Upper Truckee River Restoration Strategy

View of the Upper Truckee River Watershed

Draft
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Draft Report

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A comprehensive set of acknowledgements will be determined and described in the final draft of this Strategy document.

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Cover photo courtesy of: Swanson Hydrology and Geomorphology

Note to Readers and Review Panel Members – Document Structure

Sections 1-3 of this document are provided as background information only, and will not be the focus of the Upper Truckee River (UTR) Restoration Workshop.

Sections 4-7 comprise the UTR Restoration Strategy (Strategy) which will be the focus of the May 2013 UTR Restoration Workshop. The Upper Truckee River Watershed Advisory Group (UTRWAG) seeks panel member review and input on the Strategy.

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List of Acronyms and Terms

Basin – Lake Tahoe Basin
BLM – United States Bureau of Land Management
BMI – Benthic Macroinvertebrates
BMP – Best Management Practice
CADPR – California Department of Parks and Recreation
CDFW – California Department of Fish and Wildlife
CEQA – California Environmental Quality Act
City – City of South Lake Tahoe
Compact – Tahoe Regional Planning Compact
Conservancy – California Tahoe Conservancy
CWA – Clean Water Act
DWR – California Department of Water Resources
EA – Environmental Assessment
EIP – Environmental Improvement Program
EIR – Environmental Impact Report
EIS – Environmental Impact Statement
FONSI – Finding of No Significant Impact
EPA – Environmental Protection Agency
FSP – Fine Sediment Particle
Framework – 2nd Nature's Riparian Ecosystem Restoration Effectiveness Framework
GHG – Greenhouse gases
Guidelines – Upper Truckee River Watershed Advisory Group Guidelines
IS – Initial Study
Lahontan – Lahontan Regional Water Quality Control Board
LCT – Lahontan Cutthroat Trout
LTBMU – United States Forest Service, Lake Tahoe Basin Management Unit
LTGC – Lake Tahoe Golf Course
LTIMP – Lake Tahoe Interagency Monitoring Program
LTRA – Lake Tahoe Restoration Act
LTWA – Lake Tahoe Watershed Assessment
MND – Mitigated Negative Declaration
MOU – Memorandum of Understanding
ND – Negative Declaration
NEPA – National Environmental Policy Act
NPDES – National Pollution Discharge Elimination System
Reclamation – United States Bureau of Reclamation
RPU – Regional Plan Update
SEZ – Stream Environment Zone
SNPLMA – Southern Nevada Public Land Management Act
SLRT – Stream Load Reduction Tool
SS – Suspended Sediment
STPUD – South Tahoe Public Utilities District
SWAMP – Surface Water Ambient Monitoring Program
TERC – Tahoe Environmental Research Center
TMDL – Total Maximum Daily Load
TP – Total Phosphorus
TRCD – Tahoe Resource Conservation District
TRPA –Tahoe Regional Planning Agency
TSC – Tahoe Science Consortium
TSS – Total Suspended Solids

USACE – United States Army Corps of Engineers
USFS – United States Forest Service
USFWS – United States Fish and Wildlife Service
USGS – United States Geologic Survey
UTM – Upper Truckee Marsh
UTR – Upper Truckee River
UTRAMG – Upper Truckee River Adaptive Management Group
UTRFG – Upper Truckee River Focus Group
UTRWAG – Upper Truckee River Watershed Advisory Group
µm - microgram

Section 1: Introduction

1.1 Significance of the Upper Truckee River Watershed

The Upper Truckee River (UTR) watershed, located in Alpine and El Dorado Counties, California, is the largest watershed of Lake Tahoe, draining 56.5 square miles or 18% of the total land area of the Lake Tahoe Basin (Figure 1). Lake Tahoe is the largest alpine lake in North America, and the second deepest lake in the United States. It is widely known for its outstanding water clarity, which was measured at over 100 feet in 1968 (TERC 2012). Running 21.4 miles from its headwaters at Red Lake Peak (elevation 10,063 feet above sea level) to lake level (elevation 6,223 feet above sea level at the natural rim), the UTR is the longest watercourse in the basin. This watershed has been identified as a major source of fine sediment and nutrients flowing into Lake Tahoe, due in large part to the significant amount of urbanized land within the watershed and direct channel manipulations (Simon et al. 2003). The UTR watershed is also significant and unique because of the expansive and valuable meadow habitat areas that are especially prevalent in the lower watershed and at the river mouth. Since the 1900s, 75% of the marshlands and 50% of the meadowlands in the Basin have been lost to development (TRPA 1987). A striking example of basin land cover change over the last century is the shift in the ratio of wetland area to developed area between 1940 and 2002, from 23.1:1 to 1:1.2 (Raumann and Cablk 2008). The relative proportion of wetlands and meadows is important because these areas provide for a number of ecosystem services including flood attenuation, wildlife habitat diversity, groundwater recharge, water filtration, and aesthetic and recreational values (TRPA 2012). Agencies have targeted the UTR watershed for restoration for over 20 years given these well-documented resource impairments and the opportunities to improve watershed conditions. This Upper Truckee River Restoration Strategy (Strategy) provides the background, approach, and framework for the coordinated interagency effort to restore the condition and functionality of the UTR watershed.

1.2 Summary of Development History and Impacts to Watershed

In 2004, Swanson Hydrology and Geomorphology provided a detailed history of impacts to the UTR watershed in the Upper Truckee River Environmental Assessment, summarized below:

The UTR watershed has been modified from its natural conditions since its earliest discovery to the present day. Human activities such as logging, livestock grazing, gravel mining, fire suppression, and modern development (roads, golf courses, airport, residential, commercial, and industrial developments) have directly and indirectly impacted the watershed. Human land use in the Lake Tahoe Basin first began with the Washoe Indian Tribe. Major changes in land use later occurred with the discovery of the Comstock Lode in Virginia City, Nevada from 1860-1890. Trees in the Lake Tahoe Basin, including those in the Upper Truckee River watershed, were harvested to provide shoring timbers for the Comstock mines. Road development began and meadows were grazed extensively throughout the watershed.

The Comstock era began to decline during the late 1800s and was followed by a period of relatively little development between 1900 and 1950. In the 1950s, an expanding tourism economy began to take hold, including an increasing amount of year-round and summer vacation populations. Winter tourism expanded greatly following the Winter Olympics of 1960 at Squaw Valley, and Lake Tahoe became a world-renowned vacation destination. The UTR was a major focus of this change, as much of the surrounding valley floor, floodplains, and meadows were converted to accommodate an airport, golf courses, subdivisions, and supporting infrastructure (e.g. bridges, sewer lines, roads). This rapid development in the watershed began to take a toll on the ecosystem of the river and floodplain.

The dramatic environmental changes that have occurred over the past 150 years resulted in obvious physical changes to the UTR and its watershed: channels were straightened, natural floodplains were filled for roads and other infrastructure development, bridges and buildings were constructed, and marshes were converted to grazing meadows and golf courses. Perhaps the most significant impact was an underlying change to the natural processes that had formed and sustained the natural ecosystem and held the geologic landscape in equilibrium and relative stability over thousands of years. A primary example was the upset of the delicate hydrologic and geomorphic balance of the UTR, a balance that dictates the dimensions and form of the stream channel and floodplain. This balance was substantially changed by channel straightening, which led to the incision or lowering of the streambed, lowering of the groundwater table, drying of floodplain areas, conversion of riparian vegetation to less erosion-resistant species, and narrowing of the riparian corridor.

The alteration to the geomorphic processes and functions of the UTR led to degradation of aquatic and terrestrial habitat: meadow vegetation is decadent and struggling, conifers have encroached on the floodplain, riparian cover has been reduced, substrate has simplified, and pools and riffles are poorly developed.

Lake Tahoe is famed for its clear waters; however, lake clarity has been declining ever since clarity measurements began in 1968. The observed decline in lake transparency is a result of light scattering from fine sediment particles and light absorption from phytoplankton. Current research shows that fine sediment particles are the primary concern. They are responsible for around two-thirds of the total clarity condition (CRWQCB and NDEP 2010). The UTR contributes fine sediment loading to the lake due to accelerated bank erosion and unstable channel conditions caused by decades of watershed and direct channel disturbances. In addition, the natural filtering floodplains of the UTR are no longer highly functional for retaining fine sediment, as flood flows rarely inundate the floodplain. The loss of floodplain connectivity impacts the ability of the UTR to reduce fine sediment loads that originate from all upstream sources, including the highly important urban stormwater source. The UTR watershed is the largest sediment contributor to the lake, discharging approximately 2,200 tonnes per year (T/y) of suspended sediment and 1,010 T/y of fine sediment (Simon et al. 2003).

1.3 Summary of Restoration Activities

Agencies in the Lake Tahoe Basin have embarked on an extensive plan to restore natural processes and functions on the UTR. Restoration project planning was initiated in the 1980s as key property acquisitions of the floodplain began. The California Tahoe Conservancy (Conservancy), United States Forest Service, Lake Tahoe Basin Management Unit (LTBMU), California Department of Parks and Recreation (CADPR), and City of South Lake Tahoe (City) are the project proponents leading the effort to restore the UTR. Additional stakeholders, including funding agencies, regulatory agencies, local jurisdictions, non-profits, and the public also regularly engage in this restoration effort. The UTR restoration approach is based on the re-establishment of natural geomorphic processes and functions, with the fundamental tenet of the designs being restoration of channel characteristics that are representative of the geologic, geomorphic, and climatic setting. The projects are intended to create natural planforms, slopes, and capacities within the specific constraints of each project area. Benefits to ecology, hydrology, geomorphology, and water quality in the watershed are anticipated to result from project improvements, which in turn will provide much needed advancement towards regional environmental goals and thresholds. Numerous projects, led primarily by the public land owners of specific project reaches, are in various project phases, from conceptual planning to post-project monitoring.

This Strategy provides details of past land use impacts to the watershed, the management and restoration framework, development of goals and objectives, approach and process, monitoring, public participation, the specific projects, and the program’s financing strategy.

Section 2: Assessment Efforts

2.1 Watershed Assessments

Three watershed condition assessments provide detailed, scientifically rigorous accounts of historic conditions and processes, the impacts of human activities on those conditions and processes over time, and the ramifications of those impacts:

- Lake Tahoe Watershed Assessment (Murphy and Knopp 2000)
- Upper Truckee River Environmental Assessment (Swanson Hydrology and Geomorphology 2004)
- Upper Truckee River Restoration Project Riparian Ecosystem Feasibility Report (River Run Consulting 2006)

Information from these assessments is summarized in the following sections.

2.2 Watershed Description

The UTR watershed is broken into the following areas as shown in Figure 1:

- Upper Watershed
- Christmas Valley
- Meyers Area
- Sunset Stables (Sunset Ranch)/Lake Tahoe Airport
- Upper Truckee Marsh - Lake Tahoe Boulevard to Tahoe Keys

Upper Watershed
From its headwaters, the UTR flows north through relatively pristine and undeveloped terrain consisting of lakes, meadows, and forests. With generally steep slopes, the UTR cascades in multiple waterfalls over bedrock and large boulders to the head of Christmas Valley. The upper watershed is almost exclusively owned and managed by the United States Forest Service – Lake Tahoe Basin Management Unit (LTBMU) and is characterized by very limited development. Only one public road, State Route 89, is open for vehicular access in the upper watershed. Current land use in this area is recreational, consisting of foot trails, equestrian access, and some designated mountain bike trails.

Christmas Valley
The floor of Christmas Valley is relatively flat and bounded by walls on the east and west that rise steeply over 1,000 feet. Coniferous forest dominates the area but is interspersed with meadows and aspen groves along tributary streams and springs. The UTR flows down the middle of the geologically incised corridor of the valley for six miles as deep, boulder-lined reaches separate wider, alluvial floodplain areas to the U.S. Highway 50 (Highway 50) crossing in Meyers. Development on the valley floor started in the 1960s, occurring mostly as residential housing and summer cabins on city-sized lots on a grid of numerous, all-season roads. Today,

land ownership in Christmas Valley is a mix of private residential and ranch lands and State and LTBMU holdings.

Meyers Area

Downstream of Christmas Valley is the Meyers Area, situated between the Meyers and Elks Club Highway 50 crossings. At Highway 50 in Meyers, the UTR changes abruptly from a confined, boulder-lined, geologically-incised channel to a wider, alluvial river/floodplain corridor free of boulders and bedrock and contained within the wider floor of the valley. In this reach, the UTR flows within a 100 to 200-foot-wide, recently formed channel/floodplain system bounded by low terraces of recently abandoned floodplain and high terraces of ancient ice age glacial outwash. It then courses through a narrow band of mixed conifer and riparian forest, past the reclaimed gravel pits of Lake Baron and through Washoe Meadows State Park before emerging into a reach bounded by a former large meadow that is now the Lake Tahoe Golf Course (LTGC).

At the downstream end of LTGC, Angora Creek flows into the UTR; it drains a 5.9-square-mile watershed originating at Angora Lakes and flows through residential neighborhoods, large meadows, and the LTGC. The State of California, via the California Department of Parks and Recreation (CADPR), owns most of the Meyers Area of the UTR. In addition to LTGC and Highway 50, the adjacent uplands are residentially developed.

Lowland areas on and adjacent to the UTR floodplain, particularly those encompassed by the Meyers and South Lake Tahoe communities, have been extensively developed. Ownership in the uplands is a mix of private residential, commercial, and public open space, and floodplain ownership is mostly public.

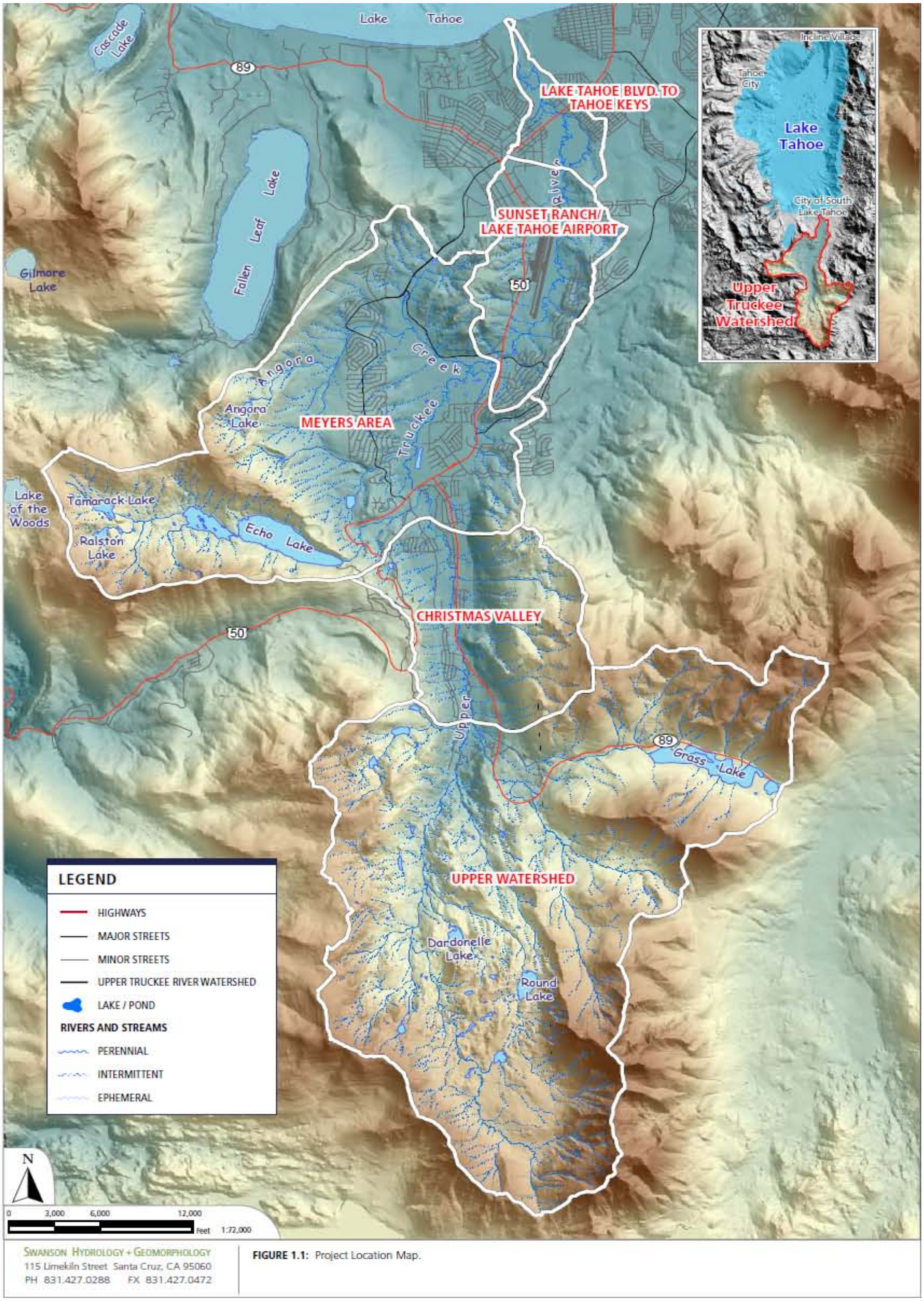
Sunset Stables (Referred to as Sunset Ranch in Figure 1) – Lake Tahoe Airport

Below the Elk's Club Highway 50 crossing, the UTR flows next to the Lake Tahoe Airport and through broad meadows surrounded by urbanized land. A significant portion of the lower reaches was channelized to accommodate grazing and the construction of the Lake Tahoe Airport.
Both public and private entities are responsible for significant floodplain encroachments, including the South Lake Tahoe Airport and residential development. Ownership in the uplands is a mix of private residential, commercial, and public open space, and floodplain ownership is mostly public with one significant private in-holding remaining.

Upper Truckee Marsh – Lake Tahoe Boulevard to Tahoe Keys

North of Highway 50 in South Lake Tahoe, the UTR enters its lowermost reach, the Upper Truckee Marsh. Here, the UTR changes from an alluvial to a deltaic environment in which the meandering planform changes to more of a dendritic pattern. Just prior to discharging into Lake Tahoe, another large tributary, Trout Creek, joins the UTR from the east. The reach below the confluence with Trout Creek is characterized by very low slopes and historically dispersed flows and undefined channels. The development of the Tahoe Keys in the 1950s filled a significant portion of the marsh and divided the marsh into two distinct, hydrologically separated areas. The development also constructed a straightened channelized river and dredged the mouth to facilitate access into the marina. The current marsh comprises only 592 of the historic 1,300 acres.

Figure 1: UTR Watershed Map



2.3 Geologic History and Context

In order to understand the impacts to ecosystem function, it is important to understand recent geologic history, land use changes and their effect on ecosystems, and the hydrologic and geomorphic processes that create and sustain the ecological habitat. The UTR's river form and process prior to the introduction of non-native land use in the 1860s resulted from geologic forces and recent climatic history in which native vegetation and wildlife communities evolved and adapted to the environment of the late Holocene Epoch (past 10,000 years). This epoch followed the end of the last glacial period of 26,000 to 18,000 years before the present.

Historically, the UTR was subjected to a dynamic sequence of rising and falling lake levels, changing the base level of the UTR and the position of deltaic formation. Dramatic increases in sediment supply and stream flow during glacial periods were followed by drier interglacial periods, similar to present day conditions. Glacial outwash terraces, composed of large lag boulders, sand, and gravel deposits, form the terraces along the floor of Christmas Valley extending into Meyers. These outwash terraces merge into deltaic deposits in Meyers, which appear related to the 90-foot-high lake stand of the Tahoe glacial period 60,000 to 90,000 years before the present. The boulders lining the bed of the UTR in many reaches of Christmas Valley may be the remnants of the early glaciations, and these end abruptly at the Meyers Highway 50 crossing.

Older outwash deposits are found along the hills east of the Lake Tahoe Airport and west of the Lake Tahoe Golf Course. Examination of aerial photographs and alluvial deposits along the UTR show evidence of the development of the modern, pre-disturbance UTR. An investigation of pollen from Osgood Pond (Cushing and Wright 1967), located just off Highway 50 near the Meyers Highway 50 crossing, recorded a sequence of climatic change and vegetative response in which the UTR gradually dried up starting 10,000 years ago, then went through a warm and dry period 5,000 to 8,000 years ago. The present interglacial period became slightly colder over the past 3,000 years, though temperatures have remained fairly steady. The modern river form was shaped in the past 10,000 years, as sediment supply and flow to the UTR from the watershed were greatly reduced.

In general, the pre-disturbance UTR was down-cutting through the glacial outwash deposits, forming a meander belt and floodplain, riparian, and wetland zones. There is evidence of past small lakes and ponds that have become meadows within the modern floodplain. The UTR reworked and transported the materials in the outwash terraces and incised a narrow river corridor. Today, there are places where erosion of the glacial outwash terraces continues. Although the UTR is geologically constrained, it is slowly eroding through older outwash deposits.

Additional background information related to the geologic and glacial history is provided in Appendix 1.

2.4 History of European Land Use

Aerial photos in conjunction with topography data have documented changes to the river over time. The earliest aerial photograph available of the UTR is from 1940, 80 years after the introduction of intensive European land use. The image shows the river system already affected by grazing, reclamation, logging, roads, and bridges. A comparison of aerial imagery from 1940 to 2002 was conducted by the Desert Research Institute and U.S. Geological Survey in 2005 along the UTR and Trout Creek. Many historic land use impacts are identified in this study, including those described below, in addition to gravel mining just downstream of the Highway 50 crossing in Meyers and the resulting extensive bar deposits downstream (Adams and Rowe 2005).

Grazing in the UTR watershed may have started as early as the 1840s and continued into the 2000s. Sheep and cattle were both present on the landscape at different periods. The onset of the Comstock Mining Boom to the east in Virginia City in 1860 led to the development of roads through the UTR watershed to Sacramento and San Francisco. This resulted in the creation of toll houses along the way and the need for dairy and cattle products. The meadows along the UTR were ideal for grazing, and strategies to control snowmelt runoff by increasing channel depth allowed for earlier seasonal grazing entry to meadows. Furthermore, construction of river diversions enabled late season irrigation, extending meadow productivity into late summer. These practices are clearly visible on the 1940 and 1952 aerial photos throughout the lowland valley of the UTR.

