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Final



## Meeks Creek Watershed Ecosystem Assessment Report

for United States Forest Service - Lake Tahoe Basin Management Unit

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## Acknowledgments

The Meeks Creek Watershed Ecosystem Assessment was prepared by the U.S. Forest Service Lake Tahoe Basin Management Unit (LTBMU) Ecosystem Restoration Group in conjunction with Swanson Hydrology & Geomorphology (SH+G). The primary authors of this report are Mr. Mitchell Swanson and Mr. Russell Axelrod, hydrologists and geomorphologists with SH+G. Matt Weld P.E., Rodney Cahill P.E., and Gregor Patsch EIT of SH+G provided hydraulic analysis, technical designs, and drawings of restoration options and cost estimates. Kent Wingfield, Maggie Mathias and Eve Elkins of SH+G provided data collection/analysis, technical graphics and report production services.

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## LIST OF ACRONYMS

AMS	Aquatic Management System
BMPs	best management practices
CDEC	California Department of Environmental Resources – Data Exchange Center
CDFG	California Department of Fish and Game
cfs	cubic feet per second
CLM	California Land Management
CTC	California Tahoe Conservancy
CTLFC	Carson Tahoe Lumber and Flume Company
CWA	Clean Water Act
DP	dissolved phosphorus
DOC	dissolved organic compound
EAR	Ecosystem Assessment Report
EIP	Environmental Improvement Program
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency (USEPA in Appendix A)
ERL	effect range low
ERM	effect range medium
HEC-FFA	hydraulic engineering center flood frequency analysis
HEC-RAS	hydraulic engineering center river analysis system
ID Team	Interdisciplinary team
LWD	large woody debris
LCT	Lahontan cutthroat trout
LOPs	limited operating periods
LRMP	Land and Resource Management Plan
LTBMU	Lake Tahoe Basin Management Unit
LTBWQCP	Lake Tahoe Basin Water Quality Control Program
MOU	Memorandum of Understanding
msl	mean sea level
NEPA	National Environmental Policy Act
NFS	National Forest System
ONRW	Outstanding National Resource Water

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PACs	protected activity centers
PAS	Plan Area Statement
PMA	Possible management actions
RCAs	Riparian Conservation Areas
RCOs	Riparian Conservation Objectives
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board (Lahontan District)
SDWA	Safe Drinking Water Act
SEZ	Stream Environment Zone
SH+G	Swanson Hydrology & Geomorphology
SNFPA	Sierra Nevada Forest Plan Amendment
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TBT	tributyl tin
TKN	total kjeldahl nitrogen
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRBRIT	Truckee River Basin Recovery Implementation Team
TRPA	Tahoe Regional Planning Agency
USACOE	United States Army Corps of Engineers
USGS	United States Geological Survey
USDA	United States Department of Agriculture
USFS	United States Department of Agriculture Forest Service
USFWS	United States Fish & Wildlife Service
WCP	Wetland Conservation Plan
ybp	years before present

## Executive Summary

The United States Department of Agriculture Forest Service (USFS) Lake Tahoe Basin Management Unit (LTBMU) has completed an assessment of the ecosystem conditions in the Meeks Creek watershed with an emphasis on the area near the shoreline and lower meadow. LTBMU owns and manages over 90% of land in the Meeks Creek watershed:

- The upper watershed is managed as the Desolation Valley Wilderness area.
- The lower meadow consists of 350 acres of riparian and wetland areas surrounded by conifer forest extending two miles inland from the Lake Tahoe shoreline.
- The Shoreline Area located between Highway 89 and Lake Tahoe contains high value recreational facilities including the Meeks Bar Resort and Marina and the Meeks Bay Campground.

The focus area of this Ecosystem Assessment is the lower meadow and shoreline areas. LTBMU management of Meeks Creek watershed is directed by policies from the Land Management Resource Plan (LRMP 1988) and the Sierra Nevada Forest Plan Amendment Record of Decision (SNFPA 2004). These documents recognize the unique importance of high value recreational facilities at the Lake Tahoe shoreline as well as the importance of high quality ecosystem condition and function in wetland and riparian zones that support wildlife and preserve water quality. These policies direct LTBMU to conduct a site-specific assessment in order to find ways to resolve any conflicts between recreation use and ecosystem quality and to optimize conditions for both, if possible. Given this directive, the assessment compiled current and historic data on ecosystem quality, to estimate the original ecosystem and the effects of land uses on present function. Other agencies such as Tahoe Regional Planning Agency (TRPA), the Washoe Tribe of Nevada and California (Washoe Tribe or Washoe), the Lahontan District Regional Water Quality Control Board (RWQCB), and California Tahoe Conservancy (CTC) are stakeholders and have policies and programs to provide recreational uses, protect water quality and ecosystem function.

An assessment of ecosystem conditions found that the Meeks Creek Watershed contains a diverse variety of native plant communities ranging from alpine chaparral to wet meadows that potentially support a diverse assemblage of aquatic and terrestrial wildlife. Landforms in the lower meadow and shoreline zones were formed by glacial processes that were active over the past 2.1 million years; glacial erosion and deposition and fluvial processes during present and past interglacial times left a variety of soils and diverse hydrologic conditions. The dynamics of wet and dry climatic cycles, fire, flooding, and changes in the level of Lake Tahoe created rich and diverse habitats and landscape of unique and unusual beauty when humans entered the landscape perhaps 6,000 to 10,000 years ago.

