THE TRINITY RIVER RESTORATION PROGRAM

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Abstract

The Trinity River is located in far northern California and is the largest tributary to the Klamath River. Trinity Dam was constructed in 1964 by the U.S. Bureau of Reclamation as part of the Central Valley Project to enhance water supply in the Sacramento River Basin through an out-of-basin transfer from the Trinity River. Up to 90 percent of the average annual water yield of the Trinity River has been diverted since construction of Trinity Dam. Flow regulation and the downstream sediment deficit caused by dam operations has created significant changes in the downstream fluvial geomorphology and temperature regime, causing a 50 to 90 percent decline in salmonid populations.

The Trinity River Restoration Program is legally mandated to restore and maintain the natural production of salmon and steelhead on the Trinity River. Through nearly two decades of scientific study it was recognized that the fishery restoration is dependant on restoring the attributes of a natural alluvial river. The restoration strategy does not strive to recreate pre-dam conditions; rather, to create a smaller, dynamic alluvial channel exhibiting all the characteristics of the pre-dam river but at a smaller scale. This strategy is intended to best achieve the restoration goals and maintain the purpose and use of the Trinity Dam water supply diversion project. The Record of Decision (Department of Interior, 2000) outlines the restoration plan and includes:

- Flow management to restore geomorphic and riparian processes
- Flow management for temperature and habitat
- Channel and watershed rehabilitation
- Fine and coarse sediment management
- Adaptive environmental assessment and management

Adaptive management requires evaluation of ecosystem response and predictive modeling on an annual time scale to inform annual management decisions. The scientific challenge is to link management actions (flow releases, bank rehabilitation projects, coarse sediment augmentation) to geomorphic and riparian processes, and ultimately link to improved salmonid habitat, habitat utilization, and increasing salmonid population levels.

INTRODUCTION

The objective of this paper is to invite independent researchers interested in sediment transport, sediment monitoring technologies, and/or fluvial geomorphology to contact the author to investigate potential collaborations. A brief overview of the Trinity River Restoration Program (TRRP) is given with special emphasis on project implementation, sediment transport and geomorphology. Available datasets and current research effort are described.

RESTORATION PROGRAM OVERVIEW

The goal of Trinity River Restoration Program is to restore and maintain the natural production of salmon and steelhead on the Trinity River. The Trinity River Flow Evaluation Study (U.S. Fish and Wildlife Service *et. al.* 1999) documents the scientific justification of behind the basic restoration premise that restoring dynamic alluvial river processes will build and maintain the habitat needed to recover the salmonid populations. The primary management actions to accomplish the restoration (flow releases from Lewiston Dam up to 11,000 cfs, mechanical rehabilitation of 14 bank miles, coarse sediment augmentation, and watershed restoration) are structured around restoring dynamic alluvial river processes to create a "healthy alluvial river" that is define by the by U.S. Fish and Wildlife Service *et. al.* (1999) as possessing the following ten attributes:

1. Spatially complex morphology and habitat
2. Variable flow and temperature regime
3. Frequent mobilization of channel bed
4. Periodic scour and redeposition of coarse sediments
5. Balanced sediment budget (fine and coarse)
6. Periodic channel migration
7. Frequently inundated floodplain
8. Infrequent large floods to re-organize channel and riparian vegetation
9. Self-sustaining and diverse riparian vegetation
10. River often connects with adjacent water table

Most of the 10 attributes of an alluvial river and all of the high flow objectives are related directly or indirectly to sediment transport and deposition. Therefore, understanding the causal mechanisms between flow, sediment transport, fluvial geomorphology, and habitat are critical to effectively manage and evaluate the restoration program. The basic questions for the physical sciences to answer then become:

A. Has the coarse sediment deficit been eliminated, and full coarse sediment routing been achieved?
B. Has fine sediment supply and in-channel storage been reduced?

