BEAR CREEK WATERSHED ASSESSMENT

PLACER COUNTY, CALIFORNIA

Prepared for:

foriver
TRUCKEE RIVER WATERSHED COUNCIL

PO Box 8568

Truckee, California 96162

February 16, 2018

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1 INTRODUCTION

1.1 Project Goals and Objectives

This assessment describes the geomorphology, hydrology and ecology of the Bear Creek watershed (**Figure 1-1**), expanding on a U.S. Forest Service sediment source assessment of the Truckee River between Lake Tahoe and the Town of Truckee (USFS, 2016). The USFS assessment concluded that a more detailed investigation was needed to gather additional information pertinent to effective design and monitoring to reduce sediment contributions from Bear Creek to the Truckee River. This assessment has been carried out to provide the science needed to identify management and/or restoration opportunities in the watershed.

This assessment is a technical study to be used by the Truckee River Watershed Council (TRWC) to: 1) identify and protect functioning areas with high ecological value; 2) identify disturbed areas with impaired functions and values, 3) understand the root causes of these disturbances; and 4) present a list of possible management actions and restoration opportunities. TRWC and stakeholders will use our findings described in this assessment to select 1 to 5 projects for design.

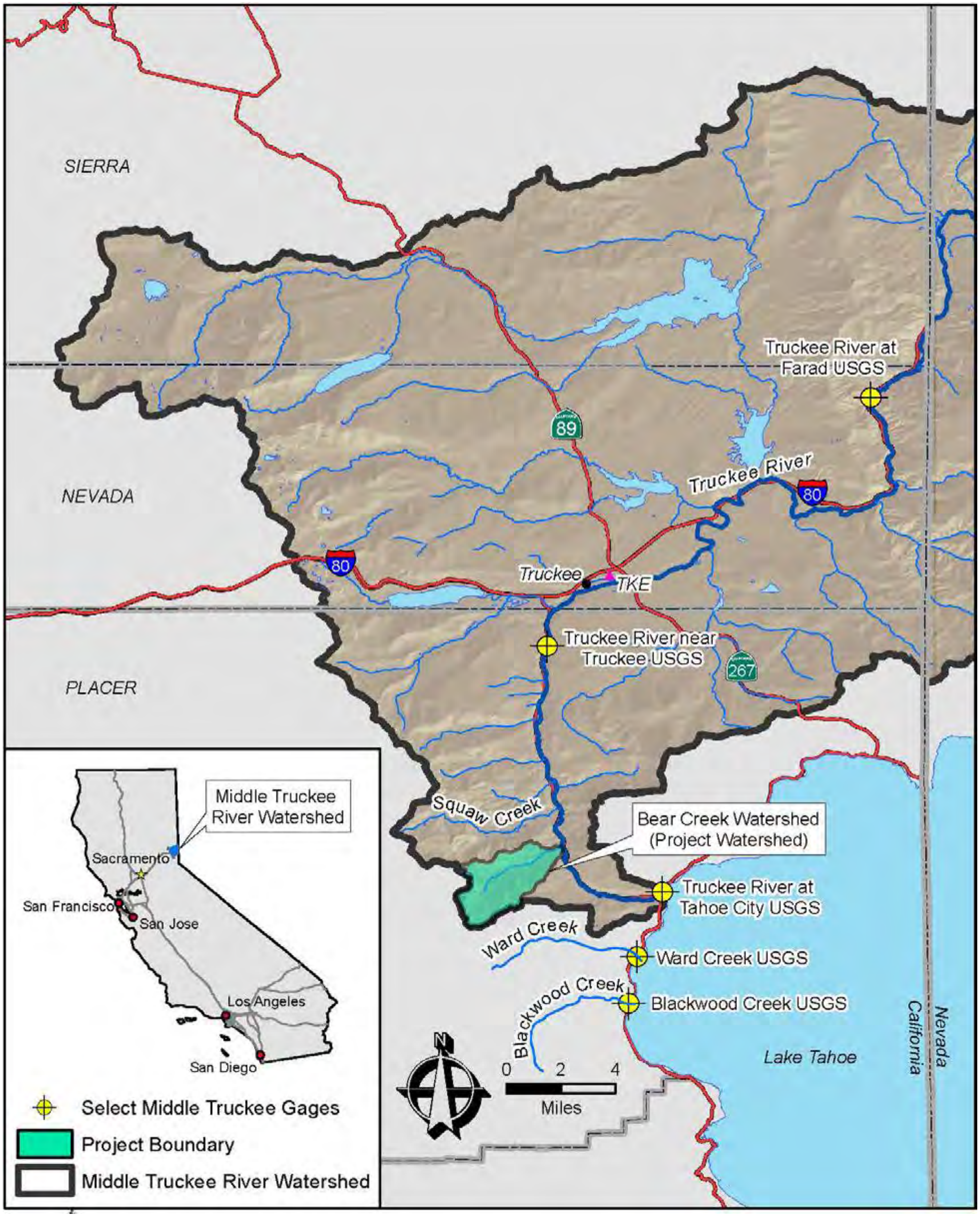

Figure 1-1 Bear Creek watershed regional location map showing streamflow gages and other features, Middle Truckee River Basin, California.

We seek to address the following questions:

- Which rock types and soils are sensitive to disturbances?
- What is the condition of botanical and vegetative communities in the meadows and to what extent is channel incision or meadow desiccation active?
- Do threatened, endangered or sensitive species occur in the watershed? If so, what are they and what habitats do they occupy?
- How important are the Bear Creek Valley springs to supporting wet meadow habitat, baseflow and aquatic habitat in the Bear Creek and the Truckee River?
- Are there management actions that could be implemented to protect the springs and maintain clean, cold waters in the Truckee River?
- How does the watershed's high annual precipitation and snowmelt interact with the road network and impact existing water quality or channel conditions?
- Are sediment sources in the watershed attributed to natural factors, legacy impacts, current land-uses or cumulative effects from both?
- What and where are the main historical land uses and to what degree have land management practices introduced or exacerbated sediment sources to Bear Creek and ultimately, the Truckee River?
- Do the watershed's impervious areas generate measurable excess stormwater runoff and how does this runoff impact Bear Creek and its tributaries?
- How do recreational uses impact watershed resources?
- What restoration and land management strategies should be implemented to protect habitat and improve water quality?

We note that this assessment was carried out within a short time frame which required our team to limit our field work to areas accessible to the public and in areas of concern as identified by other individuals familiar with the watershed, as well as our professional and personal experience in the watershed. This assessment does not attempt to a) evaluate individual landowner's 'housekeeping', b) provide an environmental 'audit' of any single land manager, or c) evaluate impacts of proposed development in the watershed. At least three proposed developments in the watershed are in various stages of planning and environmental review under the California Environmental Quality Act (CEQA), separate from this assessment. These include:

- Base to base Squaw-Alpine Gondola Project
- Alpine Sierra Subdivision
- White Wolf Subdivision and Ski Area

1.2 Structure of This Report

This report provides a comprehensive description of the historic, biologic, ecologic, hydrologic, and geomorphic setting for the Bear Creek watershed. The initial section (Section 2) provides some regulatory context for this assessment with the goal of improving water quality and aquatic habitat in the Truckee River. Section 3 describes the watershed setting including geology, hydrology, and ecology. Section 4 provides an assessment of the watershed condition based on background information collected, multi-day site reconnaissance, and limited analyses. Our assessment was primarily focused on the Bear Creek corridor, but includes limited evaluation of the watershed road network, stormwater concerns, and uplands. We summarize relevant conclusions from our assessment in Section 5 to provide the foundation for a catalogue of disturbance sites and management recommendations or restoration actions (Section 6).

1.3 Acknowledgments

This work and information presented in this report draws on information and efforts kindly provided by a number of individuals, landowners, and agencies. We would like to thank Troy Caldwell, owner of the White Wolf property, for providing our team with a tour of his land, water resources, and an outline of his land management practices. Troy also provided our team with some anecdotal historical information and ideas regarding trail and trailhead management. John Collins provided maps and access to the Alpine Springs Water District facilities and springs. Casey Blan with Squaw Valley Ski Holdings provided us access along roads on Alpine Meadows Ski Area. Katrina Smolen (HydroRestoration) provided Balance with background documents for Alpine Meadows Waste Discharge Requirements. We also thank Sharon Falvey (USFS) for her time to guide us on a tour some of the priority projects identified in the USFS Middle Truckee River Tributaries Sediment Source Assessment (2016). Finally, we thank Tim Boyer (Placer County) for his personal tour of the watershed’s stormwater infrastructure, current operations and maintenance, and existing issues.

1.4 Work Conducted

The Bear Creek Watershed Assessment was carried out by a multi-disciplinary team of staff from Balance Hydrologics (hydrology and geomorphology), H. T. Harvey & Associates (restoration ecology, botany, and wildlife biology), and Dr. Susan Lindström, Consulting Archaeologist (historical land use). We began this assessment with a review of available background information, drawing on many sources, including: historical maps, photos, aerial photographs, oral histories, land- and water-use histories, cultural resources, spatial (GIS) data, geologic and soil maps, and interviews with long-time residents of the watershed. A reconnaissance-based field assessment of the biological and hydrological resources was completed in September and October 2017.

This assessment has been conducted under contract to the Truckee River Watershed Council, and is funded by donors to the TRWC and the Martis Fund.

2 BACKGROUND

2.1 Truckee River Total Maximum Daily Load (TMDL)

Water resources in California are regulated by the Clean Water Act (CWA) and managed by the California State Water Resources Control Board (SWRCB), separated into nine different regions. Bear Creek is located within the Lahontan Region, regulated by the Lahontan Regional Water Quality Control Board (LRWQCB). The mission of the SWRCB and its regions is: *To preserve, enhance, and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use, for the benefit of present and future generations (LRWQCB, 2017).*

The CWA requires states to evaluate all surface waters, establish water quality standards sufficient to protect beneficial uses and identify constituents that impair beneficial uses. The CWA requires that the State establish a priority ranking for these impaired waters, also known as the 303(d) list of impaired waters. Furthermore, the CWA requires the state to develop and implement total maximum daily loads (TMDLs) for constituents of concern as necessary to address impairment. A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and it allocates pollutant loadings to point and non-point sources such that those standards will be met.

The Middle Truckee River, delineated as the reach between Lake Tahoe and the California-Nevada state line, was listed as impaired for suspended sediment concentration in 1992 (Amorfini and Holden, 2008). At higher stream flows, suspended sediment concentrations in the Truckee River are above those recommended for aquatic life protection. In 2008, a TMDL was adopted, and outlined actions to be taken to improve conditions watershed-wide, including reducing sediment from roads, ski areas, erodible landscapes and urban zones. The TMDL is implemented in part through the issuances of discharge permits under the National Pollutant Discharge Elimination System (NPDES), including NPDES permits for ski resorts and Municipal Separate Storm Sewer System (MS4) permits for Placer County, the Town of Truckee, and CalTrans, with assistance from local non-profits. Although sediment concentration and load trends have shown improvement based on monitoring results from WY2011 through WY2015 (CDM Smith and Balance Hydrologics, 2012, 2013, 2014, 2015, and 2016), biotic indices (numeric analyses of the population and diversity of benthic macroinvertebrates living on the streambed) indicate continued impairment by sediment as the diversity and number of insects has been impacted and decreased. The LRWQCB is currently reviewing the appropriateness of the Truckee River TMDL (LRWQCB, 2015). Efforts by land managers and non-profit organizations in the watershed continue to identify sediment sources and develop management strategies to improve water quality and habitat conditions in the Truckee River.

2.2 Water Resource Regulations Specific to Bear Creek

Bear Creek supports many beneficial uses, as identified by the LRWQCB and listed in **Table 2-1**.

Table 2-1 Beneficial Uses, Bear Creek, Placer County, California

Code	Beneficial Use
MUN	Municipal and Domestic Water Supply
AGR	Agricultural Water Supply
IND	Industrial Service Water Supply
GWR	Groundwater Recharge
REC-1	Water Contact Recreation
REC-2	Non-contact Recreation
COMM	Commercial and Sports Fishing
COLD	Cold Freshwater Habitat
WILD	Wildlife Habitat
RARE	Rare, Threatened, or Endangered Species
MIGR	Migration of Aquatic Organisms
SPWN	Spawning, Reproduction and Development

A variety of numeric and narrative water quality standards apply to all surface waters within the Lahontan Region, including Bear Creek, as shown in **Table 2-2**.

Table 2-2 Water Quality Standards, Bear Creek, Placer County, California

Constituent	Concentration*
Total Dissolved Solids	65 mg/L
Total Nitrogen	0.15 mg/L
Total Kjeldahl Nitrogen	0.10 mg/L
Total Phosphorus	0.02 mg/L
Chloride	2.0 mg/L
Sulfate	2.0 mg/L
Turbidity	3 NTU

* Mean of monthly means: arithmetic mean of the 30-day average for the period of record

Bear Creek was first included on the 303(d) list in 1991 as impaired by sedimentation and siltation, mostly affecting beneficial use as cold freshwater habitat. The data that support this listing are included in a 1976 report, Siltation Evaluation for the Lake Tahoe Basin, (LRWQCB, 1976). The report concluded that street and parking lot runoff from Alpine Meadows Ski Area was carrying silt and nutrients to Bear Creek. Snow storage operations from the parking lot were identified as the most likely source for the pollutants in question. At that time, snow was stored near the stream banks directly in Bear Creek. In addition to Alpine Meadows snow disposal management practices, a snowmaking pond embankment failed on December 6, 1988, discharging approximately one million gallons of sediment laden water directly into Bear Creek (Wilson, 2003).

In response, the LRWQCB required Alpine Meadows Ski Area to adopt Waste Discharge Requirements (WDR) and comply with the Lahontan Basin Plan (1995) water quality standards shown in **Table 2-2**. Each year, Alpine Meadows implements best management practices on the mountain to address protection of sensitive habitat and water quality. They also conduct their own water quality monitoring program to comply with the WDR (Smolen, K., pers. comm., 2017). Results from this on-going monitoring effort may be useful to our understanding of water quality in the upper watershed; however, annual reports were unavailable for review at the time of this assessment.

Stormwater and winter road sand applications were additional concerns to the LRWQCB, as they related to sedimentation of Bear Creek. In 2003, Placer County was issued a Municipal Separate Storm Sewer System (MS4) permit to discharge stormwater to Bear Creek from county-maintained roads. To comply with the permit, the County developed and implemented a Stormwater Management Plan (Phase II, Middle Truckee River), and helped to develop the Truckee River Water Quality Monitoring Program (TRWQMP, 2ND Nature, 2008). To reduce the amount of road sand applied to the roads, the County has been applying brine solution in recent years as an alternative (Boyer, T., pers. comm., 2017). The Monitoring Program is currently being carried out by CDM-Smith under the direction of Placer County, and includes rapid assessment methods and inventory and evaluation of stormwater outfalls (CDM Smith and Balance Hydrologics, 2017).

3 WATERSHED SETTING

The Bear Creek watershed is within the Sierra Nevada Range, roughly 11 miles south of Truckee, California. Bear Creek is a tributary to the Middle Truckee River approximately 3.7 miles downstream from Lake Tahoe. The 5.2 square mile watershed ranges in elevation from 6,187 feet at the confluence with the Truckee River to 8,600 feet at Ward Peak along the Sierra Nevada Crest. The watershed includes multiple springs, wet meadows and several alpine lakes, all of which support perennial flow in Bear Creek (**Figure 3-1**).

The watershed contains evidence that the area was used by the Washoe native peoples and their ancestors prior to and when European exploration and occupation began in 1860. Basque sheep herders seasonally occupied the upper portions of the watershed between 1880 and 1960. Trees were harvested between 1881 and 1963, but logging was limited within the watershed compared to other nearby areas. Perennial springs in the watershed attracted visitors who traveled the Tahoe railway from Truckee to Tahoe City, and recreation in the form of skiing began with development of Powder Bowl (a.k.a. Deer Park Ski Area) in the 1950s, and subsequently Ward Peak Ski Area in the 1960s, today known as Alpine Meadows Ski Area. Additional development followed in the 1970s, 1980s, and 1990s with the construction of primary and secondary homes. Today, a modern sewer and water district supports over 1,500 residential units in the watershed and recreation in the form of skiing, hiking, mountain biking, and horseback riding continues to be a major attraction.