Logging in the UTR watershed created roads and soil disturbance that likely increased sediment supply to the river and to Lake Tahoe. Intensive logging was confined to the area surrounding the UTR corridor below the Meyers Highway 50 crossing; this included clear cutting and hauling. Historical accounts and the extensive stands of old growth Jeffrey Pine, red fir, and white fir indicate that Christmas Valley and the Upper Watershed were not logged extensively. Shirley Taylor (2003) reports that her ancestors rejected a proposal to extend a rail line into the Christmas Valley for increased logging access.

The Johnson Meadows Reach, just upstream of Highway 50 in South Lake Tahoe, appears to have had direct channel manipulations that date back to the turn of the 20th century or earlier. This reach had a new channel constructed, sometime prior to 1940, along the eastern edge of the floodplain against the terrace. The new channel was likely built to facilitate grazing by drying the meadow earlier in the season and extending the season with irrigation infrastructure. The impact of these manipulations was exacerbated when the 1997 flood event fully captured a historic irrigation ditch and eroded a large gully that now carries at least half of the flow of the UTR through this reach. The original channel representing the historic condition is mostly still intact and can be seen in the meadow today. This historic channel exhibits a much larger sinuosity than is currently seen anywhere on the river.

The history of Lake Tahoe suggests that lake clarity was not seriously affected by, or perhaps was able to recover from, Comstock Era logging and grazing. In terms of impacts to basin watersheds, the period between the end of the Comstock boom (late 1800s) and the 1950s was relatively quiet, with the unique exception of the introduction of beaver in the 1930s. Although the landscape changed forever after the Comstock Era, the Lake Tahoe and its surrounding ecosystems appear to have been fairly resilient to the effects of resource use and extraction.

The expansion of tourism in the 1950s led to the development of summer homes and cabins in the South Shore and Meyers Areas surrounding the UTR. The Tahoe Paradise development in Meyers included residential subdivisions of moderate density, modeled after city suburban developments that had expanded in the post-World War II boom. This style of development resulted in many roads crossing the landscape, including roads across steep terrain.

The construction of roads has profoundly affected the UTR watershed. Roads are the primary cause of disturbance here and in other watersheds, since their construction involves soil disturbance, erosion, and groundwater and surface flow path interception. Modification of drainage patterns and localized hydraulic effects at road crossings that were often fill and culvert structures caused significant hydrologic and ecologic disruption. Road crossings often sever the continuity of stream flow and the riparian vegetation corridor and form barriers to the migration of aquatic wildlife. Roads are a component of urban hardscape that generate more runoff than the natural landscape. Finally, roads provide access to undeveloped areas and lead to construction of more structures and greater hydrologic modification.

Urban development in the UTR watershed required the expansion of infrastructure, such as highways, sewer and utility systems, and dense commercial development. The Highway 50 corridor includes a commercial strip of gas stations, restaurants, stores, and other businesses. The emphasis on recreational uses has led to the construction of two golf courses, the Tahoe Paradise Golf Course in Meyers and the LTGC. The LTGC had a particularly significant impact on the UTR as entire meanders were cut off and the channel straightened, leading to incision; the disconnected floodplain was developed into the golf course. Golf course bridges were installed that restricted flows and caused hydraulic imbalances that further exacerbated channel bed and bank instability.

Further down the river, around the former Sunset Stables property, the Lake Tahoe Airport was constructed on a significant portion of the UTR floodplain in the 1950s. Large volumes of fill were placed in the meadow to construct the runway. Although this significantly impacted the UTR system by increasing coverage and reducing floodplain area, there were no direct manipulations to the river. However, in the early 1960s, the runway was expanded to increase the capability of the airport. To facilitate this expansion, the UTR was moved to the eastern edge of the floodplain against the terrace. The UTR was channelized and oversized with rip rap banks, and although the rip rap banks remained relatively stable, habitat was greatly impaired.

At the mouth of the UTR, a large residential development called the Tahoe Keys was constructed in the 1950s and 1960s. This development bifurcated the Upper Truckee Marsh (UTM) into two separate hydrologic features, and the marsh was filled extensively to construct residential homes, a network of canals, and a marina to create boat access to the lake. The UTR was placed in a straightened, oversized channel. Additionally, the mouth of the river at the barrier beach was dredged and deepened, greatly altering the hydrologic relationship between the lake and the UTR. These uses and impacts have, directly and indirectly, led to significant physical changes to the UTR and tributary streams, and perhaps more importantly, the introduction of invasive species and new pollutant sources of sediment, nutrients, and urban toxins, such as hydrocarbons and heavy metals.

2.5 Fluvial Geomorphology Impairments

Fluvial geomorphology is the examination of the physical form and processes of a river system. Here, elements of river form will be defined in order to describe the original UTR system and changes associated with land use.

Channel morphology refers to the geometric characteristics of the channel and the pattern of the river as viewed from above. Channel geometry refers to the width and depth of the channel as viewed in cross section. The channel longitudinal profile is a plot of the lowest points (i.e. thalweg or flow line) occurring along the path of the channel and also often includes a plot of the water surface elevation, channel banks, bankfull features, and terraces. It tracks the impacts of historical land use and represents the slope of the river, providing information regarding hydraulic energy of flows, erosive force, and sediment transport. Another relevant element of fluvial geomorphology is channel pattern, which refers to the shape of the river's path and generally falls into three categories: straight, meandering and braided. Generally, the stage of interest for determining channel pattern is at bankfull, since it represents the current channel and floodplain forming processes. Sinuosity is the measure of curve of the river.

Pattern sinuosity is a naturally developed characteristic of a stream, reflecting a balance of sediment supply, sediment sizes, flow, and the natural tendency of a river to transport sediment and water in a manner that dissipates energy at an even rate. In addition to well-sorted coarse substrate, the medium for macro-invertebrates and salmonid spawning, the interplay of pattern sinuosity, vegetation, and small-scale erosion and sediment deposition patterns create hydraulic diversity in the channel, including pools, riffles, and undercut banks. Riffle elevations control surface water low-flow elevations and often seasonal groundwater elevations in the surrounding floodplain areas. Groundwater elevation is a key physical factor for wetland and riparian vegetation composition, productivity, and diversity on the adjacent floodplain areas.

It is necessary to define different flow levels, flood events, and features and associated hydrologic events between the various stages of a stream channel: the low flow channel contains the smallest flows that generally occur over 90% of the time; bankfull flow occurs less than 10% of the time and is associated with channel forming processes such as sediment deposition on floodplains, point bar development, and outer bank erosion in a meandering stream.

The flood channel occurs at a stage (or water level) that often fills the channel and spills out onto the valley floor, and larger flows may spill onto terraces (old floodplain surfaces originally constructed by the river at the bankfull stage that are now elevated above and abandoned by the active channel). The morphology of these features can vary, especially when the stream in question is not fully alluvial and has geologic controls such as bedrock or older resistant materials along its boundaries that limit erosion.

Timing and form of precipitation also affects runoff and flow. In the UTR watershed, the hydrograph is dominated by snowmelt, and the maximum flow is probably limited to about 1,000 cubic feet per second (cfs). Peak flows are typically the result of spring snowmelt. Although infrequent, large floods occur as a result of rain-on-snow events. These floods can be much larger—often several times the volume of a typical snowmelt flood. Large floods can have significant geomorphic effects. In the UTR watershed, large rain-on-snow events have occurred in 1955, 1963, 1965, and 1997.

The analysis of topographical data to estimate historical conditions shows a channel pattern that reveals an overall loss of pattern sinuosity. The reduction of pattern sinuosity indicates a trend towards channel shortening, a steepening of channel slope, and an increase in erosive force. Erosive force and the ability of the stream to move sediment is related to the flow depth and channel slope. The overall effect of reduced sinuosity is the deepening or incision of the channel into the underlying substrate and a disruption of channel stability. Channel incision is self-feeding, in that channel deepening increases erosive force, which in turn increases depth. Deepening the channel also decreases bank stability by undercutting the root strength of bank vegetation and increasing bank heights. When channel deepening occurs, streams respond by forming a wider channel to reduce flow depth and erosive force.

Early historical land uses such as grazing and logging likely account for the change in sinuosity between 1860 and 1940 and have also contributed to channel straightening and incision. Bridge and road crossing construction often involves placing earthen fill along the approaching road or construction of an undersized bridge creating a bottleneck. This squeezing effect, although quite localized, concentrates all of the hydraulic force through a bridge opening and can cause dramatic incision for considerable distances upstream and downstream of the crossing. In many cases, the channel is dredged within the local reach at the bridge to maximize channel flood conveyance capacity and minimize flooding over the roadway. These bridge impacts can create a deeper scour zone that may initiate a headcut (a step in channel bed elevation that is not supported by stable features) that over time can migrate upstream. The 1940 aerials show four bridge crossings over the UTR in alluvial reaches, and each of these has the same characteristics of fill in the floodplain and the forcing of flow through a small bridge opening.

As described above, channel deepening increases hydraulic force for erosion and increases the ability of the flow to move more sediment (i.e. increased transport capacity) and larger sediment sizes (i.e. transport competence). Thus, channel deepening often increases the supply of sediment to downstream reaches in quantities and sizes that the normal channel cannot transport except in the highest flows. When excessive coarse sediment is deposited in a channel, the channel expands its width and depth by eroding into softer materials (in the case of UTR, meadow alluvial sediments) to compensate for the loss of flow capacity due to the obstructing coarse sediment deposit. This process becomes self-reinforcing. As each reach adjusts by erosion, it releases more coarse sediment downstream that overwhelms the next reach. This process appears to be the best explanation for the channel widening and downcutting along the Christmas Valley reach of the UTR observed by long-time residents.

Log transport also likely had an impact on the UTR, especially the creation of “splash dams.” Splash dams were temporary structures that impounded river flow and created a pond where logs could be floated. Once filled, the dams would be breached sending logs downstream to Lake Tahoe and on to sawmills. Splash dams would have sent large volumes of flow instantly down the channel with logs bumping banks along the way. This method of transport would certainly have benefited from a deepened, straightened channel. Old timber “bumpers” found in the UTM provide evidence of such practices.

Later land use activities, such as the channelization of the UTR near the Lake Tahoe Airport, the Tahoe Keys, and the LTGC caused further channel incision starting in the early to mid 1900s. These events formed eroding headcuts that migrated upstream. The 1940 aerials show two recently cut-off meanders that appear to have been excavated by machinery such as bulldozers, which became more readily available in the 1940s. This more recent phase of channel straightening and deepening in the 1950s and 1960s reinforced the modifications from earlier phases, and the results were similar: decreased bank stability, chronic supply of sediment from bank erosion, a lowered water table, and a decrease in wetland and riparian vegetation cover within the river corridor. The areas of significant channel destabilization and erosion led to the installation of rip rap revetments to protect bridges, sewer lines, roads, structures, and golf course facilities. The rip rap revetments were generally successful at reducing bank erosion locally; however, the rip rap then directed energy to downstream banks or the channel bed and caused erosion in other areas. Rip rap structures also generally are barren and possess low habitat value, are undercut or flanked over time, and are an expensive long-term solution.

2.6 Ecosystem Impairments

The early reclamation of marsh and meadow areas for grazing reduced the available foraging areas for deer, bear, and other mammals. Logging decreased raptor and owl habitat quality and quantity. While these and other activities like controlling drainage, hunting, and fishing directly impacted wildlife, changes in channel morphology negatively affected the habitat-forming processes sustaining the original ecosystem and perhaps have impacted wildlife even more significantly. The modification of the relationship between the channel and the floodplain created impairments that adversely affected the ecosystems supported by the river. As discussed above, the straightening and incision of the UTR created a less stable, shorter, and larger channel than that before European settlement. Increased channel capacity and increased bank heights resulted in lower frequency and duration of floodplain inundation, reduced soil moisture, and lower groundwater elevation. Thus, the area of the active floodplain itself is dramatically reduced.

In response to lower groundwater elevation and reduced floodplain soil moisture, the relative abundance of obligatory wetland species of riparian, meadow, and floodplain plant communities declined. The cover of wetland community plant species like sedges is lower, and the plants themselves are less vigorous. Meadows on the UTR are less productive than their undisturbed counterparts. Remnant channel oxbows still support wetter vegetation communities that survived the lowering of the groundwater table by extending roots. The absence of saplings and young riparian plants, however, and the invasion of species that favor drier conditions (i.e. lodgepole pine) indicate that hydrologic conditions no longer favor the regeneration of wet meadow species. Many areas converted from wet graminoid meadows and obligate sedge wetlands to dry meadow and lodgepole pine forest. In addition, the cover and density of shrubs, particularly of willows, is lower today on floodplains and streambanks than in the 1940s. Since willows depend on floods for regeneration, the lower flood frequency is probably an important factor for willow decline. Together, these changes impair the relationship between streambank stability and streambank vegetation cover: as banks become too erosive for plants to establish or persist, vegetation cover decreases, which in turn makes banks even more unstable.

As a result of the degraded floodplain/channel relationship, terrestrial habitat quality and quantity has declined. Reduced shrub cover and density, in combination with a lower frequency of pools of standing water and wet meadow habitat, has important consequences for terrestrial wildlife. Small mammals like shrews, which depend on standing water and low-lying shrubs, are less abundant than they would be with a functioning floodplain/channel relationship. A lower shrub density and a lack of standing water results in less nesting habitat for the willow flycatcher and songbirds in general. Mating habitat for amphibians is significantly reduced by the lack of standing water. The diversity and abundance of flying insects on the UTR is also negatively impacted by infrequent flooding and reduced wet meadow habitat, and with less foraging opportunity, the UTR supports fewer bats than it did historically. Finally, waterfowl species richness has declined as a result of habitat degradation.

The quality and quantity of aquatic habitat of the UTR is also significantly reduced. River substrates are much finer today than historically and result in decreased formation of stable bar, pool, and riffle features. There is a lack of undercut banks as a result of bank instability, and the lack of vegetation on banks contributes to increased surface temperatures and decreased allocthonous inputs. Perhaps most importantly, straightening and incision produced sections of channel that are homogenous in geometry and grain size and are without pool development, riparian cover, gravel substrate, or the hydraulic characteristics that favor foraging, refuge, spawning, and rearing.

These habitat impairments caused a decrease in the condition of aquatic communities. First, the straightening of the channel reduced channel length and therefore reduced available habitat. Benthic macroinvertebrates (BMIs) are less abundant and less diverse, and the BMI community has shifted to favor species tolerant of degraded habitats. Because they are a food source, this reduction in diversity and number of BMIs has a direct impact on the fish community. The fish community has also shifted to favor species more tolerant of warmer temperatures and fine stream substrates. Changes in the UTR have generally impaired spawning, rearing, and cover habitat. Native fisheries of Lahontan cutthroat trout and mountain whitefish have been largely extirpated from the UTR and the Lake Tahoe Basin, due to overfishing and the introduction of competitive game fish such as rainbow trout, brown trout, and brook trout. All of these factors result in a highly altered aquatic ecosystem.

2.7 Water Quality Impairments

Early land use changes caused declines in UTR water quality. Grazing in the watershed and floodplain meadows introduced pathogens, elevated nutrient levels, and increased areas of soil disturbance and erosion. Along stream zones where the water course was the main supply of drinking water, chiseled banks formed with barren soils, a lack of vegetation cover, and compacted soils.

The 1940 aerial photo indicates a wide channel with fresh bars of sediment and little indication of recent vegetation colonization. These features all suggest grazing impacts were significant by 1940. Watershed conditions during the Comstock Era were also significantly affected by grazing and logging. As described above, sheep and cattle grazing were seasonal uses, particularly concentrated in meadows and lakes.

It became apparent in the mid-1960s that rapid urbanization led to a significant decline in the transparency of Lake Tahoe. Scientists attribute the loss of clarity to an increase in fine sediment and nutrient delivery to the lake. The role of fine sediment in reducing clarity is now known to be the most significant factor, as two-thirds of the clarity condition is thought to be a result of the light scattering effects of small particles. The particles of primary concern are less than 16 μm in size, so small that they do not naturally settle out like larger sediment and therefore stay in suspension for long periods of time (CRWQCB and NDEP 2010).

The U.S. Department of Agriculture National Sedimentation Laboratory performed several studies (Simon et al.2003, Simon 2006, Simon et al. 2009) to more clearly understand fine sediment loading and inform development of the Lake Tahoe Total Maximum Daily Load (TMDL). Fine sediment loading was estimated for several source categories, including urban uplands (stormwater), forested uplands, atmospheric, groundwater, shoreline erosion, and stream channel erosion. While the estimate of fine sediment loading from the stream channel erosion source is small (4%) relative to other categories (such as 72% for urban upland), the UTR is by far the largest contributor of fine sediment from stream channel sources at 60%. The high levels of fine sediment contributions of the UTR, relative to other basin streams, result from accelerated rates of bank erosion in the lower reaches combined with the relatively high amounts of fine sediment in the streambanks. These studies along with other pertinent conclusions for the UTR projects are summarized further in Section 5.4.

Floodplain processes also play an important role, albeit less understood, in water quality. Land uses in the watershed and their impacts not only led to increased erosion and runoff and, in turn, to significant increases in sediment and nutrients, but also greatly reduced the ability of the floodplain to trap sediment and nutrients. Because the UTR has a much larger capacity than it did historically, flows that once flooded over well-vegetated floodplains and meadows are now directly delivered into Lake Tahoe. Floodplains that historically trapped sediment whenever the river overbanked, through processes of stranding, flocculation, and bio retention, are now subject to flooding much less frequently and are consequently much less effective as filters of sediment and nutrients. In addition, functioning floodplains filter upland water sources before they reach the channel. While the potential benefits related to restoring floodplain processes are thought to be robust, they are very challenging to measure. For this reason, several efforts are currently underway to estimate and measure the benefits resulting from floodplain fine sediment retention (see Section 5.4).

2.8 Climate Change, Sustainability, and Ecosystem Services

Climate Change Context
Climate change impacts for the Lake Tahoe Basin and surrounding region are well-documented through research and reported impacts to watershed and riverine function (Coats 2010). At the regional and local level, climate change modeling and research present varying degrees of anticipated hydrologic and ecological impacts (Coats 2010). These changes are projected to have negative impacts on the environment, economy, and culture in the Lake Tahoe Basin (TRPA 2008). For example, the tourism economy will be threatened as less snow yields fewer wintertime visitors and lower lake levels impede summertime sports, recreation, and public access. Additionally, as temperatures rise and as more precipitation falls as rain rather than snow, management efforts to protect the basin's forests, fish and wildlife, and famed water clarity will face unprecedented challenges.

Sustainability Context
The Lake Tahoe Basin is home to unique and irreplaceable environmental and ecological values and as such, is exceedingly susceptible to stressors of changing climates. Effectively addressing the full spectrum of impacts that accompany climate change requires interdisciplinary collaboration focused on regional sustainability. Sustainability is an ever-evolving discourse, as opposed to a set of practices and benchmarks that can be calculated and achieved. Historically, sustainability has been defined as, "actions that meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987)". Further evolution of the discourse advocates for a nexus of economy, environment, and culture.

The regional priorities of the residents and visitors of the Lake Tahoe Basin are unique and differ from needs elsewhere and should therefore address sustainability issues on a regional scale. A vision of sustainability for the Lake Tahoe Basin should address the social, economic, and environmental prosperity of the region with focused attention on the scenic, recreational, educational, scientific, natural, and public health values unique to the Lake Tahoe Basin (CA Government Code §66951.f).

Ecosystem Services Context
Ecosystem services consist of flows of materials, energy, and information from natural capital stocks which combine with manufactured and human capital services to provide human welfare (Costanza 1997). The discourse surrounding ecosystem services spans many scientific disciplines including ecology, biology, and economics. After a broad review of the literature surrounding ecosystems, ecosystem services, and their associated value, a core list of ecosystem services has been identified. Table 1 describes ecosystem services identified by experts such as Dr. Gretchen C. Daily, Dr. Robert Costanza, and the many contributing authors of the collaborative international work, the Millennium Ecosystem Assessment.

Types of Ecosystem Services:

The literature broadly separates ecosystem services into three categories. These categories include:

- **Provisioning services**: Provisioning ecosystem services include services that directly produce goods consumed by humans.

- **Regulating and supporting services**: Regulating and supporting ecosystem services are defined as the benefits obtained from regulation of environmental conditions and through ecosystem processes / functions.

- **Cultural services**: Cultural ecosystem services are nonmaterial benefits obtained from ecosystems (Collins and Larry 2007).

Table 1: Comprehensive List of Ecosystem Services

Ecosystem Service	Ecosystem Functions
Provisioning Services	
Water Regulation	Regulation of water flows for drinking water, irrigation, industrial processes, recreation, and transportation
Raw Materials	That portion of gross primary production extractable as raw materials such as timber, fibers, jute, hemp, silks, non-timber forest products, and other materials
Fuel Materials	The portion of gross primary production used for fuel such as wood, dung, biofuels, and other biological material that serves as a source of energy
Food Materials	The portion of gross primary production extractable as food products such as fish, game, nuts, crops, and other products derived from plants, animals, and microbes
Biodiversity and Genetic Resources	Maintenance of biodiversity and sources of unique biological materials and products for medicinal, pharmaceutical, and genetic research and existence value
Regulating and Supporting Services	
Climate Regulation	Regulation of global temperature, greenhouse gases) GHG, precipitation, and other biologically mediated climatic processes at global or local levels through the influence of ecosystems on the energy, water, and carbon balance of the atmosphere
Disturbance Regulation	Storm and flood mitigation, drought recovery, ultraviolet protection, moderation of weather extremes, habitat response to environmental variability
Water Quality	Maintenance and protection of water quality and lake clarity through natural filtration, geomorphology, and hydrologic processes
Water Supply	Storage, retention, and recharge of water by watersheds, reservoirs, aquifers, meadows, marshes, and floodplains
Erosion and Sediment Control	Prevention of loss of soil by wind, runoff, waves, or other removal process, and storage of silt and sediments in wetlands

Soil Protection	Generation and preservation of soils and renewal of their fertility
Nutrient Cycling	Storage, nitrogen fixation, internal cycling (nitrogen, phosphorus), and processing and acquisition of nutrients
Waste Treatment	Detoxification and decomposition of wastes, pollution control, recovery of mobile nutrients, and recovery and removal of excess nutrients
Pollination	Pollination of crops and natural vegetation, and provisioning of pollinators for the reproduction of plant populations
Reproduction	Preservation of species population through seed dispersal
Biological Control	Regulation of plant and animal pests and pathogens
Refugia	Nurseries, habitat for migratory species, habitat for local species, and overwintering grounds
Cultural Services	
Public health	Regulation of human pathogens and disease vectors
Recreation	Hiking, biking, climbing, snow sports, water sports, birding, hunting, and fishing
Ecotourism	Healthy ecosystems provide economic incentives for tourism and related activities
Cultural	Aesthetic, artistic, educational, spiritual, historical, and/or scientific values of ecosystems
Costanza 1992, 1997; Daily 1997a, Daily 1997b; Millennium Ecosystem Assessment 2005; USFS 2007	

Anthropocentric activities are continuing to impair the delicate flow of ecosystem services. If current trends continue, human activity will irreversibly alter the remaining natural ecosystems (Daily et al. 1997). Changes in land cover and encroaching development, driven by the way people use land, are perhaps the most important single change in terrestrial ecosystems, affecting the supply and availability of services (MEA 2005). Of all the broad ecosystem types, inland waters are thought to be the most altered by human actions, particularly through the decline in water quality (MEA 2005).

