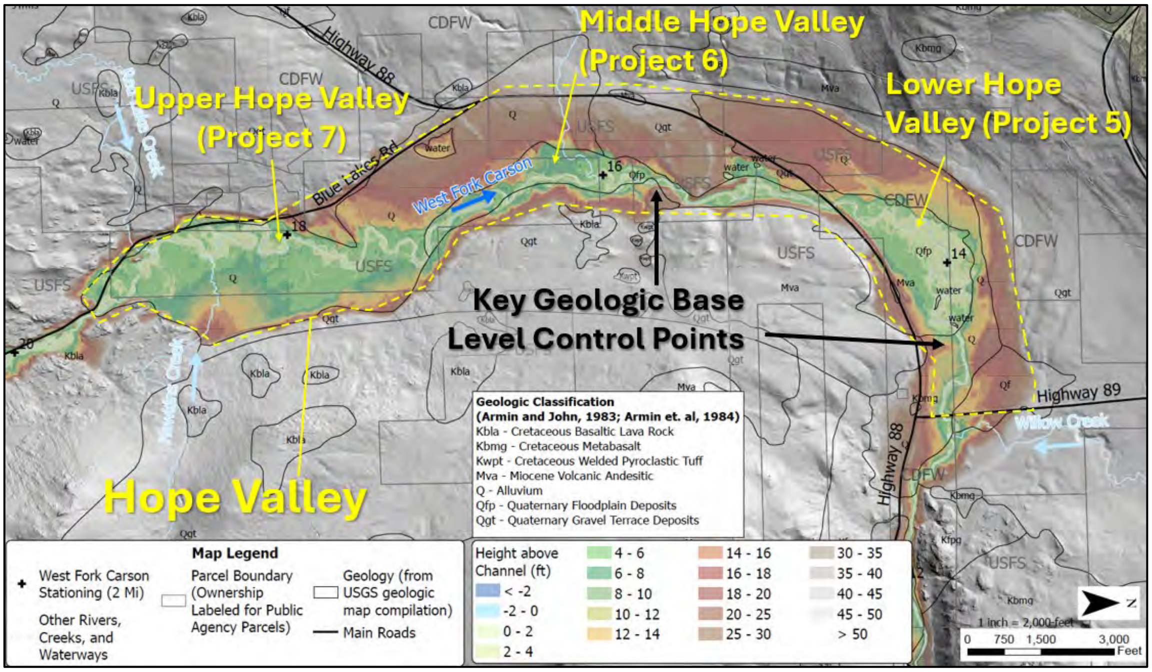


Figure 29*. Annotated REM Map of Hope Valley*

Bedload Limitations. Based on recent experience in Faith Valley, one key technical consideration for restoration planning in Hope Valley is the availability, continuity, and management of coarse sediment (bed material), which is required for channel aggradation and long-term floodplain reconnection. Although fine sediment traveling in suspension (washload) is a primary constituent driving water quality impairment, coarser sediment, including sand and gravel, transported as bedload provides the structural framework necessary to raise the channel bed and maintain restored elevations. Restoration elements such as grade control structures, BDAs, and engineered riffles that retain sediment will, by design, trap bedload, thereby reducing downstream supply of this material, potentially limiting aggradation in downstream reaches. Consequently, the spatial distribution, density, and phasing of grade control features throughout Hope Valley must be evaluated in the context of basin-scale sediment continuity to avoid adverse cumulative effects. Given the limited natural bedload supply in parts of the WFCR, it may also be appropriate to evaluate the feasibility of importing coarse sediment as part of restoration implementation, potentially from reaches of the Carson River downstream in Nevada. These issues underscore the need for a valley-scale sediment management strategy that explicitly considers interdependencies among projects and long-term sediment budgets rather than treating individual restoration sites in isolation.

3.5.2 Comprehensive, Long-Term Restoration Program

Given the scale, visibility, and complexity of Hope Valley, restoration should not be approached as a series of isolated, site-specific projects. Instead, the prioritization results point clearly toward the need for an integrated, multi-decade restoration program. While this time horizon may not always align with funding opportunities, permitting constraints, and other realities of stream restoration, that level of planning for this landscape is justified. Not only is it the nexus of the sediment budget and geomorphology in the WFCR watershed, and provides critical habitat to many animal and plant species, but Hope Valley is also a highly visible and beloved landscape to many people. Any restoration actions will be subject to public scrutiny. As a result, aesthetic outcomes, recreational compatibility, and perceived improvements to the landscape could be as important to long-term success as geomorphic or water quality performance of the specific projects.

A comprehensive program would include the following elements:

- Stakeholder Coordination: Bringing together agencies, non-profits, local land managers, and other interested parties to define shared objectives, priorities, and success metrics.
- Goal Definition and Phasing: Establishing clear, long-term goals for sediment reduction, floodplain reconnection, habitat improvement, aesthetic values, recreation benefits, and hydrologic function, and sequencing projects to maximize cumulative benefit while minimizing risks.
    - For example, although Lower Hope Valley **(Project 5**) may offer slightly greater geomorphic potential than Middle Hope Valley (**Project 6**), it may be beneficial to implement elements of Project 6 first as a demonstration and learning site before advancing to larger, more visible actions in Lower Hope Valley.
- As discussed in Section 2.3.6, bedload availability and continuity may be a limiting factor for reach-scale restoration in Hope Valley, particularly for projects that rely on sustained channel aggradation to reconnect floodplains. Although bedload transport in the WFCR is likely small relative to suspended sediment loads, this constraint suggests that some large-scale projects may require careful phasing, sediment management planning, or consideration of supplemental coarse material to achieve long-term stability.
- Monitoring and Adaptive Management: Implementing a robust monitoring framework to evaluate project outcomes, inform adaptive management, and refine restoration approaches over time.

While full restoration of Hope Valley is likely to require decades, strategically sequenced actions implemented within a coherent framework can gradually shift the system toward improved geomorphic resilience, floodplain connectivity, and water quality, while preserving recreation and aesthetic values.

3.5.1 LONG-TERM RESTORATION STRATEGY

The prioritization results support a two-track approach to long-term restoration in the West Fork Carson River watershed:

(1) The first track focuses on implementing “low-hanging fruit” projects—small, low-risk actions that can be constructed incrementally as staff time, funding, and volunteer capacity allow. These projects, often on tributaries or small reaches, are well suited to hand labor and adaptive maintenance, and can generate near-term sediment retention and habitat benefits while building local experience, monitoring data, and public support for restoration.

(2) The second track would be a comprehensive, long-term restoration program for Hope Valley. Given its geomorphic significance, sediment contribution, visibility, and public ownership, Hope Valley warrants a coordinated, valley-scale effort rather than a series of isolated projects. This program should be collaborative and multi-decadal in scope, involving federal and state agencies, non-profits, land managers, and other stakeholders, and guided by shared goals for sediment reduction, floodplain reconnection, ecological function, and aesthetic quality. Leadership of a Hope Valley Restoration Program by long-term committed partners in the basin, such as Alpine Watershed Group and/or American Rivers, would provide the continuity, technical capacity, and stakeholder coordination necessary to plan, phase, implement, and adapt restoration actions over a 20-year time horizon.

This two-track approach allows work to begin immediately while building toward a coordinated, long-term effort in Hope Valley.

4.0 REFERENCES

Alpine Watershed Group (AWG). 2024. Notice of Request for Proposals, West Fork Carson Prioritization Plan. May 15, 2024.

Armin, R.A., John, D.A., Moore, W.J., and Dohrenwend, J.C. 1984. Geologic map of the Markleeville 15-minute Quadrangle, Alpine County, California. U.S. Geological Survey IMAP 1474, 1 map :col. ; 45 x 35 cm., on sheet 69 x 89 cm., https://doi.org/10.3133/i1474.

Armin, R.A., and John, D.A. 1983. Geologic map of the Freel Peak 15-minute Quadrangle, California and Nevada: U.S. Geological Survey IMAP 1424, 1 map :col; 45 x 34 cm., on sheet 81 x 108 cm., folded in envelope 30 x 24 cm., https://doi.org/10.3133/i1424.

Dietrich, W.E., and T. Dunne. 1978. Sediment budget for a small catchment in mountainous terrain. Z. Geomorph. N.F., Suppl. Bd. 29, 191-206.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, C. 2012. Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., available online only at http://pubs.usgs.gov/sir/2012/5113/.

Hagan, J. C., Busby, C. J., Renne, P. R., & Putirka, K. D. 2009. Cenozoic palaeocanyon evolution, Ancestral Cascades arc volcanism and structure of the Hope Valley–Carson Pass region, Sierra Nevada, California. International Geology Review, 51(9-11), 777-823.

Lahontan Regional Water Quality Control Board. 2023. West Fork Carson River Vision Plan: A water quality improvement plan to address multiple pollutants in the West Fork Carson River in Alpine County, CA. October 2023. Available online: https://www.waterboards.ca.gov/rwqcb6/water_issues/programs/tmdl/docs/west_fork_carson/wfcr-vp-final.pdf.

MACTEC Engineering and Consulting, Swanson Hydrology and Geomorphology, and River Run Consulting. 2004. Upper Carson River Watershed Stream Corridor Condition Assessment. Prepared for: Alpine Watershed Group and the Sierra Nevada Alliance. June, 2004.

Reid, L.M. and Dunne, T., 1996. Rapid evaluation of sediment budgets (Vol. 29). Catena Verl., Reiskirchen, Germany 164 pp.

Reid, L.M. and Dunne, T. 2016. Sediment budgets as an organizing framework in fluvial geomorphology. Tools in Fluvial Geomorphology, pp.357-380.

Ries, K.G., III, Steeves, P.A., and McCarthy, P., 2024, StreamStats—A quarter century of delivering web-based geospatial and hydrologic information to the public, and lessons learned: U.S. Geological Survey Circular 1514, 40 p. Available online: https://pubs.usgs.gov/publication/cir1514 .

Robertson, A.M. and Shaw, S.C., 1998. Alternatives analysis for mine development and reclamation. Proceedings of the 22nd Annual British Columbia Mine Reclamation Symposium in Penticton, BC.

1998, pp. 51-62. Available online https://open.library.ubc.ca/media/download/pdf/59367/1.0042333/1

Robertson, A. and Shaw, S., 2004. Use of multiple-accounts-analysis process for sustainability optimization. Mining Engineering, 58(8), pp.33-38.

Rosgen, D.L. 2001. A practical method of computing streambank erosion rate. In Proceedings of the Seventh Federal Interagency Sedimentation Conference (Vol. 1). Reno, NV: Subcommittee on Sedimentation, p. II-9 to II-17.

Saucedo, G.J. 2005. Geologic Map of the Lake Tahoe Basin, California and Nevada–Map No. 4 in the 1: 100,000 Scale Regional Geologic Map Series. State of California, The Resources Agency, Department of Conservation, California Geological Survey.

Simon, A., Langendoen, E., Bingner, R., Wells, R., Heins, A., Jokay, N., and Jaramillo, I. 2004. Lake Tahoe Basin Framework Implementation Study: Sediment Loadings and Channel Erosion. USDA-Agricultural Research Service, National Sedimentation Laboratory, Oxford, Mississippi, NSL Report #39.

State Water Resources Control Board (SWRCB). 2021. 2018 Integrated Report for Clean Water Act Sections 305(b) and 303(d). State of California. https://www.waterboards.ca.gov/water_issues/programs/water_quality_assessment/2018_integrated_report.html

State Water Resources Control Board (SWRCB). 2023. Surface Water Ambient Monitoring Program (SWAMP): Program Overview. Sacramento, CA. Available online: https://www.waterboards.ca.gov/water_issues/programs/swamp/.

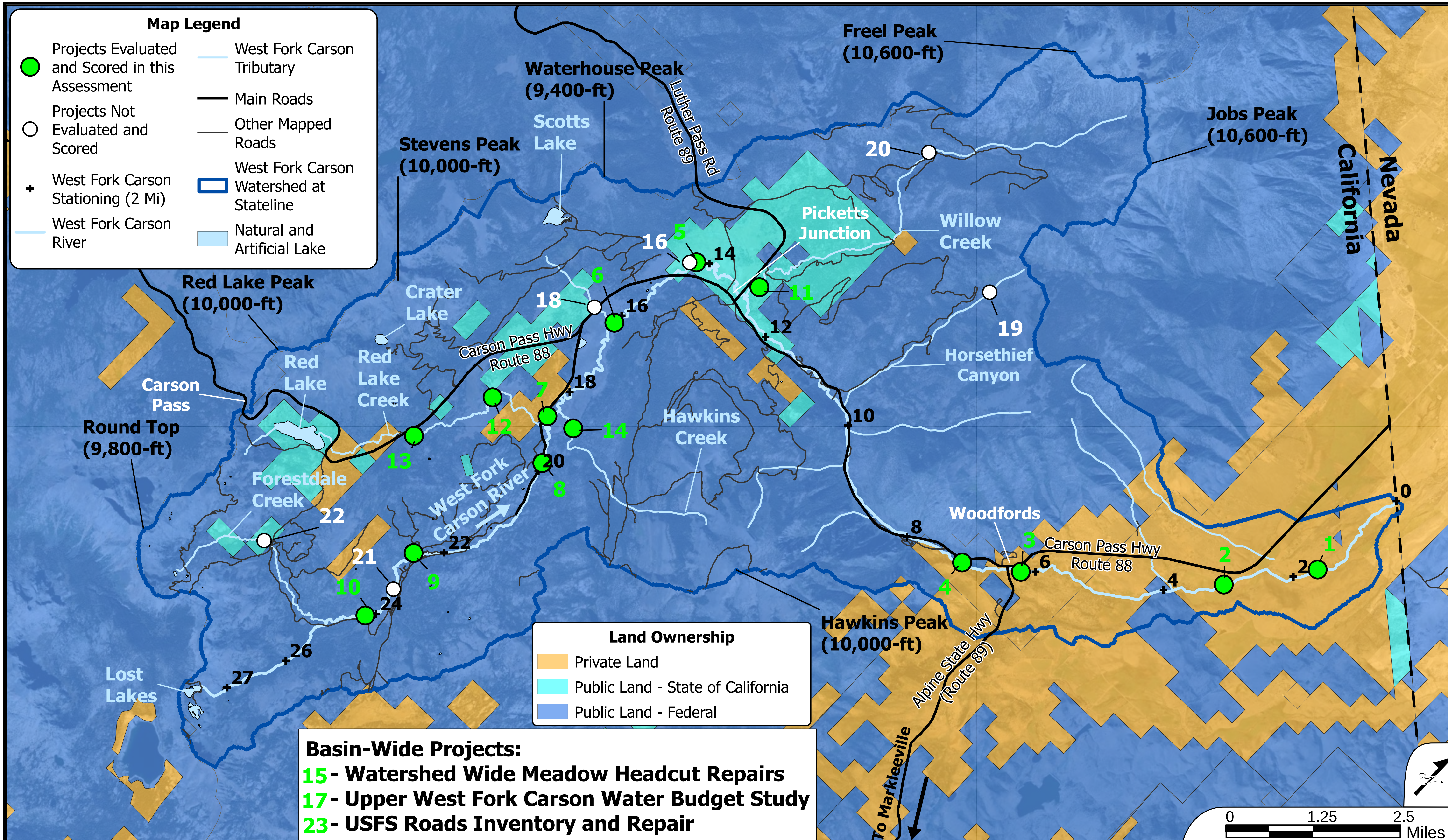
Turowski, J.M., Rickenmann, D. and Dadson, S.J., 2010. The partitioning of the total sediment load of a river into suspended load and bedload: a review of empirical data. Sedimentology, 57(4), pp.1126-1146.

United States Geological Survey (USGS). 2026. Water Data for the Nation, Real-Time Stream Gage W Fk Carson River at Woodfords, CA, USGS gage 10310000, https://nwis.waterdata.usgs.gov/ca/nwis/peak/?site_no=10310000&agency_cd=USGS . Accessed February 2026.

Wheaton J.M., Bennett S.N., Bouwes, N., Maestas J.D. and Shahverdian S.M. (Editors). 2019. Utah State University Restoration Consortium. Logan, UT. 286 pp. DOI: 10.13140/RG.2.2.19590.63049/2.

APPENDIX P-1

PROJECT DESCRIPTIONS AND SCORING FOR 15 POTENTIAL PROJECTS



Basin-Wide Projects:

15 - Watershed Wide Meadow Headcut Repairs

17 - Upper West Fork Carson Water Budget Study

23 - USFS Roads Inventory and Repair

Watershed Map including Land Ownership

West Fork Carson River Prioritization Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE XX

Project 1: River Ranch Road Floodplain Reconnection
West Fork Carson River, River Mile 0.0 to 2.0

Existing Conditions:

This reach of the WFCR immediately upstream of the California-Nevada State Line is an alluvial fan with an incised channel and boulder bed and banks. Channel incision has disconnected the main channel from the fan and isolated several fan channels that previously stored fine sediment and attenuated floods. It is not known whether the fan incision was human-caused or was caused by geological or climatic changes.

Regardless of the cause, prior to incision the river regularly switched between multiple channel threads, each of which may have supported riparian wetlands. Presently most floods pass through this reach without attenuation or depositing sediment. The incision and disconnection of the fan allowed for construction of roads and rural residential properties.

Project Concept:

The objective of the project is to spill more water during floods into fan channels by raising the channel bed. Reconnecting these channels would help attenuate floods, deposit sediment, recharge groundwater, and expand riparian and wetland habitat.

Approach: Reactivation of fan channels would mainly be achieved by raising the channel bed near key overflow points by building fish passable boulder riffles. In addition, the re-activated fan channels would be enhanced with large wood to enhance habitat and geomorphic complexity, enhance sediment deposition, and recharge groundwater. Some areas could be revegetated to take advantage of the higher water table.

Potential Project Elements:

Boulder riffles, large wood structures, boulder complexity features, revegetation

Design Considerations and Potential Constraints:

Work would occur on multiple private properties; unknown landowner interest. Big lift (~6 feet) to raise channel closer to the floodplain. Unknown compatibility with current land uses and water rights. Low and moderate base flows must not be affected, only flood flows. Project must avoid interfering with irrigation ditches, and must not increase flood risk to structures, roads and culverts.

Multiple Accounts Analysis Scores:

Technical: 2.15

Economic: 1.50

Environmental: 2.84

Social and Cultural: 1.97

Overall MAA Score: 2.27

MAA Rank: #14 of 15

Summary:
Project would have a large impact from flood and sediment storage perspective, but may not be feasible given complexities of land ownership, flood risk, and agricultural land uses.

Figure 1-A. Boulder dominated channel and irrigation diversion infrastructure near entrance to one of the high flow channels in the reach.

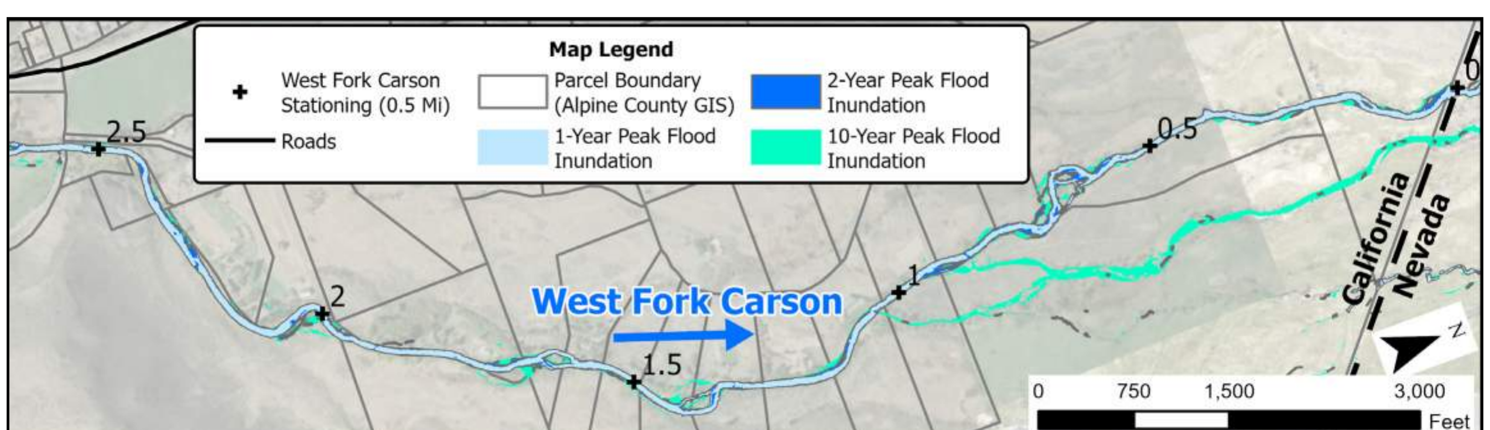


Figure 1-B. Extent of modeled 1-year, 2-year and 10-year recurrence interval high flows, showing flow concentration and hydraulic disconnection in a formerly active alluvial fan.