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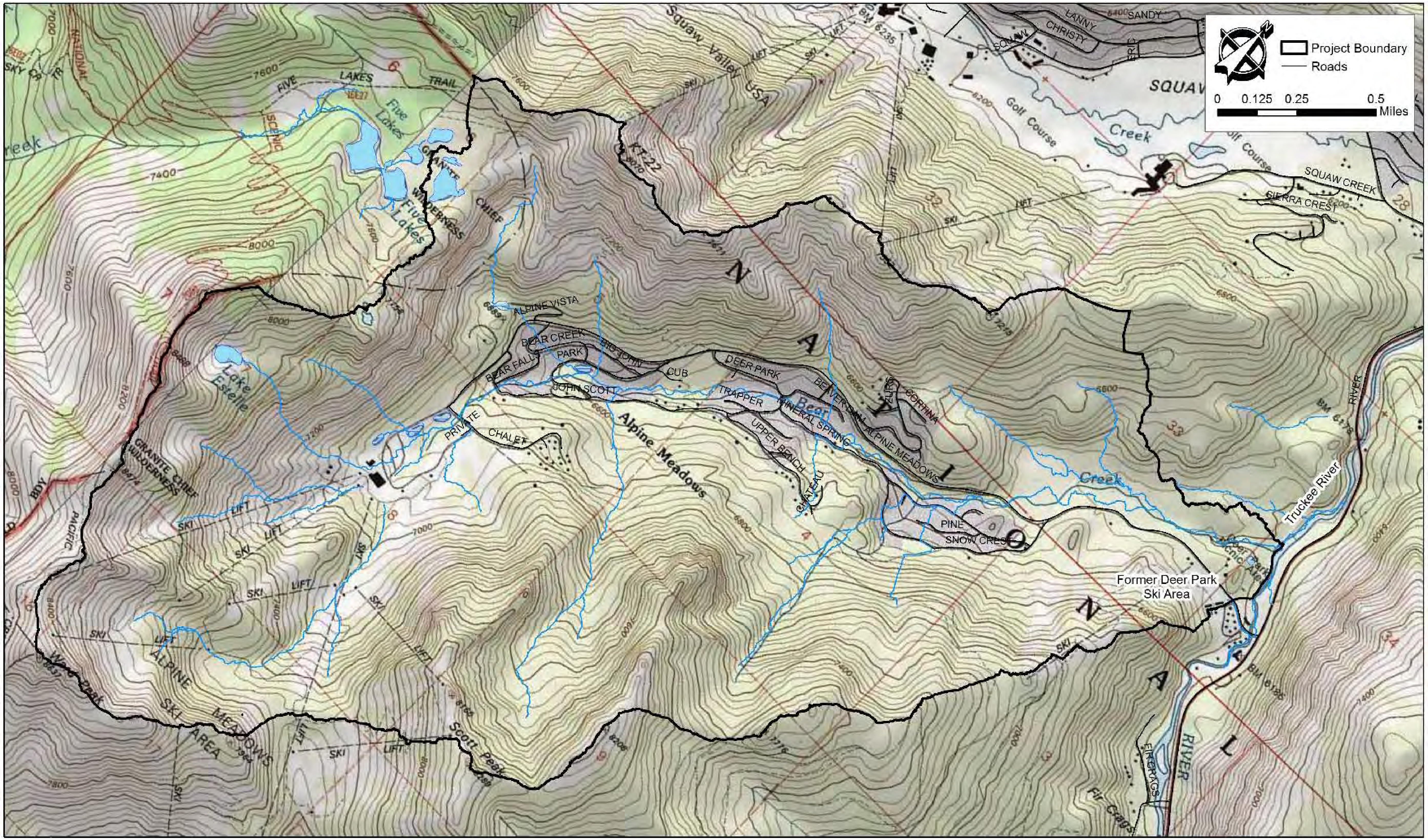

Figure 3-1 Bear Creek Watershed and study area, Placer County, California.

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3.1 Watershed Geology

The Bear Creek watershed is located within a transition zone between the Basin and Range and Sierra Nevada geomorphic provinces. The region's geology is characterized by a dynamic period of Tertiary volcanic activity that occurred between 5 and 24 million years ago, juxtaposed against older Cretaceous granodiorite as the result of intrusion and faulting. Mississippian and Jurassic metasedimentary rocks are exposed in the Alpine Meadows Ski Area near the Sierra Crest, all uplifted and displaced by faulting. Over the past 90,000 years, several periods of glaciation and erosion have given rise to the more visible features and landforms in the valley. Bear Creek continues to rework bedrock and sediment and transport it to the Truckee River. **Figure 3-2** is a watershed geologic map showing the distribution of geologic formations in the watershed, as based on Sylvester and others (2012) and discussed in greater detail below.

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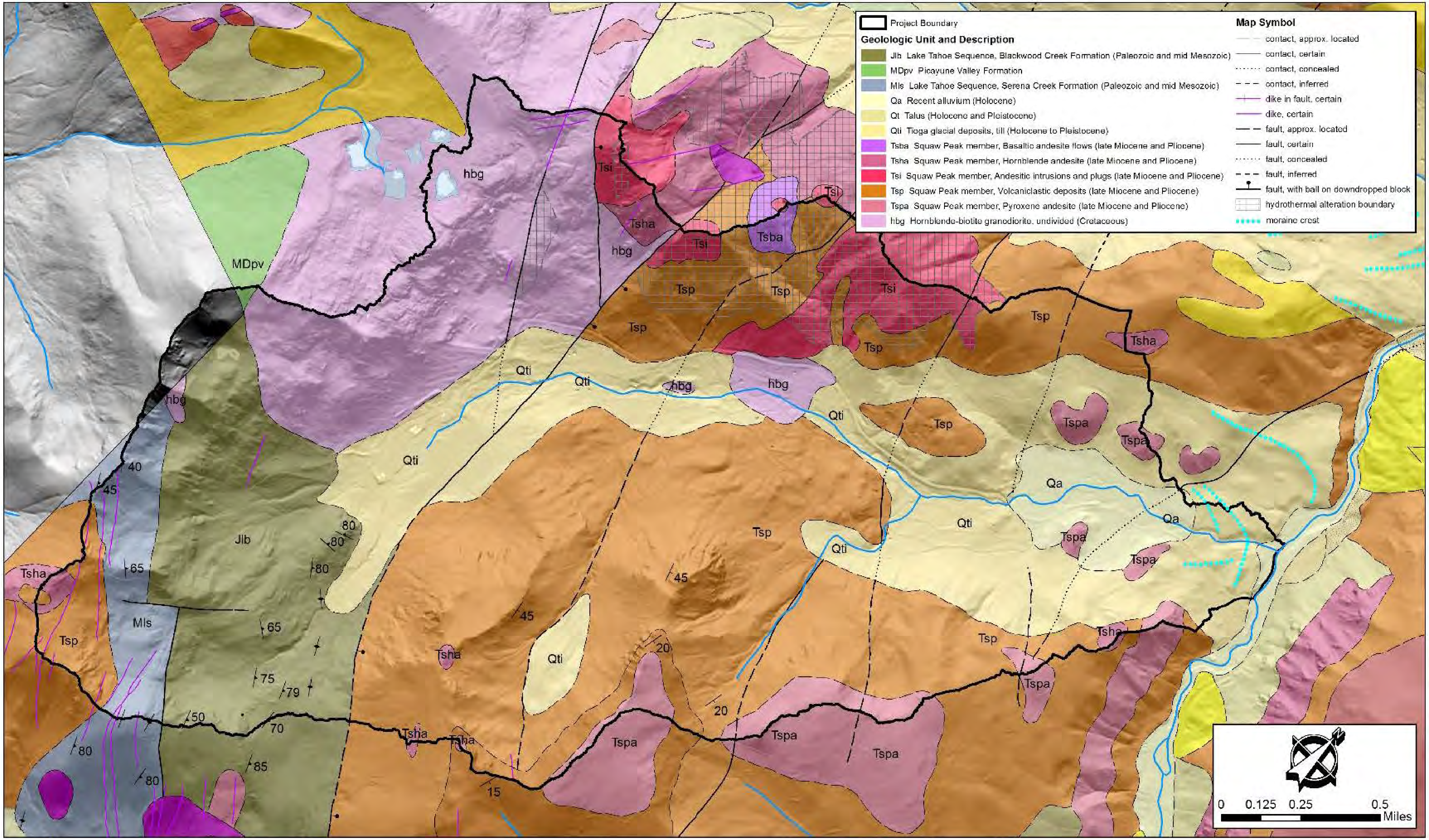

Figure 3-2 **Geologic Map, Bear Creek Watershed, Placer County, California.**

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3.1.1 Bedrock Geology and Structure

The geology of the Bear Creek watershed is a complex region of the Sierra Nevada with rocks ranging in age between ~340 Ma (Mississippian) to as recent as 3 Ma (Pliocene). To better describe the bedrock geology, we divide our discussion into three distinct periods of geologic time.

The oldest rocks in the watershed are characterized by Mississippian schist (Mls) and Jurassic metasedimentary (Jlb) rocks—both deposited originally as marine sediments before being deformed and metamorphosed by subsequent intrusions of the Sierra Nevada batholith or granitic bodies and subsequent volcanism (Sylvester and others, 2012). These rocks are moderately resistant to erosion and form coarse colluvial slopes, steep cliffs and couloirs.

The Paleozoic and Middle Mesozoic rocks describe above were uplifted and intruded by the Sierra Nevada batholith in the Cretaceous period, including hornblende-biotite-granodiorites, which characterize the Five Lakes area and White Wolf parcel. These rocks are highly resistant to erosion and form areas of exposed granitic outcrops in the watershed.

After erosion of the Jurassic crystalline rocks, the batholith was intruded by Tertiary volcanics including pillow basalts, dikes, and sills. The watershed sideslopes, downstream from Alpine Meadows, show remnants of lava flows and pyroclastic rocks. KT-22 peak is the remnant of a volcanic neck (Tsi) which once supported a stratovolcano, thousands of feet higher than existing elevations. Ward Peak, is composed of andesitic lava flows (Tsha), and Scott Peak's lower ridgelines include stratified volcaniclastic deposits (Tss, Tsp) that originated from volcanic vents and cones. These features and deposits weather and erode easily and form the couloirs and colluvial slopes seen throughout much of the watershed. A west to east cross section along the watershed's northern ridgeline is depicted in **Figure 3-3** and illustrates the inferred character of the former Pliocene stratovolcanoes which are now extinct and eroded to the current elevations.

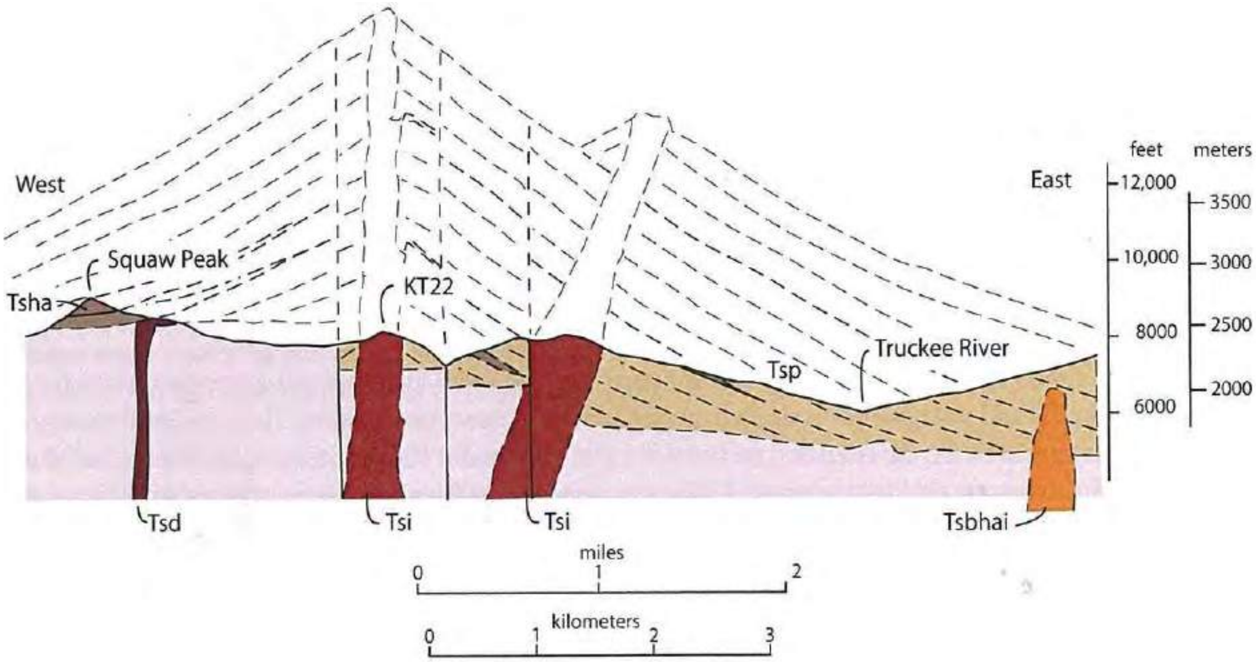

Figure 3-3 West to east geologic cross-section of the Bear Creek watershed, northern ridge, Placer County, California (adapted from Sylvester and others, 2012).

Several north-northwest trending faults dissect the watershed, part of the Tahoe-Sierra Frontal Fault Zone with normal (extensional) faulting. Movement of this fault zone has resulted in downthrow on the east side and upthrow on the west. Fault displacement is estimated between 800 and 4,000 feet (Sylvester and others, 2012) and is responsible for the juxtaposition of different aged rocks. Faults also play a role in stream channel control or planform. Several tributaries follow a north-south alignment parallel to fault traces or form 90-degree bends where they intersect fault traces. The presence of perennial springs in the watershed also appear to be related to the fault traces and provide hydrologic support to meadow systems and baseflow in Bear Creek. Recent fault activity has been documented with potential for moderate to high magnitude earthquakes. A close spatial association of landslides and active faults along other sections of the Tahoe-Sierra Frontal Fault Zone suggests that landslides have been seismically triggered (Howle and others, 2012), and may be a significant episodic source of sediment to the Truckee River.

3.1.2 GLACIATION

The Bear Creek Watershed was subject to several glaciations between 10,000 and 90,000 years ago, leaving behind distinct landforms and soil types. Glacial advance created terminal and lateral moraines-- unconsolidated boulder, gravel, and sand deposits.

During glacial retreat, streams transported glacial outwash and alluvium, ultimately filling the valley segments. Sediment accumulated behind moraines and bedrock narrows to form the meadows we observe today. The youngest (Tioga) moraines are typically well-preserved with abundant boulder frequency, and tend to control streams rather than be modified by them. Tioga-aged glacial terrace deposits are preserved in a number of locations near an elevation of 6,800 feet (Birkeland, 1964; Sylvester and others. 2012), and are highly susceptible to erosion by modern streams, serving as a source of fine and coarse sediment to downstream areas.

Other glacier landforms are well preserved in the watershed. Lake Estelle and its bowl-shaped perch is a glacial tarn and cirque. Truncated, north-facing drainages on Scott Peak are evidence of smaller tributary glaciers that converged with the mainstem trunk glacier to create hanging valleys.

Areas adjacent to the Truckee River, upstream from the Bear Creek confluence, are underlain by glacial lake clays or varves. These likely formed during the Tahoe glaciation when larger tributary glaciers dammed the Truckee River and Lake Tahoe at Squaw Creek. This low-energy environment caused deposition of glacial silts and clays at the mouth of Bear Creek. These clays are erodible and serve as another source of fine sediment to lower Bear Creek and the Truckee River when exposed.

3.2 Hydrologic Soil Groups

The soils mantling the watershed generally reflect the underlying geologic units from which they have developed. As discussed in Section 3.2, the granitic bedrock is exposed in the northern portions of the watershed with limited to no soil development. Much of the uplands and steeper slopes include soils derived from volcanic rocks. Soils located in the valley bottom are weathered from glacial deposits and alluvium. In total, over 30 different soils are mapped within the watershed (Hanes, 2002). For the purposes of this assessment, we grouped soil types into their hydrologic groups (**Figure 3-4**) with each group defined below. Hydrologic groups provide information about infiltration, runoff potential and/or saturation:

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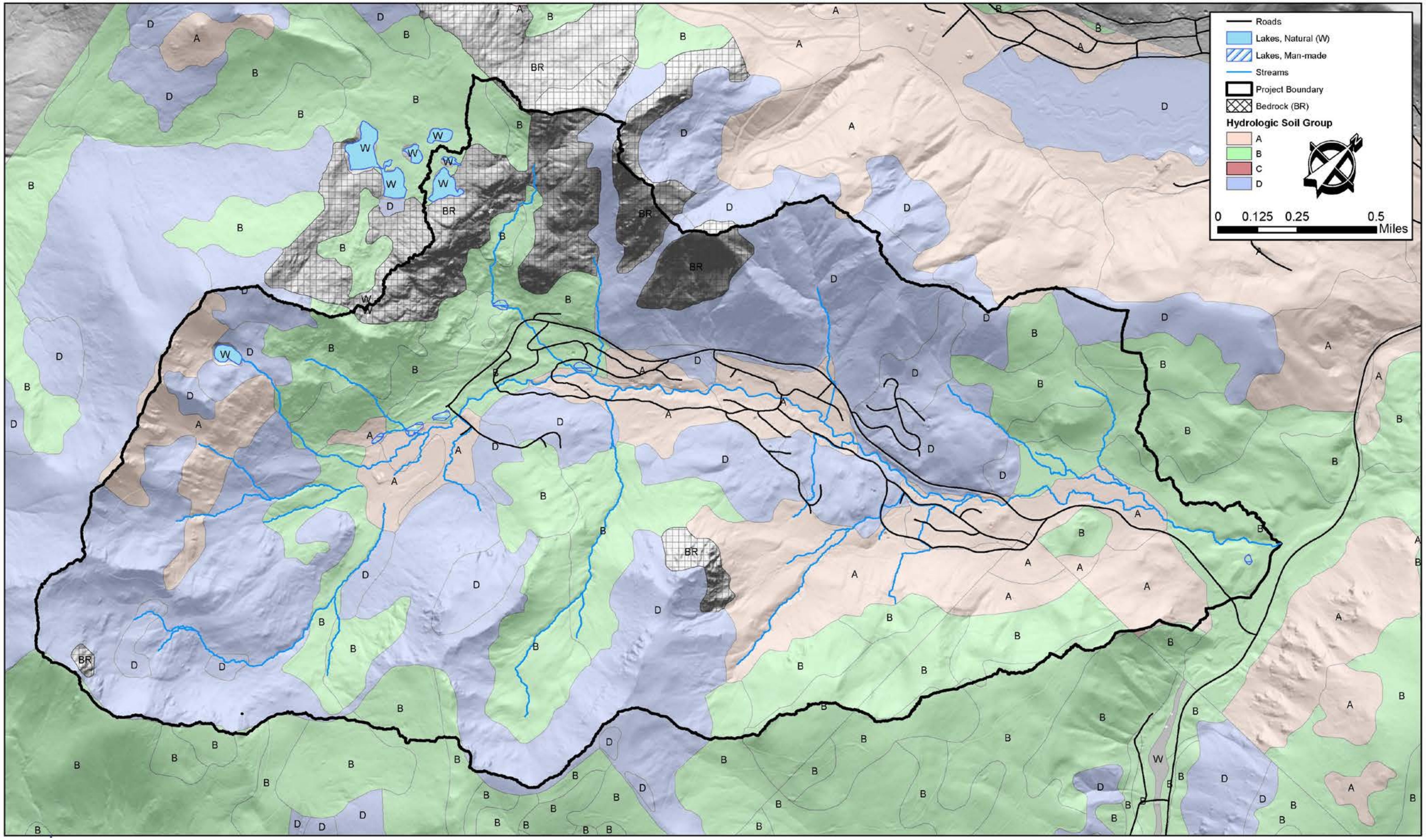

Figure 3-4 **Hydrologic soil groups, Bear Creek watershed and vicinity, Placer County, California.**

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- Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well- to excessively-drained sands or gravels and have a high rate of water transmission.