Section 3: Management Framework

This section of the Strategy describes the management framework, including the roles of the Tahoe Regional Planning Agency (TRPA) and the Lahontan Regional Water Quality Control Board (Lahontan), the influence of the Environmental Improvement Program (EIP), and the organizational structure of projects in the UTR.

3.1 Mandates

More than a hundred years ago, conservationists voiced concern about the impacts of tourism, ranching, and logging on the Lake Tahoe environment. Their proposal to make Lake Tahoe a national forest or national park did not gain wide support in Washington D.C., primarily because much of the land in the basin was already privately owned and had already been developed or logged. But conservationists continued lobbying for environmental protection as logging and ranching waned, ski resorts expanded, and high-rise casinos emerged. The debate came to a climax in the late 1960s after two decades of rapid growth. The governors and lawmakers in California and Nevada approved a bi-state compact that created a regional planning agency to oversee development at Lake Tahoe. In 1969, the United States Congress ratified the agreement and created the Tahoe Regional Planning Agency (TRPA 2013).

The 1969 Tahoe Regional Planning Compact (Compact) directives were not sufficient enough to protect Lake Tahoe's ecosystem. As a result, the Compact was revised in 1980, and TRPA was charged with leading the cooperative effort to preserve, restore, and enhance the unique natural and human environment of the Lake Tahoe Basin. The amended 1980 Compact directed the agency to adopt environmental quality standards known as Environmental Threshold Carrying Capacities (or Threshold Standards) to better focus environmental quality objectives and to address past and ongoing environmental degradation. The Compact also required that TRPA develop and implement a comprehensive Regional Plan that would result in the attainment of the Threshold Standards while still providing for orderly growth consistent with those standards.

The Threshold Standards set environmental quality targets to protect and maintain the unique natural values of the Tahoe Basin. Over 130 Threshold Standards fall into the following categories: Air Quality, Water Quality, Soil Conservation, Scenic Resources, Wildlife, Fisheries, Vegetation, Recreation, and Noise. In 1987, TRPA adopted a Regional Plan that included a strict growth control system, environmental review requirements specific to the basin, land use regulations, site development requirements, and resource management provisions addressing a wide range of topics. TRPA updated the Regional Plan in 2012 to respond to the current status and trends of Threshold Standards, incorporate information from research and monitoring activities, and make the plan consistent with state and federal laws.

Following the 1997 Presidential Forum, the Environmental Improvement Program (EIP) was initiated as a plan to help attain thresholds, replacing the Capital Improvement Program in the 1987 Regional Plan. The EIP represented a multi-faceted, collaborative, long-term strategy to preserve and restore the Lake Tahoe Basin through a combination of acquisition, site improvement, research, and monitoring, with the goal of moving closer to environmental threshold attainment. The EIP was updated in 2008 to build upon the accomplishments of the original program. Restoration of the UTR, including specific project reaches, was specifically identified in the original and updated EIP and contributes toward the attainment of most thresholds, including water quality, soil conservation, vegetation, wildlife, fisheries, scenic resources, and recreation.

Water quality is of paramount importance in the Basin. Regulations are enforced by the California Lahontan Regional Water Quality Control Board and the Nevada Department of Environmental Protection. These state agencies regulate water quality standards under the Federal Clean Water Act (CWA). Section 303(d) of the CWA requires states to compile a list of impaired water bodies that do not meet water quality standards and requires the establishment of a Total Maximum Daily Load (TMDL) to address these impaired water bodies. The California State Water Resources Control Board listed Lake Tahoe as an Impaired Water Body with respect to meeting the deep water transparency standard (defined as the average Secchi disk depth measurements taken between 1967 and 1971). The average Secchi disk depth has declined from 97.4 feet in 1971 to 69 feet in 2008. The ongoing decline in deep water transparency is a result of light scatter from fine sediment particles and light absorption from nutrients (specifically, nitrogen and phosphorous). Because these pollutants are responsible for the lake's deep water transparency loss, Lake Tahoe is listed under Section 303(d) of CWA as impaired by inputs of nitrogen, phosphorous, and fine sediment. The goal of the TMDL is to restore transparency to a Secchi disk depth of 29.7 meters, which is the lake transparency measured in 1971.

The Lake Tahoe Total Maximum Daily Load report (CRWQCB and NDEP 2010) identifies the pollutants responsible for the loss of transparency and their originating sources, the amounts of each pollutant entering the lake from these sources, the reductions needed to attain thresholds, and the implementation plan to achieve these reductions. The stream channel erosion source category was evaluated through several research efforts, including several studies by the USDA National Sedimentation Laboratory. Scientists concluded that stream channel erosion is responsible for approximately 4% of the overall fine sediment particle loading reaching Lake Tahoe. While this is a relatively small portion of the overall loading, it is important to note that the UTR is estimated to contribute 60% of the total basinwide loading in the stream channel source category.

The TMDL Implementation Plan (CRWQCB and NDEP 2010) emphasizes restoration activities on the three tributaries with the highest inputs of fine sediment particles reaching Lake Tahoe, specifically mentioning the UTR as the highest contributor. The recommended strategy targets a total fine sediment load reduction of over 50% from this source category through stream restoration activities, resulting in a reduction of approximately 2% of the basinwide total load by 2025. However, to reach the deep water transparency standard (transparency at the 1971 levels), a 90% reduction in this source category would be necessary. All large-scale UTR projects currently being planned or implemented are specifically described as elements of the TMDL implementation plan. The TMDL cost-benefit analysis in the TMDL Pollutant Reduction Opportunity Report shows that stream channel controls are one of the most cost effective methods for removing fine sediment compared to other treatment options (CRWQCB and NDEP 2008). In addition, the TMDL reports acknowledge that significant water quality benefits may result from floodplain restoration and the associated fine sediment retention on floodplains, although estimates of these potential benefits are not yet included in the TMDL due to the need for additional research (see Section 5.4 for recent research efforts on this topic).

3.2 Organizational Structure

Federal, state, and local agencies identified the importance and need to restore streams and watershed in the basin as early as the 1970s and 1980s. The UTR and its adjacent floodplain were specifically identified as degraded and in need of restoration due to the severity of their watershed impacts. Starting in the 1980s, public agencies completed several key acquisitions, and almost all of the UTR floodplain in the middle and lower reaches was placed under public ownership. However, acquisition efforts in the UTR floodplain are still underway to acquire a final significant meadow floodplain property. The USFS-LTBMU, Conservancy, CADPR, and City became the primary land owners of the UTR corridor. In general, agencies have led restoration efforts on their own lands, but collaboration and cooperation between agencies has been an important element of UTR restoration starting as early as the 1990s. The following are some of the key contributing parties, with brief descriptions of their roles in the UTR restoration effort:

California Tahoe Conservancy (Conservancy)
The Conservancy is a primary UTR floodplain landowner and project lead for several individual restoration projects. The Conservancy has also historically provided grant funding for UTR and watershed efforts led by other agencies.

United States Forest Service, Lake Tahoe Basin Management Unit (LTBMU)
LTBMU is the primary landowner in the Tahoe Basin and the project lead for the UTR Reach 5 project and Lahontan Cutthroat Trout (LCT) expansion efforts in the upper watershed. The LTBMU has also sponsored grant funds for work on non-USFS land through the Bureau of Land Management's Southern Nevada Public Land Management Act funding program. The LTBMU watershed restoration program has implemented numerous restoration projects throughout the UTR and other Tahoe watersheds. Its restoration efforts are supported through established federal (USFS and EPA) guidance and policy to restore ecosystem resiliency to riverine systems.

California Department of Parks and Recreation (CADPR)
CADPR owns and manages Washoe Meadows State Park and recreation area along the UTR. CADPR is leading the UTR Restoration and Golf Course Reconfiguration Project and has completed two restoration projects on Angora Creek, the largest tributary to the UTR.

The City of South Lake Tahoe (City)
The City, a local municipality, owns and manages land adjacent to the Lake Tahoe Airport. The City has led the UTR Airport Project, Middle Reaches 3 & 4, which was constructed between 2008 and 2011.

United State Department of the Interior, Bureau of Reclamation (Reclamation)
Reclamation has provided federal grant funds for UTR projects through the Tahoe Wetlands Program and has sponsored grant funding through the Bureau of Land Management's Southern Nevada Public Land Management Act funding program.

Army Corps of Engineers (USACE)

USACE has provided UTR funding through project cooperation agreements under the Tahoe 108 Program. USACE also provides regulatory approvals of all projects consistent with Section 404 of the Clean Water Act.

Tahoe Regional Planning Agency (TRPA)

TRPA reviews and permits UTR project consistent with the Environmental Improvement Program and Regional Plan regulations. TRPA tracks UTR accomplishments towards environmental threshold attainment. TRPA has also provided project funding from Stream Environment Zone mitigation funds collected from development project fees.

Regional Water Quality Control Board – Lahontan Region (Lahontan)

The Lahontan RWQCB has jurisdiction over all water dischargers on the eastern slope of the Sierra Nevada, including the Lake Tahoe Basin. Lahontan permits UTR projects with Section 401 Water Quality Certification and Construction Storm Water Discharge permits in accordance with National Pollution Discharge Elimination System (NPDES) requirements.

California Department of Fish and Wildlife (CDFW)

CDFW issues 1602 Streambed Alteration Agreements for projects that impact areas below the ordinary high water level and may issue Incidental Take Permits for projects that involve take of Tahoe Yellow Cress, a California endangered species and a candidate for federal listing under the Endangered Species Act.

United States Fish and Wildlife Service (USFWS)

USFWS regulates the Endangered Species Act. Of concern to UTR projects, the Lahontan Cutthroat Trout (LCT) is a federally protected species, and consultations with USFWS may be necessary for certain projects based on their potential impacts to LCT.

South Tahoe Public Utility District (STPUD)

STPUD owns several sewer and water infrastructure facilities within UTR project areas. Project teams coordinate closely with STPUD to insure that all utility infrastructure is properly protected or relocated if necessary.

El Dorado County

El Dorado County, as a local jurisdiction, coordinates UTR project activities with other County efforts. El Dorado County has completed several water quality and stream restoration projects within the UTR watershed.

Scientific Community, Science Advisory Committees, Tahoe Environmental Research Center

The scientific community has provided technical assistance and focused research for the UTR restoration effort. Scientific advisory committees in the early 2000s assisted with the development of UTM conceptual designs, and several targeted research efforts have been underway to assist on a variety of issues faced by UTR projects.

Public and Non-Profits

Members of the public and various non-profit groups (League to Save Lake Tahoe and others) have attended UTR project meetings and coordination meetings to express comments or provide input into the project development process.

3.3 Upper Truckee River Watershed Advisory Group (UTRWAG)

In the 1990s, the interagency Upper Truckee River Focused Watershed Group (UTRFWG) was formed to coordinate, share ideas, and discuss restoration of the UTR. In 2006, the group was reinvigorated due to the increase in UTR project activities. Now known as the Upper Truckee River Watershed Advisory Group (UTRWAG), it is made up of various stakeholders, including project proponents, funding agencies, non-profit groups, regulatory agencies, and members of the public.

The mission of the UTRWAG is:

> The UTRWAG will act as a forum to facilitate the discussion of issues important to the planning, implementation, and monitoring of stream environment zone (SEZ) and river improvement, enhancement, and restoration projects in the UTR watershed. The group will assist in the completion of projects identified in the Tahoe Basin EIP and will provide a forum for the sharing of knowledge, information, and methodologies.

The main impetus for the UTRWAG was to provide an open forum for coordinating project development and monitoring. Various project proponents determined it was necessary to develop guidelines for monitoring to ensure consistency. Thus, stakeholders could evaluate each project individually as well as cumulatively. UTRWAG agreed on a restoration philosophy and approach and produced programmatic goals and objectives consistent across property and project boundaries. Monitoring actions and protocols were specified to measure success relative to the goals and objectives. Agreement on the monitoring methods required a series of targeted meetings to address various resource disciplines. These meetings followed a workshop format in which local and regional resource experts engaged with the UTRWAG to determine appropriate protocols. Meetings occurred monthly during the initial period in 2006 and 2007, and since have been held quarterly.

In 2009, an additional need for UTR project coordination arose as agencies realized that coordinated adaptive management must also occur across project and property boundaries. A subcommittee of UTRWAG, the Upper Truckee River Adaptive Management Group (UTRAMG), was formed to focus on:

- sharing and evaluating monitoring data;
- determining effectiveness of implementation and monitoring;
- identifying potential actions; and
- making recommendations regarding monitoring and resource degradation in various UTR project areas.

The coordinated effort identifies potential problem areas and determines the need for corrective action for conditions likely to lead to a chronic, significant, or worsening trend. The subcommittee develops recommendations for adaptive management actions that may include changes to objectives or monitoring, minor maintenance (e.g. additional re-vegetation or spot repairs), or intervention, such as corrective action to ameliorate a chronic or worsening trend and continued monitoring to determine if there is need for future action.

The UTRAMG convenes every spring to share new info and, if conditions permit, a field visit during the spring runoff period is facilitated. In the summer/fall of each year, a meeting takes the form of a site visit or a follow-up to the spring field visit. The field meetings discuss a specific project or portion of a project and are typically conducted in the field to observe a project's performance. All completed watershed and stream restoration projects in the basin, including those outside of the UTR watershed (such as in the Blackwood, Trout, and Cold Creek watersheds), present important learning opportunities for this adaptive management group and are included in this coordinated adaptive management effort. All activities of this group, including meeting results, recommendations, and conclusions, are documented in meeting minutes.

3.4 Adaptive Management Framework

An adaptive management approach that incorporates the best available science information, monitors ecological conditions, and adjusts management approaches based on these conditions is crucial in an era of rapidly changing climate (USFS-LTBMU 2012). In watershed restoration, adaptive management is an approach that incorporates monitoring, research, and evaluation to allow projects and management activities to go forward in the face of some uncertainty and allows stakeholders to learn from implementation and make adjustments as needed. The best science and data available are used to develop a treatment strategy or plan; however, since watersheds are complex dynamic systems, stakeholders recognize that knowledge is incomplete.

During the planning process, stakeholders develop goals, prepare an implementation or management plan, and make assumptions about how the treatment strategy will work. Uncertainty and assumptions may pertain to current conditions/impairments/problems, treatment strategies or actions proposed to improve these conditions, and the expected responses and outcomes of these actions. A monitoring plan is developed with specific measurable objectives to test these assumptions. The actions are implemented, and the monitoring results are evaluated to track the effectiveness of existing and future efforts, compared with assumptions to see if the objectives were met, and used to inform adaptive management of the restoration program.

While UTR project proponent agencies coordinate on adaptive management, adaptive management processes and frameworks also exist within each respective agency, as described in individual agency management plans. Information learned from ongoing monitoring and research is continuously incorporated into current and future management practices and planning. Agencies have a clear understanding that watershed and UTR restoration projects require cost-effective monitoring and evaluation efforts over the long term to ensure that they function as intended.

Section 4: Goals, Objectives, and Approach

Environmental improvements in the stream zone can take a variety of forms ranging from structures and stabilization to enhancement to rehabilitation to full restoration. Improvements may focus on single species, ecosystems, or specific physical characteristics like water quality. The term *restoration* has been applied widely to a vast spectrum of projects but in its true sense refers to restoring to pre-disturbance or historic conditions. It also has been used for restoration of natural geomorphic processes adapted to modern conditions but without land-use constraints. For the purpose of this document, restoration will include projects that include geomorphic process restoration as well as projects that have broad enhancement aspects but may have constraints that limit full restoration.

Figure 2: Restoration, Rehabilitation, Enhancement, Stabilization

Restoration	Rehabilitation/ Remediation	Enhancement	Stabilization
Intention: Return to historic natural channel conditions and process. **Description:** Reach-scale channel elements are deformable, consist of native materials, and habitat elements are self-sustaining and resilient. Flow, sediment, and vegetative conditions are restored at valley and watershed scale. **Example 1:** Reconstruction of meanders coupled with beaver reintroduction otherwise un-disturbed watershed. **Example 2:** Installation of debris jams coupled with reforestation of riparian corridor and watershed in unimpounded watershed	**Intention:** Improvement of degraded natural conditions and processes, but not necessarily to historic **Description:** Reach-style channel condition is improved. Varying degrees of channel deformability and use of non-native materials. Flow, sediment and vegetative condition may be permanently altered at watershed scale. **Example 1:** Reconstruction of degraded channel and floodplain using native materials and accommodating altered flow or sediment regime. **Example 2:** Removal of contaminated sediments in a physically constrained stream channel	**Intention:** Creation of habitat value where it did not previously exist. **Description:** Creation of reach- or site-scale habitat. Varying degrees of channel deformability and use of non-native materials. Flow, sediment and vegetative condition may be permanently alerted at watershed scale. **Example 1:** Creation of off-channel rearing habitat where none existed before, typically requiring some degree of structural control to maintain and protect investment. **Example 2:** Installation of habitat elements without restoration of processes that sustain them.	**Intention:** Contain or stabilize degraded state **Description:** Installation of physical process controls at a reach-or site scale to limit channel adjustment. May include use of non-native materials. Flow, sediment and vegetative condition may not be addressed or may be permanently altered. **Example 1:** Installation of rootwads, riprap, bioengineering or other bank hardening techniques to prevent bank erosion and channel migration. **Example 2:** Installation of rock weirs, armored riffles, or other immobile features to limit bed mobility and channel migration.

Decreasing ecological resilience and sustainability
Decreasing freedom to adjust channel boundaries
Increasing factor of safety, structural rigidity
Increasing species-specific or remedy-specific objectives

Adapted from Gillilan et al 2005

4.1 Restoration Approach and Philosophy

Identification of project goals and objectives is critical, but project proponents must first determine an approach and adopt a restoration philosophy. The river restoration partnership in the Lake Tahoe Basin has adopted a philosophy focused on re-establishing natural geomorphic processes and functions. The fundamental tenet of the restoration design is to restore channel characteristics that are representative of the geologic, geomorphic, and climatic setting. On the UTR, projects are intended to create meandering planforms and a hydraulic channel capacity that will result in more frequent floodplain inundation; improve pool/riffle form and dynamics; reduce excessive toe scour and bank failures; raise groundwater levels; and re-establish mesic and wet meadow vegetation. Re-establishment of these characteristics, common in geomorphically- table channels, will likely maintain functional channel characteristics over the long term and provide the multiple benefits (e.g. improved aquatic and terrestrial habitat conditions). This ecosystem approach guides the design process to restore balance and the natural processes and functions of the system, and may include mimicry or replication of historic forms where appropriate.

Once the UTRWAG envisioned its philosophical approach to restoration, it spent a number of months developing general goals and objectives to guide restoration activities on the UTR. The developed process was not designed as a generic methodology for all projects, but instead as an analytical tool to inform decision making on projects, each of which exhibit unique challenges, characteristics, opportunities, and constraints.

With the UTR restoration philosophy and its subsequent restoration goals in place, UTRWAG can focus on the connection between a geomorphically-functioning channel and the benefits it provides to various resources. This multi-benefit or linked resources concept promotes a comprehensive restoration approach that reduces significant risks to the system, because the ultimate goal is to bring it back to its pre-degradation state or nudge it to a new state of equilibrium. An example of linked benefits in geomorphic process restoration is an improved channel-floodplain relationship. In this instance, a properly functioning floodplain stores water and sediment and raises local groundwater levels. More readily available water and nutrients then result in a more vibrant, thriving wetland community. This improved vegetative condition enhances aquatic and terrestrial habitat, improves water quality by creating erosion-resistant banks and surfaces, increases the system's resiliency to change, and retains sediment that passes over the floodplain via settling, stranding, and bio-retention.

The following UTRWAG goals and objectives are not project specific. The intention is for each project to use them as consistent guiding principles for developing more detailed goals and objectives for each project. Individual projects and their associated monitoring plans should provide clearly defined, quantifiable, and measurable objectives that are appropriate for each project setting and management action.

Goal 1: Restore properly functioning geomorphic channel configuration

- Objective 1a: Increase frequency of inundation on floodplain to approximate estimated historic flood frequency (about 1.5-2-year return interval)
- Objective 1b: Improve pool and riffle dynamics through restoration of meandering planform

- Objective 1c: Increase stability of banks by increasing the elevation of groundwater and associated improvement in riparian vegetation
- Objective 1d: Eliminate or reduce the need for maintenance by designing a geomorphically stable channel; note that stability in this sense is a dynamic equilibrium; the channel is not intended to be perfectly stable in one location over time, however, change should not be catastrophic, but rather characterized by slow movement of meanders over time, with erosion and depositional processes in balance

Goal 2: Improve aquatic and wildlife habitat/populations

- Objective 2a: Increase or enhance aquatic and terrestrial wildlife habitats (fish, birds, small mammals, reptiles, amphibians, macro-invertebrates, etc.)
- Objective 2b: Add complexity to aquatic habitat by increasing the number of pools and riffles
- Objective 2c: Improve stream substrate for fish spawning and aquatic macro-invertebrate habitat through increased sorting of substrate
- Objective 2d: Improve habitat for terrestrial wildlife that use riparian habitat
- Objective 2e: Decrease peak water temperatures (decreased width to depth ratios and increased channel shading from riparian vegetation)
- Objective 2f: Protect sensitive wildlife habitat areas from excessive public use by managing public access

Goal 3: Improve functionality of floodplain for improving water quality

- Objective 3a: Increase storage of flood flows on and in floodplain (increase contact time with wetland plants)
- Objective 3b: Raise the level of groundwater and the potential for water quality treatment by wetland plants
- Objective 3c: Filter and store suspended sediment on floodplain by restoring the native and historic wet meadow plant communities

Goal 4: Improve riparian, meadow, and upland vegetation

- Objective 4a: Increase spatial extent and vigor of native obligate wetland species and wet meadow plant communities
- Objective 4b: Increase spatial extent, canopy cover, and recruitment of montane riparian scrub vegetation
- Objective 4c: Increase groundwater elevations and flooding (water availability) throughout the growing season in the floodplain to support wet meadow plant communities
- Objective 4d: Remove conifer encroachment in aspen stands
- Objective 4e: Reduce wildfire threat near residential areas
- Objective 4f: Improve upland forest habitat structure
- Objective 4g: Eliminate invasive species

Goal 5: Construct projects effectively and efficiently

- Objective 5a: Maintain high success in project re-vegetation
- Objective 5b: Protect existing resources during construction
- Objective 5c: High construction efficiency given project constraints

4.2 Project Process

The generalized steps involved in the project development and delivery process are described below. Although there are slight variations, all projects follow a similar planning process and have adopted the 2010 Riparian Ecosystem Restoration Framework (Framework) prepared by 2nd Nature and River Run Consulting as a guiding document for project and monitoring plan development. The framework emphasizes the linkages between geomorphic form, water table, vegetation, habitat, and biological communities.