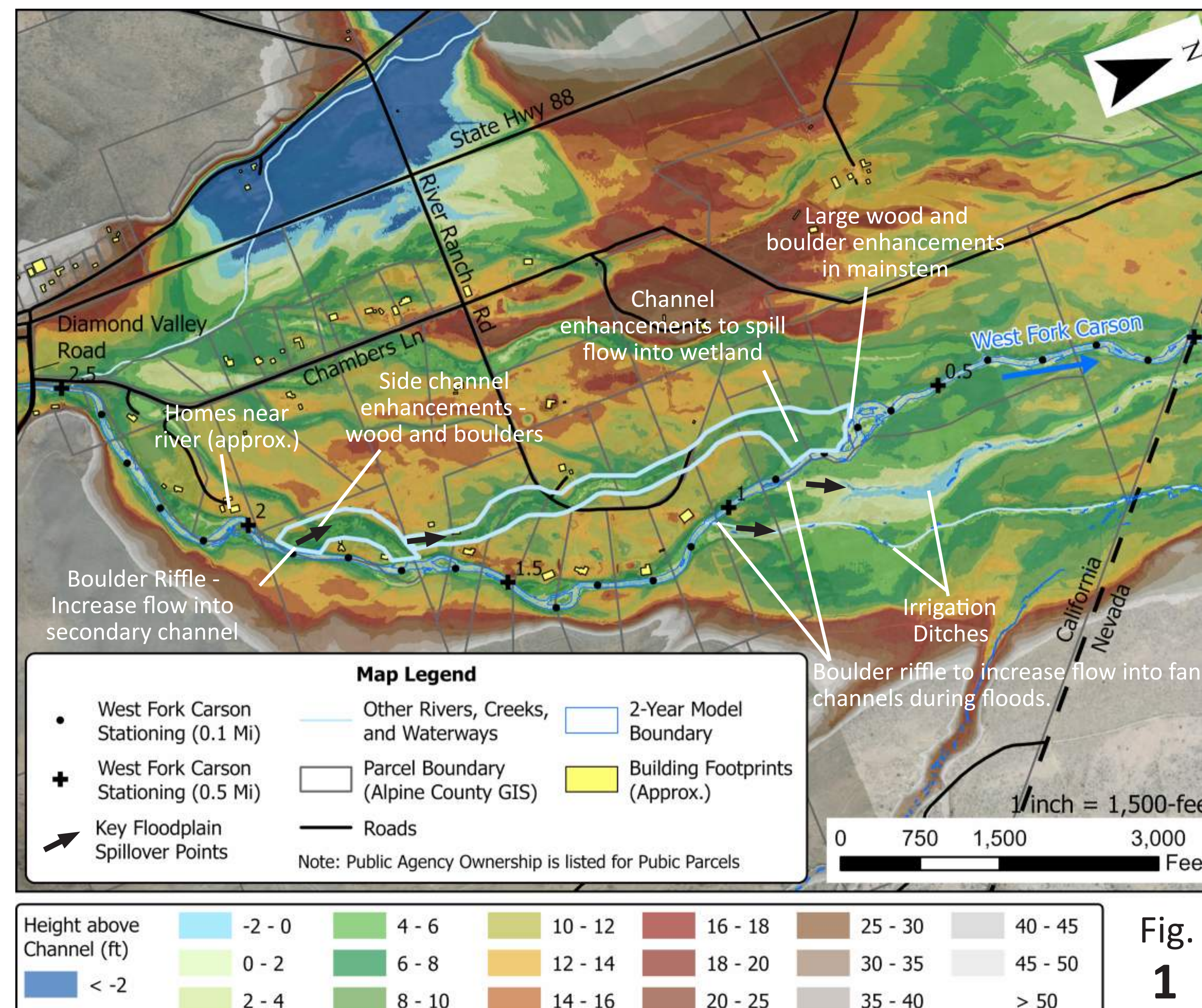


Fig. 1

Project 1 - River Ranch Road Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	2	Need to lift large channel 4 to 6 feet.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	If landowners provide permission, access for equipment should not be a problem.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	1	Would require large boulder riffles, significant earth movement, possible modification of irrigation infrastructure.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	3	Scale of the flood attenuation and sediment benefit is not yet known but probably large compared with other proposed projects. If project is built those objectives should be achievable.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	1	Relatively high risk project but risks can be managed.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	1	May require infrastructure modifications and large amounts of earth movement. May require importing boulders.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	2	Could require maintenance of irrigation infrastructure.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	Could have a large impact on sediment deposition compared with other projects.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	3	Small to moderate effect on water temperature compared with other projects. Alone, it may not produce a measurable impact on water temperature, but could contribute as part of a larger watershed wide program.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	2	Little benefit available for in-stream habitat improvements in this reach. Boulder riffles must allow fish passage or would be detrimental to habitat.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	3	Potential for off-channel reconnection and re-planting with willows in reconnected areas.

Project 1 - River Ranch Road Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	2	Only reverses degradation artificially.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Increases frequency and volume of flow in fan channels.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	3	Could enhance deposition of gravel in boulder-dominated reach.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	3	Small to moderate benefit from recharging fan channels.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	1	Multiple landowners; have not discussed project with them. It is not known whether many landowners would be interested in a project.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	4	One of the projects that would have the largest impact on flooding at the California/Nevada state line due to proximity to the state line.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	1	Complicated flood impacts, water rights, landowner requirements compared with the other project opportunities.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	No impact on recreation.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	2	Unclear whether landowners will see direct benefits. Most benefits will be downstream.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 2: Ace Hereford Ranch Floodplain Reconnection
West Fork Carson River, River Mile 2.6 to 3.3

Existing Conditions:

The steep reach is deeply incised, confined, and dominated by boulders, with bedrock exposures in the streambed (Figure 2-A). The landowner reports that the stream incised as much as 10 feet during the 1997 flood. The floodplain is now almost completely isolated from the channel even during large floods (Figure 2-B). Boulders line the channel banks preventing bank erosion or channel migration. The river transports all the water and sediment supplied to this reach without any storage or exchange. The reach lacks any geomorphic dynamics, topographic complexity, or hydrologic exchange, and the channel is frozen in place. The landowner may be open to restoration projects on the property, provided any such work would not interfere with current agricultural land uses.

Project Concept:

The main project objective is to raise the channel bed in key areas to spill more flood water into the floodplain/fan surface and high flow channels, storing fine sediment and recharging groundwater during floods.

To accomplish this the project would likely need to construct boulder riffles and excavate certain key areas of the floodplain to allow more frequent flood flows to enter abandoned fan channels. Water that would be stored in the fan deposits during floods would re-enter the river during later months, increasing flows and reducing water temperature during the dry season. The project could be combined with revegetation efforts or excavation to create wetlands near springs or other high groundwater areas of the property.

Potential Project Elements:

Boulder and sand placement in channel, floodplain excavation, possible excavation to create off-channel wetlands, revegetation, cattle exclusion fencing

Design Considerations and Potential Constraints:

Landowner may be willing to consider a restoration oriented project. A big lift is required to bring the channel closer to the floodplain. Placement of large boulders would require fine sediment infill to prevent through flow. Fish passage must be ensured. It is unclear whether the benefits outweigh the costs and disturbance.

Multiple Accounts Analysis Scores:

Technical: 2.11

Economic: 2.5

Environmental: 2.14

Social and Cultural: 2.60

Overall MAA Score: 2.28

MAA Rank: #13 of 15

Summary:
It may be difficult to achieve the technical objectives due to amount of incision. Cost-benefit ratio probably too high. There are better opportunities for wetland enhancements than channel enhancements on property.

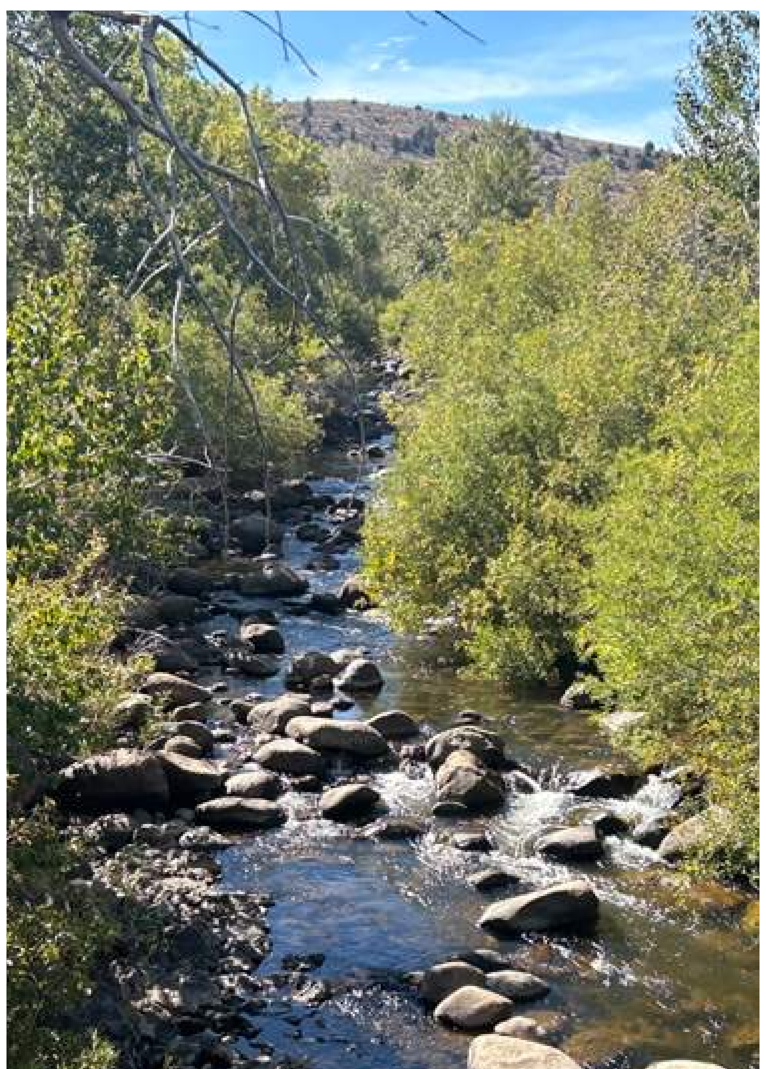


Figure 2-A. Confined boulder and bedrock channel looking upstream from bridge on Ace Hereford Ranch.

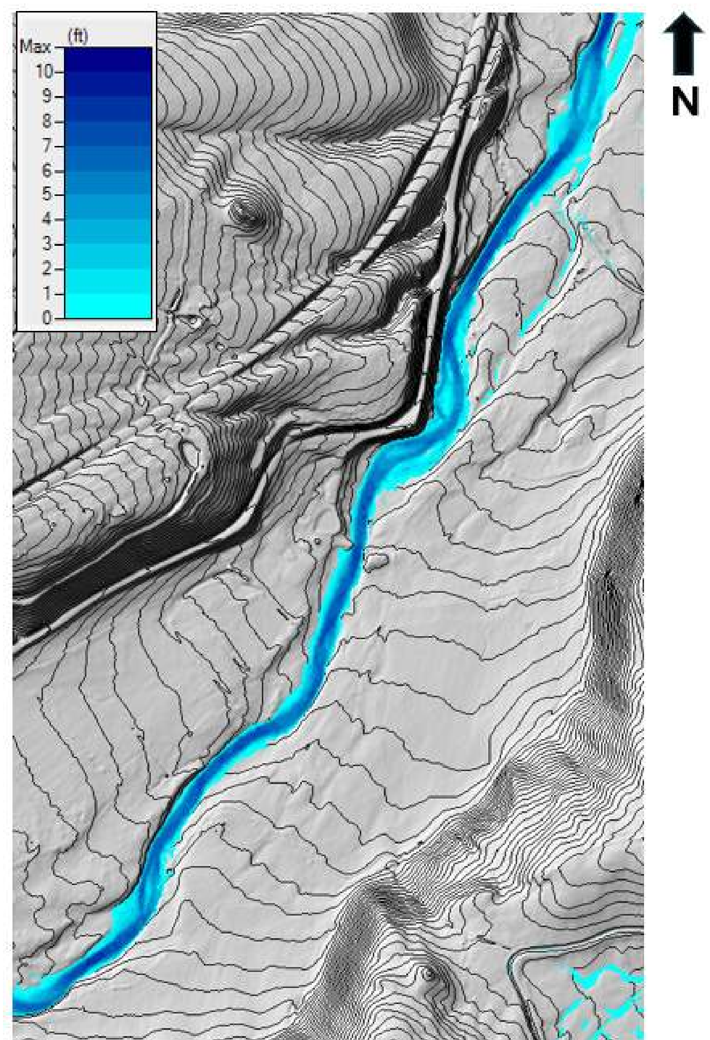


Figure 2-B. Modeled flow depths at Ace Hereford Ranch in a hypothetical 100-year flood, showing that even extreme events do not currently flood the fan surface.

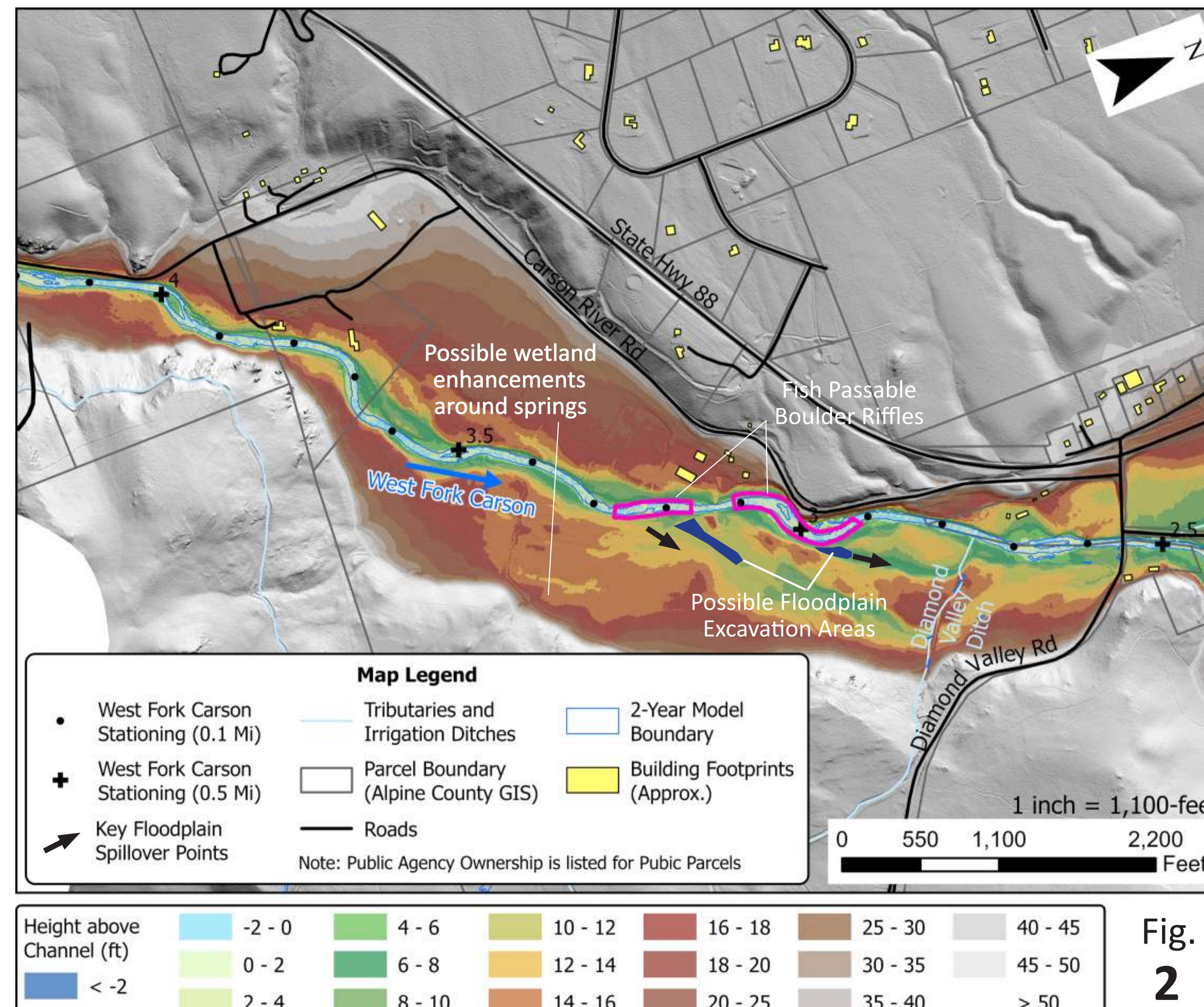


Fig. 2

Project 2 - Ace Hereford Ranch Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	1	Big lift to the floodplain. Channel is very incised.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	4	Reasonable equipment access.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Need to build two or three 8-foot-high fish passable boulder riffles with voids infilled with fine sediment to prevent subsurface flows; require significant engineering and earth movement, possible import of boulders. There may be other opportunities for off-channel restoration on property that are easier to implement, but would not contribute as much to water quality goals.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	2	Likelihood of reconnecting the floodplain is high, but the scale of the impact may be fairly limited compared with the amount of work.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	2	Little infrastructure risk, there would be relatively large short term impacts to landowner during construction. Flooding would not affect the higher elevation bank on river left.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	2	High cost project compared with those that are proposed upstream.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Mainly vegetation maintenance.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	3	It would deposit small to moderate amount of sediment compared with other projects, because fairly little water would flow into the floodplain. There is no bank erosion to be reduced.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	2	There could be some benefits to water temperature by storing flood flows in the fan. Upland and wetland opportunities could have some water quality benefits.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	1	Potential to create an artificial fish passage barrier if project is not carefully designed to avoid that.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Largest potential benefits to a project in this property are in off-channel, riparian and floodplain areas, including near springs.

Project 2 - Ace Hereford Ranch Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	2	Could capture some bed load and re-aggrade the channel bed.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	2	This is the primary goal of this project. However the amount of floodwater that could realistically be put out onto the floodplain would be low without a very large project.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	1	Cannot easily improve in-channel complexity and geomorphic function in this reach which is incised and dominated by boulders and bedrock.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	3	Potential to increase groundwater following floods is good, but water residence time is short and impact on WFCR water temps is low. There may be some additional spring and wetland enhancement opportunities on the project, similar to what the landowner has already built.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	4	Private property but landowner may be open to a project that provides water quality or flood benefits. Landowner would be inconvenienced but would likely be willing to support a high value project if one can be identified.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	2	Not much benefit here without a huge project. Reasonable scale project would affect flood storage only during large floods because it is so incised.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	Probably could permit project but there could be some hurdles due to the amount of the instream fill required, and the potential for the project to impact fish passage.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	2	Very minor recreational uses at site. Landowner may fish and has rafted through the reach. Rafting would probably not be possible with the project.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	2	Project would have little direct benefit to the landowner and only moderate downstream benefits. Off-stream wetland enhancement opportunities here would probably be seen more favorably than building in-stream structures.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 3: Woodfords Fan Reconnection

West Fork Carson River, River Mile 4.5 to 6.5

West Fork Carson River Prioritization Project - Project Description

Existing Conditions:

The project location, just downstream of Woodfords, CA, is at the head of a fan where the West Fork Carson River emerges from a narrow bedrock canyon. The channel is dominated by boulders. At the head of the fan, the channel is not deeply incised and has historically spilled water into fan channels. There is a water diversion structure and headgate for the Snowshoe Thompson Ditch at the entrance to one of these channels. From a geomorphic standpoint, this is the best location downstream of Hope Valley to raise the channel bed to encourage overbank flows to recharge groundwater and deposit fine sediment during floods. However, there are houses and irrigation infrastructure that could be affected.

Project Concept:

The project objective is to increase the amount and frequency of water and fine sediment that enters fan channels while retaining diversion and irrigation infrastructure. Several project elements would likely be required: (1) boulder placement at the head of the fan downstream to increase the frequency and volume of flood waters entering the fan channel (2) modification of diversion and headgate to accomodate more frequent and higher flows (3) modification of levee along the north side of the ditch to allow water to flow from the ditch to the fan channels. The project would be combined with revegetation and wetland restoration actions in downstream areas of the fan.

Figure 3-A. Boulder channel and existing diversion infrastructure at the head of the fan.

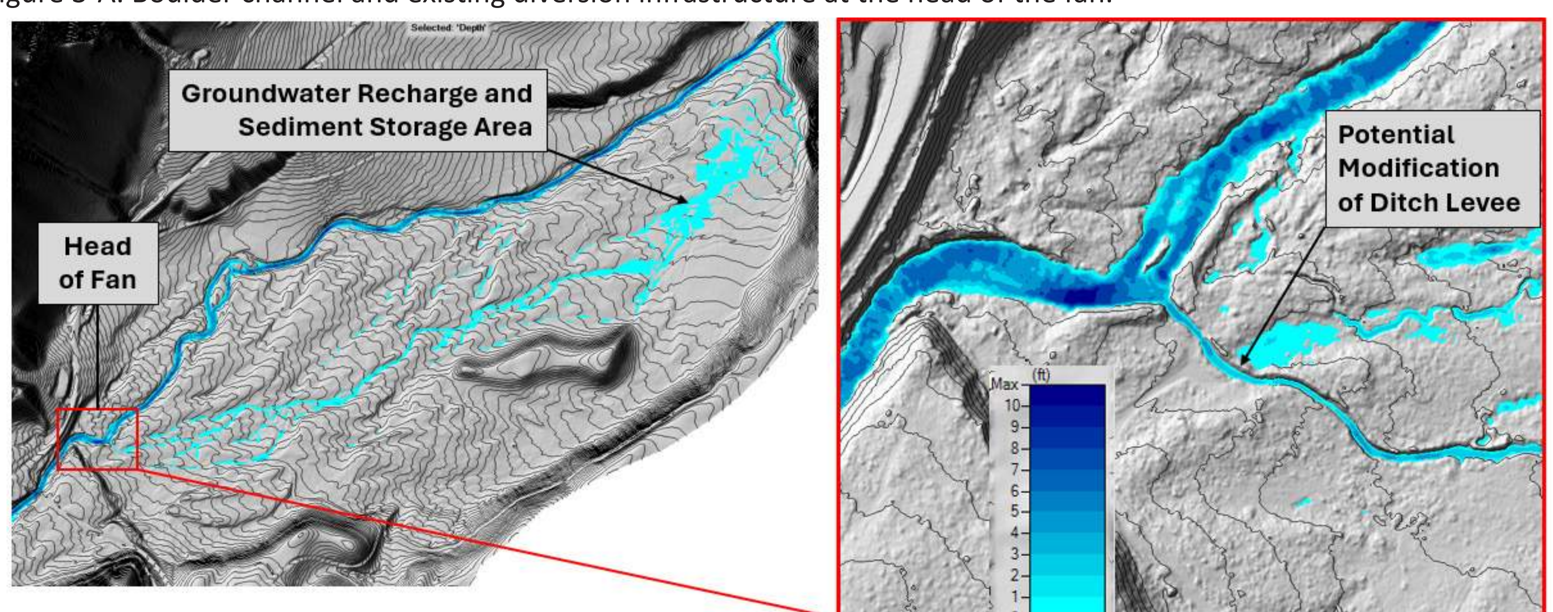


Figure 3-B. Modeled water depths during a 100-year flood event (Existing Conditions).

Potential Project Elements:

Boulder riffle, modification to ditch levee, modification of diversion intake structure and headgate, revegetation, wetland enhancements, possible wood placement.

Design Considerations and Potential Constraints:

Project would be on private property and need to be done with the approval of property owners as well as from additional private properties downstream that will be impacted. Project will need to be compatible with existing water diversion uses and infrastructure and must not present flood risk to downstream houses or outbuildings.

Multiple Accounts Analysis Scores:

Technical: 2.13

Economic: 1.5

Environmental: 2.56

Social and Cultural: 1.82

Overall MAA Score: 2.13

MAA Rank: #15 of 15

Summary:

From a geomorphic standpoint, this is an ideal location to put water and sediment into the fan to affect water quality downstream. However, private property and irrigation infrastructure may make this impractical.