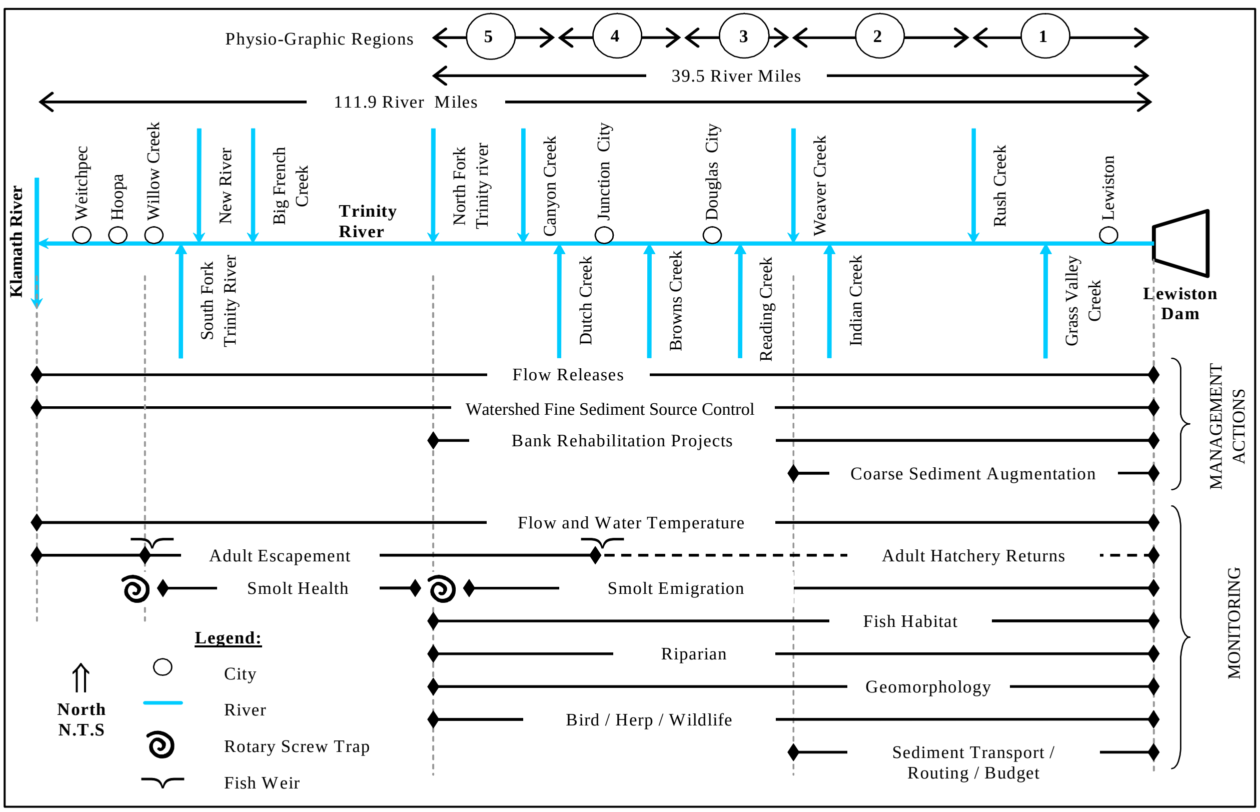
Coarse sediment provides the basic building blocks of the alternate bars and riffle sequences that create the physical habitat for salmonid spawning, rearing, and adult holding. Coarse sediment transport is the process that creates the alternate bar sequences and induces meander formation creating the complex channel morphology desired. Coarse sediment transport also effects substrate quality and riparian scour. Consequently, maintaining an adequate supply of coarse sediment and providing full coarse sediment routing (i.e. coarse sediment transport) through all river reaches is fundamental for successful restoration. Recognizing the importance of coarse sediment routing, the peak and duration of the Record of Decision (Department of Interior, 2000) flow recommendations were explicitly designed to prevent formation of large deltas at the mouth of Rush Creek and Indian Creek. Currently, both of these deltas form a large upstream backwater pool that prevents coarse sediment routing.

Fine sediment is primarily of interest because it's influence on habitat quality. The high fine sediment content of the channel bed reduces the quality and availability of spawning and rearing habitat by filling the interstitial spaces between the gravels. To appreciate the importance of this question, realize that to date, roughly $70 million (inflation adjusted) has been spent in Grass Valley Creek alone trying to control tributary input of fine sediment (predominately decomposed granite) to the Trinity River. Fine sediment also plays important roles for riparian establishment (especially on the floodplain) and can influence the rate of coarse sediment transport.

SEDIMENT MONITORING AND RESEARCH PROGRAM

Figure 1 shows the overall spatial extents of the restoration management actions and associated monitoring and evaluation. As can be seen in Figure 1, the focal area of sediment transport monitoring and evaluation overlaps with the coarse sediment deficit that extends from Lewiston Dam down to Weaver Creek (approximately 18.5 miles).

Figure 1: Spatial Scale of Restoration Management Actions and Associated Monitoring and Evaluation Program



Wilcock (2004) subdivided the reach between Lewiston Dam and Weaver Creek into 4 sediment budget cells (as shown in Figure 2). A sediment budget for each cell will be computed annually to:

- Determine if the restoration management actions described in Table 1 were met
- Set coarse and fine sediment transport objectives for the annual flow releases and determine if they were met
- Determine the annual volumes for coarse sediment augmentation (ranging up to 67,000 cubic yards annually)
- Answer questions A and B above.

Table 2 lists many of the data sets that are being collected to evaluate the sediment budget and geomorphic changes of the Trinity River and support a variety of one and two dimensional sediment transport, sediment scour, bar growth, and meander migration computer models.