While the Framework is intended to guide development of monitoring plans, it also guides the process for project development due to the importance of considering monitoring from the beginning to end of a restoration project. However, it should be understood that the methodology (as well as the UTRWAG guidelines) were developed after the initiation of many projects, and each project incorporates the details of the Framework in various ways and at different stages in the process.

The project process used in the Lake Tahoe Basin contains the following procedural steps, which have been recently further defined through the incorporation of the Framework methodology:

1. **Existing Conditions Summary –** At this early phase, project proponents define a project area and develop information on the existing resource conditions, including studies on wildlife, hydrology, soils, vegetation, cultural resources, and special status species. This step requires a comprehensive understanding of the primary impairments to the ecosystem. To evaluate a project on its impairments and their effects on ecosystem function, proponents create a diagram that illustrates the cause and effect of the ecosystem attributes resulting from the known impairments and a narrative that explains how each process is linked to the impaired attribute. By defining each project's unique setting and rationale for the restoration, an initial feasibility analysis and informed monitoring strategy can then be fully developed. Thus, the existing conditions summary allows for consistent documentation of the high-priority attributes of the specific riparian ecosystem, illustrates linkages between impairments and observed existing conditions, informs appropriate actions, and focuses the definition of project objectives.

2. **Goals and Objectives –** Once site conditions and impairments are well understood, project teams develop goals and objectives appropriate for the specific project. Project goals are clearly defined with testable objectives of the restoration effort. They are also designed to meet Lake Tahoe Environmental Improvement Program (EIP) Action Priorities and Performance Measures. The project objective development process begins with a hypothesis about the effects of the restoration actions on the ecosystem attributes

and documents the specific project objectives that will then be measured directly or through a proxy.

The UTRWAG guidelines provided the original approach for project goals and objectives, which was refined through guidance from the Framework. The Framework organizes goals and objectives slightly differently from the UTRWAG Guidelines, as it emphasizes a geomorphic process approach before other ecosystem attributes. The method for developing goals and objectives follows a process that links impairments with various ecosystem attributes beginning with geomorphic form, then addressing vegetation, habitat, and ultimately biologic communities. This concept sets geomorphic processes as the foundation on which other project attributes are built. Thus, specific geomorphic modifications are expected to result in a certain vegetation structure and habitat and biological improvements. The approach allows for the adjustment, addition, and/or removal of goals and objectives throughout the project development process.

3. **Alternatives Development –** Fully evaluated and developed project objectives inform the design plans prior to construction. Understanding the impairments and constraints to the system, as described above, guides the creation of diverse alternatives. A project develops an array of different conceptual alternatives to address the impairments and associated objectives. Alternatives are refined to address constraints and may be eliminated due to feasibility issues.

   Throughout this process, all documents and strategies are under continual review, with a critical evaluation of how well the project design will meet the intent of the goals and objectives. This process at times may encourage appropriate revisions and design changes that are necessary to produce the desired outcome.

4. **Alternatives Evaluation –** This step involves developing quantifiable metrics to compare the alternatives objectively. In some cases, proxies are used or qualitative assessments are made to evaluate the alternatives. At the end of this step, the feasibility and costs are evaluated, resulting in a preferred alternative. In some instances, projects involving an Environmental Impact Report (EIR) or Environmental Impacts Statement (EIS) may not select a preferred alternative until the final Environmental Document. Projects which prepare a less extensive level of environmental documentation (Mitigated Negative Declaration/Negative Declaration/Finding of No Significant Impact, or MND/ND/FONSI) further develop the preferred alternative to 50% design prior to environmental documentation. Specific methodologies for alternative evaluations have differed between projects due to project specifics or lead agency preference.

5. **Environmental Documentation –** Environmental documentation is required for all UTR projects and typically includes California Environmental Quality Act (CEQA), National Environmental Policy Act (NEPA), and TRPA analyses. Environmental documents detail the regulatory framework, provide detailed project descriptions, and analyze the projects for impacts and effects to all resource areas. Completed environmental documents are required before projects can receive various project approvals and move ahead towards final design and construction. Efforts during this step may vary widely due to the scale

and scope of specific projects and must be closely coordinated with all involved lead and responsible agencies.

6. **Final Design and Permits –** Once environmental documentation is complete, lead agencies and their consultants prepare final designs and specifications. In some instances, construction funding must be in place prior to authorization of final design contracts. Regulatory agencies receive design drawings for their review and consideration and issue project permits upon receipt of all necessary submittals and approvals.

7. **Implementation –** The construction phase may begin when all permits are completed and funding has been secured. Construction periods generally last three to five years for the more complex projects and several months for smaller, less complex efforts. Larger UTR efforts typically include a "seasoning period" to establish vegetation prior to channel activation. Project implementation periods also include intensive coordination between various stakeholders, and include construction compliance monitoring to adhere to project permits.

8. **Monitoring and Adaptive Management –** The final stage in the project process is the monitoring, success measurement, and adaptive management phase. This important step is necessary to demonstrate whether goals and objectives were achieved through project implementation, and is described in greater detail in Section 5 below.

4.3 Sustainability, Climate Change, and Ecosystem Services

Section 2.8 of this document provides a brief discussion on the scientific and historical context of sustainability, climate change, and ecosystem services. The following section explores the relationships between these developing fields of research and the UTR restoration effort, including the incorporation of their associated concepts into the restoration approach and project development process.

Regional project partners have adopted management strategies designed to assert sustainability and ensure the efficacy of future restoration efforts. This UTR restoration strategy is designed to provide a region-wide, unified approach reflecting shared principles and science-based practices to safeguard the biodiversity and ecosystem function of the UTR watershed and ensure the sustainable human uses of fish, wildlife, and plants under the stresses of climate change. This framework is an integral part of a larger effort to sustainably address the growing ecological impacts of a changing climate, land-use change, and development in the Lake Tahoe Basin.

Climate change is a key driver of changes in ecosystems and will continue to influence change into the future. UTR partners recognize strategies for protecting climate sensitive ecosystems will be increasingly important for management, because impacts resulting from a changing climate system are already evident and will persist into the future (SAP 2008).

Sustainability
UTRWAG is one of many stakeholders in the Lake Tahoe Basin incorporating sustainability into their efforts to address the impacts of climate change. The California Department of Water Resource's (DWR) vision of sustainability is primarily focused on healthy watersheds and provides for public health, safety, and quality of life; economic growth and business vitality; and protection and restoration of unique biological diversity, ecological values, and cultural heritage. Also, the USFS regional guidance for this area has a stated goal of retaining and restoring ecological resilience of National Forest lands to achieve sustainable ecosystems especially under changing and uncertain future environmental conditions such as those driven by climate change.

The UTR restoration partners support this Strategy to design projects that exhibit multiple environmental, economic, and cultural benefits by addressing climate change, enhancing ecosystem services, and restoring the largest watershed in the Lake Tahoe Basin.

Climate Change
Climate change is a tangible problem with noticeable impacts today. Without widespread preparation and restoration efforts, the consequences will continue to negatively impact all corners of the globe. In order to mitigate the unpredictable impacts of the future, scientists and policy makers must adopt widespread, pro-active measures now.

Current research suggests that the unique conditions of the Lake Tahoe Basin, including elevation and geography, make it more susceptible to the impacts of climate change than the surrounding region (Coats 2010). Some anticipated effects of climate change related to surface water flows in this region over the long term include a continuing trend toward earlier snowmelt and runoff during the water year, increases in drought severity, and dramatic increases in flood magnitude (Coats 2010). This expected shift to an earlier runoff period results in less moisture availability late in the growing season and late season river base flows. Floodplain restoration projects help mitigate this anticipate impact through increased water storage, making water available for plants and downstream sources later in the dry season, as compared to current incised channel and floodplain conditions.

Traditional restoration project planning evaluates site baselines based on historical conditions and ecosystem capabilities. Climate change requires project planners to account for current and projected variations in historical conditions and ecosystem carrying capacities to inform project designs. UTR restoration proponents recognize the importance of climate change and have designed multi-benefit improvements into targeted project areas such as channel sinuosity, floodplain connectivity, and overbanking to ensure the effective accommodation of additional stressors and impacts caused by climate change. The efficacy of current planning and design strategies applied under a changing climate will depend upon the nature of the climatic changes (spatial and temporal), the vulnerability of ecosystems to these changes, and the current status and degree of human alteration of the ecosystems (i.e., development, land-use change, grazing, and resource extraction) (Solomon et al. 2009).

In addition to project planning based on predicted increases in precipitation and temperatures, UTR restoration projects provide climate benefits including large-scale habitat restoration that would increase climate change resiliency of riverine systems through the restoration of ecosystem functions. This approach is consistent with the EPA's recently released "National Water Program 2012 Strategy: Response to Climate Change." One of the document's goals is to incorporate climate resilience into watershed restoration and floodplain management. The document's strategies promote working with federal, state, interstate, tribal, and local partners to protect and restore the natural resources and functions of riverine and coastal floodplains as a means of building resiliency and protecting water quality.

Ecosystem Services

The UTR watershed supports over 80% of the approximately 340 wildlife species found in the Lake Tahoe Basin (Conservancy 2003). This system regulates water quality to protect lake clarity, maintains water supply to protect summer flows, and plays an intricate role in reducing impacts of climate change through carbon sequestration and temperature regulation. The UTR region also provides access to recreation opportunities to residents and visitors of Lake Tahoe in the form of snow and water sports, hiking, biking, climbing, birding, hunting, and fishing.

The UTR watershed provides ecosystem services such as water supply. This ecosystem service controls the timing and magnitude of runoff, flooding, and groundwater and aquifer recharge. The meadows, marshes, and riverine floodplains found in the Lake Tahoe Basin and the Sierra Nevada have historically provided these essential functions. Due to human disturbances such as the conversion of wetlands and impacts leading to stream incision, land uses have changed and altered the ability of ecosystems to retain water storage. UTR restoration projects plan to restore over 700 acres of SEZ and provide water supply benefits derived from the goals listed above in Section 4.1. These improvements will increase overbanking and floodplain inundation, raise groundwater levels, improve forage and habitat for fish and wildlife, and prolong downstream and summer flows (Millar 1996, Loheide et al. 2009). Additionally, natural water storage and flow regulation have indirect use values and, when downstream benefits are accounted, have a tangible economic value (Guo 2000).

Unfortunately, the use and unseen exploitation of ecosystem services comes with a cost. Years of extensive land use changes and modification by logging, grazing, roads, stream channelization, urban development, recreation, and airport construction resulted in the loss of wetland acreage and subsequently the loss of valuable ecosystem services (TRCD 2003, Conservancy 2004). Many stream reaches are now deeply incised, wider, and straighter. The loss of ecosystem services is further evidenced by substantial declines in floodplain inundation and bank stability, lower water tables, and degraded wetland and aquatic habitat (Conservancy 2004, UTRWAG 2007).

The river restoration community in the Lake Tahoe Basin recognizes the value of the UTR watershed and the many ecosystem services it provides. A variety of partnerships have been established to engage in a collaborative restoration effort to re-establish the UTR's natural function, address the impacts of climate change, and create, enhance, protect, and expand the services generated from healthy ecosystems. UTR projects plan to address the following ecosystem services: water supply; water quality; nutrient cycling; erosion and sediment control; disturbance regulation; refugia; soil protection; climate regulation; recreation; biodiversity; cultural; and biological control.

Section 5: Measuring Success

UTR project success is measured in a variety of ways, including project effectiveness monitoring and reporting as well as annual reporting to regulatory agencies. Project effectiveness and success evaluations are performed to determine whether projects met their objectives as further described in Sections 5.1 through 5.3 below. Implementing agencies provide EIP reporting to TRPA in the form of performance measures relative to various resource areas (see Section 5.4). Project expenditures are also reported to TRPA to acknowledge investments from various sources. Lahontan tracks project completions for the TMDL implementation plan through TRPA's performance measures since Lahontan does not require additional specific reporting at this time.

5.1 Monitoring Approach/Plan Development

A critical component of restoring the UTR is monitoring the effects of the projects in order to measure their success. The project proponents realize that although they may have their own projects, the effort truly is river-wide, and a consistent methodology for all projects is necessary so that projects can be evaluated individually and collectively. These concepts, in combination with the understanding that the design of the projects needed to be coordinated, led to the reformation of the UTRWAG in 2006. The group worked closely to develop guidelines for the overall river-wide goals and objectives. Monitoring protocols were then agreed upon to ensure projects are measuring metrics consistently, and that these metrics are directly linked to goals and objectives. To determine the protocols, a series of targeted meetings were conducted to address the various disciplines. These meetings followed a workshop format where local and regional resource experts engaged with the UTRWAG to determine appropriate protocols.

As mentioned in Section 4, another effort was later initiated by a consultant team led by 2NDNature through a SNPLMA research grant, focusing on improving the quality of stream restoration effectiveness evaluations. This effort, although similar to the UTRWAG's guidelines, delved much deeper into the issues and process of developing and implementing successful stream restoration monitoring plans. Many of the UTR project proponents worked closely on the development of this project, and the result was the Riparian Ecosystem Restoration Effectiveness Framework (Framework). Section 4.2 of this document incorporates the existing conditions and goals and objectives guidance as provided by the Framework, all of which feed important thinking and information into the monitoring plan development stage. This process provides specific steps planners should take to achieve a successful monitoring program and has subsequently been adopted by project proponents.

Monitoring Strategy Development

Once the project proponent has gone through the initial phases (existing conditions assessment and goals and objectives development) of monitoring plan development, the monitoring strategy can be developed. The monitoring strategy describes the basic approach for monitoring project effectiveness with respect to the stated project objectives showing progress toward project goals.

The monitoring strategy's development is used to select and define the metrics and protocols that provide quantitative evidence of project effectiveness.
A variety of potential metrics and protocols are evaluated and reviewed for each project objective. This process further refines project objectives and determines whether they are clearly measureable. In this phase, the Framework provides a process by which project proponents can effectively determine which protocols would be most effective for their project. When selecting appropriate metrics, project proponents consider the following:

- Ability to repeat the monitoring pre and post project
- Magnitude of project effect
- Response time between restoration and measureable result
- Relative cost
- Cost effectiveness
- Established protocols
- EIP status and trend monitoring alignment; this consideration ensures that project monitoring complements larger regional efforts led by TRPA

After all possible metrics and protocols have been evaluated and documented they are screened based on priority objectives for the project, monitoring resources available, and their ability to effectively meet project needs. The final selection will inherently omit certain monitoring activities. The final combination of metrics, however, should be able to evaluate the riparian ecosystem improvements as a whole while considering cost, restoration signal to noise variability within datasets, precision, and response time criteria. In some instances, resources or time may not be available to allow adequate evaluation of the ecosystem categories that are expected to have longer response times (e.g. biological community metrics) or may require evaluations annually over many years to smooth natural variability in the datasets (e.g. water quality metrics). The project team should discuss these limitations and attempt to find workable solutions that are possible within resource constraints.

Adaptive Management
In the final component of the Framework, project proponents define the process to periodically review synthesized monitoring results and make adaptive management recommendations. The purpose of the adaptive management process is to incorporate the monitoring results into future management decisions about the project and communicate findings that may be helpful for future project designs. This process is used to motivate the development and critical review of effectiveness evaluation reports after project implementation, facilitate programmatic decisions based on scientific findings, and communicate lessons learned. The adaptive management plan should be created prior to implementation of the restoration project to guide the effectiveness evaluation process after the project is constructed.

Steps of adaptive management are included below:

1. Develop project goals (general broad statements of intention and not measurable)
2. Develop implementation or management (action) plan with project objectives
3. Develop monitoring objectives (specific, measurable, and test assumptions) based on project objectives and monitoring plans

4. Implement action and document implementation/management practices
5. Collect monitoring data
6. Evaluate monitoring results
7. Recommend next steps (revise objectives, continue/revise monitoring, implement minor or major interventions, document conditions and actions)

The goal of adaptive management is to understand whether objectives are met and why. Adaptation includes learning from monitoring results to improve future management/projects and may include taking action to improve the project. Some reasons why objectives may not be met include:

- Objectives were wrong (outcome assumption flaw)
- Design errors (incomplete data or design flaw)
- Not implemented correctly (implementation flaw)
- External influence (condition change, such as flood or landslide)
- Monitoring faulty (data collection errors, wrong protocol, or missing data)
- Timeframe for measurement is too short

Evaluation of monitoring results thus triggers feedback and adaptation. This feedback will guide the next steps and can include recommendations for various management actions such as revising objectives/assumptions, adding or changing monitoring, intervening, or just documenting conditions. Intervention may include minor repairs or maintenance, major repairs (due to systemic chronic problem), or management changes.

5.2 Past and Current Monitoring Efforts

Monitoring Considerations

Monitoring efforts, as described in the UTRWAG Guidelines, are generally categorized into five major groups: photographs, hydrology and geomorphology, water quality, vegetation, and wildlife. Appendix 2 includes the Guidelines, which describe standardized protocols for several metrics. While the UTRWAG Guidelines standardize several monitoring approaches and protocols, each implementing agency is tasked to develop project-specific monitoring plans. The plans relate specific project goals and objectives to measurable metrics and outcomes.

UTRWAG agreed upon the approaches to implementing and coordinating monitoring efforts. In one approach, each project lead conducts independent, project-specific monitoring following UTRWAG Guidelines. This method is supported by the following considerations:

- Certain metrics are well documented, standardized and easily repeatable. Examples include groundwater monitoring, geomorphic surveys (cross sections and long profiles), and pebble counts. Each proponent can conduct this monitoring with a high degree of confidence that high quality data would be collected.
- Project funding typically has strict and/or limited timelines, making it challenging to administratively pool funds for implementation of a broad river-wide monitoring effort.

- The effort to restore the UTR is likely to take several decades, and each project would need to report its own successes on project-specific timelines.

Despite the benefits of independent project monitoring, certain metrics can be more effectively measured using a collaborative approach. Monitoring on a larger, river-wide scale has the following advantages:

- When measuring more complex metrics, such as benthic macroinvertebrates, cooperative data collection is more consistent across project boundaries, and results can be easily shared among partner agencies.
- Economies of scale will often increase cost efficiency. In the case of water quality monitoring, monitoring stations can be shared to eliminate redundant data collection.
- Large-scale monitoring can more effectively assess cumulative conditions, such as fish populations and diversity. Fish are transient within a system, so measuring on a project scale would be ineffective and may reduce the accuracy of the data.

Water quality monitoring is considered the most challenging metric, as establishing a cost effective and scientifically defensible approach is very complex. Restoration of the UTR is expected to improve water quality in Lake Tahoe over the long term, due to decreased bank erosion and increased fine sediment retention on floodplains. Unfortunately, determining the effect of the UTR projects on water quality would be very expensive and possibly inconclusive due to the natural variability in sediment and nutrient delivery. Water quality monitoring is further complicated by the scale of the projects and the runoff inputs from urban sources within specific project reaches. Water quality monitoring stations may be utilized to obtain continuous turbidity and flow data, but may result in limited scientific defensibility.

UTRWAG considered installation of large-scale water quality monitoring systems above and below each of the major UTR projects, but the extreme high cost led UTRWAG to explore alternative options for monitoring water quality benefits. In addition to cost, there are other significant challenges associated with water quality monitoring efforts on the UTR, including the backwater effects of Lake Tahoe, feeder tributaries within project reaches, buffering effects of upland flows spreading on floodplains, and the high noise to signal ratio expected in the typically low sediment concentrations of Tahoe streams.

Due to the difficulties involved with a comprehensive water quality monitoring effort, UTR lead agencies are exploring the following alternate options for assessing project effects on water quality:

- Engage with researchers to better estimate the benefits related to bank erosion and floodplain processes through the use and refinement of state-of-the-art models. Section 5.4 below summarizes the results of these efforts to date.
- Target a small discrete reach to more comprehensively monitor floodplain benefits, and then scale the results up to specific sections of UTR floodplain. This approach would reduce costs and statistical significance but may not capture the uniqueness of each project and therefore would only provide an estimate.

- Install turbidity monitoring stations above and below all project reaches in order to quantify the cumulative benefit of all the projects after all projects are completed. This would significantly reduce costs and increase the potential to get statistically significant data, although this would still be a costly effort.
- Utilize water quality surrogates, including benthic macroinvertebrate sampling, direct measurements of channel cross-sections, documentation of inundation areas and durations, floodplain vegetation conditions, and field measurements of fine sediment deposition on floodplains to evaluate effects.