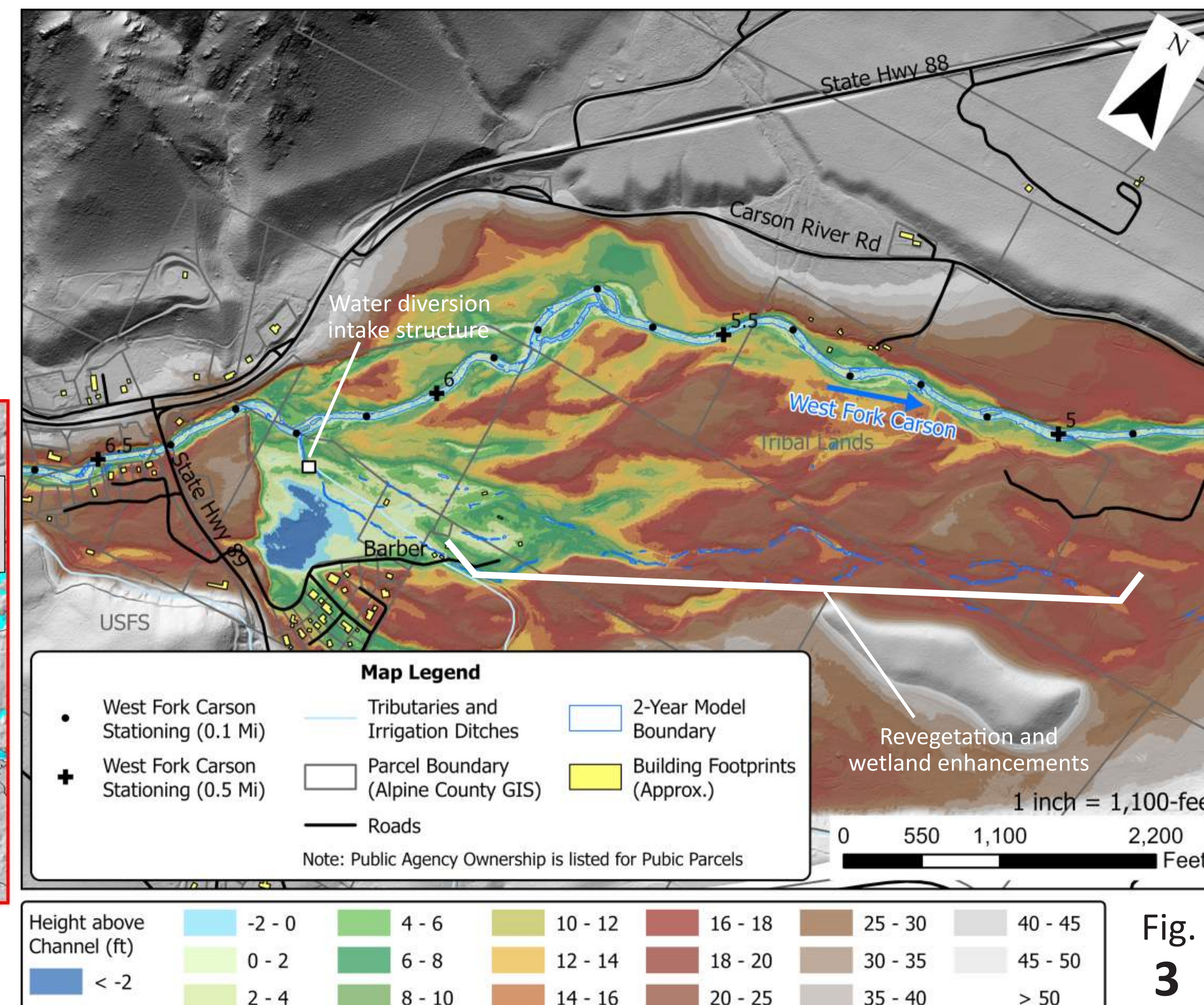


Fig. 3

Project 3 - Woodfords Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Based on modeling, not much lift is required to spill more floodwater into the remnant fan channel to the east (river right).
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	2	Private property and confined topography.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	1	Would require earth movement, placement of large rock, and irrigation infrastructure modifications.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	2	Geomorphically, a lot of flood water and fine sediment could be spilled into the floodplain here, and most of the sediment will be deposited in the fan due to the long flow pathways. However, irrigation and private infrastructure constraints may not be compatible with the project.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	1	Risk to current infrastructure not known but could be higher than other proposed projects. A failure here could adversely impact people and property. The first step would be to analyze risk to downstream structures using hydraulic modeling.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	1	Requires placing large amount of rock in the channel and protecting infrastructure, complicated permitting.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	2	Unclear maintenance requirements, but may require repeatedly cleaning the ditch.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	3	The fan downstream of Woodfords may be one of the largest opportunities to store fine sediment in the upper WFCR basin, but not with the current constraints.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	4	There would be a relatively large amount of water infiltration into the fan during floods, with this water re-emerging up to months later in the channel with potential cooling effect in WFCR.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	3	Opportunity to include wood, pools to provide in-channel benefit.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Reconnecting large area of fan and revegetation should improve habitat in semi-arid fan.

Project 3 - Woodfords Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	2	Reach is not very degraded at the head of the fan and the project wouldn't substantially improve conditions.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	3	Could greatly increase the amount of out of channel flow and geomorphic dynamics at the head of a fan, but may be difficult with current constraints.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	2	Would deposit some more bedload, may raise grade, but would have minor benefit.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	2	Unclear if it would raise water table due to large area, and the steepness and high infiltration rates of the fan.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	1	Multiple property owners would be impacted, none have been contacted yet about the project.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	3	Project in this location be the biggest opportunity for flood attenuation benefit in the CA portion of the WFCR watershed, but may be difficult to achieve given the current constraints.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	1	Likely to be complicated because of property ownership and water rights.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	No benefits or impacts on recreation.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	2	Benefits would mostly be downstream of the project area, it would not be obvious locally what the impacts of the project would be.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 4: Crystal Springs Road Floodplain Reconnection

West Fork Carson River, River Mile 6.8 to 7.5

Existing Conditions:

This is the only location within Woodfords Canyon where the valley floor is wide enough to allow any active floodplain reconnection. There are two multi thread reaches where the river is not deeply incised and includes side channels, each about 500 feet long. The side channels are barely connected in a 2-year flood, and contain a significant amount of water during 10-year flood events (Figure 4-B).

Project Concept:

This is the only reach within miles where a potential floodplain reconnection project would be geologically possible. The overall objective would be to increase the frequency and amount of flow in two side channels while enhancing channel complexity in both the main channel and side channels.

Improving connectivity could be done by building large boulder riffles to increase frequency of flooding and fines deposition. This could possibly be supplemented with excavation of sediment near the side channel entrances to increase connectivity. Engineered log jams could be built in the main stem and side channels to create cover and split flow.

Potential Project Elements:

Boulder riffles, excavation at side channel inlets, engineered log jams, revegetation.

Design Considerations and Potential Constraints:

Channel and floodplain restoration project here would be possible, but the benefits would be small. Access may be difficult.

Multiple Accounts Analysis Scores:

Technical: 2.31

Economic: 2.5

Environmental: 1.90

Social and Cultural: 2.7

Overall MAA Score: 2.26

MAA Rank: #12 of 15

Summary:
From the standpoint of geomorphology, this is the only potential location for a floodplain restoration project within many miles; however, the costs would be high and the benefits fairly low.

Figure 4-A. Confined boulder reach looking downstream from Crystal Springs Road.

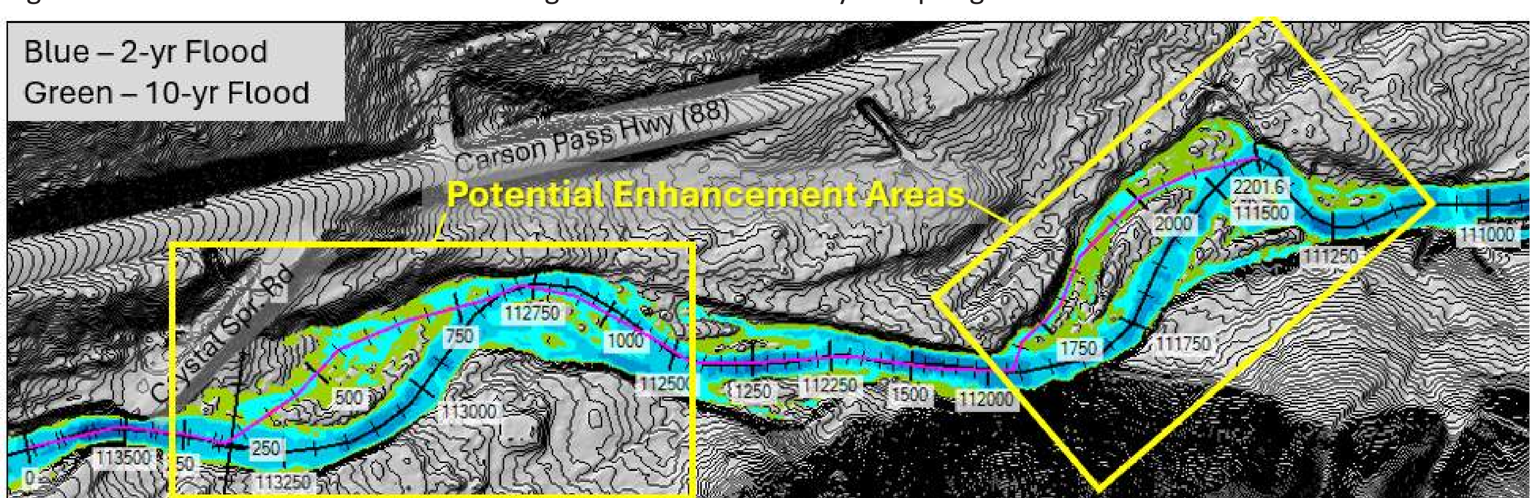


Figure 4-B. Modeled extent of the 2-year and 10-year recurrence interval floods under Existing Conditions.

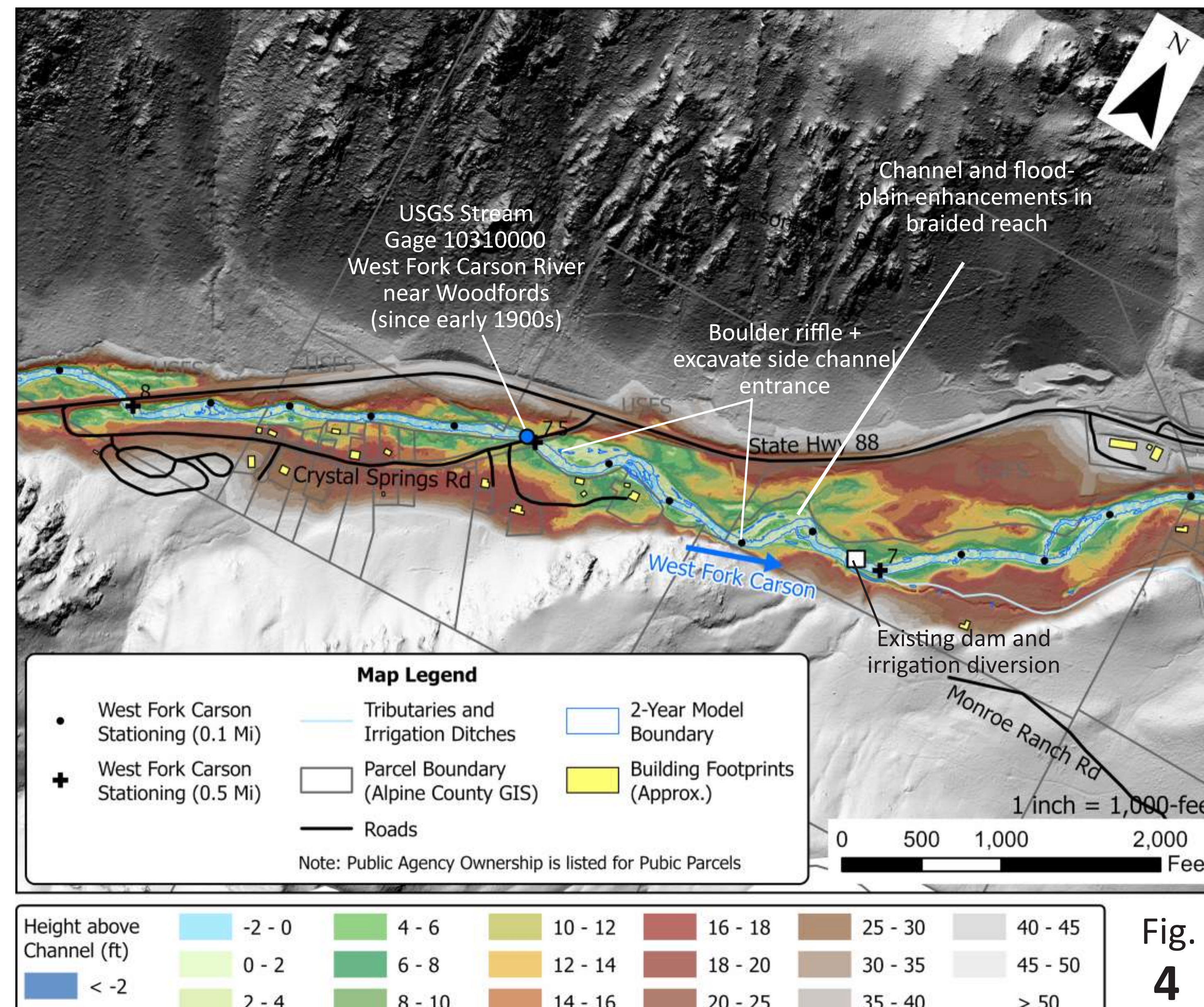


Fig. 4

Project 4 - Crystal Springs Road Floodplain Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	2	Two to three foot lift to reconnect side channels. This would require importing boulders. Excavation at side channel inlets could also increase flow into side channels.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Equipment access possible. Limited staging areas.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Requires equipment for excavation and boulder placement, possible importation of boulders.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	2	Side channel inlets could plug with gravel.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	3	Bridge, highway, and houses nearby but will not be impacted. There is irrigation diversion infrastructure near downstream end of project area.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	2	Depends on volume of boulders fill required.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Unknown maintenance costs.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	1	Steep side channels will have lower trap efficiency for fines compared with floodplain.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	1	Negligible impact on water water quality.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Little to moderate improvement due to reconnecting side channels.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	3	Improves hydrology and therefore riparian growth potential in two side channels; small to moderate benefit.

Project 4 - Crystal Springs Road Floodplain Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	3	Boulder riffles may deposit more gravel and aggrade channel upstream.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Improves connectivity at two side channels.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Large woody debris structures in main channel, split flow and side channel reconnection.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	2	May increase water table in off channel areas slightly.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	2	Combination of USFS and private property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	3	Some minor flood attenuation benefit.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	3	In-stream fill required.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	No benefit or harm to recreation.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	3	Area of benefit in side channels would not be visible from road or properties.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 5: Lower Hope Valley Restoration
West Fork Carson River, River Mile 12.9 to 14.7

Existing Conditions:

The West Fork Carson River in lower Hope Valley meanders through its most downstream glacial meadow before flowing through a confined boulder moraine reach (Figure 5-A), and then a long, steep, boulder and bedrock reach in Woodfords Canyon. This section of the river in lower Hope Valley follows Highway 88 and is extensively used for recreation. The river has an incised, single thread channel with extensive erosion along vertical banks on outsides of bends. Bank exposures indicate that there was more wet meadow and frequent and extensive overbank flooding and fine sediment storage in this reach, which is now a major source of fine sediment from bank erosion.

Near the bottom of the reach is a glacial end moraine that provides a reach-scale base level control. Past restoration work in the meadow attempted to reduce bank erosion on several specific bends, but a reach-scale restoration effort has not been developed.

Figure 5-A. View of Lower Hope Valley looking upstream from moraine (July 2025).

Project Concept:

The project envisioned here would be a multi-faceted, reach-scale design that would make use of multiple techniques applied in conjunction with one another to accomplish the reach-scale objectives of more frequently engaging the floodplain and depositing sediment. A downstream grade control structure would be constructed at the moraine to raise base level, accumulate bedload sediment, and encourage more overbank flow. Upstream of this, site-appropriate applications of design elements such as rock riffles, beaver dam analogs, and large wood could be installed at strategic locations to encourage water to flow into the floodplain, raise the channel bed, deposit fine sediment and create more in-channel variability. Willow trenches and microbenches near eroding bends and willow planting in areas anticipated to see more frequent flow could help establish a healthier wetland meadow vegetation assemblage with less severe bank erosion. Project would have similar components and objectives as the Faith Valley restoration project, but at a larger scale and with more flow energy. The design process could benefit from lessons learned in the Faith Valley project.

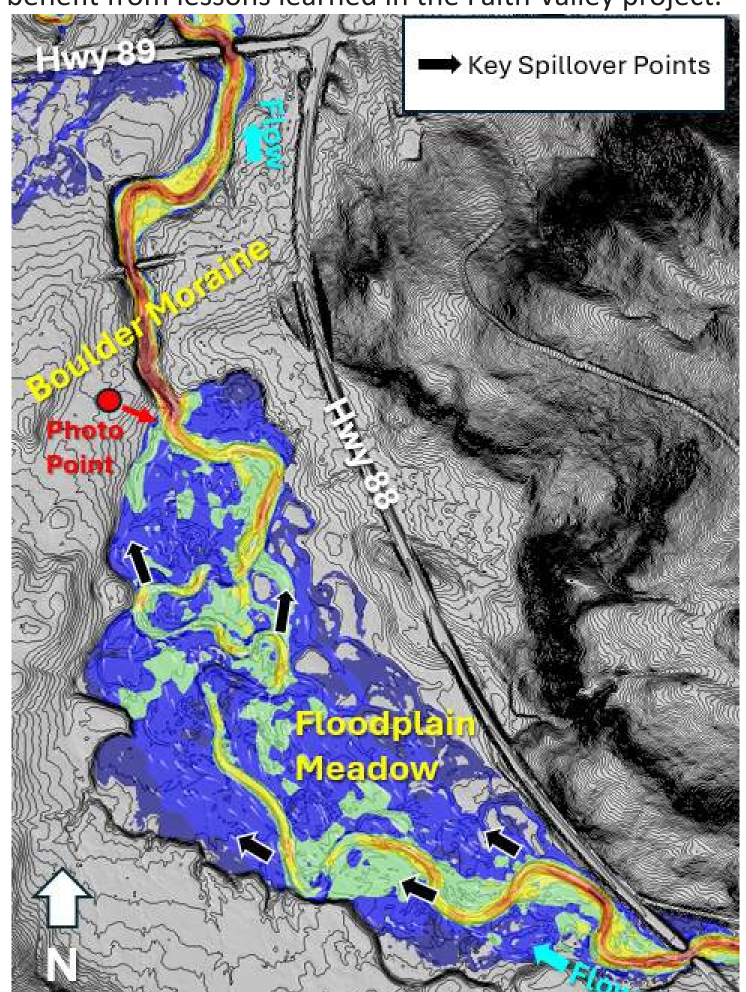


Figure 5-B. Modeled water velocities and flow direction under existing conditions during a hypothetical 10-year flood event showing main spillover points.

Potential Project Elements:

Rock grade control structure, beaver dam analogs, rock riffles, post-assisted log structures, engineered log jams, microbenching, log weirs, willow trenches, willow plantings, other potential techniques.

Design Considerations and Potential Constraints:

The potential project area is a high visibility and high use recreation area. The design process must include an Alternatives Analysis and a public engagement effort to ensure the project aligns with stakeholder preferences. Access may require closing or crossing sensitive cultural or recreational areas during construction. Planning and phasing of channel spanning structures will be needed to avoid starving downstream areas of bedload.

Multiple Accounts Analysis Scores:

Technical: 3.36

Economic: 2.00

Environmental: 4.24

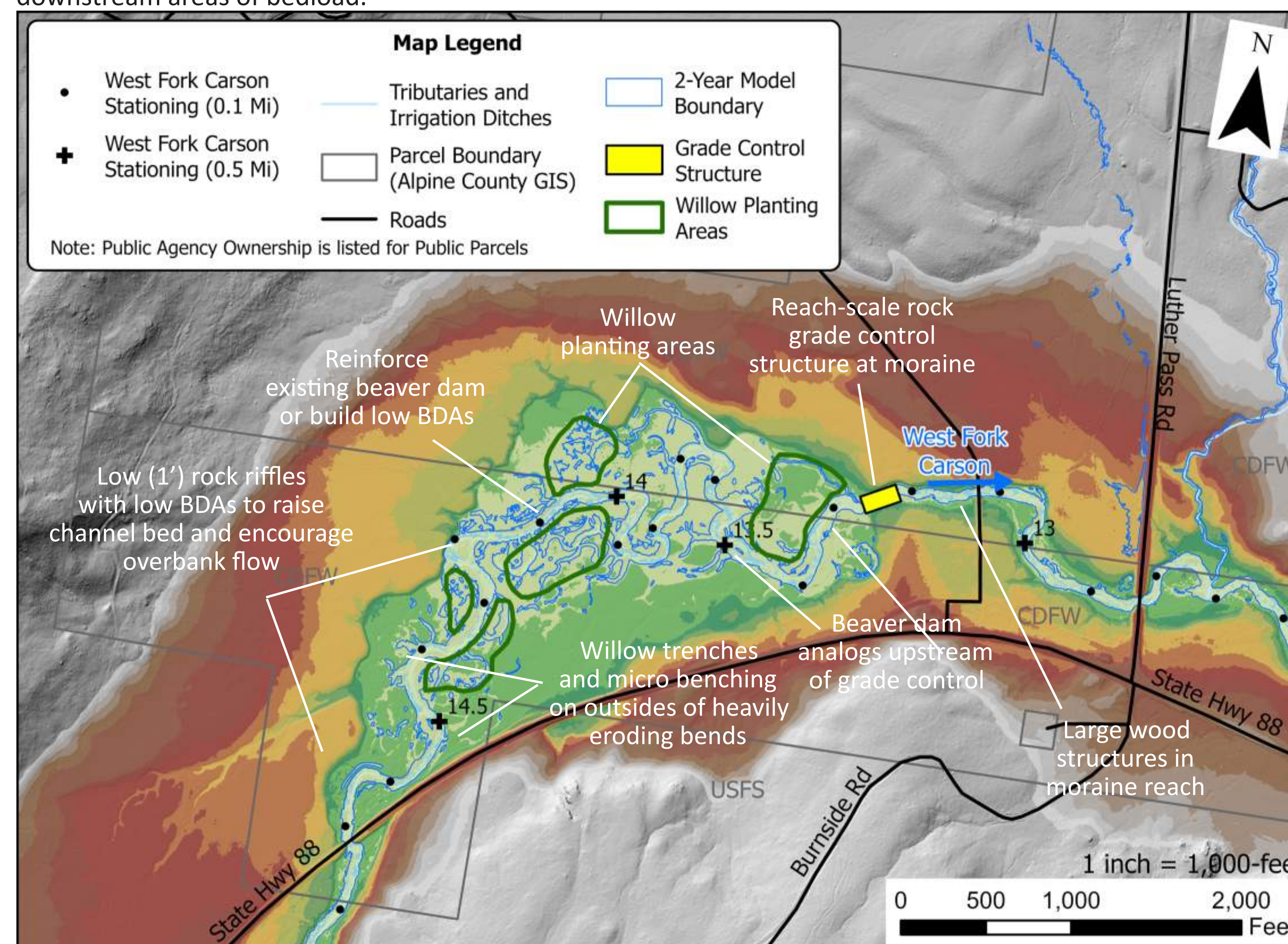
Social and Cultural: 4.15

Overall MAA Score: 3.60

MAA Rank: #4 of 15

Summary:

This would be a complex, large scale and impactful project on a highly visible section of the main stem West Fork Carson River. The project has more potential to store sediment and provide ecological benefits than most other projects in the upper basin, and can learn from and build on experience from past work.