- Group B soils have a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

- Group C have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

- Group D soils have the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils. These include soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material (i.e., bedrock).

- BR is exposed bedrock.

Many of the soils in the watershed are composed of Group D (41 percent of the watershed) and are soils that are susceptible to high runoff and subsequent erosion. These areas include many of the uplands, including: Alpine Meadows Ski Area, residential areas along the Upper Bench Road and Juniper Mountain Road, and the Five Lakes Tributary.

In contrast, many of the alluvial and glacial derived soils in the watershed are categorized as Group A. While these soils may have high infiltration properties and low rates of runoff, they can easily be eroded if subjected to vegetation removal and excessive runoff or concentrated stormwater. The Lower Bear Creek meadow is one such area we see these soils easily erode from historical land-uses and excess stormwater runoff. However, if these sources of erosion are managed, these areas also provide the greatest opportunities to restore meadow systems or areas that support wetland vegetation and habitats.

Roughly 7 percent of the watershed is composed of exposed bedrock, and 32 percent of the watershed is mapped as belonging to Hydrologic Soil Group B.

3.3 Hydrology and Climate

3.3.1 Hydrology

Bear Creek is a perennial, snowmelt-dominated stream, with annual peak flows typically occurring between March and June, coincident with snowmelt, but occasional rain-on-snow events result in significant flooding during winter months. Baseflow is supported by spring-fed tributaries. An analysis of monthly flows between WY1973 and WY2015 showed that Bear Creek provided between 10 and 15 percent of the streamflow in the Truckee River (near Truckee) during the months of April and May (Shaw, 2015). As such, springs provide an important source of baseflow and support aquatic habitat in Bear Creek and the Truckee River.

3.3.2 Climate

The Bear Creek watershed experiences cold and snowy/wet winters and warm dry summers. Average daily minimum and maximum temperatures can range between 27 and 58 degrees Fahrenheit (F) with extremes below zero and above 90 degrees F. Precipitation falls mostly as snow between the months of November and April, with rain in the fall months of September and October and occasional afternoon thunderstorms during the summer months. Mean annual precipitation ranges from approximately 50 inches (WRCC, 2017).

3.3.3 Climate Variability: Wet and Dry Periods

Watershed processes are dependent on several factors including climate variability, as marked by periods of greater than average precipitation ('wet periods') and periods of below average precipitation or drought. Identification of historical wet and dry periods is an important component of this assessment, and provides context during evaluation and comparison of current and historical conditions. For example, wetland desiccation or meadow conversion to drier conditions may be a relatively temporary phenomenon resulting from successive dry periods (e.g., Water Years[WY] 2007-2015)[1] rather than a conversion due to land-use practices, while a series of wet years or a single wet year can recharge local groundwater and support a robust meadow and riparian community (e.g., WY2017) in the short term. Similarly, a single large flood event or succession of floods can generate significant changes to channel patterns or sediment supply—in effect, resetting the riparian community (e.g., January 1, 1997, January 8, 2017), and riparian

[1] Unless otherwise noted, all years are referred to as 'water years' in this report. A water year begins on October 1 and ends on September 30 of the named year.

change associated with large floods can be further exacerbated during and shortly after dry periods, when soil stability can be compromised by weakened vegetation and root structure.

Figure 3-5 illustrates year-to-year precipitation variability. It shows the annual percent deviation and cumulative percent deviation from mean annual precipitation for Truckee Ranger Station, Truckee, California (station TKE, NRCS). This station is used for its long period of record (WY1904-current), and along with **Table 3-1,** provides context for interpretation of historical conditions, aerial photography and field investigations carried out as part of this assessment.

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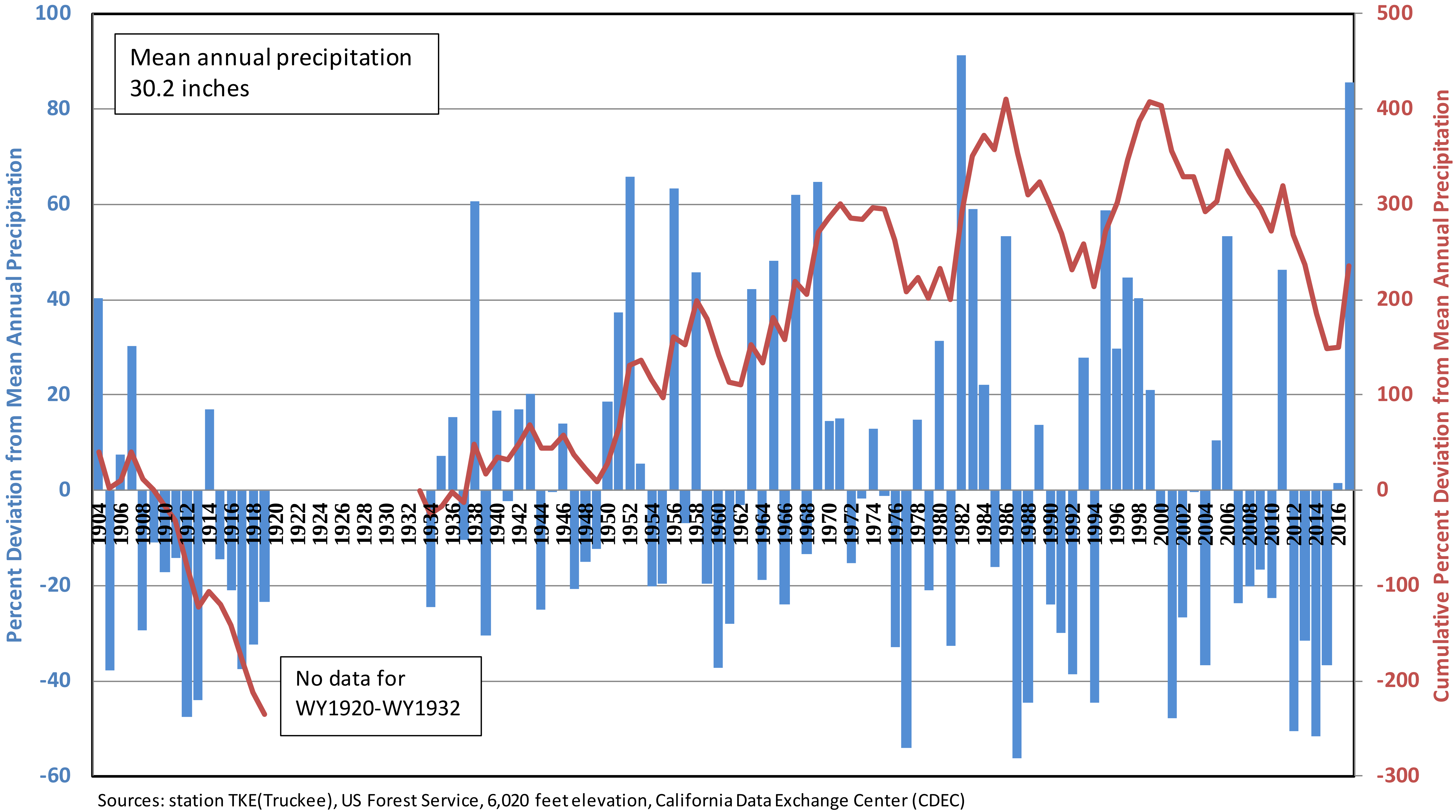

Figure 3-5 Percent Deviation and Cumulative Percent Deviation from Mean Annual Precipitation, Truckee Ranger Station, Truckee, California, WY1904-WY1919, WY1934-WY2017.

Table 3-1 Summary of recent wet and dry climate periods in Truckee River Basin

Date	Annual precipitation characteristics	Documented conditions	Source
Dry Periods			
1928-1935	Tahoe City registered annual precipitation below long-term mean annual precipitation for each year within this period.	Lake Tahoe ceased to spill to the Truckee River Canyon	Western Regional Climate Center, station #048758; National Weather Service station ID: TAC; Lindstrom, 2011
1976-1977	Significant below average precipitation for both years		
1987-1994	1994 and 1987 were the first and second driest years on record, respectively.	Lake Tahoe lake levels reached lowest recorded elevation in 1992; massive timber mortality due to insect investations; low snowfall amounts 1990-1992 for Webber Lake	USFS, 2009; Lindstrom, 2017, CDEC, 2017
2000-2004	Annual precipitation was below average in all four years	Martis wildfire, 2001; other significant wildfires in the greater Tahoe area;	USFS, 2009
2007-2015	Annual precipitation was below average in all years except 2011	observed meadow dessication; conifer encroachment; Lake Tahoe ceased to spill to the Truckee River in 2015	Balance Hydrologics observations
Wet Periods			
1875-1915	unavailable	Longest period in the documented record in which Truckee River flows were above average; era of historic logging and fluming activies; water rights first evaluated.	Lindstrom, 2011
1950-1952, 1956	Cumulative precipitation deviated +79 percent above long-term mean annual precipitation in 1952	Most significant flooding on record for the Tahoe-Reno area (1955)	Kattleman, 1992, USFS, 2009
1962-1971	Cumulative precipitation deviated +166 percent above long-term mean annual precipitation by 1971	Major floods in 1963 and 1964	USFS, 2017
1982-1983, 1986	Average annual snowpack of up to 200 percent; 1983 became the standard "High Water Year" for comparison to all other years; cumulative precipitation deviation +177 percent above long-term mean annual precipitation by 1986	Significant flooding along the Truckee River (March 1983)	Lindstrom, 2011; Kattleman, 1992, CDEC, 2017
1995-1999	Cumulative precipitation deviated +120 percent above long-term mean annual precipitation by 1999	New Years flood, 1997 recurrence: ~50-year flood, Truckee River at Farad	USGS, 2017; USFS, 2017
2010-2011	Greatest total seasonal snowfall depth since 1971; 5th highest snowfall depth on record; 120.6 inches (water-equivient) of snow in April-May, 2011 at Webber Lake.	April 1, 2011: 178 percent of normal snowpack	Central Sierra Snow Laboratory, Soda Springs, CA, CDEC, 2017
2016-2017	Heavy snow and multiple rain-on-snow events: Dec 10, 15, Jan 8, and Feb 9.	April 1, 2017: 194 percent of normal snowpack; Rain-on-snow event January 8, 2017: 2nd largest flood for period of record	Middle Truckee River Basin, average of SNOTEL (CDEC, 2017); Ward Creek gaging station,

Wetter-than-average years occurred at several times over the period of recorded precipitation (see **Table 3-1**), most recently in WY2011 and WY2017. In many of these years the annual peak flow resulted from spring snowmelt runoff, but more recently rain-on-snow events have become more frequent, resulting in higher magnitude floods than snowmelt runoff and occur mid-winter instead of spring.

Periods of drought, particularly prolonged drought, can stress or kill wetland and riparian vegetation and cause grazing animals to become increasingly concentrated in meadows and riparian areas, both of which can cause channel banks to become more susceptible to erosion during floods. Between WY2000 and WY2015, a dramatic decline in precipitation or cumulative percent deviation from mean annual precipitation is evident (see **Figure 3-5**). This period was followed by one of the largest flood of record (January 8, 2017). It should therefore be noted that conditions observed during this assessment may potentially reflect post-flood conditions following a period of extensive drought. As such, recent mortality in riparian trees and bankside vegetation, followed by a significant flood event, likely encouraged bank erosion and resulted in high sediment and wood loading to the stream this year.

A flood history of the region is particularly useful to evaluate geomorphic changes in the watershed as the result of floods. We show annual floods for nearby Ward Creek (USGS 10336676) and Blackwood Creek (USGS 10336660) (**Table 3-2**); both watersheds share similar elevations, drainage areas, and geology to Bear Creek, and drain to the east of the Sierra crest. We also note that the highest six annual peak flows recorded in Ward Creek and highest seven annual peak flows recorded in Blackwood Creek resulted from rain-on-snow events, including January 8, 2017.

Even though WY2017 was a wet year, the trend over the past two decades continues towards drier conditions relative to the long-term average. Given the abundance of moisture this past year, we might expect to see scoured channels and verdant meadow conditions compared to those viewed in previous years or on historical aerial photographs.

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Ward Creek at HWY89 near Tahoe Pines, CA USGS 10336676				Blackwood Creek near Tahoe City, CA USGS 10336660			
Date	Flow (cfs)	Stage (ft)	Flood Event Type	Date	Flow (cfs)	stage (ft)	Flood Event Type
1/8/2017	*2000*	8.57	Rain-on-snow	1/8/2017	--	14.42	Rain-on-snow
3/6/2016	321	6.15	Rain-on-snow	1/30/2016	534	11.02	Rain-on-snow
2/8/2015	341	6.2	Rain-on-snow	2/8/2015	577	11.13	Rain-on-snow
2/9/2014	105		Rain-on-snow	2/9/2014	120	1.74	Rain-on-snow
12/2/2012	1190	7.61	Rain-on-snow	12/2/2012	1230	3.53	Rain-on-snow
4/26/2012	595	6.44	Snowmelt	4/26/2012	483	3.2	Snowmelt
6/22/2011	493	6.72	Snowmelt	6/22/2011	571	3.25	Snowmelt
6/6/2010	363	6.25	Snowmelt	6/6/2010	462	3.09	Snowmelt
5/5/2009	425	6.36	Snowmelt	5/5/2009	599	3.48	Snowmelt
5/18/2008	196	5.73	Snowmelt	5/17/2008	343	3.01	Snowmelt
5/10/2007	88	5.28	Snowmelt	5/9/2007	178	2.57	Snowmelt
12/31/2005	1660	8.44	Rain-on-snow	12/31/2005	2260	7.43	Rain-on-snow
5/19/2005	945	7.21	Snowmelt	5/19/2005	765	4.17	Snowmelt
5/4/2004	198	5.58	Snowmelt	5/4/2004	242	2.62	Snowmelt
5/29/2003	357	6.04	Snowmelt	5/28/2003	372	3.01	Snowmelt
4/14/2002	218	5.73	Snowmelt	4/14/2002	249	3.01	Snowmelt
5/15/2001	202	5.72	Snowmelt	5/15/2001	163	2.2	Snowmelt
5/8/2000	429	6.15	Snowmelt	5/8/2000	435	3.31	Snowmelt
5/26/1999	396	6.09	Snowmelt	5/26/1999	429	3.24	Snowmelt
6/7/1998	370	6.11	Snowmelt	6/7/1998	432	3.2	Snowmelt
1/1/1997	2530	9.36	Rain-on-snow	1/1/1997	2940	9.82	Rain-on-snow
5/16/1996	1020	7.47	Snowmelt	5/16/1996	963	4.74	Snowmelt
3/9/1995	513	6.59	Rain-on-snow	5/1/1995	636	3.85	Snowmelt
5/11/1994	91	5.17	Snowmelt	5/11/1994	143	2.12	Snowmelt
5/31/1993	461	6.48	Snowmelt	5/31/1993	534	3.59	Snowmelt
4/17/1992	110	5.33	Snowmelt	4/17/1992	159	2.26	Snowmelt
5/25/1991	119	5.38	Snowmelt	5/25/1991	177	2.37	Snowmelt
4/15/1990	87	5.19	Snowmelt	4/28/1990	125	1.98	Snowmelt
5/7/1989	213	5.8	Snowmelt	5/7/1989	291	2.87	Snowmelt
5/17/1988	48	4.76	Snowmelt	5/15/1988	87	1.74	Snowmelt
4/28/1987	113	5.13	Snowmelt	4/27/1987	170	2.26	Snowmelt
3/8/1986	860	7.03	Rain-on-snow	3/8/1986	1640	6.14	Rain-on-snow
5/2/1985	164	5.29	Snowmelt	5/2/1985	202	2.36	Snowmelt
11/11/1983	351	5.66	Rain	11/17/1983	548	3.45	Rain
6/10/1983	637	6.38	Snowmelt	5/29/1983	687	3.79	Snowmelt
12/19/1981	1800	8.05	Rain-on-snow	12/20/1981	1840	8.02	Rain-on-snow
5/1/1981	148	5.57	Snowmelt	5/1/1981	208	2.46	Snowmelt
1/13/1980	1450	7.76	Rain-on-snow	1/13/1980	1100	8.65	Rain-on-snow
5/21/1979	283	5.85	Snowmelt	5/21/1979	336	2.51	Snowmelt
6/7/1978	271	5.81	Snowmelt	5/14/1978	301	2.39	Snowmelt
6/1/1977	51	4.85	Snowmelt	6/1/1977	88	1.42	Snowmelt
10/26/1975	178	5.51	Rain	10/26/1975	274	2.28	Rain
6/6/1975	492	6.22	Snowmelt	6/6/1975	449	2.87	Snowmelt
11/12/1973	800	6.65	Rain	11/12/1973	704	3.64	Rain
5/16/1973	298	5.85	Snowmelt	5/13/1973	393	2.78	Snowmelt
				5/13/1972	287	2.41	Snowmelt
				6/26/1971	585	3.38	Snowmelt
				1/21/1970	1910	8.48	Rain-on-snow
				5/24/1969	605	6.35	Snowmelt
				2/20/1968	334	6.11	Rain-on-snow
				3/16/1967	1670	7.84	Rain-on-snow
				5/10/1966	198	5.21	Snowmelt
				12/22/1964	2100		Rain-on-snow
				11/15/1963	322	4.27	Rain
				1/31/1963	2000	8.9	Rain-on-snow
				5/8/1962	238	6.13	Snowmelt
				5/10/1961	200	5.98	Snowmelt

Notes:
Stage is a relative datum and does not equate to depth of flow in creek; datum can change over time
Flood event type is estimated from direct observations, time of year and/or review of general precipitation patterns in the record.