Project-Specific Monitoring Efforts

The following are monitoring efforts that project proponents have conducted over the last decade, listed cumulatively:

- About 80 groundwater wells installed and monitored by hand and with continuous loggers
- About 150 geomorphic cross-sections installed in old and in new constructed channels and repeated over various timeframes
- About 50,000 feet of long profiles surveyed, of which several reaches have been repeated
- Numerous substrate surveys, including pebble counts and bulk sediment samples
- Extensive, multi-year meadow vegetation plots, documenting biomass, cover, and species
- Numerous wildlife assessments, including avian point counts, small mammal trapping, amphibians, herpetofauna, and bats
- Robust habitat assessments
- Numerous monumented photo points
- Comprehensive invasive species surveys
- A variety of hydrologic monitoring, including stage recorders, crest stage gages, stream temperature, and a variety of modeling efforts
- A variety of high quality aerials taken before and after projects

Watershed-Scale Monitoring Efforts

The following are watershed-wide monitoring efforts that have been or are being conducted as one single coordinated effort across multiple project area boundaries:

- A 12 mile-long fish assessment of the entire lower Upper Truckee River
- A three year study of the benthic macroinvertebrate community following the California Surface Water Ambient Monitoring Program (CA SWAMP) protocol that included at least three sites in each reach, for a total of 21 sites
- A watershed-wide mapping of the meadow vegetation community
- A watershed-wide mapping of the riparian vegetation community (greenline transect)

Other Data and Resources

Other data and resources that will assist in the UTR monitoring efforts include:

- Three United States Geological Survey (USGS) gauges in operation for over 40 years

- A comprehensive three year water quality study on the UTR with multiple continuous turbidity stations with relationships between turbidity and sediment concentration
- A river-wide aquatic habitat assessment conducted by UNR researchers in conjunction with Trout Unlimited and CalTrout
- A complete LiDAR (**Li**ght **D**etection **a**nd **R**anging) dataset of all the project areas

5.3 Reporting and Analysis

Concise, clear, and comprehensive analysis and reporting are critical in a successful restoration effectiveness evaluation. Monitoring reports are developed to:

- Synthesize the results of the monitoring information collected to date
- Evaluate project effectiveness by comparing observed results to project objectives and success measures
- Inform potential adaptive management strategies

Reporting includes enough detail to bring all available information together and provides a thorough data analysis while still brief and concise enough to allow for other agency program managers and key decision makers to review the material in a timely manner. Monitoring data must be analyzed in the reports to clearly quantify project outcomes relative to each specific objective. While the primary purpose of the analysis and reporting is to evaluate project performance, monitoring reports also provide an essential platform for education and sharing all lessons learned from each project. They inform the development, design, and monitoring of other projects and provide important information for adaptive management and maintenance actions. Monitoring reports may also demonstrate that certain objectives are not reasonable or realistic, and therefore these objectives might not be appropriate for use in future projects.

Depending on the scope and size of the monitoring efforts, reporting should take place every two to four years. Large variability exists regarding the timing of different resource responses to restoration, and this variability is carefully considered in project monitoring plans and the associated monitoring actions. For example, wildlife habitat improvements may take as long as five to ten years to be realized due to the time required for mature vegetation to establish, and groundwater benefits may be almost instantaneous due to the specific hydrology in restored meadow areas.

Monitoring reports may be written in varying formats depending on the project proponent and project scope, but most generally include an executive summary, introduction, project context, methods, results, discussion and conclusion, references, and appendices as described below. Each subsequent monitoring report should consider the previous report’s results, summarizing the overall ecosystem’s response over time.

1. **Executive Summary –** Synthesize main findings based on monitoring data relative to project objectives available and key recommendations or next steps.

2. **Introduction –** State the milestones for which the report has been produced and the report’s context to the overall restoration and monitoring plan. Provide details regarding

who is responsible for the implementation of the monitoring strategy and the generation of the report.

3. **Project Context –** Provide a summary of the implementation schedule and any actions that have occurred since construction was completed.

4. **Methods –** Describe all methods in sufficient detail so they can be repeatable from the original data. These descriptions include a description of the method, citation of relevant references, manufacturers of the equipment used, and the name and version of software packages used for data analysis.

5. **Results –**Review each project goal and supporting objective systematically and simply. For each objective, provide the metric values obtained over time, a review of the performance relative to the defined targets, and a discussion of potential considerations or other factors that may have influenced results.

6. **Discussion and Conclusion –** Present a bulleted list of findings and recommendations that are not necessarily related to a specific goal but may help with future project designs or management topics of particular interest. Recommend potential adaptive management activities or ideas for incorporation into future projects.

7. **Appendices –** Include spreadsheets, monitoring protocols used, database files tabulating all data, unalterable copies of field forms and laboratory data reports, and other supporting information as necessary.

5.4 Tahoe Regional Planning Agency Performance Measures from the Environmental Improvement Program

All projects proposed in the Tahoe Basin, including restoration projects, are evaluated in terms of their impact on TRPA Threshold Standards and their contribution toward threshold attainment. Watershed restoration projects planned for the UTR have the potential to impact thresholds; however, most impacts resulting from UTR projects are only temporary and related to construction implementation. More commonly, projects provide benefits and contribute to meeting the threshold standards. Once UTR projects are complete, project proponents report progress to TRPA based on established performance measures. This practice documents project contributions towards threshold attainment and tabulates the results along with other basin EIP projects.

The threshold indicators and the performance measures associated with UTR projects are listed below.

- **Soil Conservation - Naturally Functioning Stream Environment Zone**
- **Threshold Standard Goal:** Restore all disturbed SEZ's in undisturbed and unsubdivided lands and 25 percent of SEZ lands identified as disturbed, developed; or subdivided, for a five percent increase in acres of naturally-functioning SEZ lands

Performance Measure: Acres of Stream Environment Zone restored or enhanced

- **Wildlife - Special Interest Species, Habitats of Special Significance**

  Threshold Standard Goal: Enhance the suitability and acres of riparian habitats for wildlife

  Performance Measures: Acres of habitat restored or enhanced; Acres of habitat protected

- **Fisheries - Stream Habitat, In-Stream Flows, Lahontan Cutthroat Trout**

  Threshold Standard Goal: Improve stream fish habitats to achieve an increase in miles of streams in good or excellent condition

  Performance Measure: Linear feet of stream habitat restored or enhanced

- **Vegetation - Uncommon Plant Communities, Sensitive Plants, Common Vegetation**

  Threshold Standard Goal: Maintain vegetation community richness and protect and enhance acres of uncommon plant communities

  Performance Measure: Special status species sites protected or reestablished

- **Recreation - Quality of Recreation Experiences**

  Threshold Standard Goal: Improve and maintain acres of lands that provide a high quality outdoor recreation experience.

  Performance Measures: Miles of pedestrian and bicycle routes improved or constructed; miles of trails developed or improved; educational and interpretive programs produced

Historically, UTR projects have not reported the following water quality performance measures. However, they may be reported in the future. Improved science and modeling efforts may provide additional support for incorporation of these measures into annual EIP reporting.

- **Water Quality - Tributary Water Quality, Groundwater, Pelagic Lake Tahoe, Littoral Lake Tahoe**

  Threshold Standard Goal: Reduce nutrient and sediment loads

  Performance Measures: Fine sediment load reduction achieved; phosphorus load reduction achieved; nitrogen load reduction achieved

5.4 Science and Research

The Lake Tahoe Basin has valued science as a key component of making informed management decisions. The University of California, Davis Tahoe Environmental Research Center and the University of Nevada, Reno Desert Research Institute have conducted extensive research in the Basin since the 1960s. Early research, such as lake clarity monitoring with the Secchi disk, was pivotal in creating policies that protect Lake Tahoe. These early efforts led to important actions such as the creation of TRPA, centralizing and pumping sewage out of the Basin, and developing

Best Management Practices (BMPs) and urban erosion control programs to treat stormwater before entering Lake Tahoe.

In August 2005, the Tahoe Science Consortium (TSC) was formed to connect land managers in the Lake Tahoe Basin with organizations actively researching the lake and its surrounding ecosystems. The TSC was created through a memorandum of understanding; its guiding principle is that using the best and most current science will improve the success of resource management activities. Primary functions of the TSC are promoting scientific advancements and independent peer review; supporting adaptive management strategies; providing scientific consultation services; and strengthening and maintaining pathways of communication and collaboration between land managers and researchers.

Member research organizations of the TSC include University of California, Davis; University of Nevada, Reno; U.S. Geological Survey; USFS Pacific Southwest Research Station; and the Desert Research Institute. A three day Tahoe Science Conference, held annually in May, exposes managers to the most recent, pertinent research and findings of the previous year.

Much of the science and research progress over the last decade in the Lake Tahoe Basin has been due to the fact that a fixed amount of SNPLMA funds were annually dedicated to science and research in the Lake Tahoe Basin. These funds have undergone a rigorous process to ensure they have been best utilized to benefit management and environmental agencies. The project proponents have worked closely with scientists to address the complex problem of quantifying the water quality benefits (such as the decrease in bank erosion and increase in floodplain fine sediment retention) of UTR projects. A collaborative process with various stakeholders and researchers was conducted to develop models as well as simpler approaches to quantifying water quality project benefits.

Below is a description of the various research efforts to date, along with their conclusions.

Floodplain Retention Research

Stubblefield et al. (2006) measured suspended sediment (SS) and total phosphorus (TP) above and below the confluence of the UTR and Trout Creek in the Upper Truckee Marsh. They hypothesized that properly functioning reaches of the UTR and Trout Creek (i.e., reaches that were not incised) would reduce SS and TP transport more than those that were incised, as a result of overbank flooding of the meadows in the less-disturbed areas. In the spring 2003 snowmelt event, the scientists found that SS was reduced by 13-41% in the UTR and 68-90% in Trout Creek after flooding through the Upper Truckee Marsh. The study found that the marsh trapped very fine particles (<10 µm) and larger particles with similar efficiencies and supports the hypothesis that less-incised reaches have more overbank flooding, thereby reducing sediment transport.

In 2007, Stephen Andrews (UC Davis doctoral student of Dr. Geoffrey Schladow) created a hydrodynamic and scalar transport model for application to riverine floodplain environments that could be applied to restored floodplains to examine the distribution of particle residence times. The fully-developed model was applied to a leveed floodplain on the lower Cosumnes River in California with positive results. The model was then developed for use on a restored section of

Trout Creek in the Tahoe Basin. Data gathering at the site was conducted, and the model was built and run, showing significant floodplain benefits. Unfortunately, the validation of the model was not completed because during the two years that the site was intensively monitored, no overbank flow events occurred.

Dr. Geoffrey Schladow and two of his graduate students are currently conducting a project that seeks to measure the mechanisms and the efficiency of fine particle removal from urban stormwater using floodplains as a treatment BMP. The project has a lab and field component and is designed to isolate and quantify the key factors that are presently believed to control fine particle removal: attachment to surfaces via biofilms and gravitational settling. By quantifying each mechanism for fine particle removal on floodplains, it will be possible to evaluate the potential to achieve the highest overall performance.

2nd Nature developed the Stream Load Reduction Tool (SLRT) in 2010, a model for quantifying the water quality benefits of floodplain restoration, for initial use on both the UTR and Trout Creek. The City of South Lake Tahoe completed the Trout Creek restoration in 2001, a project of similar scope and scale to the UTR projects currently being planned. The SLRT is simple model that uses a water and sediment budget to determine the volume of water and suspended sediment that passes over the floodplain and the portion of that sediment that is retained on the floodplain. The fundamental concept is that floodplain characteristics such as topography, vegetation type, and density directly influence sediment retention and associated water quality benefits. Using the floodplain characteristics, a sediment retention coefficient, along with its relationship to discharge, was developed to quantify the amount of sediment retained via overbanking. The retention coefficient is related to several floodplain characteristics, including floodplain inundation area, floodplain water depth, and vegetation density, among other roughness factors. Results have been positive, and additional research currently underway focuses on validation of the methodology through direct measurements of overbanking events on Trout Creek. The SLRT is a simple method to evaluate floodplain functionality, including estimations of fine sediment particle loadings, before and after restoration.

Channel Erosion Research

Several studies have been conducted to more clearly understand the sediment sources and loadings from Lake Tahoe Basin watersheds in support of the Tahoe TMDL. As discussed in Section 3.1, the Tahoe TMDL identifies the pollutants responsible for the loss of transparency and their originating sources, the amounts of each pollutant entering the lake from these sources, the reductions needed, and the implementation plan to achieve these reductions.

The USDA National Sedimentation Laboratory estimated stream channel erosion in the Lake Tahoe Basin Framework Study: Sediment Loadings and Channel Erosion (Simon et al. 2003) through a combination of geomorphic and numerical modeling investigations with field measurements from 300 individual sites. Median annual suspended sediment and fine sediment loads and yields were estimated for Tahoe Basin watersheds, and estimates were also made for the contribution of loading originating from channel sources. Simon et al. made several significant findings following this research, some of which are relevant to the UTR, as follows:

- Streambank erosion is an important contributor of suspended sediment from disturbed streams.
- The Upper Truckee River is the greatest contributor of suspended sediment and fine sediment in the Lake Tahoe Basin.
- Sediment delivery from the Upper Truckee River could be significantly reduced by controlling streambank erosion in the reaches adjacent to the Lake Tahoe Golf Course and downstream from the Lake Tahoe Airport.

The USDA National Sedimentation Laboratory further quantified the contributions of fine sediment from stream channel erosion in Estimates of Fine Sediment Loading to Lake Tahoe from Channel and Watershed Sources (Simon 2006). This study refined the estimates of fine sediment loadings, in tonnes per year (T/y) and numbers of particles per year, from all Tahoe Basin watersheds to inform the TMDL and associated Lake Clarity Model. Important and relevant findings from this study are as follows:

- The Upper Truckee River accounts for almost 25% of the total number of fine particles entering Lake Tahoe in an average year. This is the highest number from any watershed and more than the next three highest watersheds combined.
- The Upper Truckee River is estimated to also be the highest contributing watershed for fine sediment delivery from stream channel sources, at 639 T/y. This fine sediment loading is estimated to be approximately 60% of all fine sediment loading coming from stream channel erosion source in the entire basin.

In 2009, a study was conducted to more clearly understand the treatment options and associated load reduction that can be achieved through different forms of stream bank stabilization and restoration: Quantifying Reductions of Mass-Failure Frequency and Sediment Loadings from Streambanks Using Toe Protection and Other Means (Simon et al. 2009). Estimates of load reductions achieved through various forms of bank treatments ranged from 40-90%, demonstrating the significant potential benefits of restoring disturbed sections of stream channel. These estimates were used to inform the load reduction allocations in the TMDL discussed in Section 3.1. It is important to note that these toe erosion models address stability at one location, and in some instances, excess energy may be transferred to other locations if the underlying stress is not removed from the system. This concept must be carefully considered when choosing appropriate treatments along the UTR, as unless the entire bed and bank is treated, the instability may be transferred to other sections of the channel.

Restoration Wildlife Monitoring

Pre-project wildlife monitoring for various metrics occurred in 2006, 2007, and 2008 in the Sunset Stables Reach and the Upper Truckee Marsh in support of the Sunset Reach restoration efforts (Borgmann and Morrison, 2007; Borgmann and Morrison 2008). This monitoring was intended to provide baseline condition information about the wildlife habitats and populations in these project areas and to identify potential restoration actions that could be taken in the Sunset Reach to improve these conditions. Some of the recommendations based on pre-project findings include:

- Increasing the duration and extent of meadow wetness and areas with ephemeral pools to increase the distribution of desired condition reptile and amphibian species and improve conditions for willow regeneration
- Maintaining snags and improving willow (and other understory vegetation) structural diversity to increase the richness, abundance, and productivity of songbirds
- Maintaining open, wet meadow areas and retaining adequate downed woody debris and snags to increase species richness and abundance of desired condition small mammal species.

These recommendations were based on an assessment of the existing conditions and a developed list of species that occurred in meadows throughout the Tahoe Basin to determine species that should occur at this project site based on location or expected habitat conditions following restoration, but are currently absent.

Monitoring Results from Completed Restoration Projects in the Lake Tahoe Basin
The Lake Tahoe Basin Management Unit implements a robust stream channel restoration monitoring program and is fairly unique in the nation in regards to the breadth and scale of this effort. A variety of reports are posted on the LTBMU website documenting the results of both implementation and effectiveness monitoring, including lessons learned and management recommendations. Additional implementation monitoring reports are prepared and submitted to the Lahontan as part of NPDES permitting. The results of these efforts to date have shown that overall restoration efforts have been successful in meeting project goals, resulting in measurable improvements to geomorphic function and aquatic and riparian habitat, with minimal short-term water quality impacts during project construction. These reports have also identified some deficiencies, and the LTBMU has used this information to initiate adaptive management actions on existing projects and improve planning for future projects. All lessons learned from these past efforts have been utilized by the LTBMU in project planning for UTR projects. Although future budgets are expected to decrease, the LTBMU intends to continue cost-effective, long-term effectiveness monitoring of all large-scale riverine restoration projects on USFS lands.

Completed LTBMU reports posted on the LTBMU website include Lonely Gulch, 2008; Cookhouse Meadow, 2009; Marlette Creek 2009; Blackwood Creek Phase I and II, 2009; Blackwood Creek Restoration - Vegetation, 2011; Upper Truckee LCT, 2010, 2011, and 2012; and Blackwood Reach 6 - Project Impacts, 2012.

Draft reports scheduled for completion in federal fiscal year 2013 include Blackwood Reach 6 - Effectiveness, 2013 and Cookhouse Meadow -Vegetation, 2013.

The Conservancy, City, and CADPR also have completed monitoring reports and data analysis, and efforts are currently underway to make this information more available to the public via websites or other distribution methods.

Section 6: Public Participation

Successful implementation of this Strategy requires regular opportunities for public participation and outreach. Most of the UTR projects lie in close proximity to neighborhoods and community areas, and Tahoe residents and visitors regularly use meadow and floodplain areas for a variety of recreational activities. UTR projects garner a high level of public interest which is evident in the press as well as the public outreach functions related to the UTR.

6.1 Historical Public Outreach and Participation Efforts

Project proponents have provided project specific opportunities to seek public comment and input, and project partners have also assisted with larger watershed scale field walks and discussions to engage all interested members of the public. Legal requirements under CEQA and NEPA have been met, including public scoping for NEPA, public meetings for CEQA EIRs, and public noticing.

The list below details the types of public outreach events as well as their specific purposes that have occurred to date for UTR restoration projects.

1. **Design charettes and conceptual design scoping meetings**: Project proponents have invited members of the public to engage with design teams at early stages of project development.

2. **Project specific public meetings and field walks**: Throughout the project development process, lead agencies have offered educational meetings and field walks to educate the public and answer questions related to why restoration is necessary and what changes are proposed for the landscape. As necessary, these public meetings may fulfill legal requirements under NEPA and CEQA and other environmental laws.

3. **Governing Boards, Commissions, and Council meetings**: UTR projects require numerous project approvals for project expenditures, environmental document adoption/ certification, and right-of-way use, among other actions. These meetings are always open to the public and present an important opportunity for community members to present their project related comments to decision makers.

4. **UTRWAG meetings**: UTRWAG coordination meetings occur quarterly and are open to the public. As regular meetings involve UTR stakeholders, these meetings provide an opportunity to comment and a forum to discuss and debate project specifics or challenges associated with UTR projects.

5. **Stewardship and watershed forums**: Non-profit groups have hosted UTR watershed scale events intended to educate the public while also fostering stewardship for UTR natural resources. The League to Save Lake Tahoe and Caltrout have led several field walks through project reaches with project proponent agency staff to engage the public and hear their comments and concerns.

6. **Snapshot Day**: Annual Snapshot Day is a volunteer-based event that has occurred for the last 13 years in the Tahoe region. Volunteer teams monitor various monitoring sites, including several sites along the UTR, to perform a stream walk (visual assessment), collect field data, collect samples, and take photos. Streams are field tested for dissolved oxygen, conductivity, pH, and temperature. Water samples are also measured for turbidity, nutrients, and fecal coliform bacteria. The purpose of Snapshot Day is to promote environmental education and stewardship and to collect valuable water quality information about Lake Tahoe and its watersheds.

6.2 Future Public Outreach Opportunities

While the UTR restoration effort has presented several public participation opportunities, it has become clear that additional public outreach is necessary to address the mounting public interest in the projects. Lead agencies are considering the most effective ways to increase outreach, which include some or all of the following approaches:

1. Given the long time frame often required to plan restoration projects along the UTR, engage the public more frequently on individual projects; host public information meetings throughout the entire course of the project to insure that the public is heard from beginning to end.

2. Provide additional interpretive project elements and education opportunities. This may involve additional education signage at project locations or more informational and educational field walks.

3. Social media has not been highly used to date but may provide an easy and efficient vessel for disseminating information to interested parties. Project leads are looking into opportunities to use social media for assisting with project delivery.

4. Physical involvement opportunities present a way to directly involve the public and potentially garner support while educating community members about the importance of the UTR. Volunteer and school groups may be currently underutilized and therefore may present an enormous opportunity to further engage the public on these projects.

Section 7: Action Plan

7.1 Project Descriptions

Successful implementation of this Strategy requires careful tracking and coordination of each project's information and updates, including project lead agencies, specific impairments, and project schedules. UTR projects vary greatly in size and scope, but they nonetheless have many similarities. For example, most of the project reaches demonstrate incised channels, loss of floodplain connectivity, lowered groundwater levels, and eroding banks. Table 2 below provides basic project information for UTR projects under all stages of development to assist with the organization of projects under this Strategy. Brief project summaries, as provided following the table, further accentuate the specific opportunities and constraints relative to each project endeavor. Projects are listed in the table from downstream to upstream, starting from the mouth of the UTR at Lake Tahoe to the UTR headwaters.