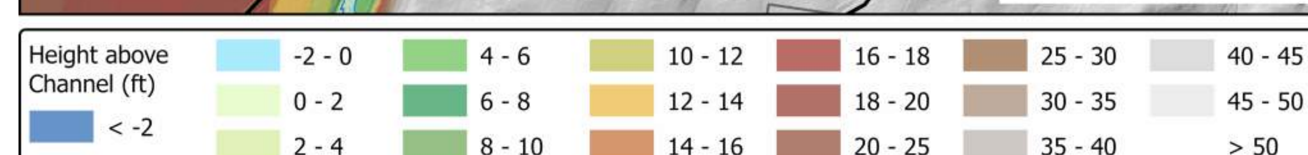


Fig. 5

Project 5 - Lower Hope Valley Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Two to three foot rise will reconnect large area of floodplain.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Relatively close to road; high traffic area; staging areas may be available outside of floodplain; potential for cultural resources to impact access and staging.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Project construction would be via heavy equipment and a river bypass/diversion would be required 24/7 during the implementation.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Boulder moraine pinch point provides a solid grade control and reduces the risk of flanking. Large area of floodplain would be reconnected. Bedload supply is limited, and must be managed carefully to achieve project goals. Good opportunity to apply lessons learned from Faith Valley project.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	3	High visibility area. Large logs would be needed, and if these mobilize in a large flood, there could be some risk to the Highway 89 crossing near Pickett's Junction.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	1	Recommend a larger-scale project for this area considering the dynamics of the entire reach. This will require a longer term design process, public engagement, and would benefit from a phased implementation strategy.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Probably will require ongoing monitoring and maintenance typical of similar reach-scale projects.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	5	Large depositional floodplain basin downstream of nearly all the sediment supply. Raising the bed 2-3 feet could push a large fraction of floodwater and fine sediment into floodplain, while reducing bank erosion.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	4	May have some water temperature benefit for a couple of months per year. Uncertain if there will be measurable impact downstream WFCR at the CA/NV state line from this specific project, but would add benefit if done in conjunction with other similar projects in the watershed.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Project can include in-channel wood, reduction in bank erosion, increase in shading over the long term. Will create more pools.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	5	Potential to improve large area of floodplain.

Project 5 - Lower Hope Valley Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	5	This is a main project benefit, but will be hard to achieve without a big, reach-scale project. Potential to reduce bank erosion while also reversing incision.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	5	Project could achieve a very large increase in frequency and volume of floodplain flow.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Reach-scale project including multiple different kinds of treatments would provide a good opportunity to increase channel dynamics.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	5	Large increase in wetted area compared with other proposed projects.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	Mostly CDFW property, some USFS property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	5	Probably the largest opportunity for flood attenuation in the upper basin.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	Large temporary impacts. Permitting has been challenging on similar large scale complex river/meadow projects. Most of project is in a wetland. Likely cultural resources sites. Highly likely to have important cultural resource considerations.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	May improve fishing and bird habitat and should improve the scenery along Highway 88.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	There will be significant temporary and permanent impacts in a high visibility and high use recreational area. There are opportunities for signage and easy access for tours. Project would have a visible and lasting change to the landscape. There is a risk of negative perception if project outcomes do not meet expectations. This risk of negative perceptions should be managed with a long term and close engagement process to ensure people have a good idea of what to expect and are in favor of project.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 6: Middle Hope Valley Restoration

West Fork Carson River, River Mile 15.5 to 16.6

Existing Conditions:

The West Fork Carson River meanders through a wide glacial valley bordered by till and alluvial fan. The river incised several feet into floodplain fine sediment, disconnecting the channel from previously connected floodplain. Bank exposures in this reach provide evidence that this geological basin has shifted from being a storage reservoir for fine sediment into a source of fine sediment (Figure 6-A). Several long heavily eroding bends (Figure 6-B) in the reach make this one of the largest contributors of fine sediment in the upper West Fork Carson River.

There is a boulder moraine on the downstream end of the reach which sets a reach-scale base level control.

Project Concept:

The project would develop a reach-scale design for a mile-long, heavily eroding section of the river with the over-arching objectives of raising the channel bed to encourage more overbank flow and sediment deposition. A rock and wood grade control structure at the downstream end would raise base level and the groundwater table. Upstream of this, multiple methods could be applied working together to reduce erosion, encourage sediment deposition, improve instream habitat, increase meadow water table, and expand willow. Actively advancing head cuts in the meadow could be stabilized using posts. “Managed avulsion” using excavation to expedite a meander cutoff that would circumvent some of the most heavily eroding banks, but this would present risks and may not be practical. An alternatives analysis process with stakeholder engagement should be employed to select the project designs.

Figure 6-A. Photo of eroding bank line in Hope Valley showing fine sediment stratigraphy.

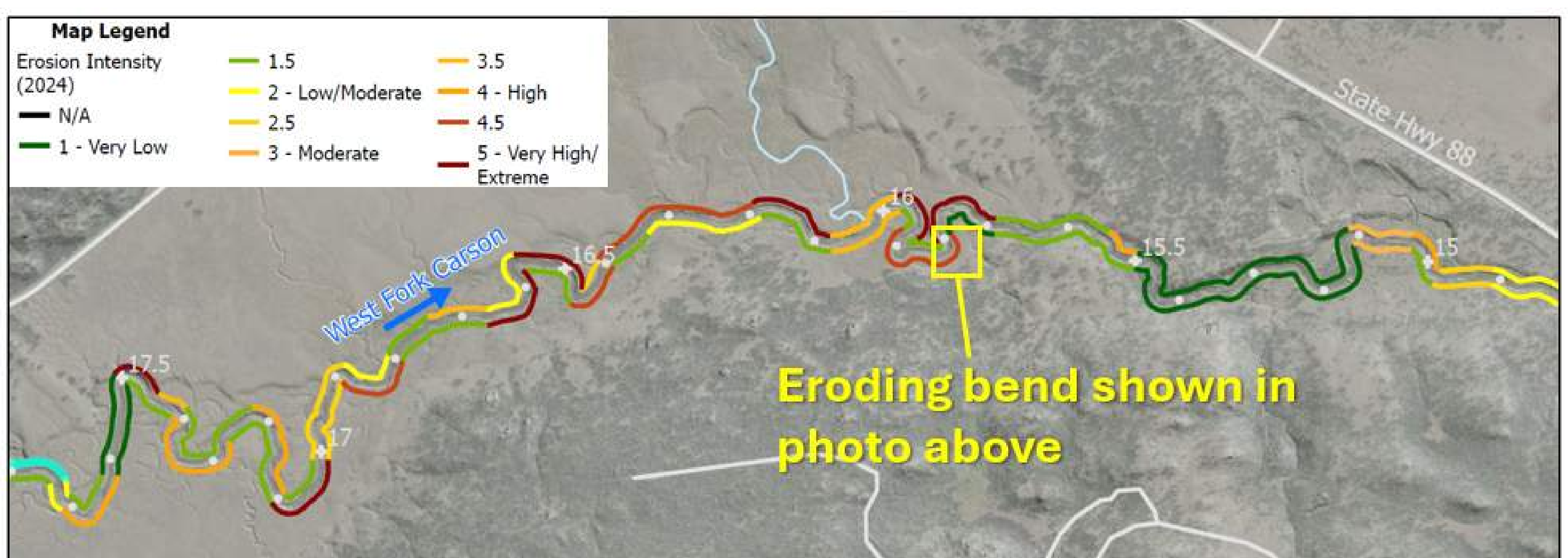


Figure 6-B. Mapped erosion intensity within middle Hope Valley project reach, as observed in summer 2024.

Potential Project Elements:

Rock grade control structure, beaver dam analogs, rock riffles, post-assisted log structures, engineered log jams, microbenching, log weirs, willow trenches, willow plantings, other potential techniques.

Design Considerations and Potential Constraints:

Equipment access would likely have to cross the Emigrant Trail. A large, reach-scale project, rather than site specific treatments, would be required to have the desired impact. Therefore, a significant alternatives analysis and stakeholder engagement process should be included. Some of the potential project components, including “managed avulsion”, should be considered but they may not be appropriate or practical given the risks.

Multiple Accounts Analysis Scores:

Technical: 3.34

Economic: 2.00

Environmental: 4.24

Social and Cultural: 4.00

Overall MAA Score: 3.57

MAA Rank: #5 of 15

Summary:

This would be a large-scale project with a high cost and significant environmental benefits and temporary impacts. This location is less visited than Potential Project #5, but has a similar geomorphic setting, objectives, and scale. The design process could benefit from lessons learned through the Faith Valley Restoration project.

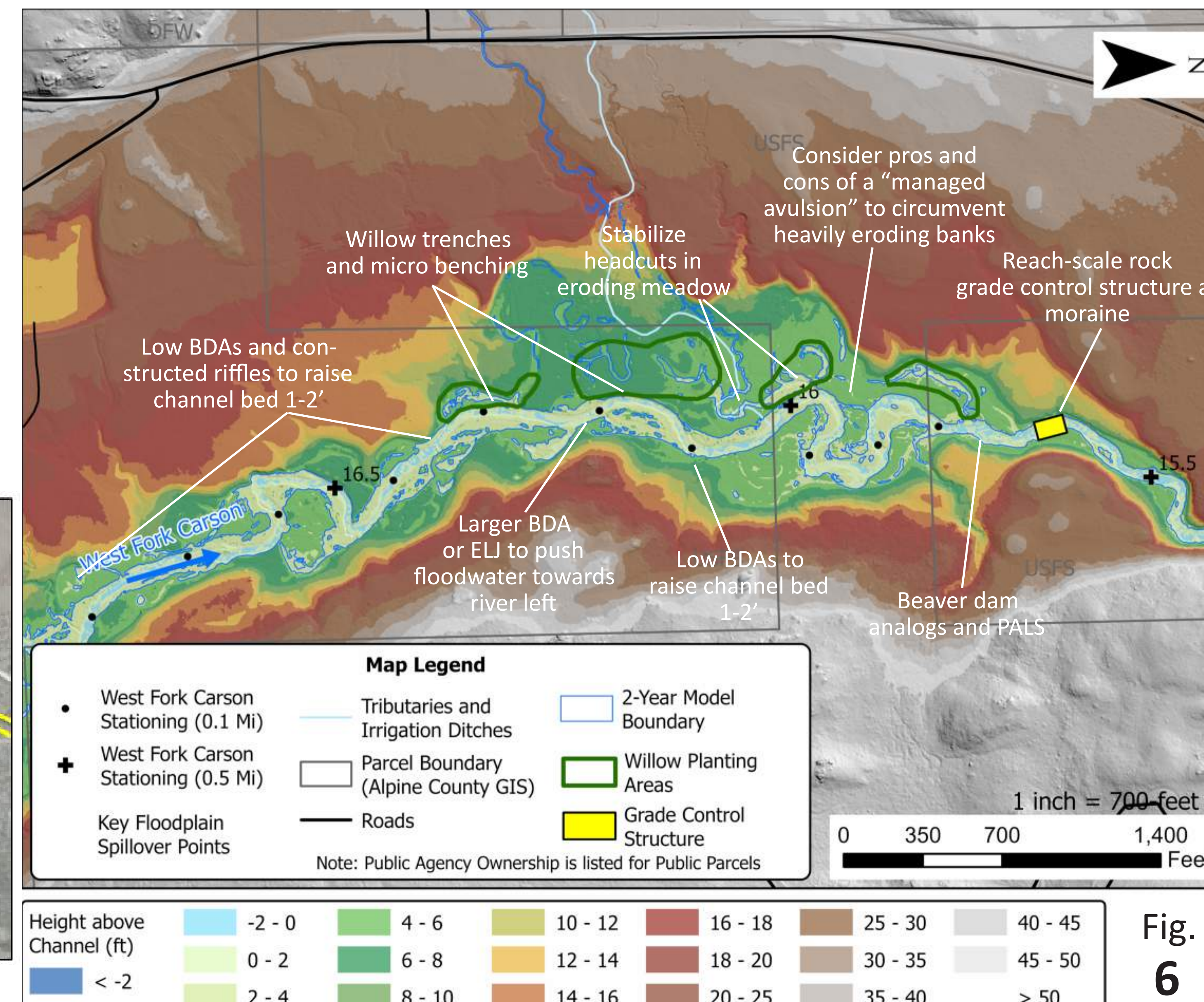


Fig. 6

Project 6 - Middle Hope Valley Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	More difficult to connect than in lower Hope Valley; should be possible esp. with the grade control structure.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	2	Good access nearly to the site. Crosses historic Emigrant trail. Staging areas are available.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Heavy handed approach. Would be constructed using heavy equipment and a river bypass/diversion would be required 24/7 during the implementation, but implementation would be on par with similar projects.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Good chance of meeting project objectives, similar to lower Hope Valley but with less visibility.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	4	No infrastructure nearby. Risk of temporary and permanent alteration of the scenery that may be undesired to some people. Additional project risk is cutting off the bedload supply to Lower Hope Valley.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	1	Close to a $2M project based on 2026 costs.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Monitoring and adaptive management will be required typical of similar scale projects.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	5	Good opportunity to deposit fine sediment and re-engage high flow channels.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	4	Moderate localized benefit, similar to Lower Hope Valley.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Multiple opportunities to create pools, install wood, reduce bank erosion.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	5	Potential to increase relatively large wetted riparian area.

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	5	Will not aggrade the channel much but will increase water level in the floodplain.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	5	Increases frequency and volume of floodplain flows.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Good opportunity for in-channel improvements; similar to Lower Hope Valley.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	4	Similar to Lower Hope Valley.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	CDFW property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	4	Mainstem flood project - larger impact than most other projects.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	Moderately difficult permitting pathway. Work in wetlands. Highly likely to have important cultural resource considerations.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Could improve fishing, less visited area than Lower or Upper Hope Valley.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	Similar to Lower Hope Valley, but less visited.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 7: Upper Hope Valley Restoration

West Fork Carson River, River Mile 17.8 to 19.5

Existing Conditions:

This is a highly dynamic reach of the West Fork Carson River where the river flows from a confined canyon reach into Hope Valley. The transition from narrow and confined by bedrock and moraine to a wide alluvial valley causes gravel deposition in point bars and active meander migration. The active portion of the valley is confined by the Hawkins Creek fan (Figure 7-A). The channel in this reach is incised and heavily eroding, with banks typically more than 6 feet high (Figure 7-B). The floodplain is mostly abandoned, and modeling shows that it is inundated only during infrequent very large flood events. Unlike potential projects #5 and #6, there is not a boulder moraine that provides a base level control. Past restoration work has aimed to reduce erosion in parts of the reach.

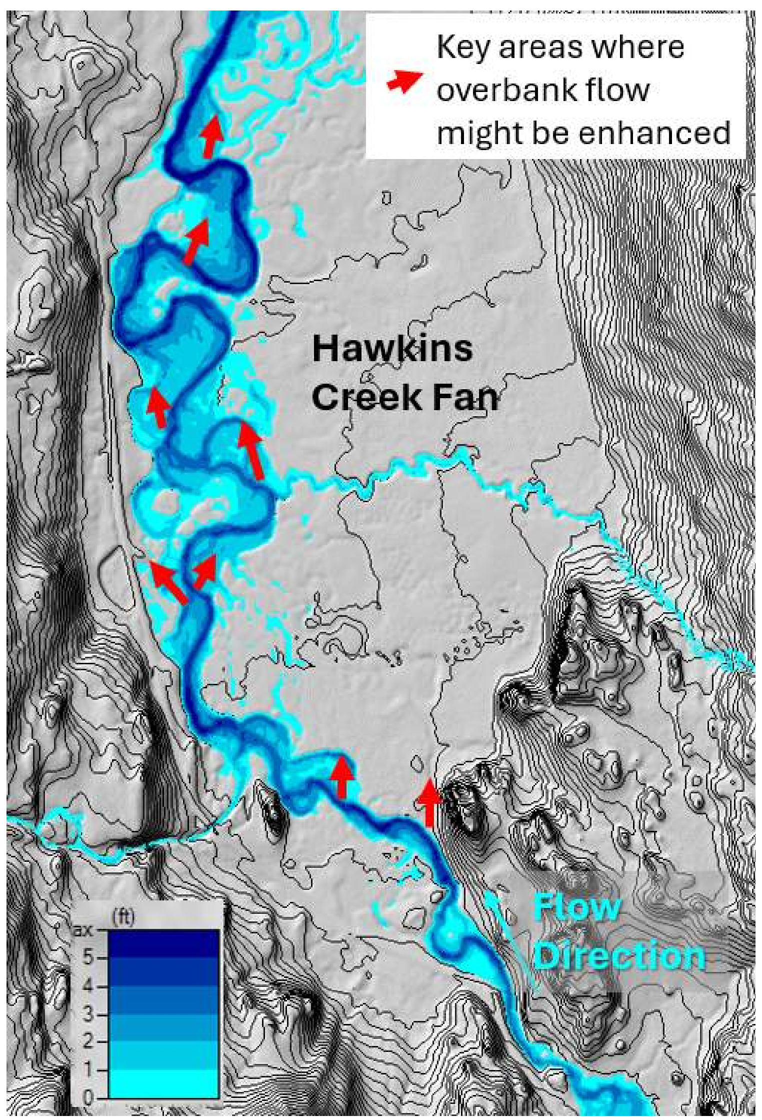


Figure 7-A Modeled water depths in a 2-year flood at the upstream end of Hope Valley, showing areas where flow into meadow could be enhanced.

Project Concept:

The project would aim to reconnect the floodplain, reduce bank erosion, and improve in-stream habitat through a multi-faceted, reach-scale restoration plan with a primary objective being to raise the bed and reconnect the floodplain at key locations. A key location at the upstream end of the reach, if it could be reconnected to a small floodplain channel, provides an opportunity to deposit fine sediment during floods and re-wet large area of floodplain; however, this may not be feasible due to geological and infrastructure constraints. Further downstream, multiple treatments such as constructed riffles, beaver dam analogs and large wood structures could be constructed to provide cover and complexity. Non-channel spanning features may perform better due to the high energy and dynamics in the reach. "Managed avulsions" could be evaluated to circumvent particularly heavily eroding banks, with measures taken to stabilize the channel bed where it becomes steeper; but these features would come with higher risk and may not be appropriate. In-stream actions and extensive willow planting in the potentially rewetted areas of the floodplain would also help improve meadow quality.

Figure 7-B. Example of typical conditions near the upstream end of the reach where the river enters Hope Valley, deposits sediment, and is highly dynamic.

Potential Project Elements:

Fish passable rock riffles, minor excavation to connect floodplain channels, beaver dam analogs, engineered log jams, willow trenches, microbenching, headcut stabilization, willow planting, other possible features.

Design Considerations and Potential Constraints:

Highly visible area of Hope Valley near campground. It may not be feasible to raise the channel bed closer to the floodplain at the upstream end of Hope Valley because it would require significant boulder and sand fill close to Blue Lakes Road. Highly dynamic channel in upper Hope Valley creates a risk that engineered treatments would be flanked and abandoned. Managed meander cutoff would reverse past efforts at preventing such cutoffs and may not be desireable.

Multiple Accounts Analysis Scores:

Technical: 2.47

Economic: 2.00

Environmental: 3.24

Social and Cultural: 2.97

Overall MAA Score: 2.77

MAA Rank: #10 of 15

Summary:

A large, reach-scale project in a degraded reach could increase flow into the floodplain, reduce bank erosion, and improve in-stream habitat. However, geological and geomorphic conditions may constrain the magnitude of project benefits compared with some other locations.

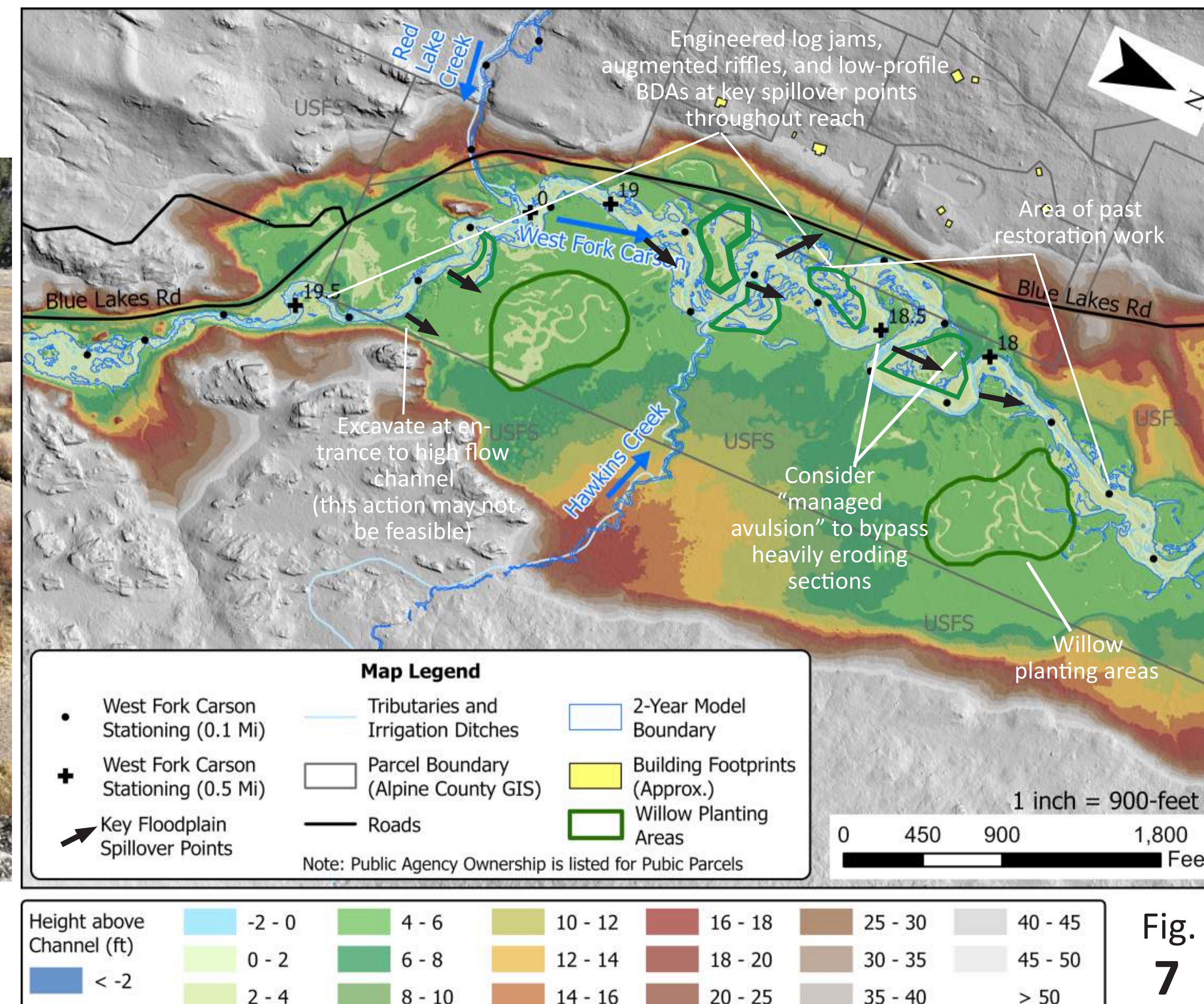


Fig. 7

Project 7 - Upper Hope Valley Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	2	Probably difficult or impossible to do to a meaningful extent without an extremely large rock fill near the upper end of Hope Valley. But because of the shape of the valley, amount of incision, and nearby road and campground, this will be very difficult to achieve.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Relatively easy access aside from permitting, may be some stream crossings.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Project construction would be via heavy equipment and a river bypass/diversion would be required 24/7 during the implementation. The proposed project would require a large area of impact and large amounts of imported materials, but implementation would be on par with similar projects.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	3	No downstream base level control and an actively migrating stream., making it difficult to raise the grade to achieve the project goals. Installed structures could fail due to flanking or abandoned by channel shifting.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	2	Blue Lakes Road and Hope Valley Campground are close to upper end of project but probably not affected. A complete failure could push flood flows towards Blue Lakes Road.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	1	Depends on which project elements are included, > $2M if largest project is designed.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	May require ongoing maintenance, typical of similar projects in the area.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	This is a heavily eroding reach and a significant contributor to the overall sediment load of the WFCR. However it is unclear how much this can be reduced in this reach. It may be possible to reduce some bank erosion, but it may be difficult to get much more of the meadow floodplain activated due to much of it being a tributary fan from Hawkins Creek.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	3	Relatively little benefit due to the relatively small amount of water that can be pushed into the floodplain.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Multiple opportunities to install in-channel treatments to create pools or complexity or reduce bank erosion.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Little floodplain area would be reconnected because of the amount of incision. However, if significant water were to be put into the floodplain the area of beneficial impact would be large.