The Washoe traditionally used Meeks Bay during the warmer seasons to gather and cultivate plants and to fish and hunt. Europeans came to Meeks as early as 1860 and used meadows for grazing and hay production. Logging in the 1880s removed the original old growth conifer forest

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by 1900. Recreational use and development along the shoreline of Meeks Bay began in 1928 and grew steadily into a resort destination that included cabins, a dance hall, a movie theater, boat house, stable, a pier and car camping. In 1960, a marina was dredged at the mouth of Meeks Creek for over 100 boat slips and a boat launch facility. In 1974, the Meeks Bay Resort and Marina and the Meeks Bay Campground were acquired by the U.S. Forest Service LTBMU. Although some cabins at the shoreline were removed, LTBMU maintained the resort, marina and campground operations through special use permits. The Meeks Bay Resort and Marina and Meeks Bay Campground are popular and highly used and valued recreation areas for beach use, camping and boating. Due to the aging and piecemeal development of recreational facilities, several resource deficiencies exist, including: poor visual quality in some areas, poor pedestrian and auto traffic circulation, safety problems, a lack of water quality BMPs, and degraded vegetation conditions.

The effects of historic land use on ecosystem function were found to be greater in the shoreline zone below Highway 89 than in the lower meadow. The Highway 89 bridge built in 1928 was found to be a fish passage barrier under low flow conditions and an erosion hazard as it concentrates all runoff, including large floods, into two 10-foot wide box culverts. The bridge did allow the meadow upstream to maintain geomorphic stability and high quality ecosystem function by halting channel incision. The stream below Highway 89 to the Lake Tahoe shoreline was found to be highly altered due to channel incision and construction and maintenance of the deep marina. Placement of fill, roads and parking lots marina converted original wetland and riparian areas to sparsely vegetated uplands. Steel sheet piling has fixed the mouth of the creek. The modification of broad marsh areas and sloughs to filled uplands removed landforms from the backwater of Lake Tahoe and left land too high or too low for wetland plant sustenance. The deep marina basin reduces circulation and as a result supports a low level of aquatic biological activity compared to other shoreline lagoons.

Four Possible Management Actions (PMAs) were developed to assess possible ecosystem restoration projects and their socio/economic impacts. The PMA analysis is a preliminary assessment that did not examine potential mitigation or alternative projects to offset impacts to recreation resources. Examination of potential mitigation projects and an expanded and more detailed assessment of alternatives will be conducted in future planning efforts by a USFS Interdisciplinary Team (ID Team), who will also conduct an environmental review per National Environmental Policy Act (NEPA) to ultimately develop a proposed action(s).

**Possible Management Action 1** involves development of a Restoration Plan for the lower meadow in order to return ecological conditions to pre-disturbance levels to the extent possible. Vegetation management will be the centerpiece of this plan and may include re-introduction of vegetation management techniques used by the Washoe, including cultivation and harvest of specific native plants, and use of fire to encourage growth of specific plants. The Plan would also address the management of beaver populations which were introduced and now affect the hydrology of Meeks Creek and the vegetation cover of the meadow. An assessment of

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socio/economic impacts found little effect of changing vegetation cover. The Restoration Plan is currently under development and will be generated later this year for consideration by LTBMU for implementation.

**Possible Management Action 2** involves replacement of the Highway 89 Bridge with a wider structure that serves to provide fish passage over the range of flows during periods when fish are migrating. The new span would be at least 70 feet wide and would incorporate grade control to maintain the high quality function of the meadow upstream as well as reduce hydraulic force on the downstream side. The new bridge may also include improvements for pedestrian circulation and bike paths. Replacing the bridge was found to have potentially beneficial efforts on socio/economic conditions as a result of improved circulation, access, and safety. A planning document currently in preparation by LTBMU will present a plan for the design and planning processes with timelines and cost estimates.

**Possible Management Action 3** presents a range of options to address the ecological conditions around the Meeks Bay Marina facility and the Creek up to Highway 89.

**Option 1** involved no action and a continuance of present conditions into the future; this was found to be the least desirable scenario as erosion problems and a low level of biological activity would persist.

**Option 2** involves stabilizing and vegetating Meeks Creek from the upstream end of the marina to Highway 89; it would involve placement of a series of boulders weirs and excavation of floodplain surfaces within the channel in order to lengthen the grade between the outlet of the Highway 89 bridge and the head of the marina. This project would enhance native vegetation and erosional stability, but would not substantially increase ecological function and would not address the low biological activity of the marina basin. Socio/economic conditions and recreational experiences could improve as the creek could become more inviting to users and associated enhancements could improve circulation patterns.

**Option 3** would include the measures of Option 2 upstream of the marina plus the removal of fill from the upland area surrounding the marina in order to restore marsh plain landforms in the elevation range that supports wetland vegetation. Option 3 would partially restore ecosystem function on newly created marsh plain surfaces, however with the marina in place the creek would remain in an incised condition and not fully restored. Principal socio/economic impacts would include loss of parking spaces south and north of marina and loss of convenience for access as walkways to marina would have to be extended. Investigation of measures to offset impacts to recreation resources such as relocating parking spaces will be conducted during next planning phase.

**Option 4** would remove the marina from the creek mouth and restore the creek and shoreline wetland to the boundaries and the condition that existed prior to Comstock Era. This option would achieve the highest degree of ecosystem restoration as it would restore that geomorphic and hydrologic processes such as meandering, overbank flooding, and lateral movement of the creek mouth through the beach which creates and sustains landforms for native riparian and wetland plants and aquatic habitats. Option 4 would, however, substantially influence socio/economic conditions including loss of over 100 boat slips and associated loss of revenue (40% of Meeks Bay Resort revenue), as well as loss of parking, boat launch and other facilities. It is also possible that resort and campground occupancy might decline if the marina were eliminated. Measures to replace the marina uses such as installing a pier, buoy fields, or other replacements could offset these impacts and will be analyzed in the next planning phase.

**Possible Management Action 4** would restore native Lahontan cutthroat trout (LCT) to isolated reaches of Meeks Creek above the lower meadow where populations of non-native fish could be excluded. This would require removing non-native fish, reintroducing LCT stocks, and then monitoring success for a period of several years.