Table 2: Upper Truckee River Projects

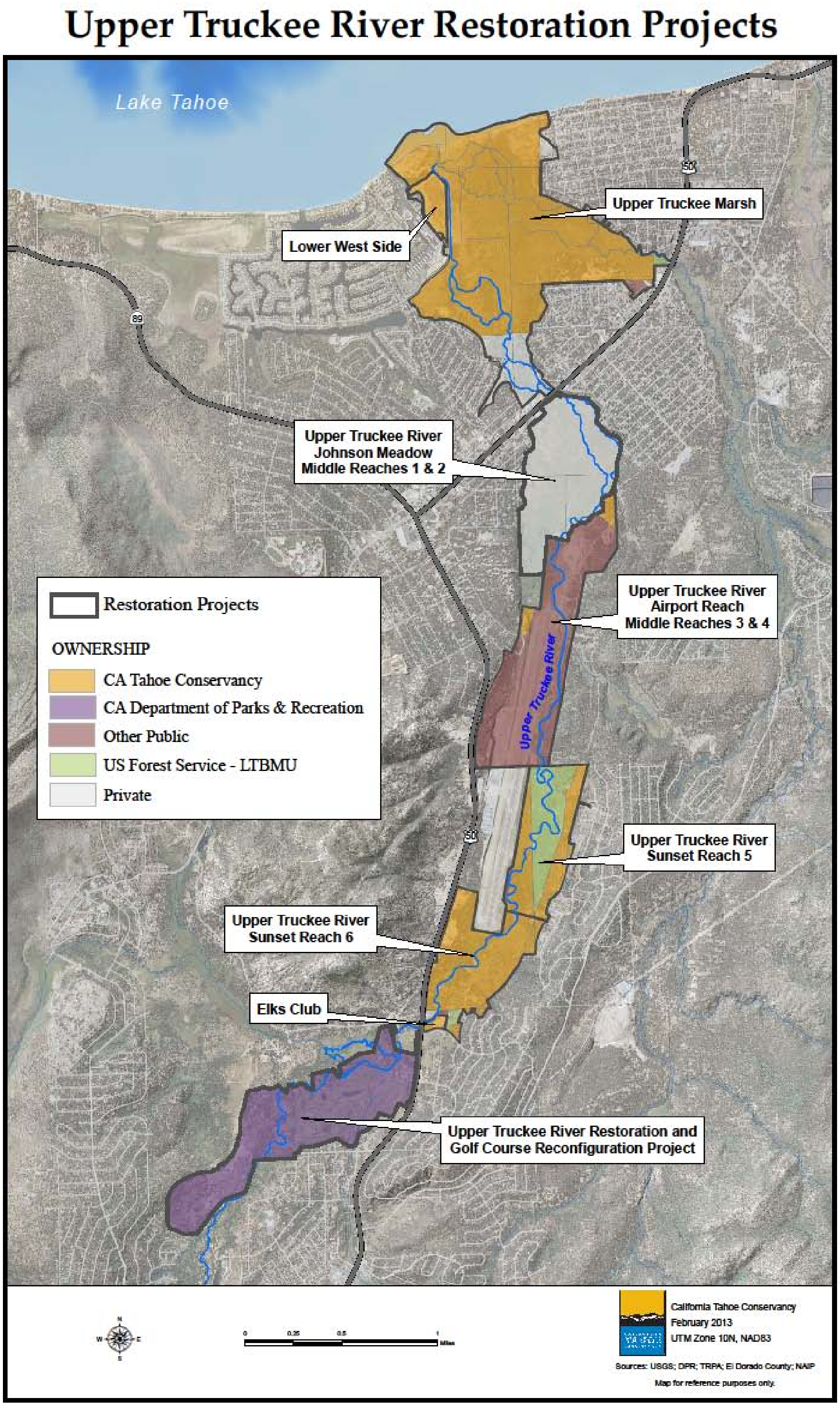
Project	Project Proponents	Approximate Acres of Floodplain Restored/ Enhanced	Approximate Length of Channel Restored/ Enhanced	Specific Impairments	Schedule
Upper Truckee Marsh	Conservancy	400	12,000	Loss of deltaic function, Tahoe Keys development, straightened channel, incision	Currently in environmental review period; construction of initial phase to start in 2015
Johnson Meadows, Middle Reaches 1&2	Conservancy/ LTBMU	180	5,000	Relocated channel to valley side, gully channel formation and incision, fish barriers	Property acquisition efforts currently underway; construction may occur in 2015 or 2016
Airport, Middle Reaches 3&4	City of South Lake Tahoe	18	4,000	Airport development: loss and filling of floodplain, straightened channel, incision, fish barriers	Constructed in 2008-2011

Project	Project Proponents	Approximate Acres of Floodplain Restored/ Enhanced	Approximate Length of Channel Restored/ Enhanced	Specific Impairments	Schedule
Sunset Stables Reach 5	USFS	120	7,416	Incision, loss of floodplain function, poor aquatic habitat	Construction to occur 2013-2016
Sunset Stables Reach 6	Conservancy	66	4,584	Incision, conifer encroachment	Pending final design, construction to begin in 2015 or later
Elks Club	Conservancy	2	NA	Fill in floodplain	In conceptual development; construction may occur as early as 2015
Restoration and Golf Course Reconfiguration	DPR	90	4,190	Lake Tahoe Golf Course in floodplain: loss of habitat, straightening, incision	Currently in environmental review period; construction may start in 2015 or later
Tahoe Pines Campground	Conservancy	1	300	Campground development on floodplain, riprap on banks	Floodplain/ bank revegetation project to be constructed in 2013
Upper Watershed	USFS	NA	NA	Loss of Lahontan cutthroat trout	Ongoing non-native trout removal for LCT expansion
Angora Creek above Lake Tahoe Boulevard	USFS	20	3,950	Former road crossing constriction, agriculture, fire suppression followed by wildfire	Final designs completed; anticipated construction in 2015
Tahoe Paradise	Tahoe Resource Conservation District	NA	NA	Fish barriers, eroding bank	No schedule due to funding constraints

Upper Truckee River Restoration Project Map

The UTR Project Map (Figure 3) below shows the lower portions of the UTR watershed and the project areas for the significant UTR projects, including those completed and under development. Property ownership is also displayed on this map to present the scale of the various public and private ownerships as of this writing. Several smaller projects located further upstream are not shown on the map.

Figure 3: UTR Project Map



Upper Truckee River Marsh

The Upper Truckee Marsh (UTM) is the largest remaining wetland in the Sierra Nevada and has endured decades of direct manipulation. The dendritic channel form typical of this type of system was lost along with this area's capacity to filter river flows. The Conservancy acquired these properties, now known as the UTM, via two distinct efforts: a litigation settlement agreement with a developer in the late 1980s, and a fair market value purchase from a ranching family in the early 2000s. The southernmost portion of the project area is still under private ownership, and easements would be necessary to construct project improvements in these areas. Resource assessments and project planning began in the mid 1990s, and an initial project called the Lower West Side Project was constructed in the early 2000s to restore a filled wetland within the current project area (see the past project section below for more project details).

Currently, the UTM Project is under environmental review, in which project proponents analyze the environmental impacts of five conceptual alternatives. These alternatives include various approaches to re-establishing floodplain and ecological functionality, including channel aggradation and narrowing, new channel construction, passive distributary channels, an inset floodplain, and a no project option. The UTM Project targets similar objectives as other UTR projects; however, it is unique due to the magnitude of potential benefits. For instance, the UTM may have the potential to improve water quality discharges in all flow conditions due to the spreading of water through distributary channels in a deltaic system. Habitat benefits are expected to be robust due to the extensive use of marsh areas by many wildlife species as well as the close proximity to the lake.

UTM Project designs must balance objectives within the physical constraints presented in this area, as there is no anticipation that the Tahoe Keys are going to be removed. The UTM is also highly influenced by the level of Lake Tahoe, presenting additional design and construction challenges. The project area is highly used by Tahoe visitors and residents, and ongoing use must be carefully considered for all restoration management activities.

Johnson Meadows, Middle Reaches 1 & 2

Currently, the Johnson Meadows Project is located almost entirely on privately-owned land. To proceed with any government action, including restoration, it is essential that private land be brought into public ownership before any work commences. Acquisition of this property has been attempted in a variety of ways, with outright purchase determined to be the only viable course of action. Processes are currently underway to ensure a public alignment of the lands needed for implementing restoration activities in Middle Reaches 1 & 2.

Similarly to the UTR in the UTM project area, the river in this reach was displaced from its historic location. In this instance, it was placed along the valley edge to facilitate grazing efforts, and the historical channel in the middle of the meadow was deactivated. Following a large flood event in 1997, an old irrigation ditch was captured by the UTR, forming a new channel that carries as much as half the flow of the UTR through this area. This gully channel has been deemed a major sediment producer to Lake Tahoe because it exhibits particularly severe bank erosion and degraded habitat conditions.

UTR Airport Project, Middle Reaches 3 & 4

The UTR Airport Project, Middle Reaches 3 & 4 (Airport Project), is located along a the northern third of the Lake Tahoe Airport runway on property owned by the City of South Lake Tahoe. The City is the project lead. The objectives of the Airport Project are similar to the other large-scale UTR projects, but the project area is unique due to the extensive filling of the floodplain associated with airport development. It is constrained because a large portion of the floodplain will likely never be restored (due to the airport's development) and also because the South Tahoe Public Utility District (STPUD) water and sewer infrastructure extends through the project area adjacent to the airport.

The Airport Project was constructed between 2008 and 2011, and the project is currently in the monitoring phase. Eighteen acres of floodplain were excavated and restored, and 4,000 feet of geomorphically sized channel was constructed to replace the straightened channel segment. As this project is the first channel reconstruction implemented on the UTR, it is important to document lessons learned and incorporate this knowledge into other UTR projects.

Sunset Stables, UTR Middle Reaches 5 & 6

The Sunset Stables Project is jointly owned and led by the Conservancy and LTBMU. The project area covers approximately 297 acres within a section of the UTR that extends from the middle of the Lake Tahoe Airport runway to the Highway 50 crossing near Elks Club Boulevard, and encompasses about 13,000 linear feet of the UTR channel. Although this channel section has not been significantly directly modified, indirect anthropogenic effects are largely the cause of the incision that is apparent today. As a result, floodplain areas are inundated less frequently, the water table is lower in adjacent meadows, banks are exposed and less stable, and the meadow and aquatic habitat are degraded. This project has the potential to reconnect the UTR to a very large floodplain while restoring the ecological functionality of this large meadow area.

The primary constraint in this area is STPUD infrastructure, as project designs require relocation or avoidance of several utility lines. Project implementation is scheduled for two phases to be completed by different lead agencies: LTBMU is leading the Reach 5 Project, scheduled to start construction in 2013. It includes approximately 7,416 linear feet of channel and 120 acres of floodplain restoration. The Conservancy is leading the Reach 6 Project, which may begin as early as 2015. It includes approximately 4,584 linear feet of channel and 66 acres of floodplain restoration. The channel and floodplain characteristics and observed impairments in Reach 6 are specific to this reach and different from Reach 5. Project designs for the Reach 6 are currently at a conceptual stage, and specific project improvements are not proposed at this time.

Elks Club

In 2008, the Conservancy acquired the Elk's Club property adjacent to the Sunset Stables Reach 5 project area. Sections of the floodplain in this area were historically filled for development, and riprap was placed in the channel to slow channel erosion. The Conservancy intends to begin conceptual planning in this area in 2013 or 2014 to investigate opportunities for floodplain and habitat enhancement.

UTR Restoration and Golf Course Relocation Project, Washoe Meadows State Park
The UTR in the project area, owned by CADPR, was straightened prior to the 1940s and led to channel incision and habitat degradation. This reach was identified as a major sediment producer in the 2003 Simon study. The Lake Tahoe Golf Course now occupies the former floodplain with little or no riparian buffer zone, leading to further degradation of water quality and habitat. The project seeks to restore the geomorphic function of a 1.5 mile reach of channel and the associated floodplain while relocating golf course holes out of sensitive floodplain habitat. Project designs incorporate the reconnection of several relic meanders to restore sinuosity and channel form in this reach and reconnect the channel to the restored floodplain.

The main constraint is that several existing golf course holes currently occupy the meander belt and ten year floodplain. CADPR revenues from the golf course are significant, and restoration that may jeopardize these revenues may not be supported. The EIR/EIS for the project has been completed, but is being contested by a local community group. CADPR hopes to start construction in 2015 or 2016.

Upper Watershed and Christmas Valley
Upper sections of the watershed are relatively pristine, and currently no significant geomorphic restoration planning is underway. However, since 2009, the LTBMU has been actively restoring LCT populations in the upper watershed above Christmas Valley through removal of non-native trout species.

The Upper Reach report (Swanson Hydrology and Geomorphology 2004) identified numerous smaller projects in Christmas Valley, but due to the diverse ownership, no lead agency has emerged, and no planning has begun on these potential restoration projects.

Tahoe Pines Campground
In 2007, the Conservancy acquired the property formerly known as Tahoe Pines Campground, located in Meyers upstream of the Highway 50 bridge crossing over the UTR. The Conservancy, in partnership with Reclamation, plans to scarify and restore former campsites on this property to improve riparian habitat and floodplain function. No significant channel modifications are proposed with this project, and construction is scheduled for fall of 2013.

Angora Creek above Lake Tahoe Boulevard
Since the 2007 Angora Fire, the LTBMU has been planning restoration activities along Angora Creek above Lake Tahoe Boulevard within the burn area. The final design plans for the Angora Creek Project have been completed and include a combination of new channel construction and the use of woody structures constructed within the existing channel to increase stability in this reach and provide better aquatic habitat. Construction is scheduled to begin in 2015, and will likely take two to three years to complete.

Tahoe Paradise Project
The Tahoe Resource Conservation District (TRCD) has pursued conceptual ideas for improving sections of the UTR near Lake Baron in Meyers. While design ideas are very preliminary at this time, they may involve bank stabilization, removal of debris/structures in the channel, and recreation enhancements.

Completed Restoration Projects in the UTR Watershed

Lower West Side Wetland Restoration
This project, located in the current UTM project area, involved extensive fill removal in a floodplain area that was filled in the 1960s and slated for development in the 1970s and 1980s. Over 80,000 cubic yards of fill were excavated over 12 acres, resulting in the restoration of the large wetland area near the mouth of the UTR. This project complements the future UTM project and can be considered phase one of this larger effort.

Angora Creek Restoration
Between 1998 and 2002, CADPR completed two stream restoration projects on Angora Creek, a tributary to the UTR, yielding 7,500 linear feet of restored channel and floodplain. These projects involved reconstruction of the channel and/or re-occupation of old remnant channels. The objectives were to overcome historic incision, raise groundwater elevations, restore geomorphic function, and improve meadow habitat.

El Dorado County has also completed two additional projects on Angora Creek. The first one, the Angora SEZ Project, filled a highly erosive channel and established a geomorphically stable channel in the center of the floodplain. The Angora Fisheries Project removed culverts and replaced them with a fully spanning bridge to improve fish passage. Small sections of channel were reconstructed to improve channel function above and below the new bridge.

Cookhouse Meadow Restoration
LTBMU restored Cookhouse Meadow, located in the upper UTR watershed adjacent to State Route 89, in 2004 and 2005. This project involved the construction of new channel and the filling of a highly incised gully. Significant groundwater, geomorphic, and ecological benefits have been documented following this project’s construction (Norman and Immeker 2009).

7.2 Project Prioritization

All of the UTR project areas discussed in this Strategy have been identified to need restoration by the UTRWAG coordination and planning process, the EIP project list, and in the various UTR watershed assessments (TRCD 2003, Swanson 2004). While each project is characterized by varying levels of impairment and each has different opportunities for improvement, they are all priorities for achievement of the TMDL targets and attainment of objectives such as improved aquatic habitat quality, improved wet meadow habitat conditions, and improved water quality. Project planning and the timing of implementation for each project is driven primarily by the unique challenges and constraints faced by the individual land managers for each reach, including agency capacity, the availability of funding, the level of involvement by the public (including litigation in some cases), and coordination needs between affected agencies.

Section 8: Financing Plan

Financing this Strategy requires the development and coordination of many important partnerships. Several funding sources have provided planning and construction funding throughout the history of the UTR restoration program. These sources are listed below along with brief summaries of their purposes and other associated information.

California State Funds

The State of California has provided funding from several different sources, the most significant being voter-approved bonds from Propositions 12, 40, 50, and 84. These funds were largely allocated under the authority given to the Conservancy. Funding from Proposition 117, otherwise known as the Habitat Conservation Fund, is also distributed through the Conservancy for projects which support riparian, meadow, and aquatic habitat restoration. Staff funding is provided through a variety of sources depending on the lead agency and may be reimbursable through various cost share agreements.

United States Army Corps of Engineers (USACE) 108 Program Funds

Under the USACE 108 Program, the Secretary of the Army is authorized to provide planning, design, and construction assistance in the form of grants or reimbursements of the federal share of project costs, for water-related environmental infrastructure, and resource protection and development projects in the Lake Tahoe watershed pursuant to Section 108 of Division C of the Consolidated Appropriations Act of 2005, Public Law 108-447 (Section 108). Section 108 provides that the Secretary of the Army may provide assistance only if the project is publicly-owned; $25,000,000 in federal funds are authorized to be appropriated.

United States Bureau of Reclamation (Reclamation) Regional Wetlands Development Program

The purpose of the Program is to assist in addressing the past degradation of Lake Tahoe and its watersheds by undertaking projects, either directly or through financial assistance to others, to meet the environmental thresholds defined in the TRPA's EIP. The environmental thresholds are defined as the environmental standards necessary to protect the natural environment and public health and safety within the Lake Tahoe Basin. The environmental thresholds of interest include water quality, soil conservation, wildlife, fisheries, vegetation, and recreation.

Southern Nevada Public Lands Management Act (SNPLMA) Funds

SNPLMA funds, as authorized by the original Lake Tahoe Restoration Act (LTRA), were generated from sales of surplus land in the Las Vegas area under the jurisdiction of the US Bureau of Land Management (BLM). Proceeds from these sales are available for land management and restoration activities in the State of Nevada and in the Lake Tahoe Basin. These funds are distributed by BLM through federal sponsors, which in the case of the UTR have included the USFS LTBMU and Reclamation.

Mitigation Funds
Mitigation funds have been generated from fees incurred due to the development of or associated litigation settlements from various Basin projects. These fees are generally distributed through TRPA or Lahontan after being collected at the time of construction. The mitigation occurs through the construction of restoration projects funded by these fees.

Funding Status
Table 3 provides the funding status for significant UTR projects. Smaller UTR projects are not included here as they may not be active or do not have any obligated funding or project cost estimates. Total project costs presented include planning and construction costs; acquisition expenditures are not included in these totals. Secured funding, composed of all committed or obligated funds and, in some instances, funds that have not yet been expended, is provided for all sources. Those funds with agreements in place with USACE but pending appropriation are not included in this table.

Table 3: UTR Restoration Project Funding

Project	Total Project Costs	Secured Funding					Additional Funds Needed
		CA State Funds	USACE Funds	SNPLMA Funds	Reclamation Funds	Mitigation Funds	
Upper Truckee Marsh	$15,291,394	$3,679,394		$1,162,000	$450,000		$10,000,000
Lower West Side	$13,461,452	$12,262,452				$1,199,000	$0
Johnson Meadows Phase 1	$4,285,200	$344,500		$500,000	$440,700		$3,000,000
Airport Restoration	$8,269,500	$4,669,500	$1,230,000	$2,000,000		$370,000	$0
Sunset Stables Reach 5	$7,100,000	$1,550,000		$5,550,000			$0
Sunset Stables Reach 6	$5,180,000	$930,000	$200,000	$1,110,000		$400,000	$2,540,000
Elks Club	$1,050,000						$1,050,000
Golf Course*	$9,102,750	$597,750		$1,510,000	$395,000		$6,600,000
Tahoe Pines	$425,000	$125,000			$200,000		$100,000
Totals	**$64,165,296**	**$24,158,596**	**$1,430,000**	**$11,832,000**	**$1,485,700**	**$1,969,000**	**$23,290,000**

*Totals do not include costs related to golf course relocation

In the future, there will be a significant reduction in funding availability from these sources.

Funding available through both the Conservancy and SNPLMA will be greatly reduced in the near term, due to the lack of new bond funds available from the State of California and the reduction of federal land sales in the Las Vegas area.

All opportunities for future funding will be explored with partner agencies, and new funding sources may become available for UTR projects. Through the careful coordination of this Strategy, project proponents expect projects to compete better for funding as a comprehensive UTR effort rather than as discrete individual projects. While the historic funding stream is dwindling, several efforts are underway to leverage future funding to finance this UTR strategy.

Future funding sources for UTR projects may include the following:

- State Bond funds managed by the California Wildlife Conservation Board
- 391h grant funding through the EPA and State Water Resources Control Board
- Additional appropriations from the USACE
- Future voter-approved California State Bond Acts, including the potential 2014 Water Bond
- A new piece of legislation, recently introduced in the United States Senate, which would renew the Lake Tahoe Restoration Act and increase funding authority for several of the programs that in the past have provided funding to stream restoration projects at Lake Tahoe. This authority would still be subject to the appropriation process before actual project funding would be available.
- Cap and trade funding from the State of California from carbon emission fees

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Appendix 1: Geologic and Glacial History

Additional background Information related to the geologic and glacial history of the UTR watershed from the 2004 Watershed Assessment, performed by Swanson Hydrology and Geomorphology, is summarized further below:

The geology of the UTR has been highly influenced by the large scale tectonic interaction of the Pacific and North American Plates and the evolution of the west coast of North America and San Andreas Fault system to the west. The oldest rocks in the watershed date back to the Mesozoic Era (over 150 million years ago) when the west coast of North America was expanding westward by accretion of continental crust that floated in on eastward moving plates. At this time, the west coast of California was a subduction zone, similar to the present west coast of South America where denser, eastward moving plates of oceanic crust plunged under the lighter and more buoyant continental crust. The ubiquitous outcroppings of granite visible in the Sierra Nevada today originated through the partial melting of the consumed oceanic crusts in the upper mantle. The melted constituents were lighter and more buoyant. The crust began a long cooling period that allowed for the formation of crystalline granitic rocks; these granitic rocks were later exposed by tectonic uplift and erosion to form today's Sierra Nevada.

The present Sierra Nevada began uplifting 5.0 million years ago during the Pliocene Epoch, and since that time, the Sierra Nevada crest has risen over 5,000 feet in the UTR / Lake Tahoe area. As the Sierra Nevada uplifted, the land around Lake Tahoe stretched until three large blocks broke apart and formed, from west to east, the uplifted Sierra Nevada Crest, the down dropped Lake Tahoe graben and the uplifted Carson Range. Lake Tahoe was originally a northward sloping valley until volcanic flows and movement along faults formed the mountains along the north end of the Lake from Mount Rose to the Truckee River, which blocked drainage and created the Lake. The UTR lies at the boundary of the Sierra Nevada and Basin and Range Provinces. The major faults that bound the three blocks originate in the UTR Upper Watershed and form the boundaries of Christmas Valley, before trending northward to Meyers where they split; the western fault continues north along the west shore of Lake Tahoe and the Sierra Nevada Front; the eastern fault bends eastward toward the Nevada side of Lake Tahoe and the Carson Range. These faults are still active and, in places, display ground breaks through sediments less than 10,000 years old.

The bedrock of the UTR watershed is predominately granitic; however there are significant outcroppings of highly erodible, tertiary-aged volcanic rocks that occur along the crest of the Upper Watershed. These were formed during the major volcanic eruptions of the Miocene period (5-24 million years ago) that covered the entire Sierra Nevada; subsequent erosion by glaciers and flowing water removed much of the original volcanic rock cover.