Project 7 - Upper Hope Valley Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	Highly degraded reach but it will be difficult to fully reverse incision and degradation in this location.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	3	This would be the primary goal of the project but it will be difficult to achieve.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	In-channel treatments could improve in-channel conditions in localized areas. Constructed wood structures are prone to being abandoned or flanked in this reach.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	3	Likely only infrequent groundwater recharge due to the amount of incision.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	3	Combination of private and USFS property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	3	Good location for flood attenuation at head of valley. However, it is not clear how much floodwater can enter the floodplain. Flood benefit may be significant in very large floods, but little to no effect in smaller (10-yr) floods.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	More difficult than average.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Relatively neutral. May improve fishing at certain locations, especially around constructed wood features.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	3	High visibility site. Public will see local impacts of project, as well as the disturbance. Benefits are mostly local, not too much impact on downstream water quality.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 8: Blue Lakes Road Restoration

West Fork Carson River, River Mile 19.7 to 20.6

Existing Conditions:

This is in a confined floodplain section of West Fork Carson River within the moraine and bedrock canyon separating Faith Valley from Hope Valley. Beaver activity is widespread in these areas, including many intact and collapsed dams, canals, and lodges (Figure 8-A). In this reach, which is mostly narrowly confined boulder and bedrock step pool without any floodplain, there are a few wider sections with pool-riffle morphology and narrow floodplains (Figure 8-B). Some of the dams breach during annual higher winter and spring flows, but beaver rebuild where possible. Some of the most successful dams are built off of fallen logs that are wedged between boulders.

Project Concept:

The project objective is to use low-cost and low impact techniques to improve instream habitat and support beaver. Project would employ so called "low tech process-based restoration" (LTPBR) treatments to assist beaver in establishing more stable dams along a 1- to 2-mile-long stretch of the river along Blue Lakes Road. The project could be extended beyond the area shown here to other small areas of confined floodplain between Hope Valley and Faith Valley. Treatments would be done using hand crews only, and involve working with site-specific features to improve beaver habitat and improve the connectivity of the confined floodplain. In some locations, beaver dams would be reinforced with posts and felled trees; in other places, new beaver dam analogs or post-assisted log structures would be built.

Potential Project Elements:

Post-reinforced beaver dams, tree felling, beaver dam analogs (BDAs), post-assisted log structures (PALS), willow planting.

Design Considerations and Potential Constraints:

Project would rely exclusively on hand crews. Easy and cheap project to implement. Access and staging are limited along Blue Lakes Road. No water quality benefits to this project. The reach is not severely degraded, so the uplift potential is limited.

Multiple Accounts Analysis Scores:

Technical: 4.15

Economic: 4.00

Environmental: 1.60

Social and Cultural: 3.45

Overall MAA Score: 3.01

MAA Rank: #8 of 15

Summary:
This would be a small, easy-to-construct project with low cost and low risk, but with modest environmental benefits. The project could be extended to other parts of the reach between Hope Valley and Faith Valley.

Figure 8-A. Existing beaver dam and partly confined floodplain showing typical reach conditions (looking up-stream).

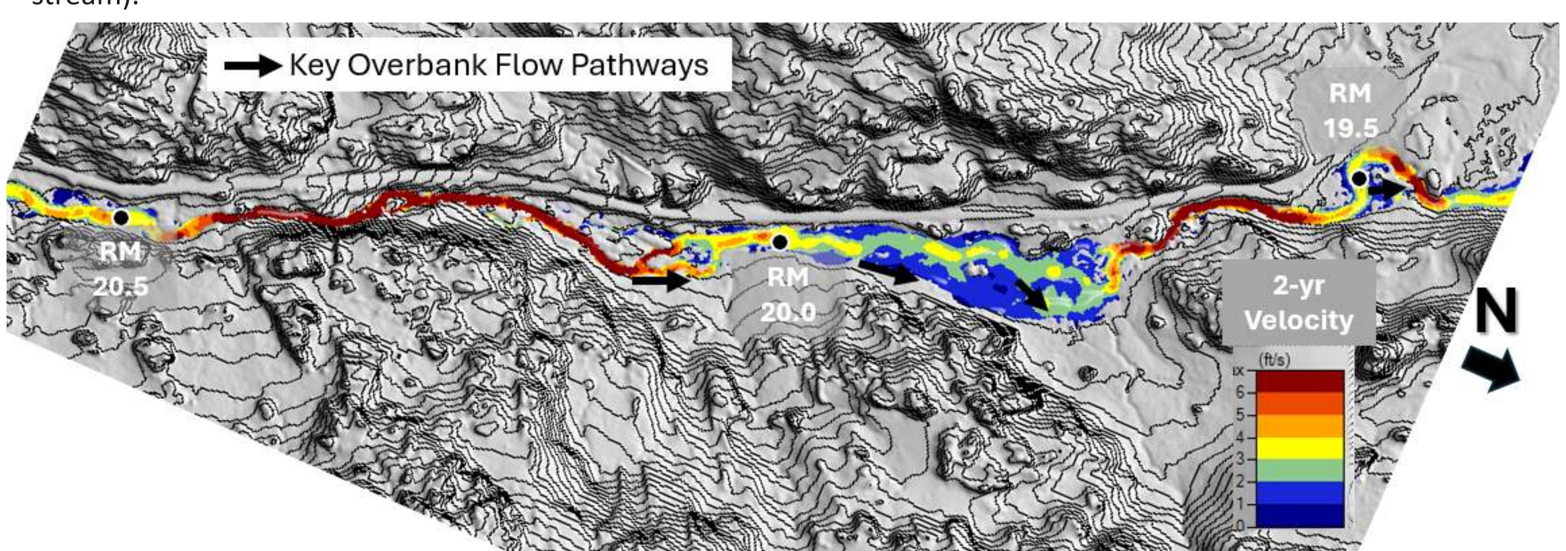


Figure 8-B. Modeled water velocity in the 2-year flood showing confined floodplain reach within narrow bedrock and moraine section of the West Fork Carson River between Faith Valley and Hope Valley.

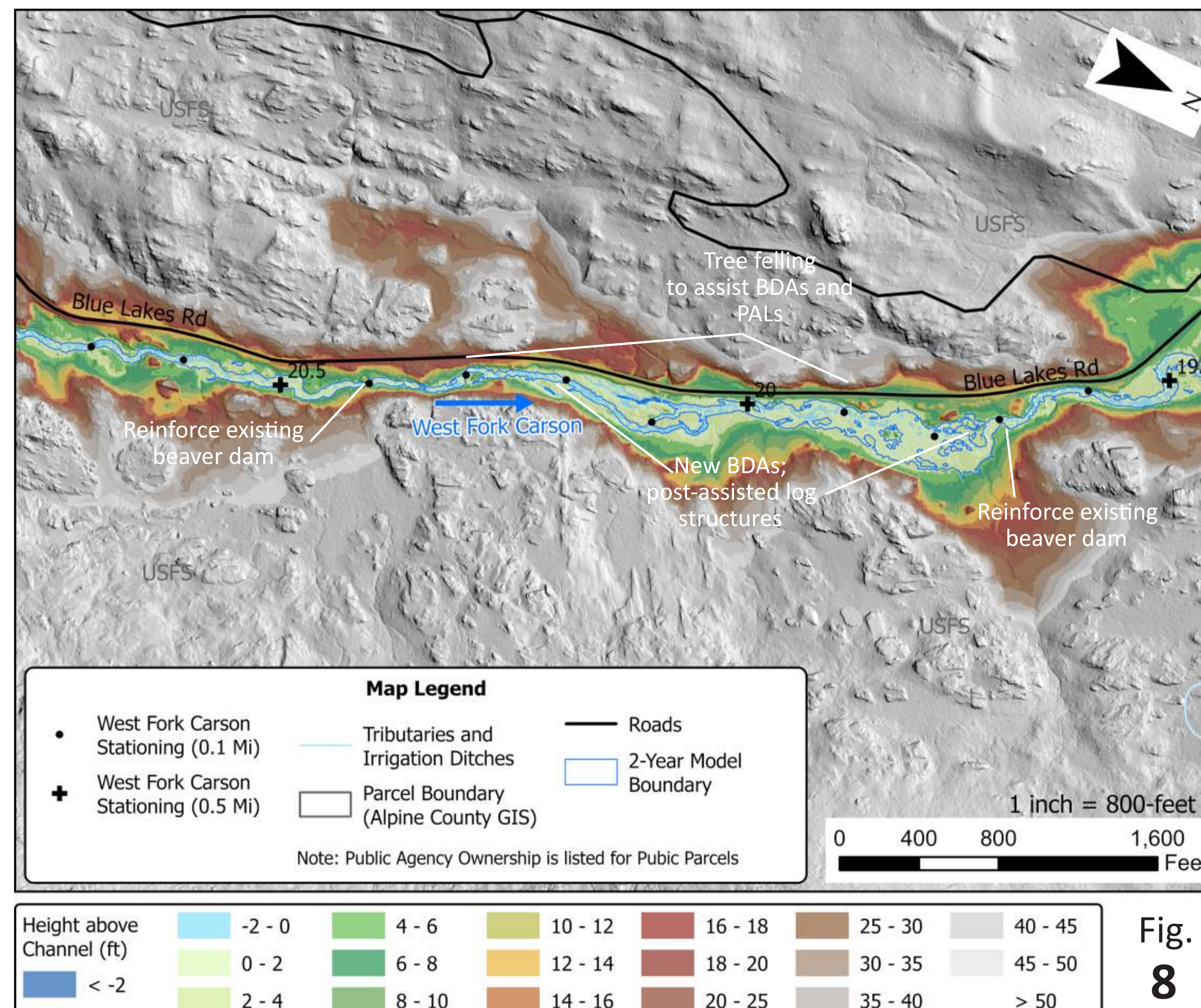


Fig. 8

Project 8- Blue Lakes Road Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Two to three foot high floodplain. Each small meadow within this reach has an existing compromised beaver dam/log jam that could be reinforced with either very small low-impact equipment or by hand work. Additional PALs/BDAs could be installed to supplement existing dams.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Hand crews only. Access & staging off of Blue Lakes Road would be fairly easy. Limited parking along Blue Lakes Road.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	5	Low tech PBR methods. Easy to construct.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	High probability of achieving a modest benefit. The overall reach is confined and reinforcing existing structures, installing small new structures should be successful.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	Low risk project.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than \$2M, 2-\$1M to \$2M, 3-\$500K to \$1M, 4-\$250K to \$500K, 5-less than \$250K)	5	Low cost project.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Typical monitoring and adaptive management.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	1	Negligible change in erosion or fine sediment deposition at the watershed scale.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	1	Negligible impact on water quality.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Expanding beaver influenced area of channel will increase the area of pools.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	2	Relatively small area to be connected.

Project 8- Blue Lakes Road Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	1	Reach is not currently degraded or incised.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	3	Increases connectivity but only in a small area.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	2	Improves complexity locally.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	1	Not a project benefit. Very slight increase locally.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	USFS property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	1	No impact on flood attenuation at the CA/NV state line.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	4	Relatively easy permitting.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	Little benefit in low use area.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	3	Probably will not be noticed by many people.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 9: Faith Valley Campground Restoration

West Fork Carson River, River Mile 22.0 to 22.9

Existing Conditions:

The potential project area is near dispersed campsites along a reach of the West Fork Carson River below Faith Valley. The stream bank on river right, on the outside of a bend directly beneath one of the campsites, is heavily eroded (Figure 9-A).

The reach downstream of Faith Valley is mostly confined by moraine deposits and bedrock, but this is a wider alluvial section, which has been intermittently occupied by beavers. Two large beaver dams, which were present in 2024 (Figure 9-B), had breached by 2025, dewatering an area that was impounded and inundated.

Project Concept:

This project would combine infrastructure protection and ecological restoration at a USFS campsite and fishing area. The infrastructure part would involve repairing and protecting about 200 feet of eroding streambank directly adjacent to the campsite to protect resource and improve safety. The specific bank repair design would need to be determined but could involve bank layback, stacked logs, log and root wad toe protection, and filling voids in rock with fine sediment and planting willows. The project would be combined with ecological enhancements along the West Fork Carson focusing on beaver restoration and pushing water into the floodplain on river left. The restoration would include reinforcing or rebuilding recent dams, building new dams using fallen trees, and non-channel spanning wood structures. Upstream of the campsites, a grade control feature built with rock and/or wood could be used to increase flow into the floodplain on river left. Selective tree felling could be used to help raise grade and provide channel complexity.

Figure 9-A. August 2019 aerial showing eroding bank at campground with no beaver dams.

Figure 9-B. May 2024 aerial with two intact beaver dams. The dams had blown out by summer 2025.

Potential Project Elements:

Biomechanical bank repair, reinforcing existing beaver dams, tree felling, beaver dam analogs (BDAs), post-assisted log structures (PALS), possible engineered log jam, possible rock grade control.

Design Considerations and Potential Constraints:

It is not clear if protecting the campsite justifies the relatively high cost of the bank stabilization project. US Forest Service would need to prioritize the project to allow it to occur. The benefit to sediment storage or reducing erosion would be relatively limited. Campsites would need to be closed during construction. Access and staging are good.

Multiple Accounts Analysis Scores:

Technical: 3.55

Economic: 2.50

Environmental: 2.54

Social and Cultural: 3.55

Overall MAA Score: 2.97

MAA Rank: #9 of 15

Summary:

This would be a relatively easy project to improve recreational user experience at an eroding camp site, and would provide moderate environmental benefit locally. Habitat benefit is moderate, water quality impacts are negligible. The USFS would need to determine whether the cost of the bank repairs would justify the benefit.

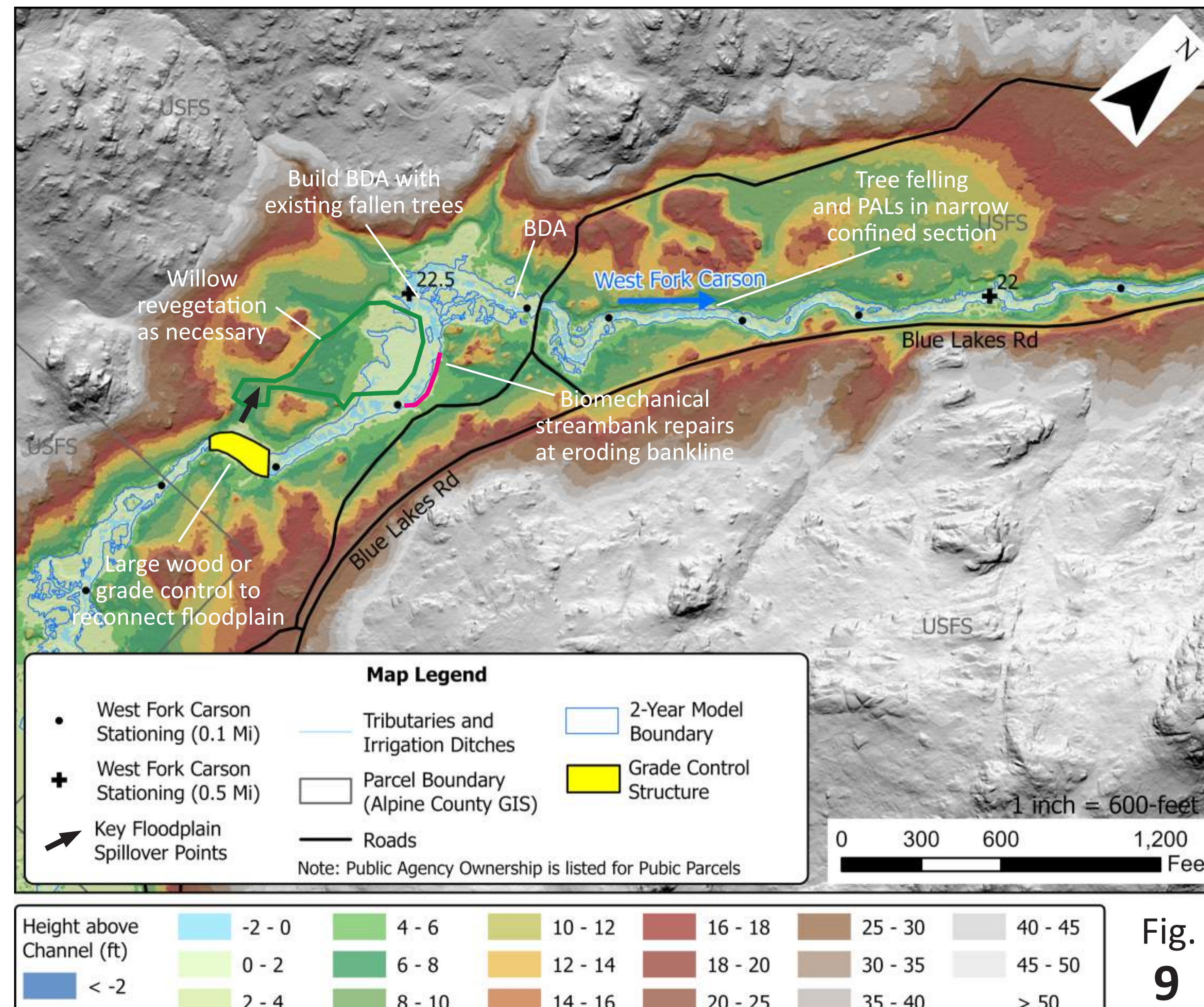


Fig. 9

Project 9 - Faith Valley Campground Restoration and Repair

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Low floodplain, recently was connected. Modification/reinforcement on a couple existing compromised beaver dams/log jams will re-engage the existing floodplain.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	5	Established road and staging area at campsite.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	3	Would require heavy equipment for bank stabilization. Unclear whether grade control structure would be worthwhile. Remainder would be low tech PBR, low impact.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	3	Engineered feature will stabilize eroding bank; LTPBR will improve habitat locally. The success of floodplain inundation is dependent on the beaver dam/log jams, therefore if they are compromised then the area will drain out. The engineered structures have a lower chance of failure.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	3	Frequently used campsite. Project may provide slight reduction in risk of injuries.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	2	Biomechanical bank stabilization and grading over about 200' of bank line. Benefit to cost ratio is not known.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Typical monitoring and maintenance expected.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	2	Small to negligible impact on fine sediment and turbidity.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	1	Not an expected project benefit.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	3	Local improvements over a short reach.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Project would improve local floodplain riparian habitat on heavily eroding bend, plus in previous beaver complex that is now dewatered.

Project 9 - Faith Valley Campground Restoration and Repair

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	Moderate improvement in slightly degraded areas by repairing collapsed beaver dam, and stabilizing eroding bank line with large wood.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Local improvement in floodplain connectivity.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	3	Local improvements around constructed features.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	2	Little to no wetlands benefit.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	USFS land.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	1	No impact on flood attenuation at the CA/NV state line.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	Permitting and logistics may be slightly more than average due to disturbance and USFS procedures.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Improved fishing near campground; more scenic with a more stable beaver population. Slight reduction in risk of injury at currently eroding campsite.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	Obvious benefit at a well used camp site.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 10: Upper Faith Valley Restoration

West Fork Carson River, River Mile 24.1 to 25.0

Existing Conditions:

The potential project area is downstream of the confluence with Forestdale Creek and upstream of the past Faith Valley restoration project constructed between 2022 and 2024. In this reach, the West Fork Carson River exits a narrow section, where the active floodplain is constrained by ridges of boulder moraine, into a wider floodplain reach with a broad depositional surface that modeling shows is inundated during floods (Figure 10-A). The stream is not severely incised in this reach with 2- to 3-foot high banks (Figure 10-B), pool-riffle morphology, and some boulders present. There are remnants of former short-lived beaver dams near the downstream end of the reach (dams are visible in the 1992 and 2017 images but not in any other images). There are several active headcuts where floodplain flow re-enters the river during overbank flood events.

Project Concept:

The main objective of the project is to increase overbank flows, sediment storage, and groundwater recharge in the floodplain on river left just downstream of the narrows below the confluence of Forestdale Creek and West Carson River.

This would be accomplished using felled trees, boulders, and/or post-assisted log structures, depending on whether equipment access would be permitted. This work could be supplemented by adding floodplain roughness in the form of logs, and driving posts to stabilize headcuts, especially in areas where flow returns to the channel. Willow are already established on the floodplain but supplemental plantings in bare areas could provide benefit. Tree felling and beaver dam analogs could be added to the reach to further improve in-stream complexity.

Potential Project Elements:

Measures to increase overbank flow, tree felling, stabilize head cuts, beaver dam analogs (BDAs), post-assisted log structures (PALS), willow planting

Design Considerations and Potential Constraints:

Equipment access is a constraint, but project may be able to be built with hand crews. The reach is not severely incised or degraded, but the floodplain is low enough that relatively small actions could cause a fairly significant increase in overbank flows. Bedload is limited and channel spanning structures could interfere with the delivery of gravel to the downstream project reach. Project should apply lessons learned from the previous Faith Valley project.

Multiple Accounts Analysis Scores:

Technical: 3.65

Economic: 2.50

Environmental: 3.34

Social and Cultural: 3.30

Overall MAA Score: 3.26

MAA Rank: #7 of 15

Summary:

Moderate-size project with relatively large impact on sediment storage and erosion reduction. Access will be difficult, but it might be possible to partly accomplish project objectives using only hand crews.