## Summary

This ecological assessment report presents an evaluation of ecosystem quality and function in the Meeks Creek watershed above the west shore of Lake Tahoe, specifically within National Forest System lands managed by the United States Department of Agriculture Forest Service (USFS) Lake Tahoe Basin Management Unit (LTBMU). The purpose of this document is to provide site-specific information to support a USFS interdisciplinary planning process that will ultimately result in “proposed actions” to achieve the goals of the 1988 LTBMU Land and Resource Management Plan (LRMP), as amended by the Sierra Nevada Forest Plan Amendment (SNFPA) (SNFPA 2001), the SNFPA final supplemental environmental impact statement (EIS) Record of Decision (ROD) (SNFPA 2004), and including other USFS guidance and policy directives described in this report. The ecological assessment objectives include the following:

- Provide the LTBMU an evaluation of current (existing) ecosystem conditions
- Assess how land use has affected ecosystem quality and function and resultant wildlife populations and native plant communities
- Identify a range of possible management actions to enhance and/or restore ecosystem function
- Provide the foundation for developing proposed actions that achieve the highest level of ecosystem function while maximizing social and economic resources, including recreational opportunities.
- Survey present land uses and preliminarily assess influence on recreation elements from possible management actions.

This assessment is an initial step to implement the Aquatic Management Strategy (AMS) of the SNFPA Final EIS (SNFPA 2001), as amended (SNFPA 2004), to develop a sound framework for ecological restoration of the Meeks Creek watershed. From a watershed perspective, the fundamental principle of AMS is to retain, restore, and protect the processes and landforms that provide habitat for aquatic and riparian-dependent organisms, and produce and deliver high-quality waters for which the national forests were established. The regional effort to address water quality and ecological restoration was established in the early 1990s after recognition that the ecosystems of the Sierra Nevada were in a degraded condition and that pressure from urbanization and other land uses was increasing. The LTBMU is evaluating their lands to identify opportunities for ecosystem restoration consistent with these objectives and USFS governing guidelines and policies.

This study seeks to explore a range of opportunities for improving ecosystem function while identifying on a preliminary basis the potential influence (including enhancement) of restoration projects on the recreation, social, and other economic resources at Meeks Bay, particularly the shoreline area downstream from Highway 89. The LTBMU will thoroughly explore the opportunities for management actions that enhance both ecological and social resources in

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future planning efforts, including the NEPA process, and envisions that ecological restoration can be accomplished while improving the recreational opportunities at this unique location. An overriding goal in the future condition of Meeks Creek is that quality recreation at the Lake Tahoe shoreline can coexist with a healthy ecosystem in the lower Meeks Creek watershed.

## LTBMU MANAGEMENT AND OTHER INTERESTED AGENCIES

LTBMU management guidelines and policies are fundamental to the approach and planning process necessary for ecosystem restoration. These policies make strong statements in support of ecosystem restoration and recreation uses; the ultimate plan for Meeks will reflect a balance of these interests. The LTBMU manages over 90 percent of the land in the Meeks Creek watershed, including the Meeks Bay Resort, Marina, and Campgrounds at the shoreline. Efforts to protect and restore riparian and aquatic ecosystems, wildlife populations, and water quality discharge to Lake Tahoe involve a number of regulatory and/or funding agencies, as well as public interest groups and other interested parties. The primary partners in the watershed restoration project include the Washoe Tribe of Nevada and California (Washoe Tribe or Washoe), Tahoe Regional Planning Agency (TRPA), Lahontan District Regional Water Quality Control Board (RWQCB), and the California Tahoe Conservancy (CTC). Other agencies that have involvement through ownership of land or facilities in the study area and/or have an interest by virtue of their agency authority and mandate, include: Caltrans; California Department of Fish and Game; U.S. Fish and Wildlife Service; El Dorado County; U.S. Army Corps of Engineers Regulatory Branch; and the Tahoe City Public Utility District.

## RECREATION USE AT MEEKS

The Meeks management area includes the Meeks and General Creek drainages adjacent to Desolation Wilderness. The Meeks Bay shoreline is popular for many reasons, but primarily because of its beautiful scenery, sprawling clean beaches, and easy access. The recreation users are diverse with a broad range of expectations and desires. Developed and dispersed recreation opportunities available include camping, swimming, picnicking, hiking, biking, boating, and marina and other resort activities. Desolation Wilderness is one of the most heavily used wilderness areas for its size in the nation, and the Meeks Trailhead offers some early season access due to its lower elevation. Current management strategies for the area dictate that quality recreation experiences in the area should be closely tied to maintaining healthy ecosystems in the Lake Tahoe Basin.

Many of the USFS recreation facilities at Meeks Bay are in need of improvement to better meet the expectations of the contemporary public for high quality recreation, as well as Lake Tahoe environmental standards. These include problems associated with highway corridor traffic, parking, general auto and pedestrian circulation, and the need to upgrade general facilities and infrastructure.

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## SUMMARY OF REGULATORY ASSESSMENT AND ECOSYSTEM RESTORATION OBJECTIVES

A key focus of this analysis is to define a desired condition for the wetland, riparian, and meadow ecosystems located in the Meeks Creek watershed consistent with USFS restoration guidelines and policies. The SNFPA (2004) desired condition for meadow and riparian ecosystems translated to the following AMS restoration objectives for the Meeks Creek lower meadow and shoreline zones:

- 1) Restore, protect and maintain the ecosystem function in Meeks Creek that is important to the sustenance of healthy wildlife populations and species diversity.
- 2) Restore and maintain healthy ecosystem function in the unique shoreline wetland habitat area situated at the mouth of Meeks Creek along the shore of Lake Tahoe.
- 3) Rearrange and redefine land use facilities, structures, and activities in and around Meeks Creek such that their presence and operations do not adversely affect healthy physical and hydrologic function of the riparian, meadow, and wetland ecosystems. The optimum desired condition calls for healthy ecosystem function and compatible and enhanced recreational opportunities.
- 4) Restore ecosystem function conditions as close as feasible to those which existed prior to modification by European settlement (beginning at approximately 1850), including the effects of Washoe sustainable land management practices.