Figure 2: Sediment Budget Cells for the Trinity River

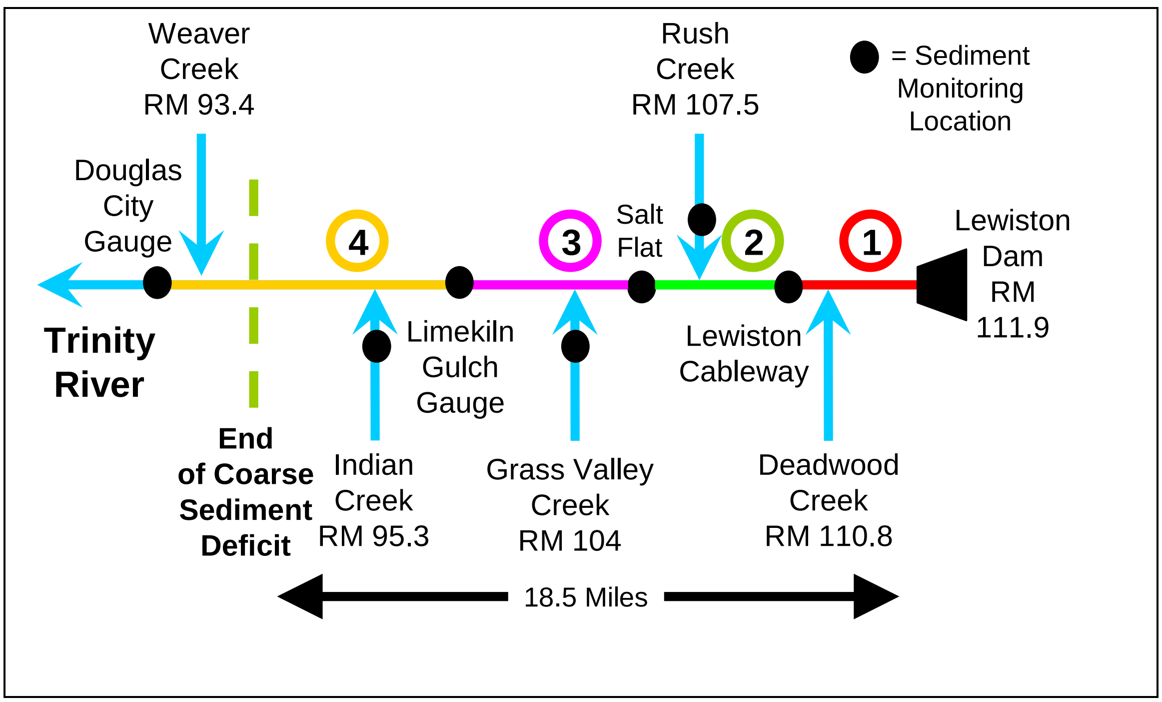


Table 1: Restoration Management Actions for each Sediment Budget Cell

Sediment Budget Cell	**Management Objective**	**Management Actions**
Cell 1: Lewiston Dam	Eliminate Coarse Sediment Deficit	• Short-term Coarse Sediment Augmentation • Long-term Coarse Sediment Augmentation
	Coarse Sediment Routing	• High Flow Releases
Cell 2: Rush Creek	Eliminate Coarse Sediment Deficit	• Short-term Coarse Sediment Augmentation
	Coarse Sediment Routing	• High Flow Releases • Rush Creek Delta Modification • Watershed Restoration • Consider Tributary Sediment Trap
Cell 3: Grass Valley Creek	Reduce Fine Bed Material Load	• Watershed Restoration • Tributary Sediment Traps • High Flow Releases
	Eliminate Coarse Sediment Deficit	• Short-term Coarse Sediment Augmentation
	Coarse Sediment Routing	• High Flow Releases
Cell 4: Indian Creek	Reduce Fine Bed Material Load	• Watershed Restoration • ROD Flows • Tributary Sediment Trap
	Coarse Sediment Routing	• High Flow Releases • Indian Creek Delta Modification

Table 2: Data Holdings

Data Type	**Data Set**
Streamflow	Fifteen active real-time USGS streamgages
Sediment Transport	Synoptic suspended sediment and bedload data is collected concurrently at 4 mainstem locations (see Figure 2) for the annual high flow releases and at three tributary locations for winter storms. Turbidity is collected at all sediment monitoring locations and acoustical bedload probes are being beta tested at all four mainstem sites.
Sediment Storage	Terrestrial and bathymetric topography. Bathymetric topography has been collected using both acoustical methods and bathymetric LIDAR.
Geomorphology	High resolution aerial photography, detailed geomorphic and substrate mapping, cross-sections, tracer rock sets, scour cores, bulk sediment samples.
Riparian	Riparian transects and mapping

CONCLUSION

The Trinity River offers a unique opportunity to the study the sediment, fluvial geomorphic, and habitat responses to the implementation of large scale restoration actions including dam re-operation, bank rehabilitation, coarse sediment augmentation, etc.

REFERENCES

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