Table 3-2 Annual Peak Flows in Watersheds near Bear Creek, Placer County, California

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3.3.4 Climate Change

Under modeled scenarios, summers in the Sierra Nevada are expected to become drier and hotter while winters become warmer and wetter. Extreme precipitation events may happen more frequently, while meadow and riparian vegetation may be more stressed (Furniss and others, 2010). The Bear Creek watershed is in a particularly sensitive elevation range, such that rainfall may become more common during the winter months, resulting in a reduced snowpack and more frequent rain-on-snow events. The timing and volume of runoff is therefore expected to be altered in future years, such that summer baseflow would likely be reduced, with peak snowmelt occurring earlier in the spring, and more frequent flooding and/or extreme events. Hastings and others (in preparation) identified increased fine sediment loading in tributaries to the Truckee River during rain-on-snow events over the past 7 to 8 years; in fact, we found that a single rain-on-snow event can transport more fine sediment than the entire snowmelt runoff season in most years.

The Truckee River has seen nearly a century of conflict over water rights and water supply, and the U.S. Bureau of Reclamation has identified the Truckee River basin as having a high likelihood of experiencing water-supply conflicts in the future (USBOR, 2015). With projected earlier spring runoff and reductions in snowpack, along with increased frequency and magnitude of flooding events, proposed land management and watershed restoration strategies that can effectively retain and recharge groundwater supplies, moderate floods, and maintain or extend low flows into the summer are likely to provide benefits to a wide range of water users, and should therefore be prioritized.

3.4 Bear Creek Water Quality

3.4.1 Review of Available Water Quality Data

As mentioned earlier, Bear Creek was first included on the 303(d) list in 1991 as impaired by sedimentation and siltation. Water quality in Bear Creek has been collected by multiple entities since 1986. LRWQCB collected water quality data, including turbidity, from the upper reaches of Bear Creek between 1986 and 2001. During this period, water quality standards for turbidity were met (Wilson, 2003); however, concerns about bed conditions and aquatic life remained given the listing in 1991. Subsequently, McGraw and others (2001) examined watersheds within the larger Middle Truckee River Basin and found that Bear Creek was within the top three sediment contributing sub-basins. However, this conclusion was based on historical data and modeling.

In an effort to examine Bear Creek in greater detail, Dr. Herbst carried out bioassessments in the lower portion of Bear Creek above the confluence with the Truckee River and downstream of the Alpine Meadows ski area parking lot (Herbst, 2001). The biologic data were assessed using an Index of Biologic Integrity (IBI) developed specifically for streams in the Truckee River watershed. Bear Creek's IBI score indicated that the biologic health in the creek below the ski was well within the desired conditions exhibited by regional reference streams (Herbst, 2001). In a similar study, Chan (2001) also sampled the upper, middle and lower reaches of Bear Creek evaluating the benthic macroinvertebrate communities. Field sampling was conducted in July 2001 according to the California Department of Fish and Game's California Stream Bioassessment Procedure (CSBP). The sampling results showed that a robust benthic community existed in Bear Creek at that time, and no evidence of acute impairment was detectable (Chan, 2001). Based on the findings from Chan (2001) and Herbst (2001), the RWQCB delisted Bear Creek in 2006 from the CWA 303(d) list.

In 2010, Herbst (2011) evaluated benthic macroinvertebrates in the Middle Truckee River including reaches at and downstream of the confluence with Bear Creek. He concluded that sites surveyed were in poor-to-fair condition, and usually inferior to reference rivers of the region of similar size or catchment area. Since, efforts to identify, evaluate, and reduce sediment sources in tributary watersheds have been on-going, prioritizing watersheds ranked as high or medium within the Truckee River Monitoring Plan (2nd Nature, 2008). In this document, Bear Creek is ranked as a moderate sediment source. Questions remained on the sources of sediment within the Bear Creek Watershed.

Homeowner reports to Placer County of erosion and flooding issues have increased over the past decade (T. Boyer, pers. comm., 2017), especially in more urban zones of the watershed. Reports of eroding banks, flooded infrastructure, and property loss suggested that Bear Creek may be incurring changes from historic and current land-use practices; notably, stormwater management. As a result, the County--one of several entities permitted to discharge stormwater to Bear Creek, carried out monitoring using Rapid Assessment Methods (RAM) as part of the Truckee River Water Quality Monitoring Program in WY2010, WY2012, and WY2014. RAM included physical measurements of channel substrate grain size and embeddedness as indirect methods used to evaluate channel and aquatic habitat conditions. Results suggested that fines comprised between 4 and 22 percent of the bed (CDM Smith, 2015). While these values were similar to other watersheds, they did not provide sufficient information to detect impairment. As such, the RAM approach was suspended in WY2014 on Bear Creek and replaced with GIS analysis of stormwater outfalls to better evaluate Bear Creek and its stormwater quality. The analysis was used to establish catchment land-use types and degree of imperviousness and develop a ranking or prioritization of possible sediment sources from stormwater outfalls. Results in WY2016 suggested that subwatersheds and associated outfalls in the middle watershed are high priorities for maintenance or stormwater BMP improvements (CDM Smith, 2017) focused on reducing stormwater and winter-applied road sand to Bear Creek.

Trained volunteers with the Truckee River Watershed Council have conducted water-quality monitoring in Bear Creek, immediately above its confluence with the Truckee River four times a year between May and October since 2001—the longest dataset available to understand water quality trends in Bear Creek. Samples are collected as grab samples and submitted for analysis of basic physical parameters, turbidity, nutrients, and bacteria. Data from 2003 to 2016 were available for review in this assessment. In general, physical parameters suggested adequate water quality with few exceptions as illustrated below in **Figure 3-6**, **Figure 3-7**, **Figure 3-8**, and **Figure 3-9**. Because volunteer collected data are grab samples, representing single values, it may be difficult to compare some results to the water quality standards established by the Basin Plan (1995), since these standards represent arithmetic mean of 30-day averages.

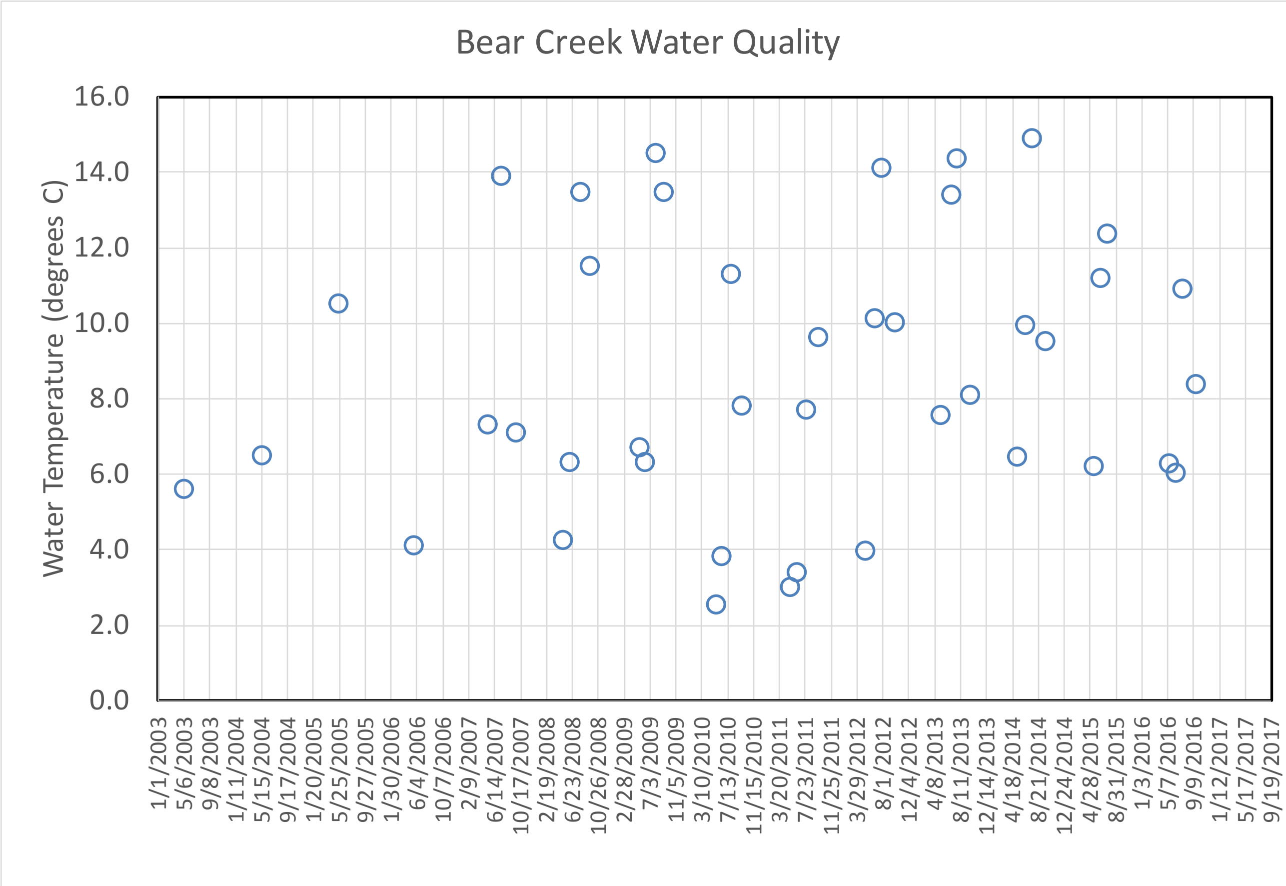

Figure 3-6 Instantaneous water temperature in Bear Creek (Reach A), WY2003-WY2016, Placer County, California.

Water temperatures fluctuate depending on time of year and time of day and were measured to be between 2.5 and 14.9 degrees Celsius (C). While there are no numeric water quality standards for temperature, the Lahontan Basin Plan (LRWQCB, 1995) suggests temperatures shall not be altered from their natural conditions for cold freshwater habitat. Moyle (2002) reports that lethal conditions for native fish are temperatures that exceed 22 or 23 degrees C. Volunteer measurements were collected during daylight and summer months, periods when lethal conditions are likely to exist.

pH was measured within the acceptable range of 6.5 to 8.5 (LRWQCB, 1995) with few exceptions (i.e., 6.4 in 2004, 5.5 in 2005, and 8.6 in 2007).

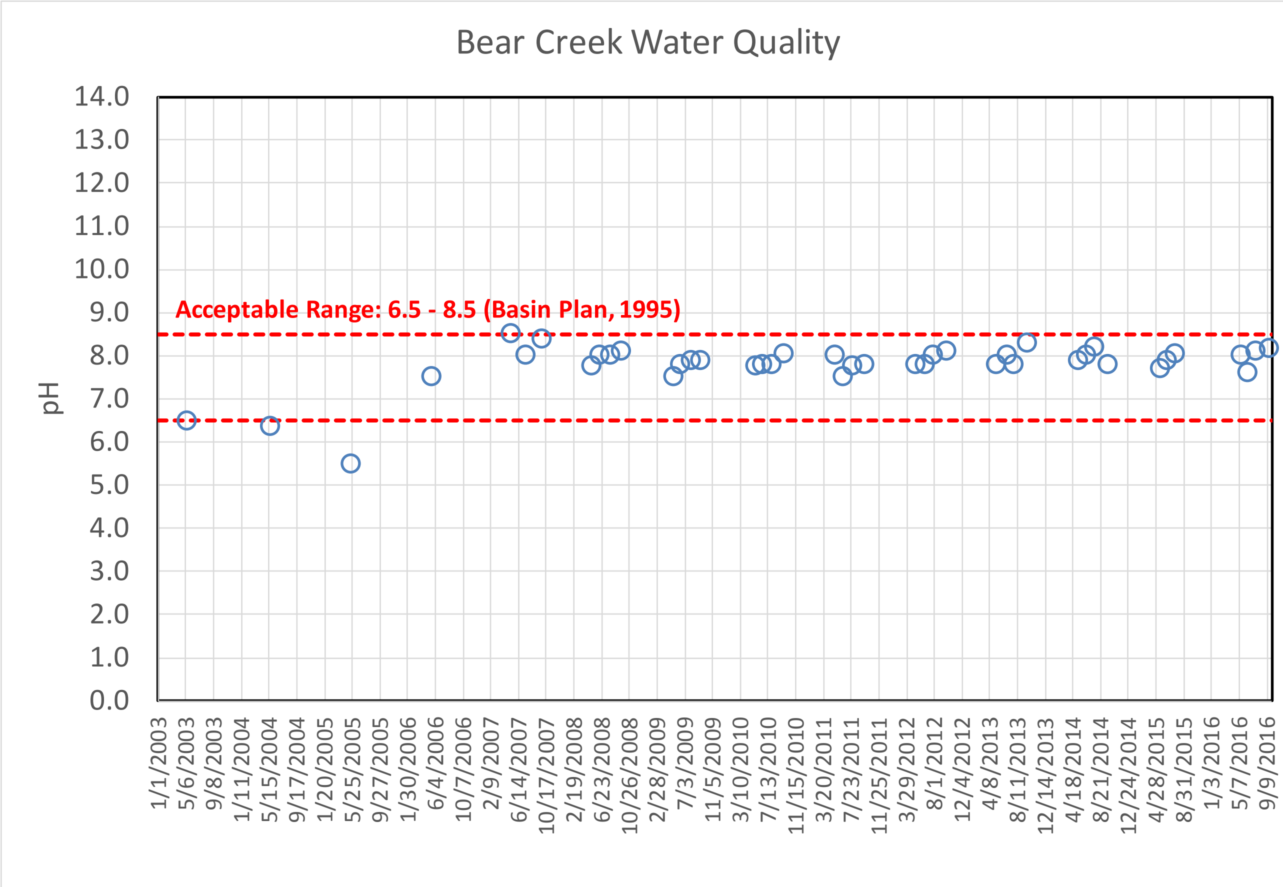

Figure 3-7 Instantaneous pH values in Bear Creek (Reach A), WY2003-WY2016, Placer County, California.

Dissolved oxygen (DO) has been measured periodically to fall below the 1-day minimum limit for supporting the beneficial use of cold freshwater habitat (8.0 mg/L; LRWQCB, 1995). Most measurements of DO have ranged above 8.0 mg/L; however, a handful of measurements over the years have recorded DO values less than this standard.

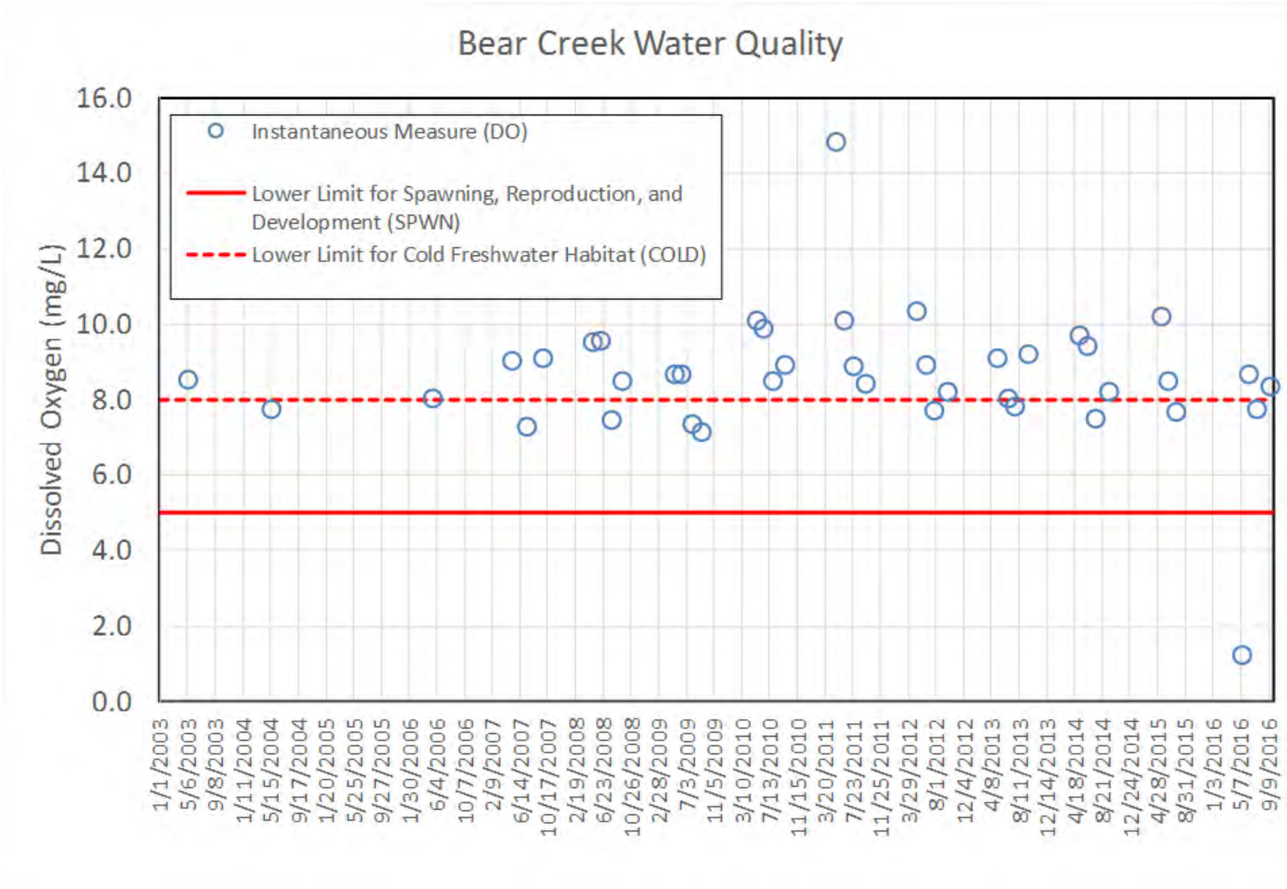

Figure 3-8 Instantaneous dissolved oxygen values in Bear Creek (Reach A), WY2003-WY2016, Placer County, California.