These restoration objectives for the Meeks Creek watershed will need to be evaluated along with recreational resource interests and other factors to determine the extent or degree to which AMS objectives are implemented in the future stages of the Meeks Creek improvement projects. These decisions will involve future public input and guidance from the many interested partners consistent with the NEPA process in a site-specific analysis.

## ECOSYSTEM CONDITIONS AND HUMAN LAND USE

Ecosystems in the scientific community are typically defined as assemblages of plants and animals interacting with the physical landscape; this may also be interpreted to mean a wildlife ecosystem. At USFS, ecosystems management can include cultural/social elements, thus, in applying ecosystem management to forest service lands, ecosystem includes the interaction of living organisms (including people) with their environment.

At Meeks Creek, human activity has always been an important influence on ecosystem function. Beginning with the ancestral Washoe inhabitants, vegetation and wildlife were cultivated, harvested, and managed using sustainable practices for several thousand years prior to 1860. Human activity markedly changed in magnitude and form beginning in the 1860s Comstock Era when logging, grazing, and widespread resource extraction fed the mining boom in western Nevada. This was followed by the expansion in tourism and urbanization at Meeks Bay from the 1920s to present day. These land use activities since approximately 1850 brought important and

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often deleterious changes to the natural resources and landscape at Meeks, with clear cutting and the removal of old growth trees, and destruction of the marsh and lagoon habitats with major development activities near and across the shoreline area.

It is clear from the complex history at Meeks Creek that ecological conditions have declined, while recreation, economic, and transportation resources have been developed on the shore of Lake Tahoe. Not unlike many developments in the early 20<sup>th</sup> century, the recreation resources at Meeks were largely developed in piecemeal fashion and with little consideration of ecological habitat and landscape stewardship. Today however, with established guidance, policies, and vision of the USFS and other partners, Meeks presents an opportunity to both improve ecosystem function and enhance recreation at this unique setting. Thus, the challenge of restoration at Meeks is to recognize the importance of these multiple resources and to develop a scientific framework and plan that balances these multiple interests.

## WATERSHED DESCRIPTION AND ENVIRONMENTAL SETTING

The Meeks Creek watershed is a unique “L” shaped basin that drains approximately 8.1 square miles eastward from the crest of the Sierra Nevada at over 9,200 feet above mean sea level (MSL), into Lake Tahoe at elevation 6,625 feet. The Upper Watershed is located fully within the boundaries of Desolation Wilderness which is managed by the LTBMU and El Dorado National Forest. No roads exist for vehicular access, though there are numerous trails for hiking and cross country skiing. The Meeks Creek is roughly 7.5 miles in length and the watershed is separated into three distinct areas: upper watershed, lower meadow, and shoreline zone (or lower reach). The U-shaped valley of the Upper Watershed extends from the crest of the Sierra Nevada, passing through forests, small meadows, and numerous lakes. Meeks Creek then cascades down a glacial step to the wide flat valley floor of the lower meadow then into the shoreline zone at Lake Tahoe.

The watershed is underlain predominantly by granitic bedrock and its present soils, landforms, and hydrologic conditions have resulted from glacial processes from the advancement and retreat of ice masses during the last 2 million years before present (ybp), and especially in the last 60,000 years. Lateral moraines bound the edges of the meadow rising to approximately 400 to 1,000 feet above the valley floor, and recessional moraines cross portions of the basin in several locations. This has created a complex environment of landforms and soils, including lacustrine (glacial lake) deposits, fluvial deltaic deposits, glacial outwash, alluvial deposits, side valley alluvial fans, peat soils, and cobble/boulder lag deposits. These complex valley floor landforms and soils have led to a diverse set of soil and hydrologic conditions whose influence persists today. The modern Meeks Creek is an underfit stream which generates only a fraction of the hydraulic force of the prior glacial period responsible for the formation of the present valley floor landforms. Another important ecological factor for habitat at lower Meeks Creek and shoreline area is the interaction with various stands or elevations of Lake Tahoe.

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The hydrology of Meeks Creek is driven by the seasonal precipitation patterns (rain and snow) and temperature conditions. The majority of precipitation falls as snow in the winter months from November to April, and the highest volume of runoff is generated by spring snowmelt of the upper watershed snowpack from April through June. Warm winter rains that fall on snow typical of El Nino year storms can contribute the highest instantaneous peak runoff. There is little runoff during the dry summer months, but runoff increases in November and December with the onset of winter rain. Through the cold winter months precipitation is stored in the snowpack, and then with rising temperatures the majority of Meeks Creek runoff is generated during spring snowmelt.

Meeks Creek watershed supports a wide range of montane and sub alpine plant communities. Conifer forested areas includes some original old growth Jeffrey pine forest in the upper watershed area of Desolation Wilderness, however, most other vegetation communities have been affected by past logging, grazing, introduction of beaver, and fire suppression. The Washoe's cultural practices also influenced vegetation cover in meadow, riparian, and forest settings. The shoreline zone has predominantly conifer forest cover of second growth Jeffrey pine and lodgepole pine with developed understory supporting campgrounds, roads, buildings, and parking lots. Riparian vegetation along Meeks Creek downstream of Highway 89 is very limited due to channel incision and the dominance of open water and steep banks along Meeks Bay Marina.

The Lower Meadow has a wide variety of plant coverage ranging from mixed conifer forest to emergent marsh areas. The edges of the valley floor consist of mixed conifer forest with shrub understory merging into dry graminoid then wet graminoid meadows. Peat soils provide conditions for unique vegetation establishment in some areas supporting vernal pools. Several species of willow and alder dominate woody riparian vegetation along Meeks Creek; alder are found along the edges of recessional moraines in five locations on the valley floor. Fire suppression in the meadow areas allowed for invasion of single-aged lodgepole pine, which has been thinned through timber harvests conducted by the LTBMU in the late 1980s and early 1990s. Obligate sedge meadow and open water areas surrounding large clumps of willow are found within the impoundments of several beaver dams which have created valuable willow flycatcher habitat.