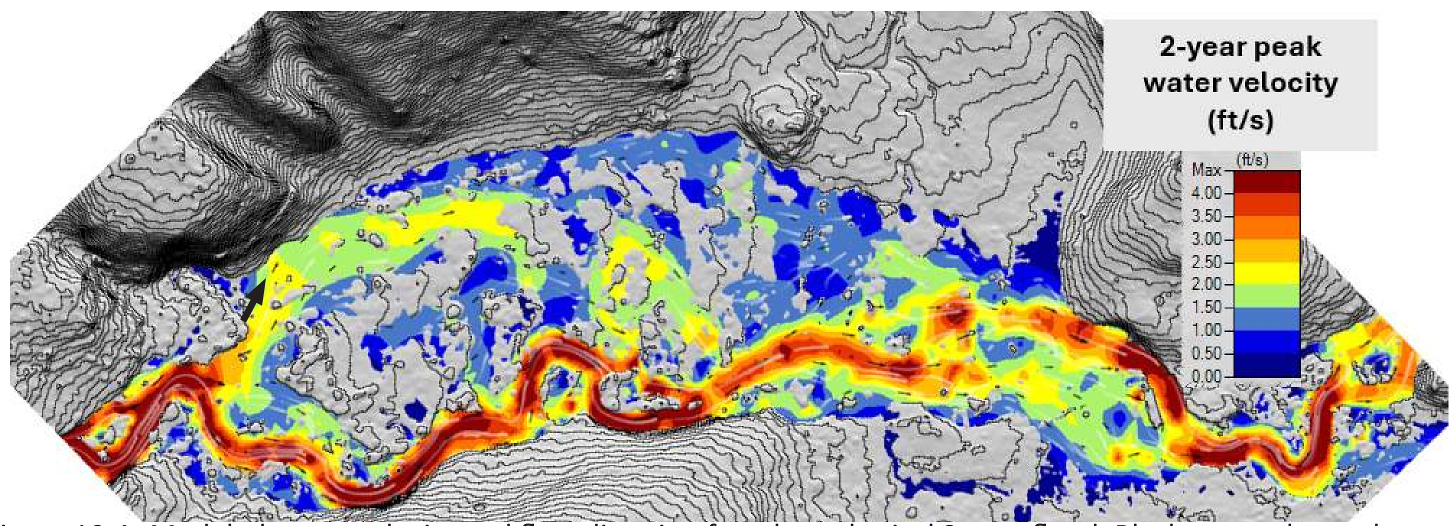
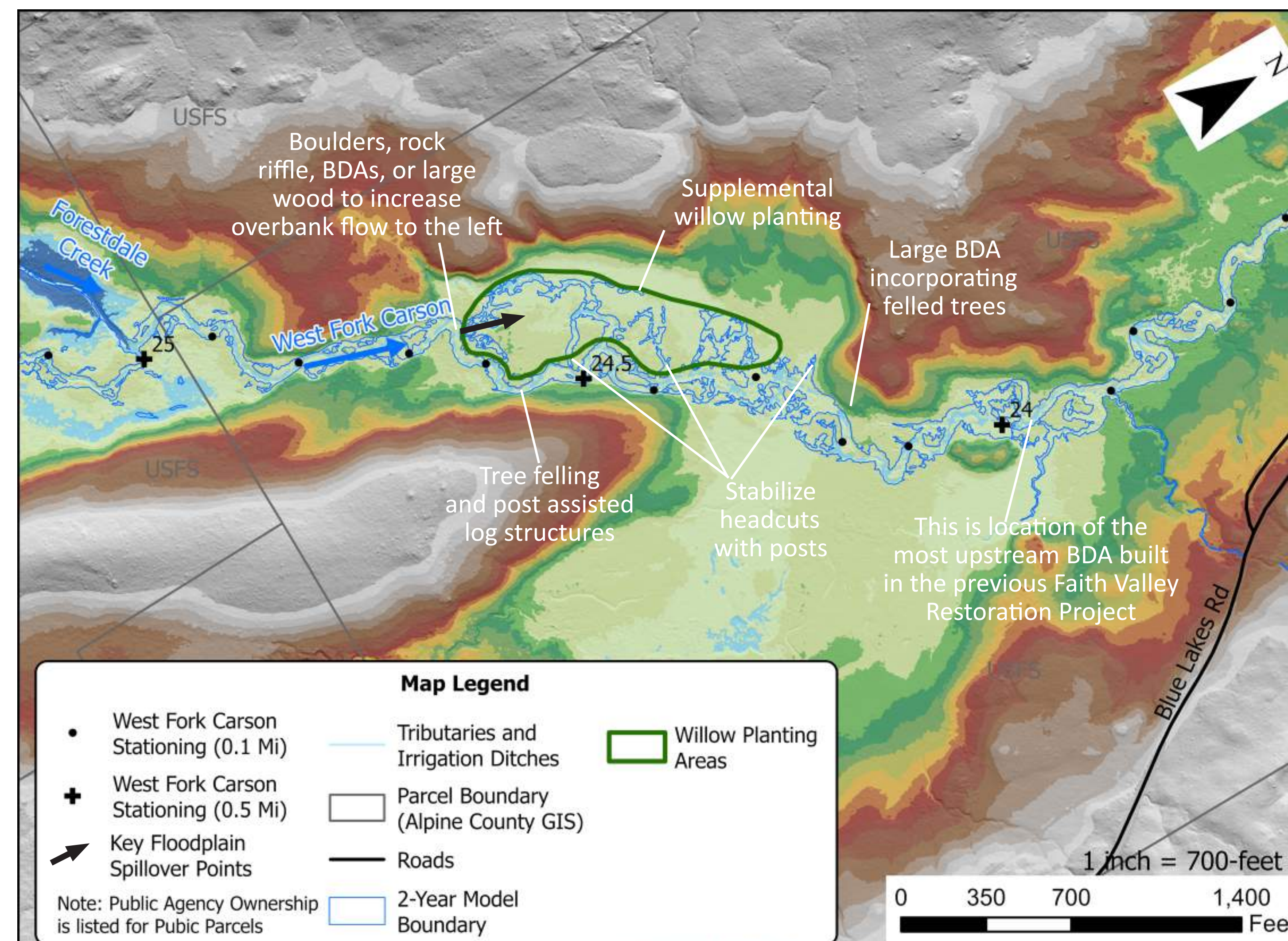


Figure 10-A. Modeled water velocity and flow direction for a hypothetical 2-year flood. Black arrow shows the main location where flow into the floodplain can be enhanced, which is pictured below.

Figure 10-B. Photo of outside of bank where most of flooding occurs (black arrow on Figure 10-A). Raising bed level at this location by 1 to 3 feet would increase the amount of flow and fine sediment entering the floodplain.`



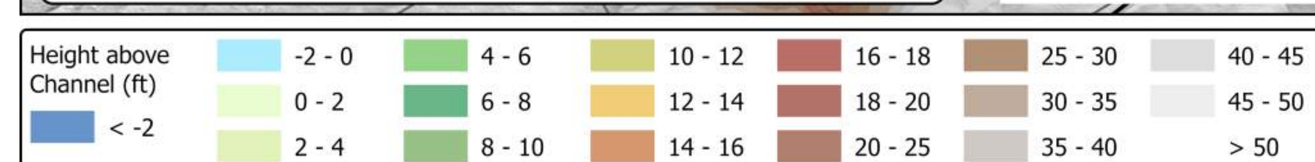


Fig. 10

Project 10 - Upper Faith Valley Floodplain Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Three-foot-high bank at outside of bend. Raising bed by two feet would accomplish objectives. Easy if equipment is allowed, more difficult with hand crews.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	2	Mostly hand crews. There may be a possibility of bringing in equipment via the old Forestdale Road alignment. May be able to deliver materials via snowmobile in winter.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	3	Could accomplish goals with mostly hand crews. Mini excavator would be helpful to move logs. Project construction would be slightly more difficult than the average project due to the remote location and possible import of material.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Will not be difficult to achieve objectives. A well designed and implemented grade control/diversion structure would train flows into this vast relic area and revive healthy meadow function, groundwater storage, and fine sediment reduction/storage.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	No infrastructure risks. Rarely visited area.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	2	Moderately large project the scale of which will depend on pre-design work, modeling, and access logistics. It could be as large as a $1-2M, or could be a lower cost effort.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Typical ongoing monitoring and maintenance.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	Relatively large volume of floodwater over a large area, with high sediment trap efficiency. However, it is very high up in the watershed, upstream of much of the fine sediment production areas in Faith and Hope Valley.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	3	May have small local improvement, but may not impact water temperatures further downstream where temperature is a larger concern.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	3	Multiple possibilities for wood structures, PALs and BDAs to improve instream habitat in a small reach.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Connects a relatively large area of floodplain on river left.

Project 10 - Upper Faith Valley Floodplain Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	Brings channel closer to the floodplain. Moderately degraded reach.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Would increase connectivity to relatively large floodplain.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Moderate improvements to in-channel complexity.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	4	Relatively large floodplain area that would see benefits from increased groundwater levels.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	USFS Land.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	2	Would have minimal impact on flood attenuation at CA/NV state line, especially being so high in the watershed.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	2	Depends on what the eventual project winds up being. If it's a large and impactful project, permitting process may be a challenge.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	Little used area. Not much impact on recreation. Could improve recreational experience in the reach and encourage more people to visit.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	3	Neutral. Few people would see the project.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 11: Willow Creek Meadow Restoration
Willow Creek, River Mile 0.0 to 1.7

Existing Conditions:

The potential project area is along Willow Creek from its confluence with the West Fork Carson River to approximately 2 miles upstream. The upper section is in a geologically confined basin with a floodplain 100 to 250 feet wide, and the lower section encompasses the Willow Creek fan as it enters the West Fork Carson River. In the upper area, the channel is about 2 to 4 feet below the meadow surface (see Figure 11-B). In the lower part of Willow Creek the channel is mostly disconnected from its floodplain (see Figure 11-A). Beaver are extensive in Willow Creek, but their influence is confined to areas where there are healthy willow stands. The channel has incised about two to three feet, leading to a drop in the water table in the meadow, a loss of connectivity, and loss of willow in some meadow areas.

The upper and middle portions of the project area are rarely visited but the lower portion near the West Carson River is close to Pickett's Junction and gets significant foot traffic.

Project Concept:

The project would employ "low-tech process based restoration" (LTPBR) techniques to reconnect the floodplain, expand and enhance wetlands, store sediment, and support beaver in lower Willow Creek. The scale of the channel and the relatively moderate amount of incision makes this area a good candidate for a low cost, low risk, beaver-focused restoration effort. Hand crews would build beaver dam analogs and post-assisted log structures, fell trees, and install willow in strategic locations to accomplish the project objectives of raising the water table, storing fine sediment, improving in-channel habitat, and expanding beaver influence. There is a small fen in the confined section that could be protected with additional BDAs and fencing. There are opportunities for public education and outreach in the frequently visited lower portion of Willow Creek.

Potential Project Elements:

Beaver dam analogs (BDAs), tree felling, post-reinforced beaver dams, post assisted log structures (PALS), willow plantings, fencing to protect fen.

Design Considerations and Potential Constraints:

The primary constraint is proximity to busy intersection and popular recreational area. The main constraint in the upper section is the relatively difficult access. No roads or infrastructure would be impacted, and there would be little impact to recreational uses during construction. Opportunities for signage, education, and tours. The upper project area could be built using hand crews and materials could be harvested on site or brought in by pack animals or ATVs.

Multiple Accounts Analysis Scores:

Technical: 4.31

Economic: 3.50

Environmental: 3.48

Social and Cultural: 4.28

Overall MAA Score: 3.84

MAA Rank: #2 of 15

Summary:

Relatively small, low risk project would reconnect small meadow and store sediment, plus provide opportunities for education and signage in a high visibility area.

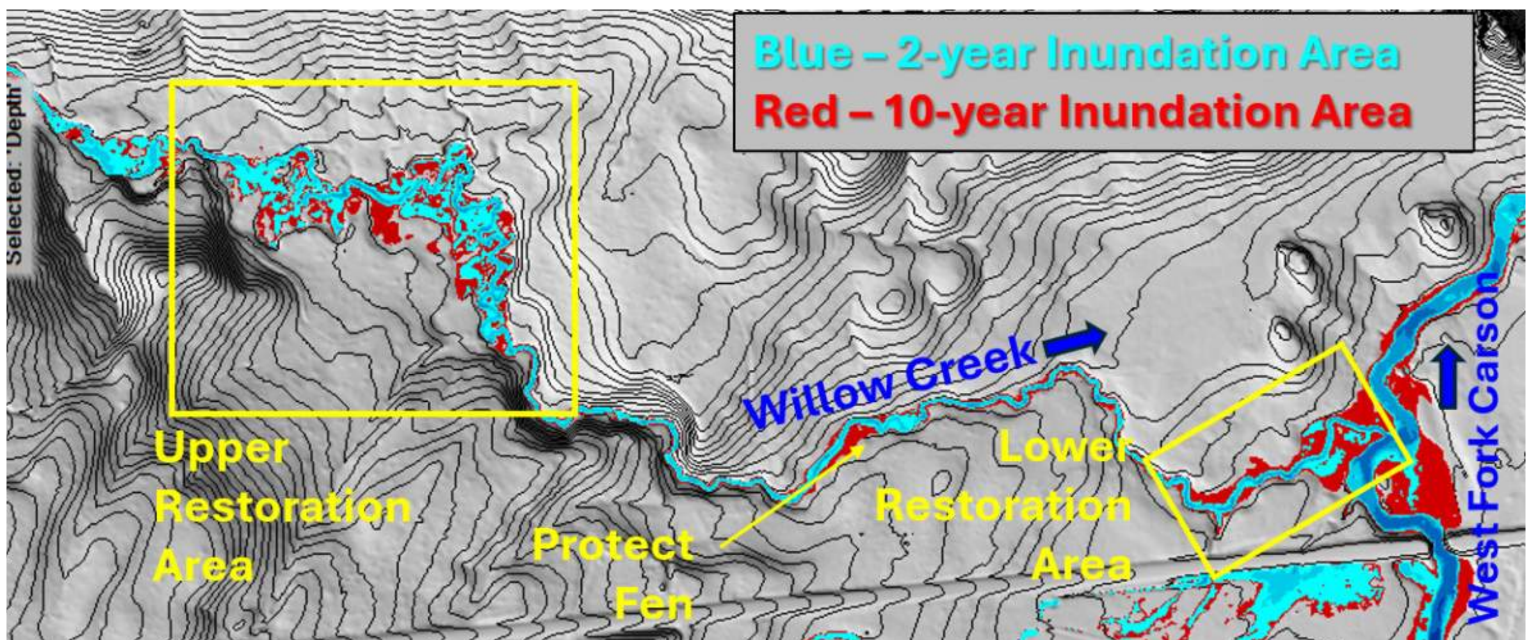


Figure 11-A. Topography and hydraulic model results showing flood extent during 2-year and 10-year events in the lower portion of Willow Creek (existing conditions).

Figure 11-B. Photo of Willow Creek channel and floodplain in the upper area, which could be easily reconnected with LTPBR.

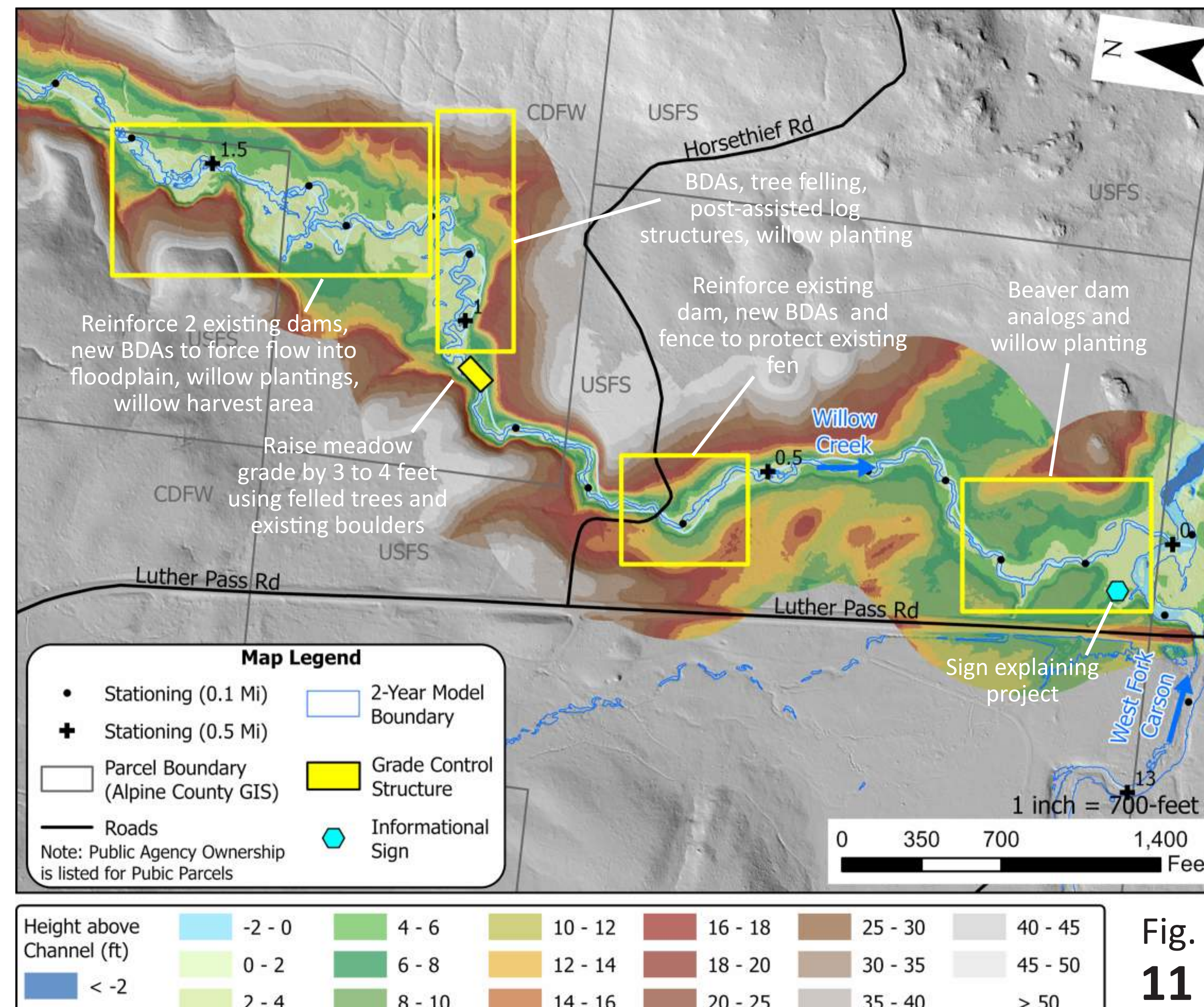


Fig. 11

Project 11 - Willow Creek Beaver Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	Not severely incised, small lift to reconnect floodplain.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	4	Hand crews only; could bring materials to upper work area with livestock.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	5	Low tech methods with hand crews.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	High chance of achieving positive response for relatively small effort.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	CDFW property, rarely used. Cattle grazing could be affected.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	4	Envision a small low tech, low risk project with some engagement and permitting required. Design cost will be high compared with construction.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Monitoring and adaptive maintenance typical for LTPBR projects.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	Willow Creek watershed produces a lot of sediment. Could deposit a relatively large portion of this in the lower meadow. Would also reduce bank erosion.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	2	Slight water temp reduction through more groundwater recharge.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Opportunities to expand the amount of beaver-influenced channel, which will improve in-channel habitat for aquatic organisms.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Relatively large area of floodplain can be reconnected with somewhat little effort.

Project 11 - Willow Creek Beaver Restoration

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	This is a primary project objective, with high probability of success. Moderate to small area of impact (on the order of 5-10 acres).
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	5	Improves floodplain connectivity in two separate incised meadows.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Adds felled trees, PALS and BDAs to the channel.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	3	Several acres of enhanced wetlands. BDAs will protect existing spring and fen from headcut and dewatering.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	CDFW property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	2	Hardly any impact on flood attenuation at the CA/NV state line.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	4	Probably will be easy to permit if kept to a LTPBR project. Reasonably high likelihood of cultural resources in the area but these would not be disturbed.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Opportunities for education in high visibility area. Upper part of project is rarely visited, which may be a benefit. Could improve fishing.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	5	Lower part is next to Pickett's Junction, easy access, lots of visitors. Could incorporate signage to explain the project and do field tours.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 12: Red Lake Creek Lower Meadow Restoration

Red Lake Creek, River Mile 0.9 to 2.7

Existing Conditions:

The project area encompasses almost two miles of Red Lake Creek and the lower portion of an unnamed tributary within a large meadow complex. Red Lake Creek emerges from a narrowly confined section into a wide, glacially formed valley, before entering another narrow canyon. The upper third of the project reach is a low-gradient alluvial fan, and the lower two-thirds is a sinuous, meandering floodplain (Figure 12-A). There is evidence that the creek may occasionally switch between its current course through the lower meadow and a separate path through a different meadow farther to the east (Figure 12-B). The channel is narrow and moderately incised, and the meadow has only sparse willow. Currently there is only one intact beaver dam, probably because of a lack of nearby willow. Prior to human intervention (i.e., more than 150 years ago), the meadow was probably characterized by many beaver dams, multiple channel pathways, widespread lateral flow, and sediment deposition in the floodplain. Presently the channel is moderately incised in a single, meandering channel. Historical aerial photographs show that the creek has been in its current location for at least 80 years with only minor channel changes.

Project Concept:

The project would use “low tech” methods implemented by hand crews to begin to convert the meadow back to a condition in which the floodplain is more frequently wetted and trapping fine sediment—similar to a condition that probably existed 150 years ago.

In the lower portion of the meadow, beaver dam analogs (BDAs) would be constructed, especially near key overbank flow pathways, to encourage more water and sediment to spread onto the floodplain. Where appropriate, the BDAs would be complimented with felled trees, and willow would be planted in areas of the floodplain that will be wetted. A different approach would be taken in the fan reach, where non-channel spanning structures may be preferred to allow bedload to move through the reach. Measures could be taken along the right bank near the head of the fan to reduce the chances of the channel avulsing into the eastern portion of the meadow where vegetation conditions are worse. In the tributary meadow small BDAs and posts would be installed to halt the eroding knickpoints that are dissecting this meadow and raise the ground water table. Willow could be harvested on site in the tributary meadow.

Figure 12-A. Meandering channel in lower meadow with moderate incision, sparse willow, and vertical eroding banks.

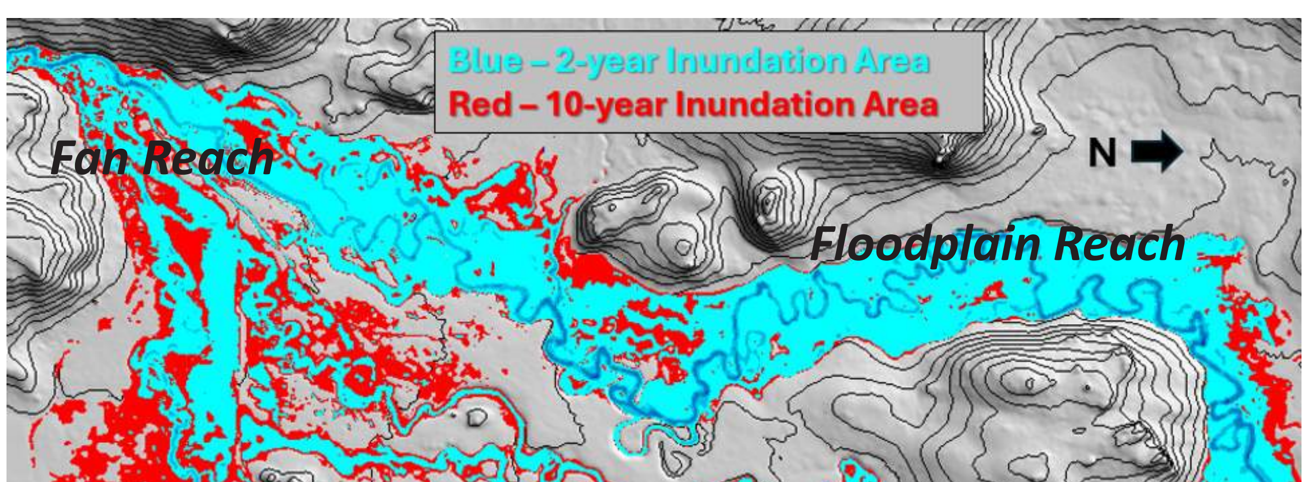


Figure 12-B. Hydraulic model results for lower Red Lake Meadow showing extent of flooding in the 2-year and 10-year recurrence interval events

Potential Project Elements:

Beaver dam analogs, felled trees, post-assisted log structures (PALS), willow planting.