Turbidity values have ranged between 0 and 5.1 Nephelometric Units (NTU), representing generally clear water conditions. However, most samples were collected during non-rain events or after the peak snowmelt runoff period.

Samples were also analyzed for nutrients, but since these data are from infrequent grab samples, isolated to low-flow and non-storm conditions, they do not characterize the full range of possible conditions.

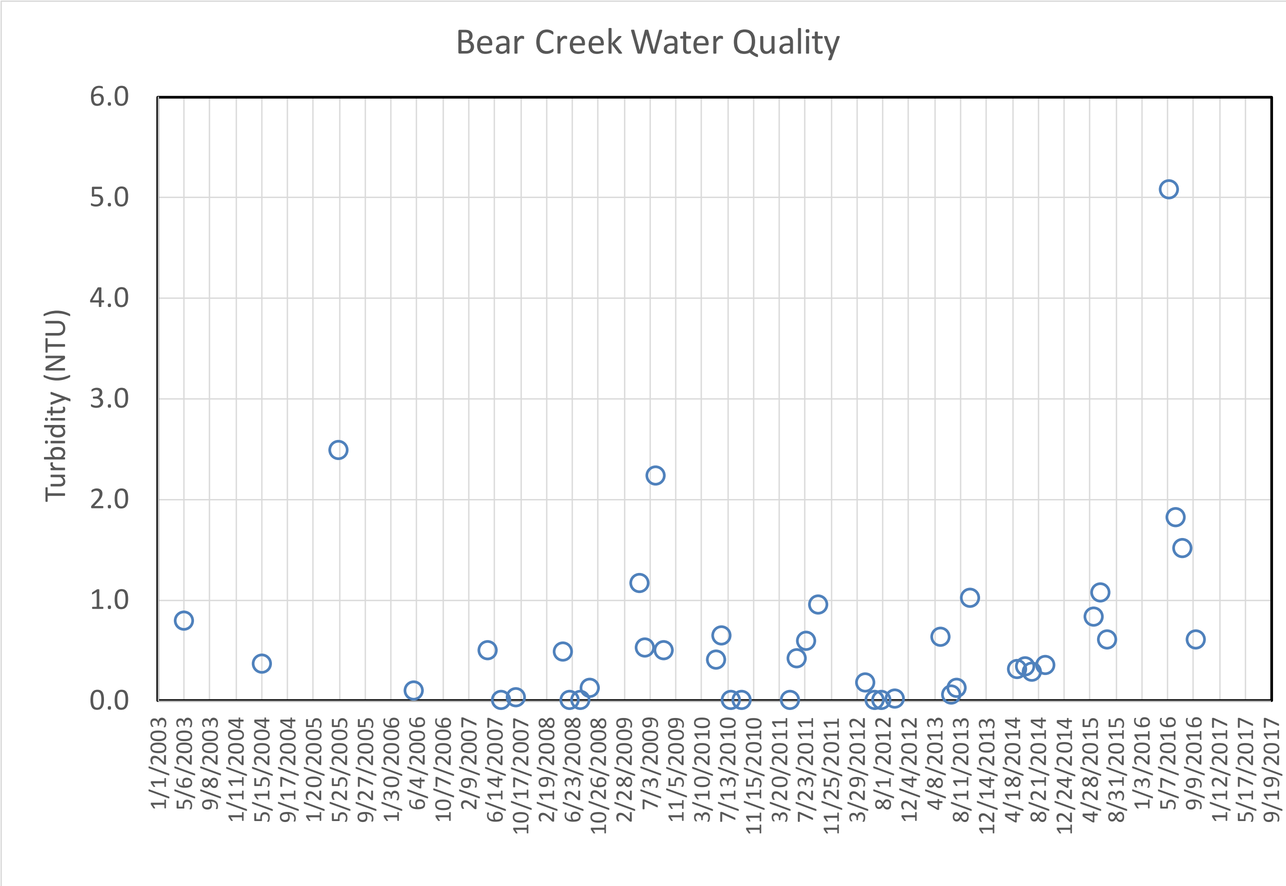

Figure 3-9 **Instantaneous turbidity values in Bear Creek (Reach A), partial WY2003-WY2016, Placer County, California.**

Overall, these monitoring results may illustrate a generally healthy Bear Creek. In the absence of continuous measurements or more detailed previous studies, the status of Bear Creek channel, water, and habitat quality is uncertain.

3.5 Sediment Transport

Because earlier studies suggest that fine sediment may be the source of impairment to the Truckee River, we revisited studies focused on sediment transport in Bear Creek. McGraw and others (2001) estimated suspended sediment discharge from Bear Creek using a modeled approach with samples collected by different entities in WY1997 and WY2000 and a record of flow correlated with nearby streams. The correlation between streamflow and suspended-sediment discharge is shown in **Figure 3-10** and found to vary by two orders of magnitude. When compared to other watersheds in the Middle Truckee River Basin, Bear Creek predicted annual suspended-sediment loads were higher than others, but lower than Squaw Creek, Donner Creek, Prosser Creek, and Gray Creek. In the absence of recent data, current loads cannot be assessed. However, given observations by watershed residents and reports to Placer County over the last decade, suspended sediment monitoring may be a priority to compare to these historical estimated data or if watershed-wide restoration activities are proposed.

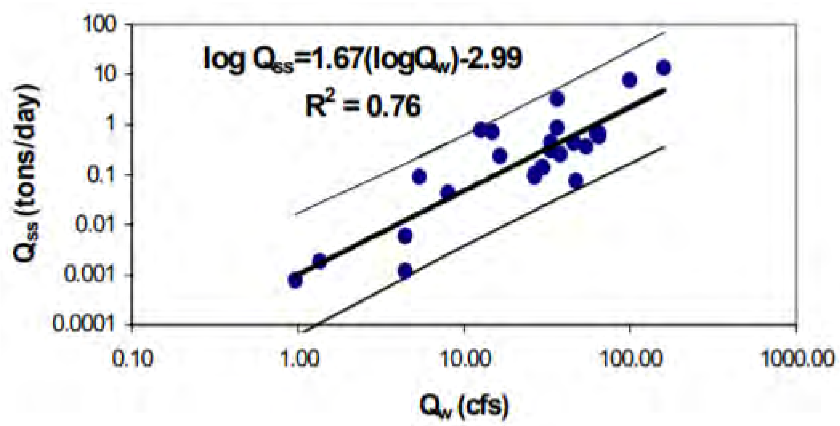

Figure 3-10 Estimated streamflow and suspended-sediment discharge correlation, Bear Creek, Placer County, California. (adapted from McGraw and others, 2001).

Overall, a review of previous Bear Creek water quality studies is inconclusive. As such, this assessment qualitatively assesses current conditions based on further review and observations using acceptable physical and biological methods.

3.6 Biological Resources

3.6.1 Land Cover and Vegetation Communities

The Tahoe National Forest mapped fourteen land cover types (i.e., vegetation communities and other land covers that do not include significant cover of native vegetation, such as urban and developed land or barren land) within the Bear Creek Watershed (TNF, 2014) and classified according to the California Wildlife Habitat Relationships System (CDFG, 1988).[2] The distribution of land cover types in the watershed is shown in **Figure 4-1**. The acreage of each land cover in the watershed is summarized in **Table 4-1**, and the primary characteristics of each land cover type are described in the subsections below. Descriptions of land covers in the watershed were developed

[2] A small portion of the watershed near the Five Lakes Basin was mapped by H. T. Harvey & Associates using high-resolution color aerial imagery. This area was not mapped by TNF nor included in the land cover dataset provided to assist in preparation of the watershed assessment.

based on professional experience with similar habitat types in the central Sierra Nevada and Lake Tahoe region. Field surveys of the watershed for the purpose of describing land covers were not included in the scope of the watershed assessment; however, a site visit by H. T. Harvey & Associates in September 2017 helped refine coarse-level descriptions of land covers occurring in the Bear Creek Watershed.

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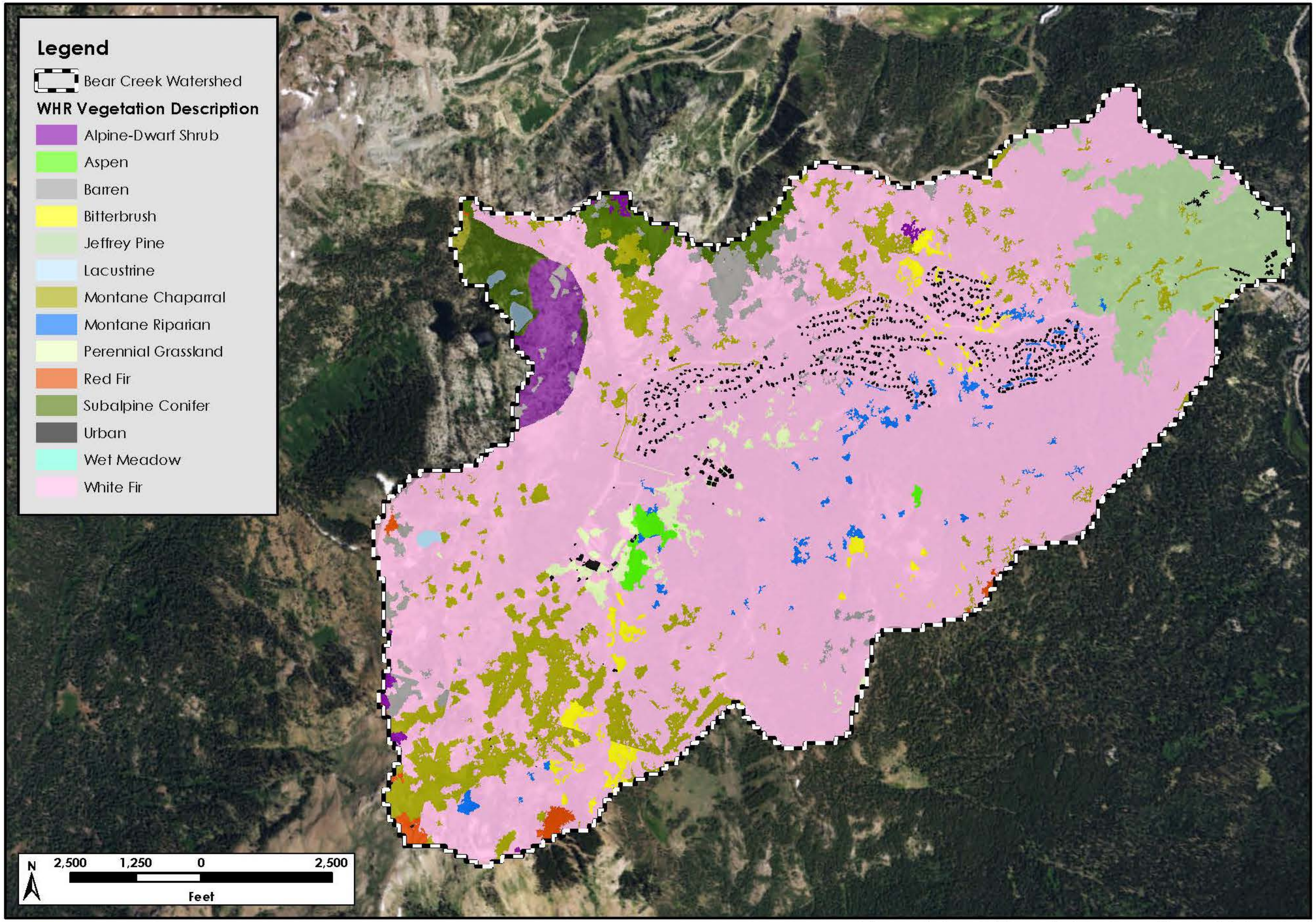

Figure 3-11 Vegetation communities, Bear Creek Watershed, Placer County, California.

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Table 3-3 Land Cover Types in the Bear Creek Watershed

Land Cover Type	Acres
Alpine-Dwarf Shrub	71.5
Aspen	14.8
Barren	68.0
Bitterbrush	36.8
Jeffrey Pine	224.5
Lacustrine	8.1
Montane Chaparral	259.7
Montane Riparian	25.5
Perennial Grassland	40.7
Subalpine Conifer	87.8
Red Fir	16.6
White Fir	2,441.4
Wet Meadow	0.1
Urban	41.9
Total	3,337.5
Source: TNF (2014).	

Alpine-Dwarf Shrub – Alpine-dwarf shrub is characterized by low stature graminoids (i.e., grasses and grass-like plants such as sedges and rushes) and small shrubs on rocky, well-drained ridgelines and slopes. Plants in this community generally grow slowly and do not reach great heights because of the harsh environmental conditions (CDFG 1988). Common species occurring in this community include ocean spray (*Holodiscus discolor*), Greene's goldenbush (*Ericameria greenei*), rose meadowsweet (*Spirea splendens*), and white mountain-heather (*Cassiope mertensiana*). Forbs and grasses that commonly occur in alpine-dwarf shrub communities include crimson columbine (*Aquilegia formosa*), heart willowweed (*Epilobium obcordatum*), Jacobs-ladder (*Polemonium pulcherrimum*), prickly phlox (*Linanthus pungens*), squirreltail (*Elymus elymoides*), bluegrass (*Poa* spp.), buckwheat (*Eriogonum* spp.), rock-cress (*Arabis* spp. and *Boechera* spp.), Eschscholtz buttercup (*Ranunculus eschscholtzii*), and alpine mountain sorrel (*Oxyria digyna*) (Parker and Matyas 1981, Cheatham and Haller 1975). Alpine-dwarf shrub is found in a large rocky area in the northwest corner of the watershed, as well as several small, scattered patches elsewhere in the watershed, which collectively total approximately 71 acres (**Figure 3-11**, **Table 3-3**).

Aspen – Aspen (*Populus tremuloides*) may be found in monocultures or in mixed stands with other deciduous trees (e.g., black cottonwood [*Populus trichocarpa*]) and conifers. Aspen stands are characterized by a relatively open canopy that supports an herbaceous understory; however, mature stands may also support a tall shrub layer. Regionally, aspen stands occur at relatively high elevations (6,000–10,000 feet) near reliable sources of relatively shallow groundwater, such as in wet meadows, seeps, and streams. Associated plant communities can include Jeffrey pine (*Pinus jeffreyi)*, red fir (*Abies magnifica*), white fir (*Abies concolor*), montane riparian, and subalpine conifer as well as montane chaparral (CNPS 2017, Thorne 1977, Parker and Matyas 1981). Stands of aspen totaling approximately 15 acres are found scattered along Bear Creek and just east of the Alpine Meadows parking lot (**Figure 3-11**, **Table 3-3**). Although not mapped, aspen stands also occur in other locations in the watershed, particularly in association with hillslope seeps along the southern side of the watershed where groundwater is available.

Barren – Barren land is characterized by rock, gravel, sand, silt, clay, or other earthen material with less than 15 percent vegetation cover. Vegetation, if present, is more widely spaced and scrubby. Generally, these are areas of bedrock, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material. Barren areas in the watershed total approximately 68 acres and are primarily located on the south- and east-facing slopes of KT-22 and the Granite Chief Wilderness/Five Lakes area in the northwest corner of the watershed (**Figure 3-11**, **Table 3-3**).

Bitterbrush – Bitterbrush (*Purshia tridentata*) communities are primarily located on the eastern slopes of the Sierra Nevada at elevations of approximately 3,500–11,000 feet, often in areas with deep and well-drained soil. Stands of bitterbrush are often composed of shrub codominants, including big sagebrush (*Artemisia tridentata*), buck brush (*Ceanothus cuneatus*), curl leaf mountain mahogany (*Cercocarpus ledifolius*), and green rabbitbrush (*Chrysothamnus viscidiflorus*) (CNPS 2017). Tree species commonly associated with bitterbrush stands include Jeffrey pine and lodgepole pine (*Pinus contorta* ssp. *murrayana*) (CDFG 1988). Bitterbrush is scattered in a few locations throughout the watershed, totaling approximately 37 acres (**Figure 3-11**, **Table 3-3**).