The Meeks Creek Watershed provides habitat for a variety of terrestrial wildlife including black bear (*Ursus americanus*), coyote (*Canis latrans*), pine marten (*Martes pennanti*), raccoon (*Procyon lotor*), and mule deer (*Odocoileus hemionus*). The Washoe traditionally hunted a variety of species, including mountain cottontail (*Sylvilagus nuttalli*), mule deer (*Odocoileus hemionus*), ground squirrels (*Spermophilus* spp.), and various fish species. Common waterfowl species found in the Lower Meadow include Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), and Wilson's snipe (*Gallinago gallinago*). A variety of neotropical migratory birds are found within the Lower Meadow including warbling vireo (*Vireo gilvus*), western wood-pewee (*Contopus sordidulus*), yellow-rumped warbler (*Dendroica coronata*), and MacGillivray's

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warbler (*Oporornis tolmiei*). Tree swallows (*Tachycineta bicolor*) are common cavity nesters in the area. Bald eagles (*Haliaeetus leucocephalus*) and ospreys (*Pandion haliaetus*) might have nested in the lower portion of the Meeks Creek watershed prior to human encroachment. Fisheries resources in Meeks Creek are dominated by introduced species including brown trout, rainbow trout and brook trout. The native Lahontan cutthroat trout (LCT) has been eliminated due to past over-fishing and competition from non-native species. Trout observed above Highway 89 are predominantly rainbow trout, which, owing to their spring time adfluvial, upstream migration during seasonally high flows, are able to negotiate the low flow passage barrier at Highway 89 and reach spawning areas upstream. The conditions above Highway 89 seem to favor other species such as brook trout.

## LAND USE INFLUENCE ON ECOLOGICAL FUNCTION

Meeks Creek above Highway 89 is, in general, in very good condition with regard to ecological function and the resultant riparian, aquatic, and wetland habitats. This relatively high quality function is the result of a naturally high resilience to abrupt geomorphic change. The primary ecosystem function problems in the Lower Meadow above Highway 89 are encroachment of lodgepole pine into meadow areas and possibly some aspects related to the presence of beaver.

Meeks Creek below Highway 89 is in a highly degraded, ecological state of dysfunction. The channel is deeply incised (4-6 feet) and eroding as a result of marina construction and continued maintenance dredging. Incision has reduced the local groundwater table and dried adjacent floodplain areas and wetlands. Geomorphic processes are now isolated to a narrow band of the stream bed and little, if any, beneficial processes are now occurring. The containment of flooding and sediment transport has virtually eliminated any beneficial hydrologic conditions usually present in a lower floodplain and shoreline wetland environment. These changes, in conjunction with development filling of former wetland and floodplain areas, have eliminated floodplain function and floodplain marsh surfaces within the critical elevation range necessary to support wetlands along the Lake Tahoe shoreline. The marina has been dredged into an artificially deepened, widened, and fixed configuration, resulting in a lack of natural geomorphologic and hydraulic processes and function in the dynamic floodplain/shoreline area, and resulting in generally poor primary benthic productivity and species viability.

The historic land use activities at Meeks Creek changed the natural ecosystem and the physical and biotic processes supporting ecosystem function:

- 1) Clear cutting in the mid to late 1800s removed all of the virgin old growth timber stands in the lower watershed. All trees over 15 inches in diameter were removed. Fire suppression since the early 1900s, along with clear cuts in the 1800s, led to the present forest structure that is dominated by dense single aged stands of white fir. Conifer species have shifted from a dominance of Jeffrey pine to dense white fir and lodgepole pine.

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- 2) Washoe cultural practices at Meeks Creek included control burning of meadows and forest understory and harvesting and cultivation of a variety of native plants for medicinal, utilitarian, and food needs. These practices were curtailed and then eliminated in the early 1900s. This likely led to the invasion of dense stands of lodgepole pines into meadow areas.
- 3) The original shoreline wetland at Meeks Bay has been highly altered as a result of development of the Meeks Bay Resort and Marina, and Campground. Historical information including photographic records show elements of a functional lagoon and marsh system, which supported native vegetation communities and fish habitat. The shoreline wetland/lagoon system was lost when the Meeks Bay Marina was constructed in 1960, along with associated dredging and filling of the lower floodplain areas. This created a configuration that eliminated landforms at the proper elevations to support wetland vegetation. Furthermore, the present marina has created a static physical system, eliminating the dynamic geomorphic processes necessary to sustain a functional ecosystem.
- 4) The dredging of the marina and the construction of the Highway 89 bridge has caused severe channel bed incision in Meeks Creek between the Lake Tahoe shoreline and Highway 89. The incision has caused severe and chronic bank erosion and drying of the floodplain surface, which once supported wetland and riparian vegetation and habitat.

## FINDINGS OF ECOLOGICAL ASSESSMENT RELEVANT TO AMS GOALS

To meet the AMS goals for Meeks Creek watershed, some restoration efforts are needed for the areas above Highway 89 and major restoration efforts are needed to restore ecosystem function below the Highway 89 bridge extending to the shoreline of Lake Tahoe. The AMS goals, existing conditions, and basis for proposed restoration approaches are summarized below:

**AMS Goal — Water Quality:** Meeks Creek upstream of Highway 89 discharges some of the cleanest water measured in the Lake Tahoe Basin. Measurements taken at Highway 89 have led many researchers to cite Meeks Creek as the baseline of pre-disturbance water quality.

Below Highway 89, however, the degraded channel conditions have simultaneously increased fine sediment production through bank erosion and eliminated floodplain fine sediment deposition; this has likely increased fine sediment discharge into Lake Tahoe. Detection of selected metals in the Meeks Bay Marina, while generally low, indicate pollution directly related to marina use. Leaching of organic carbon from natural drift matter (e.g., leaves and woody debris) trapped and decomposing in Meeks Bay Marina results in discoloration of the water discharged into Lake Tahoe.