Design Considerations and Potential Constraints:

Heavy equipment access will be difficult without disturbing the meadow and should be avoided. The vast scale of the meadow and short growing season will reduce the rate of willow expansion and growth. The relatively small supply of bedload from upstream will limit the amount of channel aggradation that can be expected. To maximize the benefits of the limited bedload supply the location of the upper most BDA should be carefully determined based on specific geomorphic objectives and local conditions. Low recreational use in the meadow may be an advantage.

Multiple Accounts Analysis Scores:

Technical: 4.37

Economic: 3.50

Environmental: 4.08

Social and Cultural: 4.18

Overall MAA Score: 4.07

MAA Rank: #1 of 15

Summary:

This would be a relatively low cost, low risk project that could have a significant impact of rewetting and storing sediment in a large glacial meadow, with both local habitat benefits and downstream water quality impacts.

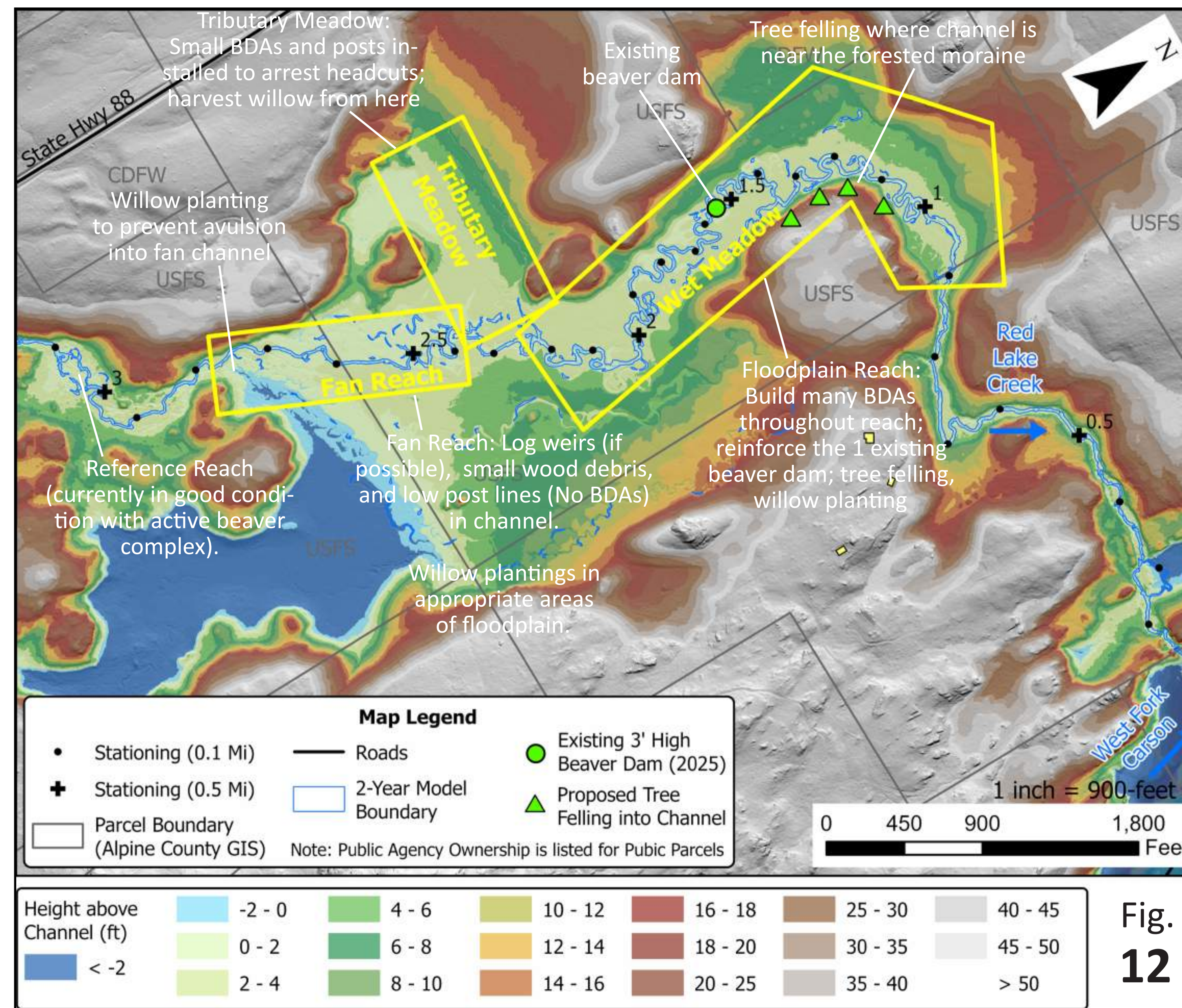


Fig. 12

Project 12 -Red Lake Creek Lower Meadow Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	5	Moderate incision. 2-foot to 3-foot BDAs will wet the meadow in most places.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Hand crews only. Could bring in supplies with pack animals, or by snowmobile in winter if approved.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	5	Easy. Commonly used, well tested, and low tech methods will accomplish project goals. Getting materials to the site may be a bit more challenging, but most materials will be from onsite.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Project will almost definitely accomplish floodwater and sediment goals. Unclear how well the willow revegetation effort will be due to poorly drained soils.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	No infrastructure risks, little used area.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	4	Mostly low cost, but large project area.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Typical monitoring and maintenance for a LTPBR project.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	5	One of the largest meadows in the watershed; good opportunity to store sediment and reduce bank erosion.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	3	Will store water during floods and release during dry season, which should reduce water temperature. Scale of impact is limited because the base flows in Red Lake Creek are relatively low compared with WFCR.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	4	Beaver expansion will improve channel habitat in degraded reach.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	5	Will expand large area of wetted floodplain; combined with willow planting it will impact a larger area than most of the potential projects.

Project 12 -Red Lake Creek Lower Meadow Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	This would have been a beaver dominated reach prior to human impacts; project would re-establish this. Reach is only moderately degraded.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	5	Large impact on connectivity of one of the largest meadows in the WFCR watershed.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	4	Beaver complex is more complex than incised channel. Some free-flowing reaches should be preserved.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	5	Large area of hydrologic impact in meadow.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	USFS property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	4	This is a large enough meadow that it could have a impact on flood attenuation at the watershed scale, by attenuating floods in a main tributary of WFCR.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	4	Should be relatively straightforward as it is on a tributary, public land, and no disturbances from equipment.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	Neutral: minor impact on recreational use. Rarely used meadow. May improve fishing. Wetter meadow conditions could make fishing access more difficult.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	Low risk that this would be considered a failed project. Immediate and sustained impact. Won't be seen by many people due to remoteness.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 13: Red Lake Creek Upper Meadows Restoration

Red Lake Creek, River Mile 3.2 to 4.3

Existing Conditions:

If possible, the potential project area would encompass two meadows along Red Lake Creek separated by Highway 88, one on private land and the other on USFS property. Beavers are present now and have been an important part of meadow function in historic times and probably since the end of the last glaciation. The upper meadow is on private property and was not visited as part of the assessment, but air photos show that there was a large active beaver complex that has reduced in size, possibly because of a breach in the main dam. Immediately downstream of Highway 88, a new beaver dam complex has been built from aspen in the adjacent hillslope (Figure 13-A). The existing complex includes at least three large dams and a large lodge. Further downstream there is evidence of multiple recently breached dams and unused lodges (Figure 13-B). The downstream end of the project reach is marked by a 3-foot-high bedrock waterfall before the creek flows through a short canyon reach before entering a much larger valley.

Project Concept:

This project would focus on strengthening and expanding beaver influence in the meadows to increase overbank flows, groundwater levels, and habitat quality. On the US Forest Service-owned parcels downstream of Highway 88, existing dams could be reinforced with posts and the downstream former beaver complex would be re-established by building stout structures that will hold up better to floods. Where possible, trees would be felled into the creek to create complexity and to form the key pieces in stable dams. Willow and aspen would be planted in and on the margins of the valley to provide bird habitat and beaver food. More stable structures combined with more food would allow and encourage beaver population and influence to expand in these meadows, which would improve habitat, reduce bank erosion, and store fine sediment. Work on the upstream meadow has not been approved by the landowner, and no site visits have been performed, but would likely include low-tech, low-impact methods such as BDAs, selective tree felling, and willow planting.

Figure 13-A. Part of a beaver complex with three large dams and downed aspen trees.

Figure 13-B. Abandoned beaver lodge in floodplain near where former dam breached in recent floods.

Potential Project Elements:

Beaver dam analogs, reinforcement of existing beaver dams, tree felling, post-assisted log structures, willow and aspen plantings

Design Considerations and Potential Constraints:

The upper portion of the project area is on private property whose owner has not given access or permission for a potential project. The downstream meadow is owned by USFS. Project could be worth doing even if the property access to the upper meadow is not granted. Equipment access may be possible, but may not be necessary. The lower meadow has relatively little willow. Establishing willow in these areas for beaver food will be important but may be difficult and require protecting young plants from beaver.

Multiple Accounts Analysis Scores:

Technical: 3.84

Economic: 4.00

Environmental: 3.04

Social and Cultural: 3.43

Overall MAA Score: 3.49

MAA Rank: #6 of 15

Summary:

Project would expand and strengthen beaver habitat in two medium size meadows using low impact methods, but the part of the project on private property may not be allowed.

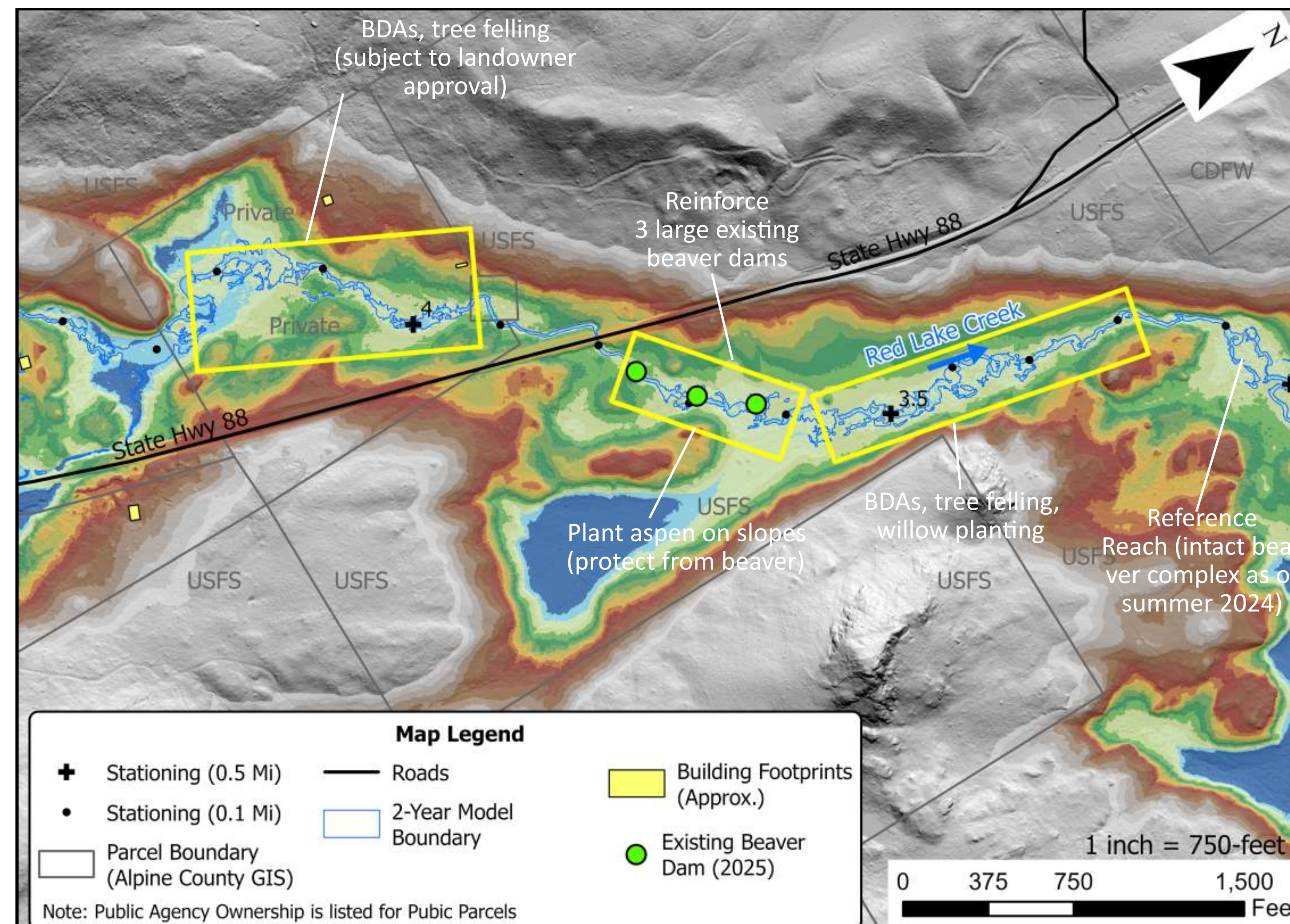


Fig. 13

Project 13 -Red Lake Creek Upstream Meadows Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	4	2-3' lift required. Former beaver ponded areas, these were recently connected by natural beaver dams.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	3	Hand crews only. Could bring in supplies by snowmobile in winter.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	4	Should be pretty easy. Commonly used well tested low tech methods will accomplish project goals.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Hydrological impacts are certain. Revegetation success will depend on setting realistic objectives.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	4	Little to no infrastructure risk in recently beaver ponded areas.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than \$2M, 2-\$1M to \$2M, 3-\$500K to \$1M, 4-\$250K to \$500K, 5-less than \$250K)	5	Could be done for low cost. Permitting will be a big fraction of cost. Unclear whether the meadow on private property would be included.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Monitoring and adaptive management of BDAs and willow plantings.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	3	Moderate change in sediment budget on Red Lake Creek.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	2	Some minor water temperature impacts due to infiltrating water during floods.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	3	Slightly expand the area of beaver influence in the channel, leading to better in channel habitat.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Floodplain areas that have been abandoned due to beaver dam collapses could be re-established.

Project 13 -Red Lake Creek Upstream Meadows Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	4	Re-establish beaver dominated system.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Re-wets a meadow, several acres in size.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	3	Will improve channel complexity moderately through expanding the existing beaver complex further downstream, raising grade and depositing sediment.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	4	Infiltrates water to expand wet meadow over a moderate area (several acres)
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	3	Upstream half on private land. Alpine Watershed Group attempted but did not make contact with landowner for this assessment. If landowner is not in agreement, a good but smaller project could be done on the public parcels.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	3	Could slightly attenuate floods out of Red Lake Creek, but the impacts of this one project on flood sizes at the CA/NV state line may be small.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	4	Relatively straightforward permitting with landowner permission. High likelihood of cultural resources significance.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	Little to no impact on recreation. Some people may fish here. Visible from Highway 88 and lot of people stop to admire and photograph scenery in this area.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	In a relatively high visibility area off of Highway 88.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Project 14: Hawkins Creek Fan Reconnection

Hawkins Creek, River Mile 0.0 to 0.5

Existing Conditions:

On the east margin of Hope Valley, Hawkins Creek emerges out of a canyon onto an alluvial fan deposited over the West Fork Carson River (WFCR) floodplain (Figure 14-B). Flows in Hawkins Creek rarely overtop the high vertical banks, even during flows as large as the 10-year recurrence interval flood (Figure 14-A). Riparian vegetation is concentrated along the main channel. As a result of channel incision, most likely caused by climatic changes, fine sediment is no longer being stored in this fan during high flows. Instead, flows are concentrated in the incised channel, where banks are heavily eroding throughout the 0.5-mile-long reach, contributing further to the fine sediment load of the WFCR.

Project Concept:

The project would apply a variety of in-channel and near-channel treatments to shift the sediment budget in the Hawkins Creek fan towards reducing bank erosion and increasing sediment storage. The crux of the project would be increasing the frequency and volume of water and fine sediment that enters the fan at two key locations, spilling more water and sediment in the Hawkins Creek fan. This would also reduce the amount of water in the main channel during floods, presumably reducing the erosive energy. This objective could be accomplished by raising the channel bed and by increasing the channel roughness. This could be accomplished using some combination of log weirs, beaver dam analogs (BDAs), post-assisted log jams, engineered log jams, or other restoration methods. It may also be possible to use minor excavation in the floodplain to increase overbank flow. In addition, the project would include restoration near the mouth of Hawkins Creek to reduce bank erosion and attract beaver.

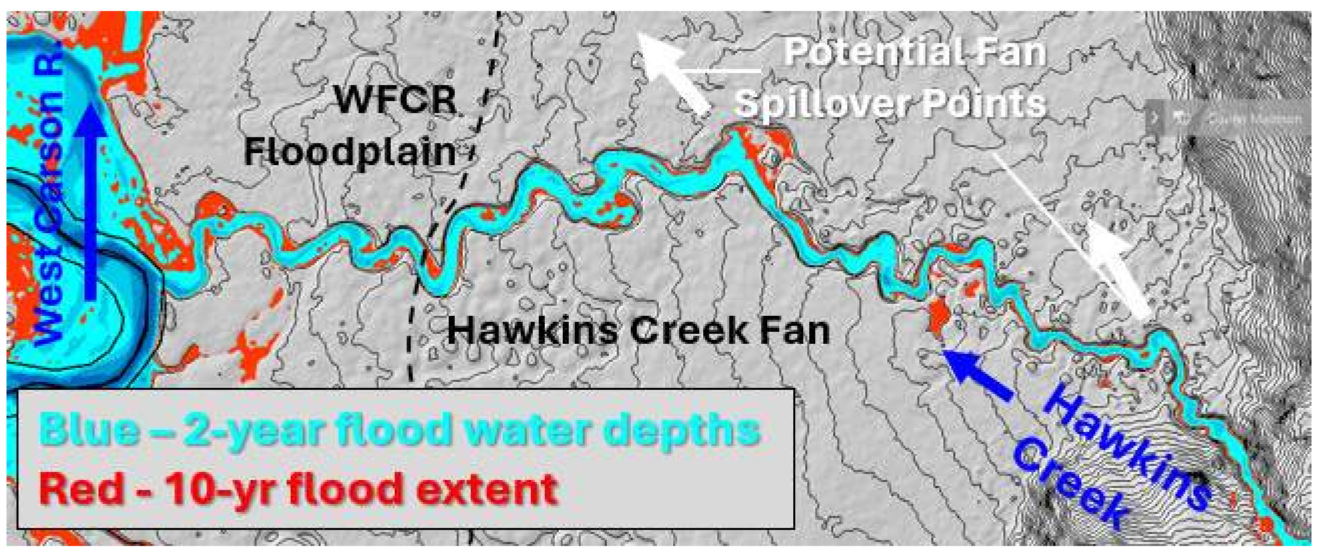


Figure 14-A. Geomorphology and modeled flood extents in the Hawkins creek fan area.

Figure 14-B. Streambank erosion in the incised fan reach of Lower Hawkins Creek.

Potential Project Elements:

BDAs, post-assisted log structures (PALS), engineered log jams, log weirs, willow planting, potential for excavation at fan channel inlets, possible 2' high cobble gravel/cobble grade control in channel.

Design Considerations and Potential Constraints:

Relatively small impact project. Spilling water into the fan may reduce bedload supply to WFCR. Uncertain whether benefits outweigh costs.

Multiple Accounts Analysis Scores:

Technical: 2.45

Economic: 3.00

Environmental: 2.68

Social and Cultural: 3.02

Overall MAA Score: 2.74

MAA Rank: #11 of 15

Summary:

This would be a relatively small scale project; moderately easy to construct, but the costs may be high due to difficult access, and environmental benefits will probably be limited.

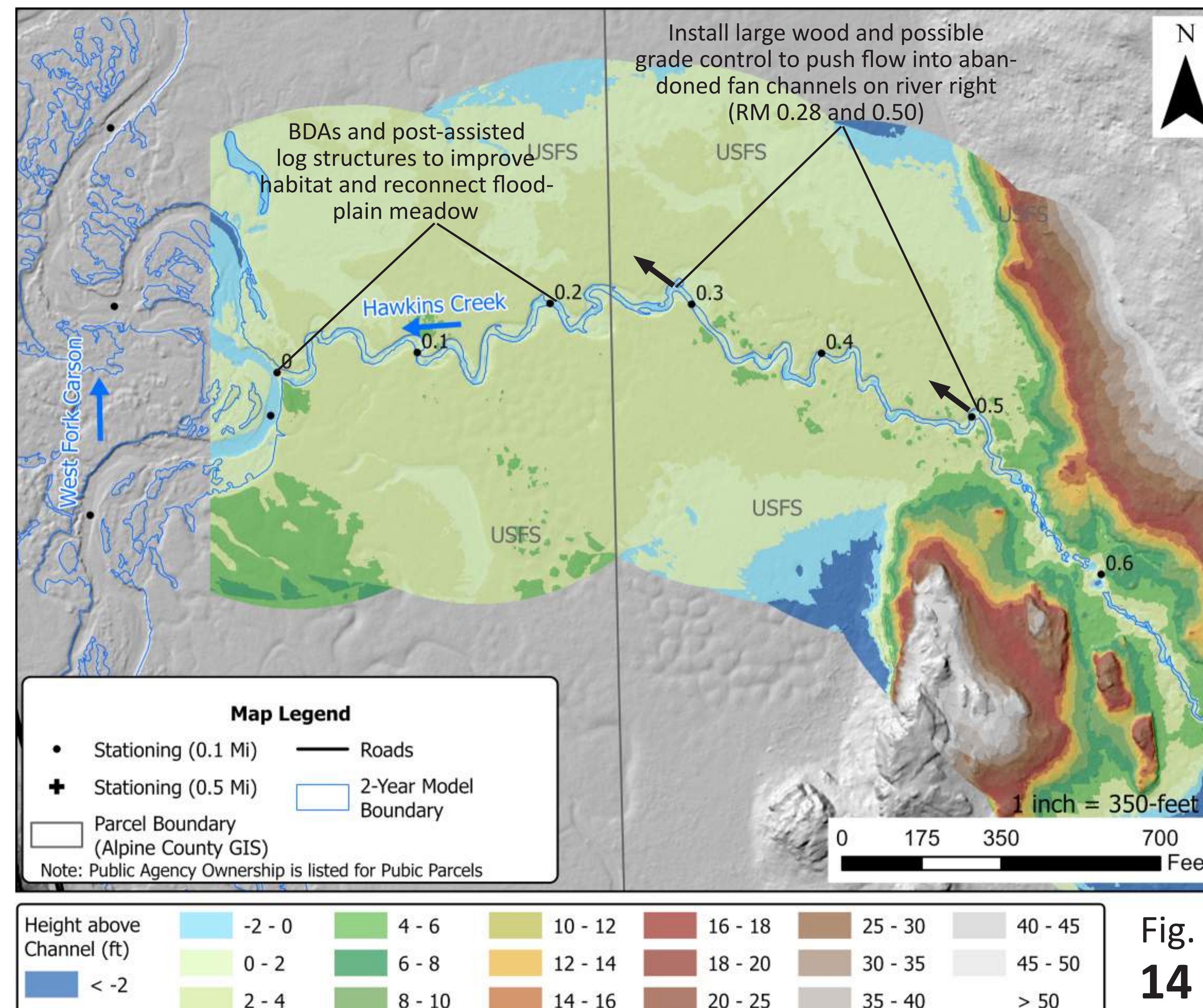


Fig. **14**

Project 14 -Hawkins Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	2	Channels are currently disconnected in a 10-year event. 2-3' lift required.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	2	Would likely need to cross WFCR with heavy equipment, and possibly logs and rock. If no equipment used, access would still be difficult and require hiking in by foot or pack animal (if approved).
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	2	Assuming all proposed features are within the LTPBR suite of options, constructability would be moderate if materials can be sourced in close proximity or more difficult if the materials have to be carried in.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	2	Goal of directing flows out and away from channel is achievable, but the goal of raising water table and expanding the meadow may be more difficult to achieve because there is not a lot of water and a coarse sandy matrix. Also, the duration of benefit may be relatively short.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	Low risk project from infrastructure perspective.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	3	Moderately high cost, especially if logs and gravel import is done.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Not known if maintenance will be needed.
Environ-mental	Water Quality	Fine Sediment Reduction	Reduces bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	4	Relatively large benefit for fine sediment compared with other projects.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	2	Stores floodwater in fan during floods, returns gradually to the WFCR in lower flows. Storage amount will be small and only during snowmelt season.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	2	Channel is intermittent, doesn't provide much habitat. Project would not change that situation.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	3	Potential slight improvement by putting more floodwater into the distal meadow, but the frequency and amount of water may not be enough to make much difference to near-channel habitat.