Geomorphology is concerned with recent and ongoing geologic processes of weathering, erosion and sediment transport and the development of landforms (e.g. hillslopes, valleys, streams, shorelines, etc.). The significant geomorphic events that formed the present UTR began over 2 million years ago when the first of four major glaciations occurred. Much of the evidence of the two earliest periods has been buried, re-worked or destroyed by the later two: the larger Tahoe period (60,000 to 90,000 years before present) and the later and smaller Tioga phase (18,000 to 26,000 years before present). Birkeland (1963) identified limited exposures of the post-Plio-Pliestocene Hobart Till north of Lake Tahoe and in the Truckee River canyon below the Lake Tahoe outlet and postulated a pre-Wisconsian (pre-Tahoe) age well over 600,000 years before present. The second pre-Wisconsian was the “Donner Lake” glacial period 400,000 to 600,000 years ago, which at times blocked the Truckee River canyon north of Tahoe City with ice raising the level of Lake Tahoe by up to 600 feet above present levels (elevation 6800 feet above sea level). Periodic breaching of the ice dams caused large, catastrophic floods to spill down the Truckee River into the Truckee Meadows of present day Reno, carrying boulders as large as ten feet in diameter.

The later Wisconsian glaciations also raised Lake Tahoe to varying degrees. The earlier and larger Tahoe glacial period may have raised Lake Tahoe 90 feet above its present level; prominent shoreline terraces around the Lake indicate a constant level, 90 feet higher than present, but other shoreline terraces are found at 40 and 80 feet above present lake level. Evidence for the Tahoe and Tioga period glaciers is well recorded on the south and west shore of Lake Tahoe (i.e. Fallen Leak Lake, Emerald Bay, Meeks Creek watershed), however the moraine deposits are not found north of the Upper Watershed of the UTR (i.e. the terminal moraines of recent times end at Cookhouse Meadow (elevation 7,000 feet)) and to the west. Terminal moraines from the Echo Lake area end just west of the Meyers Highway 50 crossing. The lack of glacial “till” deposits in Christmas Valley and downstream indicates that only the earliest glaciations could have carved Christmas Valley, Meyers and Lake Valley, and that the predominate geomorphic processes that formed the present landscape are related to active faulting, down-dropping valley floors, development of glacial outwash filled valleys and subaqueousted below elevated stands of Lake Tahoe.

The headwaters are born from a bowl-shaped cirque that glaciers occupied and receded from cyclically over the past 1.8+ million years. Glacial erosion processes carved the upper Watershed, forming perennial lakes (more than ten of which still exist today), scraping large areas of bedrock clean of soil, and leaving behind glacial till deposits and boulder erratics. The northern end of these glacial deposits rests upon a prominent, 800-foot high glacial step.

Christmas Valley is a classic U-shaped glacial valley created during the earliest and largest glaciation of over 1.8 million years ago. Since that time, glaciers have not advanced past the Upper Watershed, and the valley morphology was mainly influenced by the UTR transporting remobilized glacial sediments, carving floodplains and terraces, and interacting with the higher and lower stands of Lake Tahoe.

Appendix 2: UTRWAG Guidelines

Guidelines for Upper Truckee River Restoration Project Monitoring

Upper Truckee River Watershed Advisory Group

California Tahoe Conservancy
USDA Forest Service – Lake Tahoe Basin Management Unit
California Department of Parks and Recreation – Sierra District
City of South Lake Tahoe

October 2008

INTRODUCTION

The following document provides general guidelines for developing monitoring plans for stream restoration projects on the Upper Truckee River (UTR). This document is intended to be a working document that, in some cases, includes protocols for some of the monitoring objectives. The monitoring protocols will test specific hypothesis regarding project function with respect to stated objectives. Specific parameters unique to individual projects are not included.

Much of the UTR flowing through the lowland valley adjacent to Lake Tahoe has incised primarily in response to channelization, grazing, urban development, and airport and golf course encroachments onto the floodplain. Impacts are cumulative and degradation has occurred over time, from the Comstock era to the present day. Portions of the channel are now deeper, wider, straighter, and have greater hydraulic and sediment transport capacity than what probably would have occurred in a natural setting without landuse impacts. Consequently, the floodplain is inundated less frequently, pools and riffles are poorly developed, and banks are unstable. Fish and wildlife habitat is generally poor and riparian and meadow vegetation is relatively decadent. Furthermore, this stream/meadow complex probably provides less functional water quality improvement than it once did.

Restoration of the river is based on the re-establishment of natural geomorphic processes and functions. The fundamental tenet of the designs is to restore channel characteristics that are representative of the geologic, geomorphic, and climatic setting. The projects are intended to create meandering planforms, hydraulic channel capacity that will result in more frequent floodplain inundation, improve pool/riffle form and dynamics, reduce excessive toe scour and bank failures, raise groundwater levels, and re-establish mesic and wet meadow vegetation. Re-establishment of these characteristics, common in geomorphically stable channels, will likely maintain functional channel characteristics over the long-term and provide the needed benefits for the projects success.

It is believed that a geomorphically stable channel will improve many important ecological functions and at the same time, reduce impacts to water quality. A good example of multiple benefits from geomorphic process based restoration is restoring floodplain inundation frequency. In this instance, the hypothesis is that a properly functioning floodplain will store more water and sediment. This is believed to be true because currently inundation frequency and duration in this reach has fallen to a level below what occurs naturally. In terms of ecological function, improving surface flooding frequency provides a richer medium for ecologically valuable wetland plants. These plants typically provide a high degree of channel bank and floodplain surface resistance to erosion. Re-establishment of more vigorous wetland plant communities will likely reduce stream bank and surface erosion, which in turn benefits water quality. Also, increasing the frequency and duration of over-bank flooding places more of the load carried by the river on the floodplain. Increasing the volume of sediment stored on the floodplain implies that there should be less sediment in the water returning to the river and an improvement in the quality of water exiting the reach. Restoring the pool-riffle bedform is another example of ecological and water quality benefits through the application of this approach. Ecologically speaking, the transport and sorting dynamics of pool riffle streams are important for maintaining habitat for aquatic organisms such as fish and macro-invertebrates. In terms of water quality benefit, a dynamically stable riffle has two important functions. First, dynamically stable riffles create a back-watering effect, important for maintaining a shallow groundwater table and desirable conditions for a vigorous, high root strength, and erosion resistant wetland plant community. Second, these bedforms are sites where sediments are stored in the channel temporarily.

Presently there are four major river restoration projects in the process of planning on the UTR. Ownership is diverse and includes stakeholders from the California Tahoe Conservancy (Conservancy), CA State Parks, City of South Lake Tahoe, US Forest Service, and numerous other private entities. The Conservancy presently is funding part or all of each active project. By providing this guide, each project will be able to develop a monitoring plan with a consistent approach and philosophy. The final result should be the collection of comparable data that results in a clear understanding of not only the effects of each project, but also the collective effect of all the projects on the watershed and in turn the lake.

Each monitoring plan should provide for the collection of data sufficient to evaluate the objectives of the projects. Thus, a clear statement of project goals and objectives is an important first step in developing individual monitoring plans, as outlined in the following section.

PROJECT GOALS AND OBJECTIVES

The first step in developing each monitoring plan is to create clear statements of project goals and objectives. This is critical to ensure that the data collected can be used to evaluate the projects. For the purposes of this guideline, a goal is defined to be a broad, general statement of a desired future condition or function. An objective is more specific, and can be quantifiably tested. Individual goals may result in several objectives. Objectives can be considered specific hypotheses about the effects of the project. Not all goals and objectives are to be applied to all projects. The following is a summary of project goals and associated objectives.

Goal #1: Restore properly functioning geomorphic channel configuration

- Objective 1a: Increase frequency of inundation on floodplain to approximate estimated historic flood frequency (about 1.5-2 yr. return interval).
- Objective 1b: Increase pool and riffle dynamics through restoration of meandering planform.
- Objective 1c: Increase stability of banks by increasing the elevation of ground water, and associated improvement in riparian vegetation.
- Objective 1d: Eliminate or reduce the need for maintenance by designing a geomorphically stable channel. Note that stability in this sense is a dynamic equilibrium; the channel is not intended to be perfectly stable in one location over time. However, change should not be catastrophic, but rather characterized by slow movement of meanders over time, with erosion and depositional processes in balance.

Goal #2: Improve aquatic and wildlife habitat/populations

- Objective 2a: Increase or enhance aquatic and terrestrial wildlife habitats (fish, birds, small mammals, reptiles, amphibians, macro-invertebrates, etc.).
- Objective 2b: Add complexity to aquatic habitat by increasing the number of pools and riffles.

- Objective 2c: Improve stream substrate for fish spawning and aquatic macro-invertebrate habitat through increased sorting of substrate.
- Objective 2d: Improve habitat for terrestrial wildlife that use riparian habitat.
- Objective 2e: Decrease peak water temperatures (decreased width to depth ratios and increased channel shading from riparian vegetation).
- Objective 2f: Protect sensitive wildlife habitat areas from excessive public use by managing public access.

Goal #3: Improve functionality of floodplain for improving water quality.
- Objective 3a: Increase storage of flood flows on and in floodplain (increase contact time with wetland plants).
- Objective 3b: Raise the level of groundwater and the potential for water quality treatment by wetland plants.
- Objective 3c: Filter and store suspended sediment on floodplain by restoring the native and historic wet meadow plant communities.

Goal #4: Improve riparian, meadow, and upland vegetation.
- Objective 4a: Increase spatial extent and vigor of native obligate wetland species and wet meadow plant communities.
- Objective 4b: Increase spatial extent, canopy cover, and recruitment of montane riparian scrub vegetation.
- Objective 4c: Increase groundwater elevations and flooding (water availability) throughout the growing season in the floodplain to support wet meadow plant communities.
- Objective 4d: Remove conifer encroachment in aspen stands.
- Objective 4e: Reduce wildfire threat near residential areas.
- Objective 4f: Improve upland forest habitat structure.
- Objective 4g: Eliminate invasive species.

Goal #5: Construct projects effectively and efficiently.
- Objective 5a: High success in project re-vegetation.
- Objective 5b: Protect existing resources during construction.
- Objective 5c: High construction efficiency given project constraints.

DESCRIPTION OF MONITORING GROUPS

Monitoring efforts are categorized into five major groups: Photographs, Hydrology and Geomorphology, Water Quality, Vegetation, and Aquatic and Terrestrial Wildlife. Individual monitoring plans should consider and adopt these monitoring groups as appropriate. These monitoring groups are described below.

Photographs

Photographs are an excellent tool for assessing restoration projects and are very cost effective. Interpretation of photos is generally qualitative. However, they are extremely useful, and broad in applicability to project objectives; the success of nearly all the stated objectives can be evaluated to some extent with photos.

Both on ground photo points and aerial photos are recommended. Photo points can assist in evaluation of channel stability, success of re-vegetation, and changes in plant communities. Aerial photos can be used to evaluate planform stability, and can also be used to evaluate plant community composition (it is recommended that a low scale of 1:6000 or less be used).

Hydrology and Geomorphology

The USGS currently operates continuous recording gages on the UTR at US 50 at Carrows (10336610), US 50 at Meyers (103366092), and South Upper Truckee Road (10336580). Basic information on stream discharge (mean daily discharge, magnitude of instantaneous peaks) is an important monitoring tool. These data are used in conjunction with geomorphic information to analyze function of the channel. For example, the occurrence of bankfull discharge is measured at the gage. The channel can then be surveyed at this discharge to evaluate hydraulic function. It is important to develop an accurate understanding of the hydrology of not only the river but also the individual projects.

A potential hydrologic effect of the projects is a change in the magnitude or timing of peak flows. Because the stream can be expected to flood the meadow more frequently, the projects may produce a lag in the downstream flood hydrograph, or even attenuate the peak of some floods. The magnitude of this effect could vary by storm type and antecedent soil moisture conditions. Greater attenuation could occur during short duration, low volume storms such as thunderstorms, especially when the meadow soils are not already saturated. Attenuation is least likely to occur during spring snowmelt peak flows, when the floodplain storage capacity becomes an insignificant fraction of the total volume of runoff. Attenuation may also be limited during long duration rain-on-snow events.

Another anticipated hydrologic effect is a change in groundwater elevations in the meadows adjacent to the channel. With the channel geometry reduced and the associated increased inundation of the floodplain, higher groundwater elevations throughout the meadow are expected.

Monitoring the geomorphology of the projects is a critical component of any monitoring plan. Using quantifiable, repeatable, simple, and non-subjective protocols such as longitudinal profiles, cross-sections, and pebble counts can be used to develop long-term trends in channel geomorphology. This type of monitoring can give clear indications of changes that can dictate maintenance and adaptive management.

Vegetation

One of the major effects of channel incision and less frequent flooding is that groundwater and soil moisture levels are lowered. This leads to desiccation and senescence of wet meadow and riparian vegetation and conifer encroachment into the floodplain. This in turn reduces the stability of the soils along the riverbank and the floodplain, creating erosion and sediment inputs to Lake Tahoe.

Fire suppression has lead to dense conifer stands that need to be thinned to improve forest structure towards a historic late seral stage, reduce wildfire threats, and maintain existing aspen stands.

It is hypothesized that the following responses could occur in vegetation as a result of restoration:

- Increase in spatial extent and vigor of native obligate wetland species and wet meadow plant communities.
- Improved trend for meadow health rating/range condition per Weixelman protocols, in appropriate settings/locations.
- Increase in the recruitment of montane riparian scrub vegetation along the new river channel.
- Increase in montane riparian scrub canopy cover over the new river channel.
- Elimination of identified invasive species.
- Reduced threat of wildfires.
- Improved forest structure/habitat-trending to late seral stage forest.
- Expansion/maintenance of existing aspen stands by removing conifer encroachments.

Aquatic and Terrestrial Wildlife

One key objective of UTR restoration projects is to improve aquatic and terrestrial habitat. Monitoring in this category could include presence/absence, diversity, and/or abundance of small mammals, birds, amphibians, reptiles, fisheries, bats, terrestrial insects, and aquatic macroinvertebrates. Wildlife monitoring could include habitat quality elements, which could be captured by other parameters such as geomorphology, vegetation, or hydrology. But, monitoring habitat quality alone cannot determine the effectiveness of the projects in reaching wildlife goals because the habitat parameters measured may not be the limiting factor to wildlife species, and biotic interactions such as the effects of invasive species or cowbird parasitism would not be considered.

In general the UTR restoration projects are expected to result in an expanded area of wet meadow habitat, an increased number of temporary pools in the floodplain, more vigorous deciduous riparian vegetation, increased area of wetland and emergent vegetation habitats, and greater physical habitat diversity within the river. These habitat alterations are expected to affect species composition and abundance in several ways.

In riparian meadows, a general shift from more upland species to more mesic and wetland species can be expected. Small mammal communities are expected to experience an increase in desirable wet meadow species such as Broad-footed Mole (*Scapanus latimanus*), Western Jumping Mouse (*Zapus princeps),* and Belding's Ground Squirrel (*Spermophilus beldingi*). Herpetofauna species dependant on wet meadow conditions, such as Western Toad (*Bufo boreas*), Western Aquatic Garter Snake (*Thamnophis couchii*), and Common Garter Snake (*Thamnophis sirtalis*), are expected to increase in abundance and distribution. Desirable bat species, including Western Red Bat (*Lasiurus* *blossevillii*), Long-eared Myotis (*Myotis evotis*), and Fringed Myotis (*Myotis thysanodes*), may potentially increase in abundance and distribution due to restoration activities.

Water Quality

The most important secondary benefit of these process based geomorphic restoration projects on the UTR is an improvement in water quality. This approach utilizes natural processes to improve water quality. The three critical components of water quality with respect to Lake Tahoe are fine sediment (particles <20 microns), phosphorous, and nitrogen. Determining the effect of the projects on water quality can be very expensive and at times inconclusive due to the natural variability in sediment and nutrient delivery. There are two approaches to monitoring water quality, direct and indirect. The first involves direct measurement of suspended sediments, solids, and nutrients in the water column of the river. Measurements would take place at the upstream and downstream ends of the project reach. The signal of a load reduction is if the volume of sediments and nutrients is lower at the downstream station. This method involves complex technology, constant maintenance, special expertise, and large amounts of money to determine loads (especially nutrients). The second approach is indirect, and involves measurement of selected physical and biological parameters in the river and on the adjacent floodplain that are indicators of water quality or channel conditions. This method could involve monitoring changes in macroinvertebrate populations or geomorphic parameters. For example, changes in cross section or longitudinal surveys can serve as verification of a proper functioning channel. Proper cross section dynamics usually implies that the river and floodplain sediment regime is back in balance with the geology and climate, and so results in a load reduction. The indirect approach can be used as a check on direct measurements or it can replace direct methods altogether. One of the difficult aspects of water quality monitoring is that the pollutant loads entering the lake are very small compared to other systems and the expected change is small. Measuring this small change is very difficult and the methods used may contain enough statistical error that results could be inconclusive.

MONITORING IMPLEMENTATION

Figure 1 represents the conceptual model for monitoring described in this guide. This model involves monitoring primary parameters along the entire channel length and additional parameters at selected locations. Channel cross-section surveys (with photos and pebble counts) are the primary monitoring methods (red line on Figure 1). Periodically along the channel, additional monitoring parameters (vegetation, wildlife, macroinvertebrates, etc.) are added. The most intensive cross-section (super section) includes all parameters that can be monitored in a line or transect. The goal is to collect information on multiple parameters at one location in order to understand interactions between different parameters. For example, knowing the change in groundwater elevations will help explain changes in vegetation, wildlife, etc. Also, understanding substrate characteristics may help explain spawning habitat or macroinvertebrate populations. Although these cross-sections will be the backbone of the monitoring it is understood that there are riverwide (some wildlife, riparian vegetation, fisheries, longitudinal profiles surveys) and terminal (water quality stations, discharge) parameters that are critical and should be included in any plan. The appendix of this document outlines specific protocols for various monitoring parameters. Each protocol lists objectives it could be used to monitor. The purpose of including protocols is to attempt to have all projects monitored consistently, so that data can be not only compared within projects, but also between projects. This will add to the statistical power of the data and increase the likelihood of achieving valid results.

The other critical component of the implementation of this guideline is determining which parameters will be the responsibility of the individual projects and which parameters will be coordinated amongst the projects. For example, simple parameters such as photos, cross sections, groundwater wells, etc. would be conducted by the specific projects due to the fact methods are simple and well established. Other parameters such as water quality monitoring and macroinvertebrate surveys involve complex methods that require close coordination so data is comparable. Water quality monitoring stations especially require identical technologies and methods since data from stations located between projects are needed by Each project. Coordinating parameters amongst projects involves complicated administrative and contracting issues that will need time and proper planning.

ADAPTIVE MANAGEMENT

Adaptive management is the process of continually adjusting management in response to new information, knowledge or technologies. Monitoring is a critical element of this process that measures progress toward or success at meeting an objective and provides information for management change or continuation (Elzinga et al. 1998). Objectives form the foundation of a monitoring program (Elzinga et al. 1998). What indicator is selected, and how well and how often it is measured, is defined by how an objective is articulated. The objective describes the desired condition. Management is designed to meet the objective. Monitoring is designed to measure the response of the resource to determine if the objective is met.

There are several types of monitoring that can be used to inform management decisions. These include but are not limited to implementation monitoring, effectiveness monitoring, and status and trend monitoring. Implementation monitoring tracks whether or not management actions are being carried out on the ground as they were intended. Effectiveness monitoring is used to evaluate the impacts of resource management actions and whether or not management goals for the project were met. Status and trend monitoring seeks to understand the condition of the system over time and is not designed to specifically evaluate interactions or reactions in the system. Implementation, effectiveness, and status and trend monitoring each provide important information to inform resource management decisions.

The UTR Watershed Advisory Group (UTRWAG) includes multiple agencies representing different restoration projects within the watershed. For this reason, individual project goals differ slightly and funding levels for monitoring are project specific. Therefore, the level of monitoring and adaptive management will likely vary by project. Nonetheless, this Guidelines document provides an example of an adaptive management matrix including objectives, actions to meet those objectives, indicators of success or failure at meeting the objectives, and triggers and response actions for each objective. This template can be used by project managers to guide the adaptive management process. In addition, using this same structure for adaptive management for all of the various projects will provide consistency among the projects regarding how management actions will be informed and triggered using monitoring results.

The monitoring (implementation, effectiveness, and status and trend) for each project will be conducted by the lead agencies for those projects. The few exceptions to this will be for macroinvertebrate and water quality monitoring, which will be completed on a watershed wide basis, rather than at an individual project scale. The data gathered from monitoring in each project area will be shared through a collaborative website created by the TIIMS group (see Data Analysis and Management Section).