Stabilizing the Meeks Creek channel and restoring natural bankfull channel and floodplain morphology would restore floodplain function and filter runoff. Restoring the natural barrier

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beach processes and shoreline wetland vegetation would increase hydraulic residence time, increase water/vegetation contact time, and increase fine sediment and nutrient removal.

**AMS Goal — Wildlife Species Viability:** Habitat quality in Meeks Creek Watershed above Highway 89 is in generally good condition, notwithstanding the loss of species such as the Lahonton cutthroat trout and bald eagles due to human encroachment and loss of food sources. Below Highway 89, however, channel incision and elimination of natural geomorphic processes have dramatically reduced riparian and meadow vegetation, as evidenced by historical aerial photographs and subsurface investigations.

In order to restore and encourage sustainable habitat for wildlife, the reach below Highway 89 would have to be modified to restore geomorphic process and function. Restoring the creek function would initiate the natural geomorphic stability and lower floodplain processes that allow for colonization of native vegetation communities and form the basis for naturally sustained wildlife habitat. However, the continued human presence along the shoreline area would continue to discourage use by certain species such as the bald eagle.

**AMS Goal — Plant and Animal Community Diversity:** The diversity of plants and animals in Meeks Creek watershed is in generally good condition above Highway 89, but very poor below the highway and in the shoreline zone. This difference is related to the presence of favorable natural geomorphic function above Highway 89, and unstable and unnatural (highly disturbed) conditions below Highway 89. With the exception of the invasion of lodgepole pines into meadows above Highway 89, native vegetation diversity and wildlife habitat is generally high in the lower meadow area. Below Highway 89, conditions are much less diverse and valuable, a direct result of human encroachment and past land use activities and disturbances. The present conditions below Highway 89 would require substantial modification to restore natural geomorphic processes and hydrologic conditions in order to achieve sustained plant and animal diversity.

**AMS Goal — Special Habitats:** The Shoreline Zone at Meeks Bay constitutes special habitat status under the AMS, as this habitat is not only rare in Lake Tahoe, but has been highly degraded or lost entirely due to collective land use activities and disturbances since 1850, and particularly since the early 1900's. The original wetland ecosystem documented in historical photographs show a unique and highly-productive wetland system which has subsequently been eliminated by fixed developments involving dredging and landfilling activities, and resulting in undesired channel incision. The shoreline wetlands were likely important habitat areas for rearing native fish and for waterfowl and amphibians.

To restore self-sustaining habitat in the shoreline zone at the mouth of Meeks Creek, it will be necessary to restore geomorphic processes of sediment deposition, and marsh, meadow, and riparian vegetation development. This requires recontouring the former wetland area by

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removing anthropogenic fill and restoring the topography that existed prior to 1960, which supported the hydrology of wetlands. In addition, in order to achieve long term channel stability and minimum maintenance requirements, the incised condition of the streambed longitudinal profile must be raised to its original elevation where it discharges to the lagoon/lake system (i.e., vicinity of the current marina).

**AMS Goal — Watershed Connectivity:** Connectivity of wildlife habitat in Meeks Creek has been disrupted by the constricted Highway 89 crossing and eliminations of the shoreline wetland at Meeks Bay. This area originally provided an important connection between Lake Tahoe and the lower and upper watersheds and their wildlife habitats. In contrast, Highway 89 and the current bridge structure constrict connectivity between the lower meadow and the shoreline area and present a barrier to fish migration.

Replacing the Highway 89 bridge with a wider structure and removing the fish passage barrier are both important steps to restoring aquatic habitat connectivity between Lake Tahoe and Meeks Creek. Restoration of the shoreline wetland at the mouth of Meeks Creek, along with replacement of a wider Highway 89 bridge, would provide for an improved migration corridor for aquatic and terrestrial wildlife.

**AMS Goal — Floodplains and Water Tables:** Above Highway 89, most of Meeks Creek has good channel/floodplain connectivity, and shallow groundwater and good soil moisture conditions needed to sustain wetlands, meadow areas, and riparian vegetation.

Below Highway 89, Meeks Creek is in a highly degraded condition due to channel incision. Channel incision, induced by the dredging of Meeks Bay Marina in 1960 and anthropogenic filling, has eliminated channel/floodplain connectivity and function. The presence of fixed structures and marina dredging combined with placement of up to four feet of fill over former marsh areas, exacerbated channel incision which has lowered groundwater and soil moisture levels to the point where former wetland and marsh areas support only upland vegetation and limited diversity. The original pre-marina shoreline supported highly-productive wetlands and marsh and riparian vegetation when the functional geomorphic and hydrologic conditions and good channel floodplain connectivity were present.

In order to recover flood plain function and establish water table conditions needed to support wetlands and plant and wildlife diversity, major modification to the marina, lower creek reach, and Highway 89 bridge would be necessary. This would include removal of anthropogenic fill, raising of the channel profile, and revegetation.

**AMS Goal — Watershed Conditions:** Soil and vegetative conditions in the Meeks Creek watershed are in generally good condition upstream of Highway 89. The configuration of the Meeks Creek

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valley has a broad flat area over which runoff is dispersed over well-vegetated areas and Meeks Creek flows through several expansive meadow areas. In contrast, the reach below Highway 89, including Meeks Bay Marina, is in a highly degraded condition where sediment is released from bank erosion and water discoloration apparently results from the release of dissolved organic carbon from decaying organic matter that is trapped in the marina basin.

The watershed conditions of Meeks Creek above Highway 89 are some of the most pristine in the Lake Tahoe basin, and limited actions are needed for that portion of the watershed. However, the reach between Highway 89 and the shoreline is highly degraded and is discharging discolored water into Lake Tahoe. Substantial modification to Meeks Creek below Highway 89 would be required to take full advantage of the pristine conditions above Highway 89 and to restore watershed conditions critical for water quality and ecological function in the lower portion of the creek and shoreline area.