Project 14 -Hawkins Fan Reconnection

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	3	Helps reconnect an abandoned fan.
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Central benefit of this project is to reconnect the fan.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	3	Minor impact on channel complexity; channel is intermittent.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	1	This area is mostly on Hawkins Creek Fan. The fan is much more arid and sandy than the WFCR floodplain, so it is not a meadow with high groundwater table and probably would not be after project implementation. Groundwater benefit would be low to negligible.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	5	USFS property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	1	Little impact on floods downstream, Hawkins Creek is a minor tributary.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	3	Moderately easy to permit but may be hurdles if gravel import is done.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	3	No impact on recreation.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	2	Project will not be seen much by the public. For those who see it, the benefits will not be very obvious. Most of the benefit would be downstream impacts to water quality.

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

Existing Conditions:

Headcuts are common in incised glacial meadows throughout the West Fork Carson River watershed. Meadow headcuts generally begin where a stream channel or gully has incised, lowering the base level relative to tributary flow paths. This creates a vertical face where water concentrates in both the surface and subsurface. Upstream of headcuts, the comparatively high water tables and low banks support healthier wet meadow conditions. Downstream of headcuts, erosion and dewatered floodplains are more common. Headcuts advance upstream through surface flow over the headcuts as well as subsurface piping, a process that leads to more erosion of fine sediment, and significant losses to meadow ecological function. American Rivers (2018) referred to this process as "unravelling," and identified headcuts as a primary contributor to meadow degradation in the Carson watershed. American Rivers included an initial count of headcuts in the meadows in both West Fork and East Fork Carson River watersheds.

Project Concept:

American Rivers Carson Meadows assessment (2018) concluded that headcuts in meadows are an indicator of ***future*** erosion risk, and that "treating a headcut may be the stitch in time that saves nine." Treating headcuts in meadows can usually be done as a small action with hand crews, though there may be some headcuts that require engineered structures. This project would aim to systematically map and address headcuts using similar technologies throughout the entire basin. Techniques will include low tech and site-specific treatments depending on the conditions at each of the headcuts. Approaches would include installing vertical posts, horizontal logs, coir logs, or other biodegradable features at, above, and below specific headcuts to stabilize them, disperse focused water flow from above, or to backwater these features from below. Because the treatments will be small scale and similar throughout the watershed, considering them and treating them all as a watershed-scale project may be the most efficient and effective way to have a watershed scale impact.

Proposed Project Elements:

Installation of vertical posts, post-assisted log structures (PALS), coir rolls, low diversions or berms above headcuts, possible grade control structures or roughened channels, willow plantings

Design Considerations and Potential Constraints:

This requires a systematic assessment of headcut locations, sizes, and specific techniques to address them, building on the American Rivers study. The project extent will not be known until the assessment is completed. It may be complex to permit actions at many non-contiguous sites around the watershed.

Multiple Accounts Analysis Scores:

Technical: 4.37

Economic: 3.50

Environmental: 3.54

Social and Cultural: 3.40

Overall MAA Score: 3.72

MAA Rank: #3 of 15

Summary:

Project would take proactive measures to prevent future erosion and meadow degradation throughout the watershed, which is often cheaper than fixing problems after they occur.

Figure 15-A. Headcuts in Forestdale Meadow.

Figure 15-B. Headcut in Tributary in Upper Faith Valley.

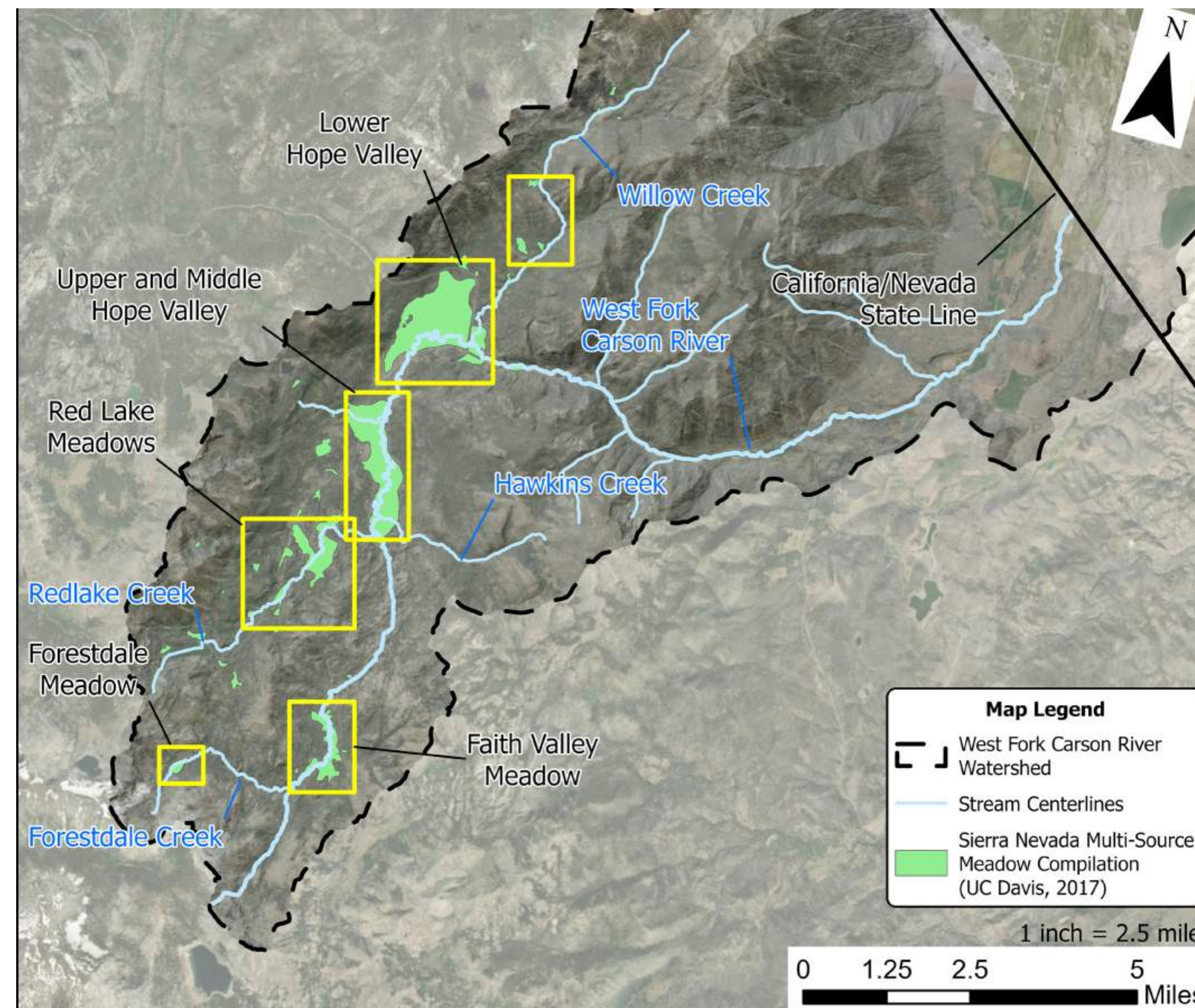


Fig. 15

Project 15 - Basin-Wide Headcut Repairs

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Technical	Engineering Feasibility	Geomorphic Difficulty	Low height to raise bed; able to use LTPBR instead of rock; narrow channel; confined channel without a risk of flanking.	(1-difficult, 3-moderate, 5-easy)	5	Project will prevent disconnection of floodplain, which is easier than re-establishing what has been lost.
		Access	Easy equipment access; adequate staging areas; minimal disturbance expected. Note: this indicator reflects physical constraints, not related to considerations around access permission from private landowners. That aspect is covered under the indicator "Property Ownership".	(1-difficult, 3-moderate, 5-easy)	4	Hand crews only. In more remote areas, there may be opportunities o bring posts or other materials with livestock.
		Constructability	Ease of construction - uses lower tech, lower impact, and lower cost methods. If using heavy equipment, requires less excavation or import of materials.	(1-difficult, 3-moderate, 5-easy)	4	Mostly simple headcut repairs driving posts. Some of the locations may require bringing posts a long distance from roads.
	Risks	Risk of Failure to Perform/Likelihood of Success	High probability of project providing intended benefits.	(1-high risk, 3-typical risk, 5-high chance of success)	4	Will slow or prevent headcut dissection. There is a chance that gullies may erode around structures in some locations.
		Potential Risks to Infrastructure or Existing Natural Resource Values	No roads, houses, or irrigation infrastructure present; unlikely to negatively impact scenery, fishing, recreation, or other qualities valued by landowners (on private land) or by the public (public land).	(1-high risk, 3-typical risk, 5-high chance of success)	5	No risk to infrastructure; most headcuts are in remote places not visited by people.
Economic	Cost	Design and Construction Costs	Low design and construction costs.	(1-more than $2M, 2-$1M to $2M, 3-$500K to $1M, 4-$250K to $500K, 5-less than $250K)	4	Design costs will be high compared with construction. Will need a desktop assessment and basinwide field assessment (~5 days). Permitting may be costly because of the scattered locations.
		Ongoing Maintenance Cost	Project will require monitoring, with minimal ongoing maintenance, adaptive management or repair.	(1-require long term commitment, 3 - monitoring and adaptive management, 5-minimal maintenance anticipated)	3	Monitoring and adaptive management will be required, but intermittently only.
Environ-mental	Water Quality	Fine Sediment Reduction	Project will reduce bank erosion and/or increases the amount of sediment that will be stored in the floodplain.	(1-little benefit compared with other projects, 3-moderate benefit, 5-highest benefit)	5	The restoration action will not reverse erosion that is currently occurring, but could prevent significant acceleration of erosion in the future.
		Water Temperature or Pollutant Reduction	Contributes to reducing warm season water temperatures; directly prevents pollutants from entering WFCR; impact would be observable downstream, where WFCR is considered impaired with respect to these parameters.	(1-negligible impact on water quality, 3-moderate impact compared with other projects, 5-one of the projects with the most WQ benefits)	4	Preventative - avoid the loss of these meadow functions.
	Habitat	In-Channel Habitat Improvement	Addresses limiting factors for aquatic species in WFCR or tributary streams.	(1 - negative impact, 3 - some improvement of in-stream habitat, 5 - significant reach-scale improvement of in-channel habitat)	2	No direct impact.
		Riparian Habitat Improvement	Improves extent and/or health of native riparian plants within project area by increasing moisture retention and overall riparian plant density and quality,	(1 - negative impact on riparian habitat quality, 3 - some improvement of riparian habitat, 5 - significant reach-scale improvement of riparian habitat)	4	Preventative action - it will significantly reduce the chances for future degradation of existing high quality riparian habitat at multiple locations around the basin.

Project 15 - Basin-Wide Headcut Repairs

Account	Sub-Account	Indicator	Project Features Creating Higher Indicator Scores	Scoring Criteria	Final Indicator Score[1] (1-5)	Notes
Environ-mental (cont)	Geomorphic Process	Prevents or Reverses Degradation	Reverses a presently degraded condition by aggrading the bed and/or hydraulically reconnecting floodplain.	(1-no impact; or the reach is already in non-degraded condition, 3- moderate improvement compared with other projects, 5-significant reversal of degraded condition)	5	Prevents significant future degradation ("A stitch in time saves nine", as described by American Rivers [2018] with reference to fixing head cuts).
		Improves Channel-Floodplain Connectivity[2]	Increases the frequency and volume of water and sediment entering the floodplain and off channel areas during floods.	(1-does not improve connectivity, 3-reconnects some meadow floodplain, 5-large benefit in terms of frequency and meadow area)	4	Prevents disconnection of presently connected floodplains and halts continued degradation and expansion of presently disconnected floodplain areas.
		Increases Channel Complexity	Increases the diversity of geomorphic and habitat types within the channel.	(1- minor improvements, 3- moderate or temporary impact, 5-larger or self-sustaining benefits)	2	Headcuts to be treated are typically on small tributary gullies that do not provide much geomorphic complexity or habitat.
	Groundwater	Increases Groundwater Recharge and Meadow Recovery	Improves and expands wet meadow and associated vegetation.	(1-no wetland benefit, 3-moderate benefit compared with other projects, 5-significant expansion or improvement of wetlands and meadows)	4	Preventative maintenance to stabilize meadows throughout the WFCR watershed.
Social and Cultural	Social	Property Ownership	Property owner(s) in favor of the project, maximizes landowner benefits, limits short term and long term negative impacts.	(1-difficult, 3-moderate, 5-easy)	4	Multiple parcels, but most or all work will be on USFS and/or CDFW property.
		Flood Benefit[2]	Attenuates the peak flood flow at the California-Nevada state line during moderate and large floods.	(1-no impact on floods downstream, 3-could contribute some flood benefit if combined with other projects, 5-one of the proposed projects with the largest flood benefits)	1	Won't see any flood benefit from this effort and that is not one of the goals of the project.
		Ease of Permitting, Water Rights, and Right of Way[3]	Clear permitting pathway, no major issues with acquiring permission for the project, water rights issues.	(1-difficult, 3-moderate, 5-easy)	3	Permitting could be tricky due to many non-contiguous sites, but impacts to existing ecosystem resources will be low.
	Cultural[3]	Recreational Impact	Improve user experience; little construction impact.	(1-negative impact, 3-neutral, 5-significant benefit)	4	Stabilize meadows enjoyed by recreationists.
		Will be viewed as a successful project by stakeholders and the public	Immediate and obvious benefits, especially in higher visibility areas; project benefits will be seen at the site, rather than only downstream.	(1-high risk of negative perceptions, 3-moderate risk 5-project benefits will be obvious to stakeholders, landowners, or the public)	4	People may not notice the work but preventing future degradation would be seen by most as a good fix ("a stitch in time saves nine," as stated by American Rivers (2018)).

Notes:

1. An initial set of indicator scores was assigned independently by Waterways and Watershed Resiliency Consulting (WRC) during field visits to potential project sites. The final indicator scores reported in this column were assigned after further analysis, considering the initial (field-based) indicator scores along with hydraulic model results, aerial photographs, and other considerations.

2. These indicators were added based on input from stakeholders. This occurred after the field assessments and scoring were completed, so these were not initially scored during field assessments by Waterways and WRC.

3. Impact to archaeological resources is not explicitly included as an indicator because the presence or absence of artifacts is not known for each of the proposed project sites. The indicator "Ease of permitting" includes a field estimation of the likelihood of cultural resources that would make it difficult to permit the project.

APPENDIX P-4

SEDIMENT LOAD REDUCTION TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

To: Kimra McAfee and Bella Kurtz, Alpine Watershed Group

From: Waterways Consulting, Inc.

Date: February 24, 2026

Re: Estimating Sediment Pollutant Load Reductions for Prioritized Restoration Projects in the West Fork Carson River Watershed

This memorandum documents the methodology used to estimate pollutant (fine sediment) load reductions for the 10 highest-priority restoration projects identified in the West Fork Carson River (WFCR) Geomorphologic Model and Prioritization Plan report (the "Report") (Waterways, 2026). These estimates were developed to support potential implementation funding through the U.S. Environmental Protection Agency (USEPA) Section 319 Nonpoint Source Program.

USEPA's Pollutant Load Estimation Tool (PLET) (USEPA, 2012) is a widely used and effective screening-level tool for estimating pollutant load reductions associated with conventional nonpoint source best management practices (BMPs), particularly those related to upland land-use changes such as road improvements, agricultural practices, urban stormwater controls, and erosion control measures. PLET estimates load reductions by applying empirically derived coefficients and BMP effectiveness factors to changes in land use or management practices. Although engineered streambank stabilization *is* included, PLET does not explicitly represent geomorphic or process-based restoration mechanisms that reduce erosion through channel aggradation, floodplain reconnection, construction of beaver dam analogs (BDAs), large wood placement, willow planting, or other in-stream restoration techniques recommended in the Report. Because the proposed projects in the WFCR watershed are designed to alter sediment generation and storage processes within the channel–floodplain system rather than modify upland land uses, PLET does not adequately characterize their sediment reduction benefits. Therefore, an alternative, process-based approach grounded in the watershed sediment budget was applied in this case.

For the projects recommended by the WFCR Prioritization Plan, pollutant load reductions were estimated using the sediment budget framework developed in Section 2 of the Report. That analysis identified streambank erosion and floodplain deposition as the dominant, management-relevant components of the fine sediment budget in the upper West Fork Carson River that could be affected by in-stream restoration actions. For each prioritized project area, existing fine sediment contributions from streambank erosion and existing rates of floodplain sediment deposition were estimated using the methods described in the Report. Baseline bank erosion rates were spatially delineated to each of the proposed project footprints using mapped bank erosion severity estimates, calibrated with air photo estimates of historical channel change (Section 2.3.2). The existing floodplain sedimentation rates for individual project areas were estimated by multiplying the floodplain inundation area (defined as the 2-year inundation boundary within the project extent, minus the area of channel) by the estimated vertical accretion rate based on the sediment budget (0.007 ft/yr), as explained in Section 2.3.3.

Project-related pollutant load reductions were estimated by applying reasonable, conservative effectiveness assumptions to baseline sediment conditions. Specifically, each project was assumed to (1) reduce existing streambank erosion by a selected percentage (typically 25, 50, or 75 percent) through reduced bank height, reduced near-bank shear stress, and increased flow dispersion, and/or (2) increase floodplain sediment storage by a selected percentage (typically 10, 20, or 30 percent) by increasing the frequency and extent of overbank flooding and sediment deposition. For each of the prioritized projects, a "reasonable" effectiveness value was selected based on project type, scale, geomorphic setting, consistency with published literature, and professional judgment[1]. For most projects, it is estimated that the proposed work could reduce bank erosion of selected reaches by 25 to 50 percent and increase floodplain sedimentation by about 10 to 20 percent. The resulting estimated annual fine sediment load reductions for the remaining top-ranked projects are summarized in **Table 1**, which presents baseline sediment contributions, assumed percentage changes, and resulting pollutant load reductions (expressed in tons per year and as a percentage of the estimated fine sediment flux exiting the basin).

The estimated sediment load reductions in **Table 1** are necessarily approximate, but they are based on site-specific rates of streambank erosion and floodplain sedimentation derived from field observations, hydraulic modeling, and the basin-scale sediment budget documented in the report. While the EPA PLET is an appropriate tool for many restoration practices, it is not designed to represent process-based geomorphic actions such as BDAs, large wood placement, and floodplain reconnection; for this set of potential project types, a sediment-budget–based approach provides a more applicable and transparent alternative.

References

U.S. Environmental Protection Agency (EPA). 2012. Pollutant Load Estimation Tool (PLET) – Technical Documentation and User's Manual. Office of Water. EPA 841-B-12-002. https://www.epa.gov/nps/pollutant-load-estimation-tool

Waterways Consulting, Inc. (Waterways). 2026. West Fork Carson Prioritization Project: Geomorphological Model, Project Identification and Prioritization. Draft Report for Alpine Watershed Group, February 2026.

[1] This approach could not be applied to Project #15 (basin-wide headcut stabilization), which is preventative in nature and intended to reduce the risk of future sediment generation rather than mitigate currently occurring pollutant loads.

Table 1. *Estimated Pollutant Load (Fine Sediment) Reduction for Proposed Projects in West Fork Carson River Basin*

				Existing Conditions Fine Sediment Contribution Estimates		Sediment Reductions from Bank Erosion for Different Effectiveness Factors[1]			Sediment Reductions from Increased Floodplain Deposition[1]			Predicted Sediment Reduction from Project	
Priority Ranking	Project #	Project Name	River Miles Treated	Estimated Bank Erosion	Estimated Floodplain Deposition	Reduce Bank Erosion by 25%	Reduce Bank Erosion by 50%	Reduce Bank Erosion by 75%	Increase Vertical Accretion Rate by 10%	Increase Vertical Accretion Rate by 20%	Increase Vertical Accretion Rate by 30%	Annual Fine Sediment Reduction[2]	Sediment Reduction as a Function of Total Basin Export[3]
				(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	percent
1	12	Red Lake Creek Lower Meadow Restoration	1.3	345	174	86	**173**	259	17	**35**	52	207	4%
2	11	Willow Creek Beaver Restoration	1.7	207	75	52	**103**	155	**8**	15	23	111	2%
3	15	Basinwide Headcut Repairs	-										
4	5	Lower Hope Valley Restoration	1.8	696	627	174	**348**	522	63	**125**	188	473	9%
5	6	Middle Hope Valley Restoration	1.1	1,265	395	316	**633**	949	**40**	79	119	672	13%
6	13	Red Lake Creek Upper Meadows Restoration	1.1	148	49	37	**74**	111	**5**	10	15	79	2%
7	10	Upper Faith Valley Floodplain Reconnection	0.35	220	74	**55**	110	165	7	**15**	22	70	1%
8	8	Blue Lakes Road Restoration	0.9	50	42	12	**25**	37	**4**	8	13	29	0.6%
9	9	Faith Valley Campground Restoration	0.9	164	30	41	82	**123**	**3**	6	9	126	3%
10	7	Upper Hope Valley Restoration	1.7	870	323	**218**	435	653	**32**	65	97	250	5%

Notes:

1. Highlighted cells identify the sediment reduction based on the most likely effectiveness value selected based on professional judgement and knowledge of the proposed project conditions.
2. Sediment reduction estimated by summing the reduced bank erosion and the increased floodplain sedimentation for each project.
3. Estimated fine sediment reduction for the project divided by the total fine sediment yield from the watershed (5,000 tons/yr).