Jeffrey Pine – Jeffrey pine is widely distributed throughout the Sierra Nevada at elevations ranging from approximately 5,000–9,500 feet. Generally, Jeffrey pine occurs as the dominant tree species in a stand; however, associates can include a variety of other conifers such as ponderosa pine (*Pinus ponderosa*), lodgepole pine, white fir, red fir, and incense-cedar (*Calocedrus decurrens*) (CDFG 1988). On the eastern slope of the Sierra Nevada, dominant shrub associates of Jeffrey pine include mountain whitethorn (*Ceanothus cordulatus*), wax currant (*Ribes cereum*), and green leaf manzanita (*Arctostaphylos patula*) at higher elevations (CDFG 1988). Jeffrey pine forest is primarily found in the northeast portion of the watershed on approximately 225 acres (**Figure 3-11**, **Table 3-3**).

Lacustrine – Although not typically considered a plant community, lacustrine habitat was mapped in the Bear Creek Watershed. This is typically a deep to shallow, open-water habitat. Floating aquatic plants such as pondweed (*Potamogeton* spp.) may be present in some areas, and shallow areas (e.g., areas less than 3 feet deep) at lake margins can support growth of various species of moderate-stature, herbaceous graminoids such as sedge (*Carex* spp.), rush (*Juncus* spp.), and bulrush (*Scirpus* spp.) that are tolerant of prolonged, shallow inundation. These marshy habitats are found at Lake Estelle in the southwestern portion of the watershed and along the northeastern border of the watershed in the Five Lakes area (**Figure 3-11**). The extent of this habitat fluctuates in response to snowmelt and runoff, but is mapped at approximately 8 acres (**Table 3-3**).

Montane Chaparral – Montane chaparral is associated with mountainous terrain from mid- to high elevation (between 3,000 and 10,000 feet) and often occurs as either an edaphic climax community (e.g., in areas with shallow, poor soils or south-facing slopes) or as an early successional community following disturbance (e.g., fire, timber harvest) (CDFG 1988). Species composition varies with elevation, geography, soil type, aspect, and successional stage; however, one or more of the following species typically characterize montane chaparral in the central Sierra Nevada and Lake Tahoe regions: mountain whitethorn, tobacco brush (*Ceanothus velutinus*), green leaf manzanita, bitter cherry (*Prunus emarginata*), huckleberry oak (*Quercus vacciniifolia*), bush chinquapin (*Chrysolepis sempervirens*), or serviceberry (*Amelanchier alnifolia*). Montane chaparral stands occur as large patches scattered throughout the watershed, covering nearly 260 acres (**Figure 3-11**, **Table 3-3**).

Montane Riparian – Montane riparian habitat is found below 8,000 feet associated with permanent or ephemeral drainages and other wet areas (e.g., lakes, ponds, seeps, bogs, wet meadows, rivers, streams, springs) (CDFG 1988). Vegetation composition and structure is variable, and may occur as dense stands of broadleaf trees or as only a shrub layer. Common species include black cottonwood, mountain alder (*Alnus incana* ssp.

tenuifolia), white alder (*A. rhombifolia*), aspen, creek dogwood (*Cornus sericea*), and various species of willows (*Salix* spp.). Montane riparian habitat in the watershed occurs along Bear Creek and as scattered patches associated with hillslope seeps and springs (**Figure 3-11**), covering approximately 26 acres (**Table 4-1**).

Perennial Grassland – Perennial grasslands in the Sierra Nevada are characterized by a rich flora of grasses and forbs, often occurring at the drier margins of meadows, in the understory of open conifer and aspen stands, and in previously disturbed areas. Common species can include mat muhly (*Muhlenbergia richardsonis*), Kentucky blue grass (*Poa pratensis* ssp. *pratensis*), western needle grass (*Stipa occidentalis*), timothy (*Phleum pratense*), orchard grass (*Dactylis glomerata*), California oat grass (*Danthonia californica*), California brome (*Bromus carinatus*), various species of wheatgrasses and wild rye (*Elymus* spp.), squirreltail, slender hairgrass (*Deschampsia elongata*), spike false oat (*Trisetum spicatum*), various annual forbs (e.g., *Navarretia* spp., *Lupinus* spp., *Leptosiphon* ssp., *Polygonum sawatchense*), and upland perennial forbs such as corn lily (*Veratrum californicum*), Parish's yampah (*Perideridia parishii* ssp. *parishii*), yarrow (*Achillea millefolium*), and potentilla (*Potentilla* spp.). Approximately 41 acres of perennial grassland (**Table 3-3**) occur in Alpine Meadows Ski Area and along the southern slopes of the watershed (**Figure 3-11**), and scattered, unmapped areas of perennial grassland occur elsewhere (e.g., at the drier margins of meadows along Bear Creek below Alpine Meadows Road).

Subalpine Conifer – Subalpine conifer forests are found at high elevations growing in thin, low-quality soils where there is heavy snow cover in the winter and spring, cool summer temperatures, and a short (i.e., 7 to 9 weeks) growing season (CDFG 1988). In the central Sierra Nevada and Lake Tahoe region, whitebark pine (*Pinus albicaulis*), western white pine (*Pinus monticola*), and lodgepole pine can all occur in subalpine conifer stands. On exposed sites and windy ridges, trees may be stunted and shrubs and herbs are generally sparse or lacking. Where there is an understory, it may include wax currant, purple mountain heather (*Phyllodoce breweri*), ocean spray, and big sagebrush in the shrub layer along with California brome, lupine (*Lupinus spp*.), and a variety of flowering annuals in the herb layer. Subalpine conifer occurs at the northern and northwestern edge of the watershed, covering nearly 88 acres (**Figure 3-11**, **Table 3-3**).

Red Fir – Red fir forests occur on frigid soils at high elevations (6,000 to 9,000 feet) where there is a deep snow pack in the winter and spring and dry conditions in the summer (CDFG 1988). Red fir may form monotypic stands or intergrade with white fir dominated stands; inclusions of aspen along riparian zones and mountain meadows, sometimes associated with small lakes, can be found in red fir habitats. Heavy shade and a thick duff layer tends to inhibit understory vegetation, with the understory of mature stands limited to less than 5 percent cover of shade tolerant species (e.g., little prince's pine [*Chimaphila menziesii*], white-veined wintergreen [*Pyrola picta*]). In the watershed, red fir forests exist in just a few locations scattered along the perimeter of the watershed, totaling approximately 17 acres (**Figure 3-11**, **Table 3-3**).

White Fir – White fir forests are found throughout mountainous areas of California, at elevations between roughly 5,000 and 7,000 feet in the central Sierra Nevada, usually on cooler north- and east-facing slopes (CDFG 1988). These forests are characterized by nearly monotypic even-aged overstory, usually with overlapping crowns that cast deep shade, although open stands may occur as well. The understory may consist of sparsely scattered grasses, forbs, and shrubs, or white fir seedlings and saplings; however, shade and downed woody material tend to inhibit understory species (Parker and Matyas 1981). Depending on elevation, various other conifers (e.g., incense cedar, Ponderosa pine, Jeffrey pine, red fir) may be associated with white fir stands along with species like green leaf manzanita and gooseberry/currant (*Ribes* spp.) in the understory. White fir is the dominant land cover in the watershed, covering 2,441 acres (**Figure 3-11**, **Table 3-3**).

Wet Meadow – Wet meadows occur on poorly drained soils where water is at or near the ground surface for most of the growing season (CDFG 1988), along active and abandoned stream channels, lake margins, groundwater seeps, and similar wet areas. This community is dominated by perennial graminoids and forbs with little bare ground. Low-statured willows (e.g., *Salix orestera*) and huckleberry (*Vaccinium* spp.) may be intermixed with graminoids and forbs in some locations, but trees are typically absent. In wetter settings, dominant species include sedges, principally Nebraska sedge (*Carex nebraskensis*), beaked sedge (*Carex utriculata*), short-beaked sedge (*Carex simulata*), and species of rushes (e.g., *Juncus nevadensis*), wood-rush (*Luzula comosa*), and bulrush (*Scirpus microcarpus*). Forbs found in wet meadows can include columbine (*Aquilegia formosa*), lupine, corn lily, clover (e.g., *Trifolium longipes*), aster (e.g., *Aster occidentalis*), primrose monkeyflower (*Mimulus primuloides*), larkspur (*Delphinium* spp.), and Sierra tiger lily (*Lilium parvum*), among many others. Wet meadows are found scattered in one area at the south end of the watershed, covering less than 0.1 acre (**Figure 3-11**, **Table 3-3**). Although not mapped, small areas of wet meadows also occur along the margins of Bear Creek, below Alpine Meadows Road, and in the far upper reaches of the watershed along drainages within Alpine Bowl, Wolverine Bowl, Estelle Bowl, and Beaver Bowl.

Urban – Developed areas are characterized by a high percentage (30 percent or greater) of structures (e.g. asphalt, concrete, buildings) and include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Within the Bear Creek Watershed, developed areas include roadways and developed recreational areas (i.e., Alpine Meadows ski resort, cabins, parking lots) that collectively cover nearly 42 acres (**Figure 3-11**, **Table 3-3**).

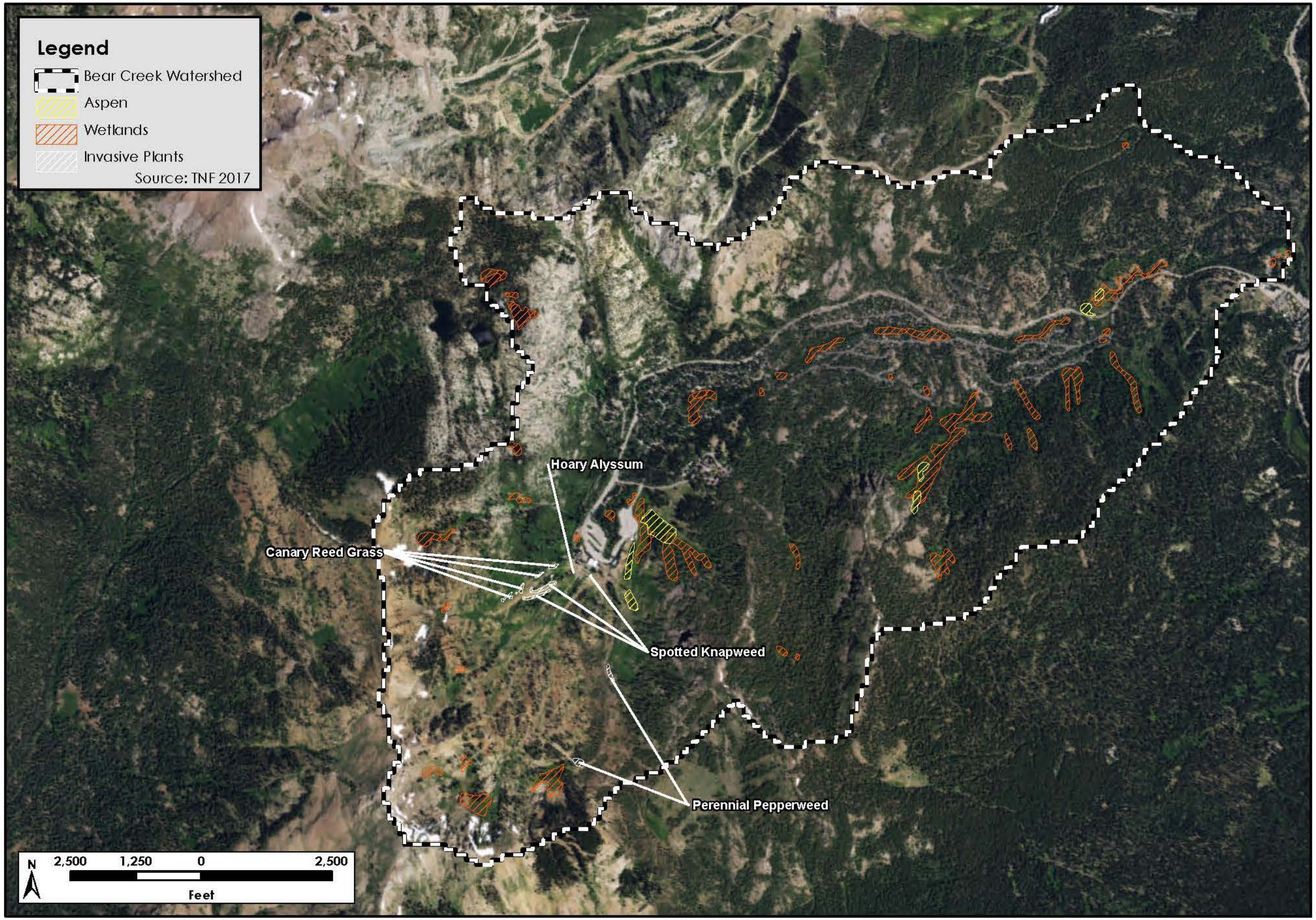

Figure 3-12 Sensitive plant communities and invasive plants, Bear Creek watershed, Placer County, California.

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3.6.2 INVASIVE SPECIES

Invasive species are plants, vertebrates, and invertebrates that, by nature of their reproductive capacities, growth habits, or other ecological characteristics, are capable of causing adverse economic or ecological effects such as altering nutrient cycles, affecting primary or secondary productivity, and increasing wildfire frequency and intensity, among many other impacts (TRPA 2014, Bossard et al. 2000).

The Lake Tahoe Region Aquatic Invasive Species Management Plan (TRPA 2014) lists aquatic invasive species that are either known to occur or that have the potential to occur in Lake Tahoe and the surrounding region. Although none of these species are known to occur in the Bear Creek watershed, Asian clams (*Corbicula fluminea*) have been recorded in the lower Truckee River (TRPA 2014), and New Zealand mudsnails (*Potamopyrgus antipodarum*) occur in the mainstem Truckee River, well downstream of the watershed in Nevada. Suitable habitat for both species exists in the watershed.

Additionally, 10 invasive plants have been recorded in the Bear Creek watershed (CalWeed Mapper 2017, TNF 2017) with the major species mapped in the watershed shown in Figure 3-12. These species are listed in **Appendix A** along with priority ratings assigned by the California Invasive Plant Council (Cal-IPC) and California Department of Food and Agriculture (CDFA). Appendix A also indicates whether the species is considered a top priority for management in the Lake Tahoe Basin (LTBWCG 2017) or a weed species of interest to the Truckee River Watershed Council (USFS 2013a).

3.6.3 WILDFIRE

Wildfire has historically played an important role in Sierra Nevadan forests, and was likely a frequent occurrence in the region prior to the arrival of emigrants. Since the early 1900s, wildfire has been actively suppressed as a policy to prevent loss of resources, property, and provide public safety. Wildfire suppression has drastically changed forest composition and structure and steadily increased the threat of wildfire over the past 100 years. When wildfires do occur in today's mixed conifer forests they can result in high intensity, high severity fire (MacDonald and Larsen, 2008). The effects of high-severity fires on watershed processes are well documented in the literature (Carroll and others, 2007, Ice and others, 2004, MacDonald and Larsen, 2008). These studies suggest that erosion resulting from wildfire can generate considerably more erosion, enlarge channel networks, and degrade water quality when compared to chronic sources of sediment (e.g., roads).

Geospatial Multi-Agency Coordination (GeoMAC, 2017) mapped recent and historical fire perimeters. These data indicate that wildfire has been absent in the Bear Creek Watershed and adjacent areas since 1880 or earlier (**Figure 3-16**). Based on limited field observations, forested uplands in the Truckee-Tahoe region exhibit very dense growth, with even-aged forest stands and show the absence of wildfire.

California Department of Forestry and Fire Protection (2008) has identified Bear Creek watershed with a low to moderate threat for wildfire with small pockets of high threat, mostly along the ridge separating Bear Creek from Squaw Creek watershed (**Figure 3-16**). The map indicates a higher threat along the watershed's southern boundary and further south (i.e., Ward Creek, Blackwood Creek). If a wildfire were to ignite in these areas, the threat of wildland fire in Bear Creek watershed may increase due to wind direction and fuel availability. We note that these data were relevant through 2008 and precede a drought period through 2016. While no current data are available, we suspect wildfire threat in the region has increased.