**AMS Goal — Streamflow Pattern and Sediment Regime:** The streamflow pattern and sediment regime in Meeks Creek above Highway 89 is in good condition for ecosystem function, and the available streamflow is unregulated and natural. It supports a variety of riparian, meadow, and marsh vegetation areas and habitats. The available sediment supply supports formation of gravel riffles in many locations where geomorphic function has not been disrupted.

Streamflow volume is not affected below Highway 89; however, hydraulic conditions below Highway 89 are deficient because too much flow is concentrated in the channel causing erosion, channel bed incision, and instability. Replacing the bridge with a wider span would allow for natural hydraulics, allow for fish passage and reduce erosion. Restoring the channel from the bridge to the lake, including reconfiguring to natural morphology and raising channel bed elevation, would achieve long term stability.

**AMS Goal — Streambanks and Shorelines:** Streambanks in Meeks Creek are in good condition above Highway 89. Streambanks are well vegetated and there are few, if any, areas of accelerated erosion. The geomorphic processes are favorable for well vegetated streambanks and development of excellent shoreline habitat.

Below Highway 89, Meeks Creek is highly degraded with steep, eroding banks supporting only sparse shoreline vegetation with limited diversity. Shoreline habitat also is of poor quality and without diversity. The reach of Meeks Creek within the Meeks Bay Marina has steep, linear, uniform, and barren banks with a flat and unnaturally wide streambed.

The lagoon area prior to marina dredging had diverse shorelines and complex bathymetry and vegetation. Restoring these conditions would require substantial modification of the lower drainage area including channel profile raising and other measures described above to reestablish the dynamic geomorphic and hydrologic function of the lower floodplain and shoreline setting.

## POSSIBLE MANAGEMENT ACTIONS FOR ECOSYSTEM RESTORATION

This assessment presents a range of possible management actions (PMAs) to enhance and restore ecosystem function at Meeks Creek to address AMS goals. The PMAs are designed to achieve incremental levels of improvement in ecosystem function and affect different portions of the watershed. Implementation of the PMAs will affect recreational resources in the lower reach and will have social/economic consequences for this area. Because of these impacts, a preliminary assessment of potential impacts on recreational resources was incorporated in the analysis. Although possible mitigation measures are not explored in this report and will be addressed in future planning efforts, it is generally believed by LTBMU Recreation Department that upgrades to the recreation resources could be integrated with ecosystem restoration projects in ways likely to also enhance recreation experiences. Thus, the PMAs presented in this study serve as starting points for the USFS and future Interdisciplinary Team to develop proposed actions that meet the agency goals for multiple resource stewardship.

Based upon the conclusions of the scientific study presented in this report, the following PMAs are identified to restore ecosystem function in the Meeks Creek watershed (i.e., the lower 350 acre meadow above Highway 89 and the stream corridor and shoreline wetland zone below Highway 89):

- 1) Restore Lower Meadow vegetation to pre-Comstock Era conditions to the extent possible;
- 2) Replace Highway 89 bridge to improve fish passage and reduce hydraulic force during floods;
- 3) Reconstruct Meeks Creek below Highway 89 through various options designed to provide increasing measures of restoration and ecosystem function;
- 4) Restore native Lahontan cutthroat trout to isolated reaches of upper Meeks Creek watershed.

It is important to recognize that although there are options to “enhance” the vegetation cover and aesthetics of lower Meeks Creek with the marina in place, it is not possible to truly “restore” geomorphic function and process within the incised channel. This report and LTBMU acknowledges that any proposal to remove the marina and change other long-standing infrastructural elements at Meeks (e.g., parking, roadway, marina, and campground locations) are substantial measures and may be controversial among certain interest groups. However, the primary objective of this EAR is to document the scientific basis for any restoration measures in the watershed and to establish a framework for review, analysis, and consideration of restoration opportunities in the future by an Interdisciplinary Team. Upgrading and improving recreational uses at the site – uses that were developed prior to the recent efforts to improve water quality and ecosystems around Lake Tahoe – will be fully explored in future ID Team planning efforts consistent with the NEPA process. It should be noted that all of the PMAs, including removal of the marina from the creek mouth, retain existing uses for shoreline access, beach use, parking, picnicking, boating and resort lodging opportunities.

## Possible Management Action 1

Measures can be taken to restore the vegetation cover in the lower 350-acre meadow and surrounding forest to pre-1850 conditions. These measures include the re-introduction of vegetation and wildlife management techniques that were in place at that time or practices that simulate natural conditions (e.g., controlled burning). The proposed restoration and management practices will likely involve management of meadow and forest areas for cultivation and harvest of culturally important plants by the Washoe. Some meadow areas may be thinned of lodgepole to expand meadow vegetation communities; white fir may be removed from dense forest stands to encourage Jeffrey Pine and Aspen stands in the forest areas. Once the fuels of dense lodgepole pines are removed, controlled burning of meadows and undergrowth in conifer forests could replicate the natural processes of the pre-Comstock Era. The basis and approach to lower meadow restoration will be detailed in a proposed Vegetation Management Plan to be prepared by a planning team, including Washoe Tribe Environmental Protection Department staff and LTBMU resource managers, fire specialists, and recreation managers.

PMA 1 affects primarily the lower meadow portion of the watershed upstream of the Highway 89 bridge, and would have little impact on current recreational resources at the developed recreation sites at Meeks Bay Resort and Meeks Bay Campground. Dispersed recreation activities such as hiking and biking in the lower meadow area, access to Desolation Wilderness, or use and maintenance of the administrative roads would not be adversely affected by the enhanced management practices envisioned by PMA 1.