DATA ANALYSIS AND MANAGEMENT

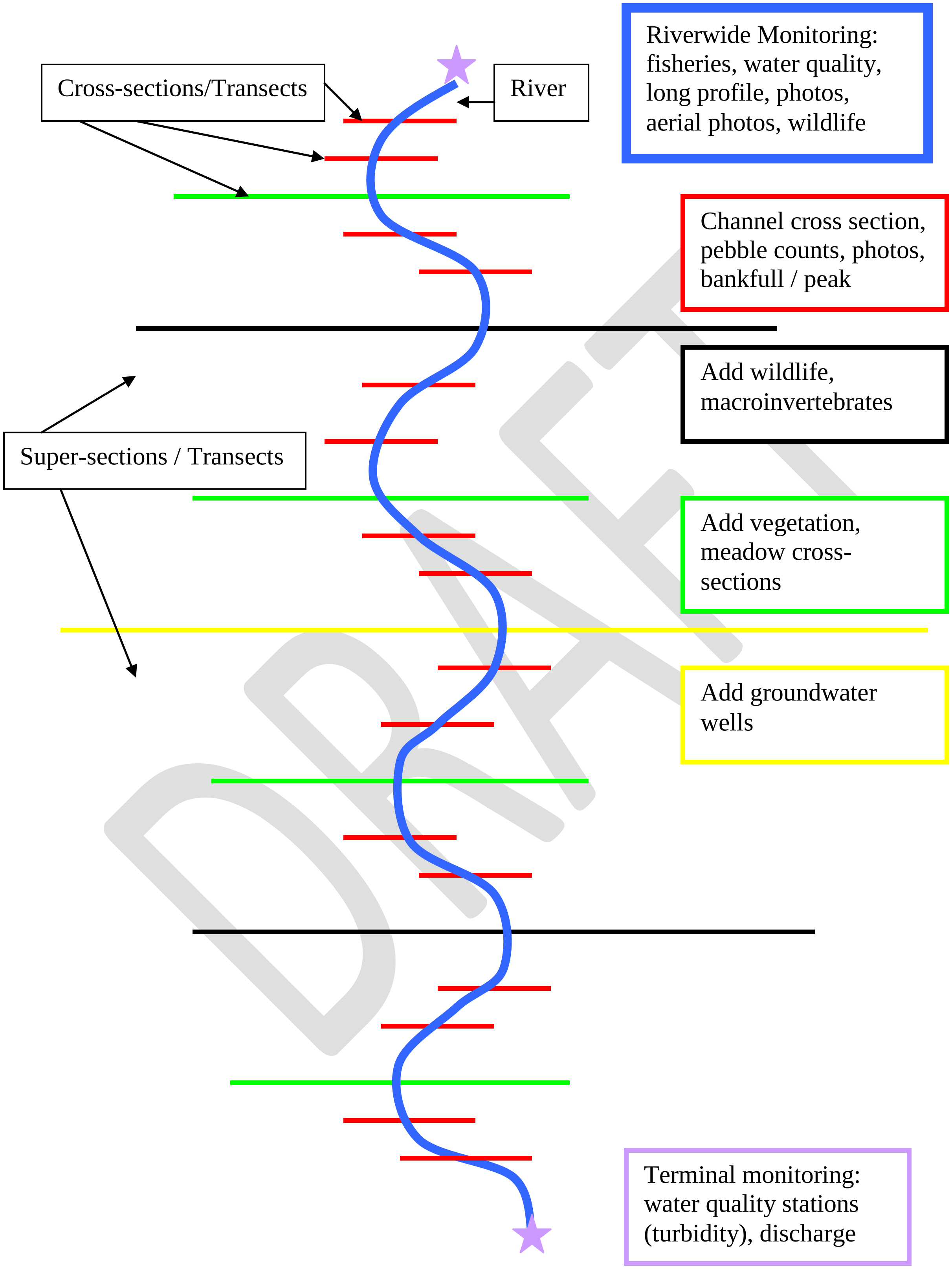
One of the most challenging aspects of creating monitoring guidelines for multiple projects by multiple agencies is creating a system to analyze and manage the data. As detailed in this document, the first step is standardizing the methods and protocols for monitoring. The next step is creating a system to share information so that it can be utilized by all those working on the various projects. This is difficult because it involves close coordination and large amounts of time and effort. Fortunately in the Lake Tahoe region there is a web based information network developed called TIIMS (Tahoe Integrated Information Management System) that can store our information. This tool was developed by TRPA and has been recently re-launched with significant updates. The site has the ability to store documents and information that can be shared under password protection between project partners. The site will host an UTRWAG site that will allow partners to upload documents for the various projects into the appropriate place (the agreed upon structure of the site is provided in Appendix XX). It is anticipated that the type of documents that will be on the site will include project specific documents, watershed wide documents and studies, and relevant resource specific documents such as studies and journal articles (this may include local, regional, national, and international references). This site can also house the raw data generated from projects so that other project planners can view and compare project information. Essential to this aspect of the data management is not only having consistent protocols but also consistent reporting. Each type of monitoring will require very specific requirements on how data will be organized in spreadsheets or databases. Each of the appropriate resource area experts will determine the format in which data will be reported. Most information will be password protected but there will be a section to allow for information to be shared with the public.

CONCLUSION

Staff of the agencies conducting stream restoration projects along the Upper Truckee River desire this document to become a guideline for overall project monitoring. This document defines specific goals and objectives for monitoring and categorizes parameters into five groups that reflect the goals and objectives. This document also provides a conceptual model for designing and implementing individual monitoring plans for each restoration project. An appendix of recommended protocols to measure each of the parameters is included. It is expected that this plan will serve as a guideline for the individual monitoring plans to be developed by each agency implementing projects on the UTR.

Other required components of individual monitoring plans will include a clear quality assurance and quality control plan that outlines protocols for data collection, entry, and analysis to achieve consistent, comparable, high quality results. A specific reporting plan will also be required. It will be essential for plans to detail how the monitoring results will be reported so that data can be used by other projects to compare results. This consistency in reporting will be critical in assessing these restoration projects at the watershed scale.

Figure 1: Conceptual Monitoring Model



Appendix 2.1

Photographs

Photo Points
Objectives Monitored
1b, 1c, 1d, 2a, 2b, 2d, 2e, 3c, 3d, 4a, 4b, 4c, 4d, 4f, 5a, 5b
Protocol

Photo points should be established at both stream cross-sections and desired locations throughout the projects. It is critical to establish photo histories at stream cross-sections, photographs on the left bank (looking downstream) should be taken looking upstream, and photographs on the right bank should be taken looking downstream. Additionally, there should be photographs taken of each of the banks from the opposite bank. In addition to cross-section photo points, there should be other photo points established that should help monitor floodplain conditions and other desired features of the specific projects.

During the first survey, the compass angle of the photograph should be noted, and the location should be monumented so it can easily be found in the future. Future surveys should replicate this compass direction and location. Photographs should be taken with a digital camera. Information on all photographs should be recorded in a field notebook, including time of day, date, etc. Photos should be stored and properly named on a computer and backed up on CD yearly. Photo points should have GPS coordinates recorded to facilitate interactions with GIS and for future relocation. Photos should be taken in control area the first year, upon completion of each phase of the project, and for at least two years after construction.

Aerial Photos
Objectives Monitored
1d, 3c, 3d, 4a, 4b
Protocol

Aerial photographs of the project area should be taken or acquired from appropriate agencies following completion of the entire project, and then in five-year increments following completion, or after a major flood, whichever occurs first. Analysis of the photos will be primarily qualitative. Large-scale changes in channel morphology will be visible on aerials, and they may also serve to document changes in vegetation communities. Photos may also be useful as basemaps for other monitoring data.

Hydrology and Geomorphology

Peak Discharge

Objectives Monitored

1a, 1d, 3a

Protocol

Hydrographs for each of the projects should be developed to not only observe the effects the restoration on attenuation of flood peaks, but also to have a clear understanding of what the effects different flows have on the river. Existing USGS gages will be instrumental in providing flow data; this long-term dataset will be imperative to detecting changes in peak flow magnitude and timing. The instantaneous peaks for all years of record when gages were operating will be compiled and analyzed. This information will be compared to post-project instantaneous peaks.

In addition to these stations, it is also important to measure flow at the upstream and downstream point of each project where presently there is no flow gage. This can be achieved by installing a stage recorder, creating velocity-area profiles, and establishing a rating curve (stage-discharge relationship). In places where continuous loggers are present it is advised that an additional crest stage recorder is installed (see Gordon et al., 1992 for detailed description of installation and maintenance). This is a simple device that measures the elevation of a peak flow. Often times flow stations fail during peak events, which are very important events to capture. This device ensures that peak flow elevations during extreme events are captured.

Groundwater Elevations

Objectives Monitored

3a, 3b

Protocol

Proximity of groundwater to the meadow surface is critical in determining plant communities. Groundwater monitoring wells should be installed in meadows adjacent to the stream, in most cases it is ideal to place them in transects to observe trends and changes in groundwater level throughout space and time. The wells should be installed at least one year prior to construction of the first phase of a project. Ideally wells should be instrumented with a pressure transducer that will collect continuous data. If a logger is not used, groundwater elevations should be measured twice per month (the 1st and 15th days) from April through October, and once monthly (the 1st day) from November through March. Groundwater elevations should also be measured during overbank runoff events and peak flows where feasible and safe for entry by field staff. This monitoring should determine changes in groundwater trends due to restoration.

Topographic Survey of Longitudinal Profiles

Objectives Monitored

1b, 1d, 2a, 2b

Protocol

A topographic survey of the thalweg elevation throughout the constructed channel should be conducted. Elevations of the streambed and the water surface (if applicable) should be measured every 25 feet or at significant breaks in longitudinal slope. Bank height should be surveyed every 100 feet. Persons conducting the surveys should have some training in geomorphology; land surveyors are not generally qualified for these surveys.

Profiles should be surveyed upon completion of construction and following snowmelt runoff for two years following construction. The profiles will be plotted at a constant scale and compared to assess general stability of channel and bedforms. Also, variability in the profiles will be evaluated to assess complexity of fish habitat (the number of pools and riffles). The presence of beavers or beaver dams will be noted during these surveys. Ideally this survey will be done at various times in the future after high flow years to create a long-term dataset. It also would be ideal to survey the profile with a Total Station in order to get not only two-dimensional but also three-dimensional data. Benchmarks should be established so that all projects will be measured at consistent elevations. All points should be tied into real world coordinates to facilitate use in GIS. This type of monitoring is ideal to determine change in channels after restoration.

Topographic Survey of Cross-Sections
Objectives Monitored
1a, 1c, 1d, 2b
Protocol

A topographic survey of cross-sections should be conducted. Valley or meadow cross-sections should span the entire meadow, channel cross-sections should extend 50 ft beyond the streambank on each side of the channel (above bankfull elevation). Channel cross-sections should be surveyed in the existing channel, the newly constructed channel, and at a couple of locations upstream and downstream of the project site. Elevations of the ground surface should be measured at regular intervals or at significant breaks in slope. Features of geomorphic interest should be noted and surveyed in the channel cross-sections, including top of bars, estimated bankfull elevations, changes in vegetation, etc. A detailed protocol can be found in Harrelson et al., 1994

Cross-sections of the existing channel and the newly constructed channel should be surveyed once prior to project completion. Following re-watering, cross-sections in the new channel should be surveyed once per year for two years. These surveys should be conducted during the summer, following snowmelt runoff. Ideally these cross-sections should be surveyed at various times in the future after high flow years to create a long-term dataset. Certain metrics can be calculated (area, width, mean depth, width-depth ratio) and contrasted over time to determine changes in channel form. Permanent monuments should be established at endpoints along with reference pins. It also would be ideal to survey the profile with a Total Station in order to get not only two-dimensional but also three-dimensional data. All points should be tied into real world coordinates to facilitate use in GIS.

Pebble Counts
Objectives Monitored
1b, 1d, 2a, 2c
Protocol

Stream substrate is an important characteristic to both fish and macroinvertebrate populations. Historic accounts indicate that the Upper Truckee River may have been a spawning stream for Lahontan cutthroat trout. Little spawning habitat currently exists—the streambed consists mostly of sand. This may be due to increased sediment produced by the watershed, but is also likely due to the sediment sorting characteristics of the disturbed channel.

Pebble counts should be conducted at all channel cross-sections when surveyed. One hundred particles will be counted, following the protocol outlined in Leopold, Wolman, and Miller (1964). Cumulative frequency distributions of particle size will be compiled and contrasted between years. This should be done to not only compare new channel substrate characteristics to existing but also to compare changes to substrate over time in newly constructed channels. Due to the fine nature of the substrate (mostly sand) it may be more appropriate to do bulk sediment sampling in order to get particle size distributions.

Bankfull Discharge Evaluation
Objectives Monitored
1a, 3a, 3d
Protocol

Elevation of the water surface should be surveyed during bankfull discharge, as measured at the upstream gage. Elevation of water surface and the top of the bank should be surveyed at as many cross-sections as possible during the flood events. This survey determines the location of water during the desired overbanking flow.

Water Quality

Turbidity/Suspended Sediment
Objectives Monitored
3d
Protocol

Water quality monitoring stations may be utilized to obtain continuous turbidity and flow data. Turbidity is a reasonable surrogate for suspended sediment within a limited geographic area. To establish a relationship between suspended sediment and turbidity, regular sampling of suspended sediment is required during storm events, through and during snowmelt peak flows, and thunderstorms. Once a relationship between turbidity and suspended sediment is known; annual and storm sediment loads can be calculated. An important aspect to calculating the loads is having accurate continuous hydrology information. The goal is to have stations located at the upstream and downstream extents of the projects and to compare the differences in loads (both annual and storm) before and after restoration. This type of monitoring is complex, labor intensive, expensive, and should be carefully controlled so that high quality data is achieved.

Vegetation

Vegetation Plots

Objectives Monitored

1c, 2a, 2d, 2e, 3b, 3c, 4a, 4b, 5a, 5b, 5c

Protocol

The Weixelman protocol has been chosen as the preferred vegetation monitoring method. This section will be developed more thoroughly in later versions.

Invasive Weed Surveys

Objectives Monitored

4a, 4b, 4g, 5a

Protocol

Surveys for invasive plant species should occur prior to restoration activities. Invasive weeds should be identified to species and their location should be mapped using GPS. Points should be recorded for individuals or small clusters, and larger colonies should be recorded as polygons depicting the spatial extent of infestation. In addition the percent cover and developmental stage of colonies of invasive species should be recorded. All known locations of invasive species should be resurveyed annually after restoration. In addition, locations experiencing soil or vegetation disturbance as a result of restoration activities should be surveyed regularly during the growing season until a native plant community becomes established. Information regarding invasive species should be distributed to existing local weed control organizations or invasive weeds should be eradicated by the agency responsible for management of the site (See http://tncweeds.ucdavis.edu/control.html for more information on invasive weed control).

Riparian Cover

Objectives Monitored

1c, 2a, 2d, 2e, 4b

Protocol

Analysis of cover for riparian plant species can indicate changes in plant vigor, and is correlated with aquatic habitat quality and bank stability. Cover measurements should be considered a rough test of vigor since observer error can account for a large portion of annual differences.

Riparian cover estimates should be conducted at the same point in the growing season for each measurement event. Permanent transects should be developed parallel to the stream bank with both ends of the transect monumented and recorded with GPS. Cover estimates should be made using the line intercept protocol described by Elzinga et al. (1998). In order to expedite data collection and ensure consistency, observers shall record a closed canopy if gaps in canopy cover are <2 cm wide, and record open canopy if where gaps exceed 2 cm.

Aquatic and Terrestrial Wildlife

Fish Population Surveys

Objectives Monitored

2a, 2b

Protocol

Populations in the existing channel should be monitored prior to restoration activities. Regular surveys should then be conducted after completion of restoration activities. Fish should be captured by electro-fishing methods; habitat should be stratified into pools, riffles and runs prior to electro-fishing, and estimates should be conducted on these discrete units. The ends of the habitat units should be blocked with nets and population size estimated within each unit by multiple-pass depletion methods. For a detailed protocol on habitat typing, see Flosi et al., 1998. For a detailed description of multiple-pass population estimates, see Platts et al, 1983. These techniques can be used to detect changes in populations, species compositions, and age-class distributions.

Spawner Surveys

Objectives Monitored

2c

Protocol

Surveys should be conducted to evaluate salmonid spawning habitat. They should be conducted twice in the spring and twice in the fall, at the anticipated peak of spawning activity, as water conditions allow. Surveys should be conducted on the existing channel prior to restoration, and on the restored channel for three years following construction. Spawning fish and redds should be noted and marked on a plan map. For a detailed description of spawner surveys, see Flosi et al., 1998.

Macroinvertebrate Surveys

Objectives Monitored

2a, 2c

Protocol

Benthic macroinvertebrate (BMI) populations are an indicator of many factors related to ecosystem health, including organic and inorganic pollutant levels and habitat variability. BMI surveys should be conducted prior to and after restoration activities, ideally establishing (where possible) 3 years worth of baseline data and 3 years worth of post project data. After 3 years worth of post-project data has been completed, sampling can be reduced to randomly select one of the project subreaches per year, and eventually, every third year. Ongoing monitoring should continue until project sites no longer show large fluctuations in results that are attributable to or resulting from the restoration projects.

Samples should be collected during the summer index period (late July through September). These surveys should be completed on at least 3 randomly or subjectively selected 250 meter (820 foot) subreaches within each project reach area. Rationale for subreach selection must be recorded for all subjectively selected sites; method of random site selection must be recorded for randomly selected sites. Each subreach will be divided into 11 transects and each transect will contain one 1 ft2 collection site. These collection sites will be determined following the reach-wide benthos (RWB) method outlined in the State of California's Surface Water Ambient Monitoring Program (SWAMP) protocol (Ode, 2007), which states that collection sites are to be located on the left, center, or right positions along a transect (25%, 50%, and 75% of wetted width, respectively). A 500 micron mesh D-frame kick net with a 12 inch diameter will be used for all sample collection. A sample will be a composite of all material collected at each of the 11 transects of a reach, meaning there will be one sample per randomly selected subreach per project site. Physical habitat and water chemistry data should also be collect for each subreach sampled following SWAMP protocols using a minimum of the "Basic" but ideally the "Full" level of effort category including cobble embeddedness, and qualitative microalgae thickness and macroalgae assessment (Ode, 2007). Larger monitoring projects (i.e. those containing greater than 10 subreaches) should select one site for every ten sampled to be sampled in duplicate. Duplicate samples are taken at the sampling location adjacent to the original sampling location (i.e. if the original sample is take at 25% wetted width, then the duplicate will be collected at 50%). The duplicate samples are collected in separate jars and processed along with the other sample sites. The SWAMP Stream Habitat Characterization form should be used to collect all field data.

Laboratory analysis should be conducted by a lab that participates in the SWAMP quality assurance/quality control program and analysis should be conducted to SAFIT level 2, standard level of taxonomic effort using a 600-organism count per sample. Results must be reported using the SWAMP Taxonomy Results Template. Project proponents should request a voucher sample of each taxa identified from the laboratory in a 1 dram (.13 oz) vial preserved in 30% alcohol. These voucher samples should be kept through the life of the monitoring program, and at least 5 years post project. One taxa should be selected to be sent to the CDFG aquatic lab for QC on taxonomic identification.

The type of subsequent analysis and interpretation of physical habitat and taxonomic data should be selected based on the objectives of the sampling. Taxonomic data may be categorized based on general taxonomic type (i.e., shredders, scrapers, collectors, etc.). Physical habitat data can be summarized and use to qualitatively interpret the taxonomic data, or quantitative non-parametric statistical approaches could be used. Experts in the field of interpreting BMI data from academia or government organizations (such as the USEPA or the CDFG) should be consulted when analyzing and interpreting taxonomic and physical habitat data. Caution should be used in using standardized biological indicators to measure stream health (such as the percentage of certain types of taxa), as many of these indices have been developed for primarily gravel, cobble and boulder streams. Macroinvertebrate taxa common in sand bed streams may be considered to indicate degraded habitat if the index was developed for coarser matrix streams.

Butterfly Surveys
<u>Objectives Monitored</u>
2a, 2d, 4a, 4d
<u>Protocol</u>

Populations of butterfly species could be monitored prior to and after restoration activities. Observers should work in teams of two-to-three and walk slowly in a zigzag pattern through a predefined search area twice a month June through August. Observers should record species and the number of individuals detected. In addition, vegetation within 5m of each butterfly detection should be recorded based on the dominant shrub species and dominant ground cover. Ground should be categorized cover as either a mixture of grasses and forbs with no soil moisture (grass/forb dry), as a mixture of grasses and forbs in wet or moist soils (grass/forb wet), bare soil containing no vegetation, or areas covered by rocks. Shrub cover should categorized by the dominant plant species in the mid-story. Categories included alder, willow, flowering shrub, non-flowering shrub, or absence of shrub layer. At each visit, observers should search each survey area for at least 30 minutes, stopping the timer to record observations. Butterflies that cannot be identified from a distance should be captured with a sweep net and released after identification.

Bird Surveys
<u>Objectives Monitored</u>
2a, 2d, 4a, 4b, 5b
<u>Protocol</u>

Point counts should be conducted to estimate changes in avian population size and diversity. Permanent point-count stations should be located at 200-meter intervals, which should be recorded with GPS and marked in the field. In order to have sufficient comparable data to detect changes and trends, all surveys within the watershed should be conducted using the exact same protocol. Point counts should be conducted in June and sites should be surveyed three times. Surveys should be conducted at least a week apart and should begin fifteen minutes before sunrise and end no later than four hours after sunset. Point counts should be conducted for five minutes, or for ten minutes with observations recorded during the first five minutes recorded separately from observations in the second five minutes. Observations should be recorded at three distance intervals, 0-50 m, 51-100m, and >100 m. See Borgmann and Morrison (2005) for more information on survey protocols. Baseline data should be collected for at least two years prior to restoration activities and for three years after completion of the project.

Additional avian surveys may be useful for detecting changes in focal species or assemblages. For example call-playback surveys may be used to monitor owls or raptors, and nest searches may be appropriate to detect changes in sensitive species such as Willow Flycatcher (*Empidonax traillii*).

Small Mammals

Objectives Monitored

2a, 2d, 5b

Protocol

Population estimates and species composition for small mammals should be collected prior to and after completion of restoration activities. Live traps should be used following standard capture-recapture techniques from June through August. Traps should be placed along established transects at 25m intervals. At each location, large Sherman live traps, or comparable traps, should be placed in the nearest appropriate location ensuring that the trap is sufficiently protected from the elements (e.g., sun). At alternating sites both large and extra large should be used. All traps should be baited with a mixture of rolled oats and peanut butter. Traps should be checked twice daily (morning and dusk) for three consecutive days. Captured animals should be identified to species, sexed, and aged if possible. Additionally, chipmunks, deer mice, and squirrels could be tagged with numbered aluminum ear tags to allow for individual identification. Baseline data should be collected for at least 2 years prior to construction to account for annual population variability. Post project data should be collected for at least three years after completion of construction. Trap positions, or the ends of transects, should be recorded using GPS, and monumented in the field. The general habitat type as well as local micro-habitat conditions should be recorded for each trap. For more information on protocols see Bookhout (1996) and Borgmann and Morrison (2005).

Bats

Objectives Monitored

2a, 2d, 5b

Protocol

Surveys for bats could be conducted prior to and after restoration activities to assess habitat conditions for bat species and as an indicator of overall meadow habitat conditions. Surveys should be conducted using Pettersson ultrasonic detectors (model D240X) to assess bat species composition. At each site, two Pettersson recorders should be placed at each site in suitable openings, near habitat transition zones, or in likely movement corridors. Bats should be recorded at each site on three different nights separated by at least one week from June to August. Detectors should be placed in different locations upon subsequent visits to ensure that the entire site has been adequately sampled, with each location at least 100 m apart.

Herpetofauna

Objectives Monitored

2a, 2d, 5b

Protocol

Reptile and amphibian diversity and population estimates could be collected prior to and after completion of restoration activities. Visual Encounter Surveys should be conducted in June in accordance with techniques described by Fellers and Freel (1995). Baseline data should be collected for at least 2 years prior to construction to account for annual population variability. Post project data should be collected for at least three years after completion of construction.

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