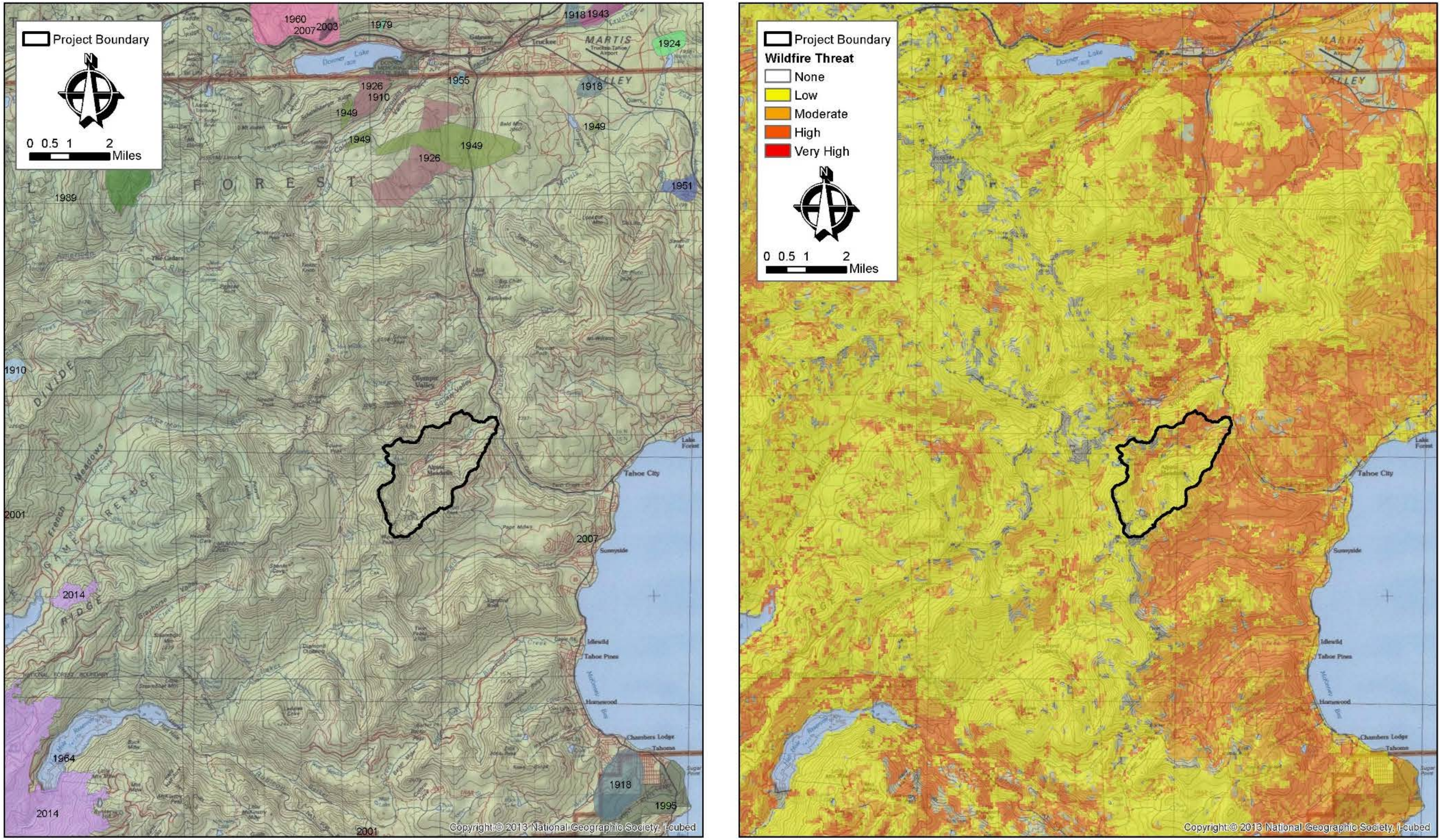

Figure 3-13 Historical wildfire perimeters (left) and wildfire threat (right) in the Bear Creek and region, Placer County, California. [Sources: Geospatial Multi-Agency Coordination (GeoMAC), Wildland Fire Support, and California Department of Forestry and Fire Protection.]

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3.6.4 General Wildlife

The Bear Creek watershed is comprised of a diverse mosaic of connected plant communities including conifer forests; aspen stands; riparian woodland and scrub; streams, wetlands, and small lakes; montane chaparral; grasslands; and montane meadows. These habitats provide breeding and foraging habitat for a wide variety of wildlife commonly found in the central Sierra Nevada and Lake Tahoe regions. Representative mammals that occur regionally include American black bear (*Ursus americanus*), introduced North American beaver (*Castor canadensis*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), long-tailed weasel (*Mustela frenata*), mountain lion (*Puma concolor*), Columbian black-tailed deer (*Odocoileus hemionus columbianus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), western spotted skunk (*Spilogale gracilis*), ground squirrels (*Otospermophilus* spp.), chipmunks (*Neotamias* spp.), voles (*Arborimus* spp.), and yellow-bellied marmot (*Marmota flaviventris*). Common amphibians and reptiles include Pacific chorus frog (*Pseudacris sierra*), western toad (*Anaxyrus boreas*), mountain gartersnake (*Thamnophis elegans elegans*), and Sierra alligator lizard (*Elgaria coerulea palmeri*).

The matrix of meadows, wetlands and other waterbodies, conifer forests, riparian areas, and aspen in the watershed also meets the ecological needs of many birds, particularly seasonal migrants through the Sierra Nevada. Examples of common bird species known to occur in the watershed (based on observations reported to eBird, an online repository of bird observations), or that are expected to occur in the watershed, include red-breasted sapsucker (*Sphyrapicus ruber*), hairy woodpecker (*Leuconotopicus villosus*), northern flicker (*Colaptes auratus*), western wood pewee (*Contopus sordidulus*), warbling vireo (*Vireo gilvus*), Steller's jay (*Cyanocitta stelleri*), common raven (*Corvus corax*), mountain chickadee (*Poecile gambeli*), red-breasted nuthatch (*Sitta canadensis*), American robin (*Turdus migratorius*), yellow-rumped warbler (*Setophaga coronata*), dark-eyed junco (*Junco hyemalis*), song sparrow (*Melospiza melodia*), Brewer's blackbird (*Euphagus cyanocephalus*), American dipper (*Cinclus mexicanus*), Cassin's finch (*Haemorhous cassinii*), turkey vulture (*Cathartes aura*), green-tailed towhee (*Pipilo chlorurus*), mallard (*Anas platyrhynchos*), red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipter striatus*), and western tanager (*Piranga ludoviciana*) (Beedy and Pandolfino 2013).

3.6.4.1 Fishes

Moyle et al. (1996) identified four zoogeographic regions (drainages) in the Sierra Nevada, each defined by distinctive native fish communities that share few species in common. The Lahontan drainage, consisting of the Susan, Truckee, Carson, and Walker River drainages on the east slope of the central and northern Sierra Nevada, is characterized by 10 native fish species that are distributed widely from lowlands to elevations above 6,600 feet. These 10 native species are mountain whitefish (*Prosopium williamsoni*), Lahontan cutthroat (*Oncorhynchus clarki henshawi*), Paiute cutthroat (*Oncorhynchus clarki seleniris*), Lahontan lake tui chub (*Gila bicolor pectinifer*), Lahontan creek tui chub (*Gila bicolor obesa*), Lahontan redside (*Richardsonius egregious*), Lahontan speckled dace (*Rhinichthys osculus robustus*), Tahoe sucker (*Catastomus tahoensis*), mountain sucker (*Catostomus platyrhynchus*), and Paiute sculpin (*Cottus beldingi*). Although the numbers and distributions of these native species has been reduced, Paiute sculpin, Lahontan speckled dace, Lahontan redside, Tahoe sucker, mountain sucker, and mountain whitefish may still occur in Bear Creek because these fishes are present in the mainstem Truckee River or other tributaries to the Truckee River (e.g., Squaw Creek, Sagehen Creek, Martis Creek) (Moyle 2002) and potentially suitable habitat for these species exists in Bear Creek.

Nonnative fish were widely introduced to the Sierra Nevada through private and government-sponsored programs beginning in the mid-1800s and continuing far into the 1900s (Knapp et al. 2001). Many of these introduced species were gamefish, such as rainbow trout (*Oncorhynchus mykiss*), eastern brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), landlocked sockeye salmon, or “kokanee” (*Oncorhynchus nerka*), and lake trout (*Salvelinus namaycush*); competition among these fishes and native species, along with predation and hybridization (particularly between Lahontan cutthroat and rainbow trout), are primary reasons for the decline in native fishes regionally and throughout the Sierra Nevada.

Although gamefish stocking programs for the Truckee River have largely ended in California, rainbow trout continue to be stocked in many lakes and reservoirs regionally (e.g., Donner, Prosser, Boca, Stampede), and a self-sustaining population of rainbow and brown trout now represents the primary target for anglers in the Truckee River and its tributaries. Numerous rainbow trout were observed in Bear Creek during a September 2017 field visit, with more fish concentrated in the reach between Alpine Meadows Road and Alpine Meadows Ski Resort. No other fish species were observed during the field visit, and far fewer rainbow trout were observed in Bear Creek downstream of Alpine Meadows Road.

3.6.5 Special-Status Species

Special-status species generally include species listed as either threatened or endangered under the California or federal Endangered Species Acts (ESA), California Species of Special Concern, state Fully Protected Species, and Tahoe National Forest Sensitive Species. For plants, special-status species also include species listed in the California Native Plant Society's (CNPS) *Inventory of Rare, Threatened, or Endangered Plants of California* (CNPS 2017). For the purpose of this watershed assessment, special-status species also include species that are of special management concern (i.e., tracked in the CNDDB) even though they do not have any formal state or federal protection. These include species whose numbers appear to be declining regionally or across the range of the species, species experiencing range restriction, and species whose habitat may be threatened because of climate change or recreational, industrial, or commercial development or land uses.

To identify special-status species potentially occurring in the Bear Creek Watershed, the California Natural Diversity Database (CNDDB) (2017) was queried for all species observations reported within 5 miles of the watershed boundary. The CNDDB is a comprehensive database of species observations maintained by the California Department of Fish and Wildlife (CDFW). It is important to note that the CNDDB contains only records of species observations that are voluntarily submitted to CDFW; thus, the lack of species observations in a particular region may indicate only a lack of previous survey efforts and not necessarily a lack of special-status species occurrences.

To supplement CNDDB data, records of special-status species occurrences also were obtained from the U.S. Forest Service (USFS) Natural Resources Inventory, provided by the Tahoe National Forest (TNF 2017). In addition, a query of the CNPS Online Inventory, 8th edition (CNPS 2017) was completed to identify special-status plants occurring on the Tahoe City 7.5-minute U.S. Geological Survey topographic quadrangle and the surrounding eight quadrangles (i.e., Kings Beach, Meeks Bay, Homewood, Wentworth Springs, Granite Chief, Norden, Truckee, and Martis Peak).

Finally, special-status species were identified as potentially occurring in the Bear Creek watershed based on the professional experiences and opinions of H. T. Harvey & Associates biologists, even if these species was not otherwise documented as occurring in or near the watershed by any of the sources described above.

The known locations of special-status wildlife and plant species in the watershed and the surrounding region, based on occurrence information contained in the CNDDB and TNF records, are shown in **Figure 3-17** and **Figure 3-15**, respectively. The distribution, ecology and life history, and potential for occurrence within the Bear Creek watershed are summarized for each species at the end of this section, in **Appendix A** for wildlife and plants.

The assessment of potential for occurrence was based on queries of existing occurrence records and professional experience and opinion. Potential is rated as follows:

- ***Known to occur:*** Species documented as occurring in the watershed
- ***May occur:*** Species not documented on the watershed, but the species is known from within 5 miles of the watershed, and habitats within the watershed are suitable for the species
- ***Potential to occur:*** Species is not known to occur on or within 5 miles of the watershed, but the species does occur regionally and/or habitats found within the watershed are marginally suitable for the species
- ***Unlikely to occur:*** Species is only rarely found regionally, restricted to particular habitat types that are unlikely to occur on the watershed (e.g., particular soil types), and/or habitats found within the watershed are unsuitable for the species

All special-status species either **known to occur** or that **may occur** within the watershed are described in more detail below.

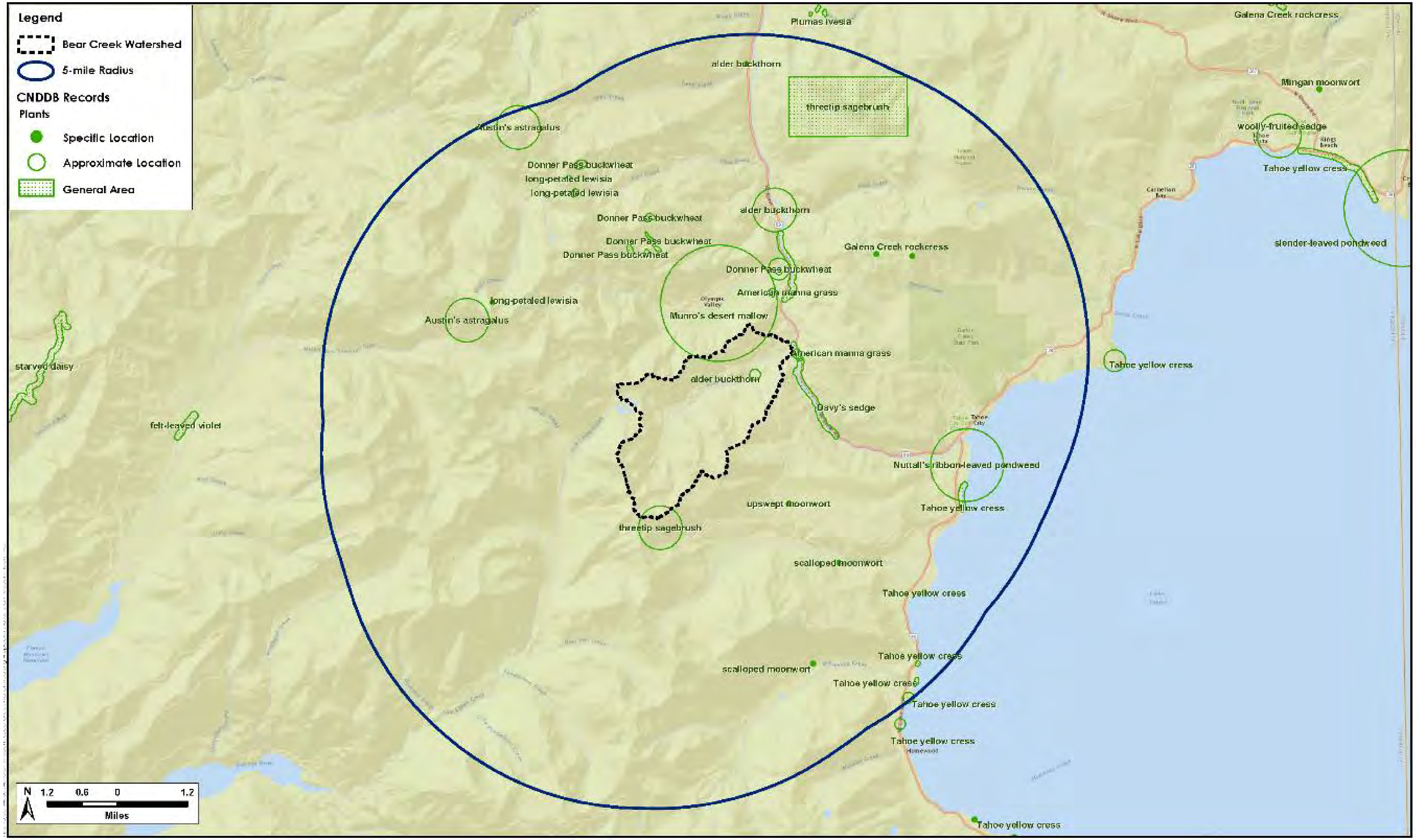

Figure 3-14 Special-status plant occurrences, Bear Creek watershed, Placer County, California.

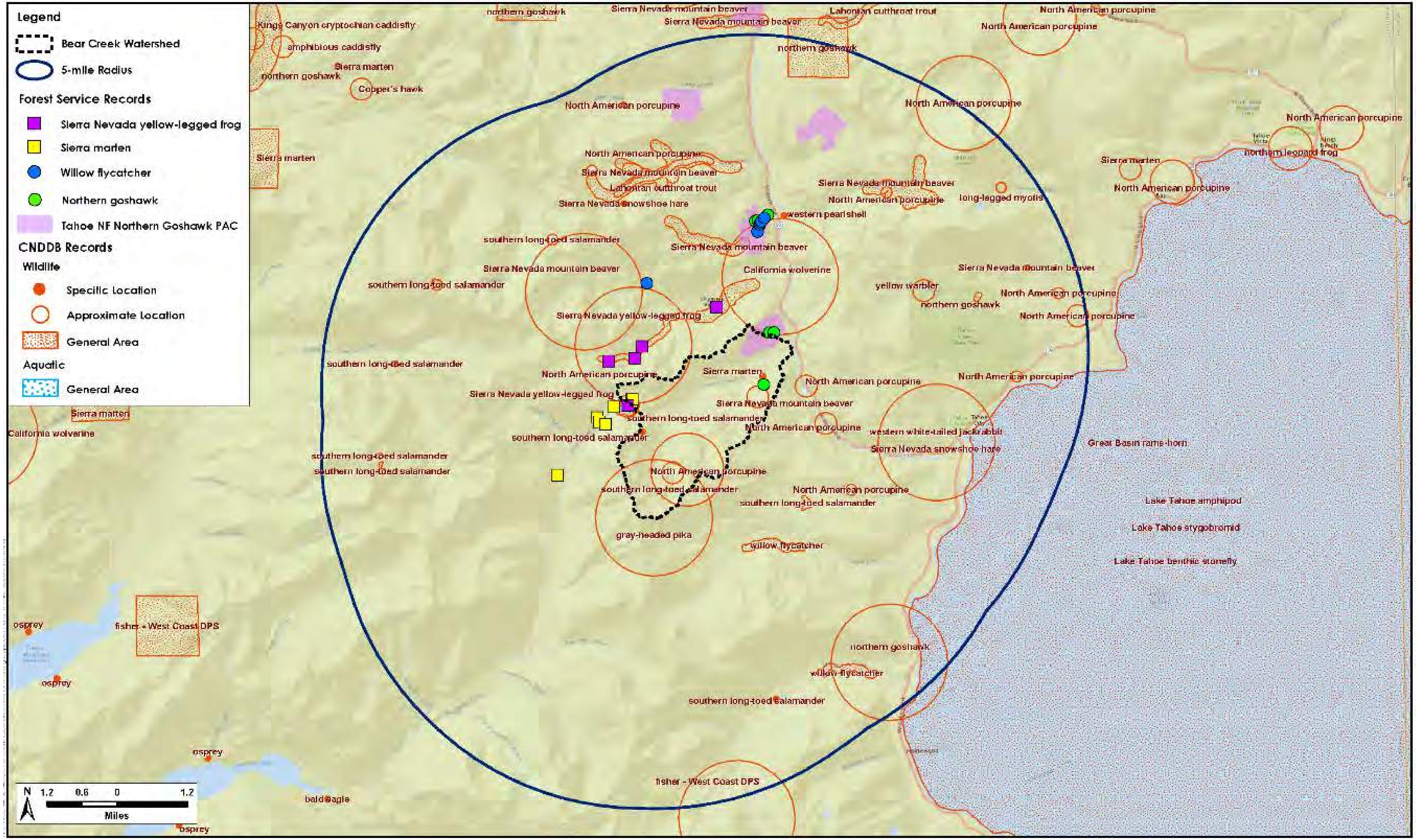

Figure 3-15 Special status wildlife occurrences, Bear Creek watershed, Placer County, California.