## Possible Management Action 2

A preliminary design for a new (expanded) bridge has been prepared to meet the restoration objectives utilizing the current highway location. The design includes a much wider (70-foot) bridge span that will dissipate hydraulic force and allow for a natural channel/floodplain configuration to sustain bankfull channel conditions from upstream to downstream sides, and to create continuous floodplain geomorphic function. While bridge replacement is essential to meet project objectives, the design and construction of the new bridge must retain its present grade control function for preserving hydrologic and geomorphic function upstream, and be compatible with implementation of any stream restoration plans downstream.

A new bridge also provides an opportunity to accommodate safe pedestrian passage, and bicycle passage, on the highway. Presently there is dispersed parking along the highway shoulder and somewhat poorly developed parking areas on both sides of the highway. LTBMU plans upgrades and improvements to the Desolation Wilderness Trailhead parking lot, which is located across the highway from the resort campground. Separate planning, investigation, and analysis to replace the bridge are in progress.

PMA 2 would improve streamside recreation activities when combined with either boulder weirs or natural grade control described under PMA 3. In general, PMA 2 also would improve safety for pedestrians and would enhance traffic flow and access across Highway 89 and between the various areas of interest to dispersed and developed recreation on both sides of the highway.

### Possible Management Action 3

As noted under PMA 2 above, the new bridge design will require a grade transition between the channel upstream of Highway 89 and the incised channel below. The precise plan for grade control will depend upon the restoration approach selected for the lower creek and marina area under PMA 3. In order to provide a range of alternatives with which to implement restoration objectives in the lower reach of Meeks Creek (from Highway 89 to the shoreline of Lake Tahoe), four options were developed and evaluated:

**Option 1:** Allow existing conditions to continue.

**Option 2:** Stabilize Meeks Creek between Highway 89 and the upstream end of Meeks Bay Marina with boulder weirs, bank protection, and revegetation treatments.

**Option 3:** Includes Option 2, plus the removal of fill around Meeks Bay Marina to create marsh/riparian zones that flank the marina.

**Option 4:** Fully restore the lower reach of Meeks Creek by removing Meeks Bay Marina, removing anthropogenic fill, and restoring the natural (historical) stream bed, floodplain, lagoon, barrier beach, and marsh areas.

All four Options assume that recreational uses at the Meeks Bay Resort and the Meeks Bay Campground would remain, but in the case of Options 3 and 4 there would be removal of some existing recreation facilities such as parking, roads, and the marina (Option 4 only). All options assume that the highway bridge is replaced (PMA 2); however, Option 1 was eliminated from further consideration as it would continue degraded ecological conditions and channel instability and thereby would not meet any of the project restoration objectives. As noted above, the bridge replacement under PMA 2 is critical to maintain geomorphic and ecosystem function upstream and provide for fish passage during critical migration periods. If the Meeks Bay Marina facility is kept and the deep streambed and marina inlet are maintained in an incised condition, a boulder weir design will be needed for grade control between the new highway bridge and the incised channel downstream (Option 2).

Option 3 would involve the removal of anthropogenic fill surrounding Meeks Creek in the vicinity of the marina to restore the topography of the original marsh and floodplain surfaces. After restoring floodplain surfaces within the desired elevation range of 6,226-6,229 feet, these areas would be revegetated with appropriate meadow, marsh, and riparian plant species. Under Option 3, some of the marina facilities (including access roads, pathways, and parking) would have to be modified and extended to accommodate the expanded floodplain marsh areas.

Only Option 4 would achieve the key objective of fully restoring natural geomorphic processes and ecosystem function to Meeks Creek. Grade control from the bridge to the shoreline barrier beach would be achieved by reconstructing Meeks Creek channel by filling and raising the bed 4-6 feet. The channel stream bed would be restored using imported channel substrates (clean boulders, cobble, gravel, and sand) overlying a compacted fill. Option 4 involves removing anthropogenic fill in the vicinity of the marina and grading of the floodplain surfaces within the desired elevation range of 6,226-6,229 feet to support wetland and meadow vegetation (equivalent to Option 3 approach), removing the steel sheet piling from the beach at the marina outlet to the lake, and filling of the marina basin to an elevation of +/- 6,223 feet with substrate (gravel and sand) to allow for sustained creek function across the redeveloped floodplain setting.

Under Option 4, most of the existing facilities including, parking, campsites, and beach access would be retained; however the marina and 119 slips would be lost or would have to be relocated. Parking would be reduced if it were not replaced. Alternatives to the marina (e.g., pier or equivalent alternative to the north of the current marina and developed area) could be considered to replace the boat slips and perhaps maintain near the level of boating resources available today. Modifications to Option 4 design (e.g., alternate locations for creek and floodplain reconstruction) could be considered to enhance recreation activities and pedestrian access and circulation flow, while at the same time further enhancing the ecological restoration.

## Possible Management Action 4

An opportunity exists to restore native LCT to sections of Meeks Creek in the watershed area reach above the first natural passage barrier in the glacial step upstream of the lower meadow area. This reach of the creek could be isolated from competitive non-native populations downstream, although it is plausible that fish spilling from upstream lakes may be able to access this reach. The greatest challenge to cutthroat re-introduction is elimination of non-native trout species and their competition for food, spawning, and rearing habitat. Brown and brook trout are highly competitive species and their presence as well as rainbow trout is thought to exclude self-sustaining and successful LCT populations. PMA 4 would first require the elimination and/or relocating of non-native species by netting/electroshocking methods, then re-introduction of appropriate strains of LCT. The project would require at least 7 years of post project monitoring, including periodic removal of non-natives and re-introduction of additional LCT.

PMA 4 affects primarily the upper basin area upstream of the lower meadow portion of the watershed, and would have little impact on current recreational activities at the Developed Recreation sites at Meeks Bay Resort and Meeks Bay Campground, or the lower meadow area. Dispersed recreation activities such as hiking and biking would not be adversely affected by the enhanced management practices envisioned by PMA 4.