3.6.5.1 Special-Status Wildlife

Sierra Nevada Yellow-Legged Frog *(Rana sierrae)* – The Sierra Nevada yellow-legged frog was listed as a California threatened species in 2012 and as a federal endangered species in 2014; additionally, the TNF considers Sierra Nevada yellow-legged frog to be a sensitive species (USFS 2013b). This species occurs in the Sierra Nevada from Plumas County to Fresno County where it is associated with streams, lakes, and ponds in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitats. This aquatic species is always encountered within a few feet of water. Reproduction does not take place until lakes and streams are free of ice. Tadpoles may require up to two over-wintering periods to complete their aquatic development (Cory 1962). During winter, adults hibernate beneath ice covered streams, lakes, and ponds. Terrestrial hibernation has not been documented. They feed primarily on aquatic and terrestrial invertebrates and favor terrestrial insects. Adults and tadpoles are commonly preyed upon by garter snakes and introduced trout (Cory 1963, Zweifel 1968).

This species is known to occur in the watershed. Populations occur in Lake Estelle and its associated drainage (CNDDB 2017, TNF 2017), and designated critical habitat for the species is found within a large portion of the watershed (USFWS 2017). Stream reaches with significant trout populations (e.g., Bear Creek) do not provide suitable habitat for this species.

Southern Long-Toed Salamander (*Ambystoma macrodactylum sigillatum*) – The Southern long-toed salamander is a California Species of Special Concern. It is found in the northern Sierra Nevada south to Spicer Reservoir in Tuolumne County, and it also occurs in the Trinity Alps in Trinity and Siskiyou Counties. The species inhabits flooded alpine meadows and high mountain ponds and lakes. During the non-breeding season, this species finds refuge in moist areas in burrows, under fallen logs, rocks, bark and other objects near ponds and similar breeding sites. In spring or early summer, Southern long-toed salamanders migrate overland to breeding sites. Females typically remain at a breeding site for 1–2 days, while males have been documented to remain at breeding sites for the duration of the breeding season.

This species is known to occur in the watershed. Individual salamanders have been observed in the Five Lakes area and in a pond northeast of Lake Estelle (CNDDB 2017).

Northern Goshawk (*Accipiter gentilis*) – The northern goshawk is a California Species of Special Concern and a TNF sensitive species (USFS 2013b). This species nests and forages primarily in mature montane coniferous forest with large diameter trees and high canopy closure. It sometimes nests and forages in mature aspen stands and will frequently forage along meadow edges or in aspen/willow shrub communities (Keane 2008). Primary prey species vary regionally but include songbirds and small mammals (e.g., squirrels, chipmunks).

This species is known to occur in the watershed. A northern goshawk alarm call was heard along Bear Creek in a mixed aspen and white fir stand along Bear Creek below Alpine Meadows Road during a September 2017 field visit, and an occurrence of northern goshawk along Alpine Meadows Road near Deer Park Drive was reported to eBird in 2016 (potentially the same bird heard in September 2017). Additionally, northern goshawks are known to nest in multiple forested locations in the watershed and within 5 miles of the watershed based on CNDDB (2017) and TNF (2017) records.

Willow Flycatcher (*Empidonax traillii*) – Two subspecies of the willow flycatcher occur in northern California — *E. t. adastus* (generally breeds in Cascade Range and Great Basin) and *E. t. brewsteri* (generally breeds on the west slope of the Sierra Nevada) (Sedgewick 2000, USFWS 2002). Both subspecies are state listed as endangered. While *E. t. adastus* could occur in the watershed during migration, only the little willow flycatcher subspecies (*E. t. brewsteri*) is known to breed in the vicinity of the watershed. The species occurs in wet, montane meadows associated with creeks and streams or in discharge slope meadows fed by groundwater (Bombay et al. 2003a, 2003b; Green et al. 2003, Mathewson 2010). Most meadows occupied by willow flycatchers have at least some surface water that persists throughout the summer and have a vegetation community dominated by dense willows and similar species (e.g., alder) that thrive in saturated and/or flooded conditions. Willow flycatcher habitat does not necessarily include tall trees, but snags and branches are used as foraging and singing perches if available (Serena 1982, Sanders and Flett 1989).

This species may occur in the watershed. Willow flycatchers have been documented to nest within 5 miles of the watershed (CNDDB 2017), and potentially suitable habitat is present on the watershed.

Yellow Warbler (*Setophaga petechia*) – The yellow warbler is a California Species of Special Concern that breeds in riparian woodlands and shrublands across much of California, excepting the Central Valley, deserts, and higher elevations of the west slope of the Sierra Nevada. The species reaches some of its greatest abundances in willow-dominated wet meadows of northeastern California and the east slope of the Sierra Nevada (Heath 2008).

Yellow warblers may occur in the watershed. This species has been observed within 5 miles of the watershed (CNDDB 2017), and suitable breeding habitat is present on the watershed.

American Pika (*Ocnotona princeps schisticeps*) –There are five currently recognized subspecies of American pika with one, *Ocnotona princeps schisticeps*, occurring in California and into the Great Basin ranges outside of California (Hafner and Smith 2010). Approximately 64% of the *schisticeps* geographic range exists in the Sierra Nevada south to Tulare and Inyo Counties, with the remainder in the southern Cascades and mountain ranges of the Great Basin (Hafner and Smith 2010). Although it has no official protective status, the American pika was petitioned for endangered species status under federal and California laws in 2007. Pikas are generalist herbivores that occur in alpine and sub-alpine environments, rarely below 8,200 feet elevation in California (Smith and Weston 1990, Ray and Beever 2007). Preferred habitats are talus slopes or lava formations with adjacent herbaceous or shrub vegetation (Beever 2002, Rodhouse et al. 2010).

American pikas are known to occur near Ward Peak in the Bear Creek watershed based on reported CNDDB (2017) records.

Fringed Myotis (*Myotis thysanodes*) – The fringed myotis is found throughout California, except in the Central Valley and Colorado and Mojave deserts; this bat also occurs in much of western North America from southern British Columbia to southern Mexico (Jones and Choate 1978, O'Farrell and Studier 1980, Hall 1981, Rasheed et al. 1995, Zeiner et al. 1990). It is a proposed California Species of Special Concern and a TNF sensitive species (USFS 2013b). Optimal habitats are open areas interspersed with pinyon-juniper, valley foothill hardwood and hardwood-conifer, generally at 4,300–7,200 feet in elevation, although the species ranges from sea level to 9,350 feet (Barbour and Davis 1969, Keinath 2004, Zeiner et al. 1990). Fringed myotis are most active for the first 1 to 2 hours after sunset and forage for insects in flight over water, forest edges, over forest canopies, in interior forests, and likely glean from vegetation near the top of the forest canopy (O'Farrell and Studier 1980, Black 1974, Banfield 1975, Keinath 2004). Ideal habitat contains a mosaic of foraging habitat, still water sources, and proximate roost structures (Pierson and Rainey 1998). Fringed myotis use caves, mines, and buildings as maternity colonies, solitary day and night roosts, and hibernacula (Musser and Durrant 1960, Davis 1966, Easterla 1966, Judd 1967, O'Farrell and Studier 1980, Perkins et al. 1990, Ellison et al. 2003). They also use bridges, rock crevices (Davis 1966, Miner et al. 1996, Brown and Berry 1998, Herder 1998, as cited in Keinath 2004), underneath bark and inside hollows of tree snags, particularly ponderosa pine and Douglas-fir (*Pseudotsuga menziesii*) as day and night roosts (Kurtzman 1994, Morell et al. 1994, Murphy 1994, Rasheed et al. 1995, Chung-MacCoubrey 2001).

Fringed myotis may occur in the Bear Creek watershed based on a reported CNDDB (2017) observation within the 5 miles of the watershed and the presence of suitable roosting and foraging habitat on the watershed.

North American Porcupine (*Erethizon dorsatum*) –The North American porcupine is one of the largest rodents in North America. The species occurs throughout the Sierra Nevada and Cascades from Kern County north to the Oregon Border, south in the Coast Ranges to Sonoma County, and from San Mateo County south to Los Angeles County. Scattered populations also occur in wooded habitats in the eastern Central Valley (Laurendine et al. 1996), as well as Los Angeles and San Bernardino Counties (Johnson and Harris 1990). Due to declines in porcupine observations (the species was historically considered to be a pest and frequently poisoned to control populations in conifer forests and conifer plantations), CDFW is actively tracking porcupine sightings, and the species is under consideration by CDFW to be added as California Species of Special Concern. The North American porcupine is most common in montane conifer, Douglas-fir, alpine dwarf-shrub, and wet meadow habitats (Johnson and Harris 1990). It requires forest with a good understory of herbs, grasses, and shrubs, and prefers open stands of conifers (Taylor 1935, Woods 1973, Johnson and Harris 1990). In spring and summer, porcupines use meadows, brushy, and riparian habitats for feeding. In winter, it is restricted to forests (Johnson and Harris 1990). In spring and summer, it feeds on aquatic and terrestrial herbs, shrubs, fruits, leaves, and buds. Winter diet consists of twigs, bark, and cambium of trees, particularly conifers, and evergreen leaves (Johnson and Harris 1990). Porcupines den in caves, crevices in rocks, cliffs, hollow logs, snags, burrows of other animals and will use dense foliage in trees if other sites are unavailable (Taylor 1935, Woods 1973, Thomas 1979). Predators include mountain lions, bobcats, wolverines, and fishers (Taylor 1935, Woods 1973). Fishers, in particular, are effective predators of porcupines, and control porcupine density in some areas (Powell and Brander 1977); the decline in porcupines is thought to be one factor related to the observed decline of fishers across the Sierra Nevada.

This species is known to occur in the Bear Creek watershed based on reported CNDDB (2017) observations near KT-22 and below Ward Peak (some of which are many years old), with other observations reported in close proximity to the watershed.

Sierra Marten (*Martes caurina sierrae*) – The Sierra marten is a subspecies of American marten with an elevational range from 3,400 to 10,400 feet (Freel and Stewart 1991). It is a TNF sensitive species (USFS 2013b) found throughout much of its historical range from Trinity and Siskiyou Counties east to Mount Shasta, south through the Cascades and Sierra Nevada to Tulare County (Zielinski et al. 2001, Grinnel et al. 1937, Kucera et al. 1996). Mesocarnivore surveys conducted on the forests of the Sierra Nevada from 1996 to 2002 reported Sierra martens in Amador, Calaveras, El Dorado, Fresno, Lassen, Madera, Mariposa, Placer, Plumas, Shasta, Sierra, Tehama, Tulare, and Tuolumne counties (Zielinksi et al. 2005). In the Sierra Nevada, martens prefer old growth fir forests and high elevation riparian-lodgepole pine associations (Spencer et al. 1983). Despite their widespread distribution throughout the Sierra Nevada, martens are considered to be locally uncommon and are known to occur in very low densities (Buskirk and Ruggiero 1994). Martens are omnivores that eat a variety of different food types including small mammals, vegetation (fruits, berries, nuts, fungi, lichens, grass, conifer needles, leaves, twigs and bark), birds, fish, insects, and carrion (Martin 1994).

This species is known to occur within the Bear Creek watershed based on multiple reports from the TNF (2017) and from CNDDB (2017) records.

Sierra Mountain Beaver (*Aplodontia rufa californica*) – The Sierra mountain beaver, a California Species of Special Concern, is one of 6 subspecies of mountain beaver occurring in California (Hall 1981). It is uncommon throughout its range and appears to have a scattered distribution in montane riparian habitats in the Sierra Nevada. This species frequents open habitats and habitats with intermediate-canopy cover in riparian-deciduous vegetation with a dense understory near water. They feed on a variety of plants, including lupines, willows, grasses, thimbleberry (*Rubus parviflorus*) (Zeiner et al. 1990), conifers, and deciduous trees (Voth 1968). Mountain beavers breed from December through March, producing one litter of two or three young per year, using deep, friable soils in dense thickets near a stream for burrowing. Predators include bobcats, long-tailed weasels, minks, coyotes, and owls (Zeiner et al. 1990).

This species is known to occur in the watershed based on a reported observation in the northeastern part of the watershed; numerous additional records occur within 5 miles of the watershed (CNDDB 2017).

Sierra Nevada Snowshoe Hare (*Lepus americanus tahoensis*) – Both subspecies of snowshoe hare that are found in California are California Species of Special Concern (Williams 1986). The Sierra Nevada snowshoe hare is primarily found in montane riparian habitats with thickets of alders and willows and in stands of young conifers interspersed with chaparral (Zeiner et al. 1990). The early seral stages of mixed conifer, subalpine conifer, red fir, Jeffrey pine, lodgepole pine, and aspen are also likely habitats, primarily along edges and especially near meadows (Orr 1940, Ingles 1965). In the summer, the diet of snowshoe hares consists of grasses, forbs, sedges, and low shrubs (Zeiner et al. 1990). Needles and bark of conifers and leaves and green twigs of willow and alder are eaten in the winter (Wolff 1980). Bobcat, weasel, fox, coyote, and great-horned owl are the main predators of snowshoe hare.

Sierra Nevada snowshoe hares may occur in the watershed. Suitable habitat for the species is present on the watershed, and an individual was observed within 5 miles of the watershed in 2013 (CNDDB 2017).

Townsend's Big-Eared Bat (*Corynorhinus townsendii*) – Townsend's big-eared bat is a California Species of Special Concern. In California, its geographic range is generally patchy and considered to encompass the entire state from sea level to 10,800 feet. The species is a colonial species that requires cavity habitat for roosting, typically caves, mines, tunnels, buildings, or other human-made structures (Zeiner et al. 1990), as well as large hollow trees (Fellers and Pierson 2002) and possibly bridges (Keeley and Tuttle 1999). Historic records suggest that populations are concentrated in areas with abundant caves (especially lava flows in northeastern part of state, Sierra Nevada, and Trinity Alps) or abandoned mines (Pierson and Fellers 1998). Habitat associations for Townsend's big-eared bat in California include inland deserts (i.e., Colorado, Mojave, and Great Basin); cool, moist coastal redwood forests; oak woodlands of the Sierra Nevada foothills and coastal mountains; and lower to mid-elevation mixed coniferous-deciduous forest (CDFW 2016). This species prefers mesic habitats, and forages for insects (principally moths) in edge habitats along streams and areas adjacent to and within wooded habitats (Zeiner et al. 1990, CDFW 2016).

This species may occur in the watershed. Although there are no reports of the species occurring within 5 miles of the watershed, Townsend's big-eared bats commonly occur in the central Sierra Nevada, and the watershed provides suitable habitat for the species.

3.6.5.2 Special-Status Plants

Alder Buckthorn (*Rhamnus alnifolia*) – Alder buckthorn is a perennial deciduous shrub in the buckthorn family (Rhamnaceae) that grows to less than 6.5 feet in height (Sawyer 2017). It is found in wet meadow edges, seeps, and stream sides in montane coniferous forest and riparian scrub from approximately 4,500 to 7,000 feet in elevation in the northern Sierra Nevada (Sawyer 2017, CNPS 2017). The California Rare Plant Rank (CRPR) for this species is 2B.2, meaning it is fairly endangered in California, but more common elsewhere (CNPS 2017). It is known from fewer than 30 occurrences in California, several of which are old (1996 or earlier) or have inexact location information (CNDDB 2017).

Alder buckthorn is known to occur in the Bear Creek watershed, and has been recorded along Bear Creek, although not observed recently (CNDDB 2017, CCH 2017).

American Manna Grass (*Glyceria grandis*) – American manna grass is a perennial rhizomatous grass that grows between 3 and 6.5 feet tall (Leppig 2017). It is found in bogs and fens, meadows and seeps, and along stream and lake margins at elevations less than 6,900 feet in the North Coast, North Coast Ranges, and Sierra Nevada (Leppig 2017, CNPS 2017). The CRPR for this species is 2B.3, which means that it is not very endangered in California, and is more common elsewhere (CNPS 2017). It is known from 10 occurrences in California, most of which area old (1949 or earlier) and have inexact location information, and only two of which are in Placer County (CNDDB 2017).

American manna grass may occur in the Bear Creek watershed because it has been recorded in close proximity (CNDDB 2017) and suitable habitat exists in wet meadows and along Bear Creek, other drainages, and lake margins in the watershed.

Amethyst Stickseed (*Hackelia amethystina*) – Amethyst stickseed is a spreading perennial herb in the borage family (Boraginaceae) that grows to between 1 and 3 feet tall (Kelley and Carr 2017). It is found in disturbed areas, meadows, forest clearings, roadsides, and occasionally along streambanks in montane coniferous forest from approximately 4,500 to 7,600 feet in elevation in the high North Coast Ranges and northern high Sierra Nevada (in Plumas and Placer Counties) (Kelley and Carr 2017, CNPS 2017). The CRPR for this species is 4.3, meaning it has limited distribution in California and is not very endangered in the state (CNPS 2017).

Amethyst stickseed is known to occur in the Bear Creek watershed; it was collected in 1912 in Deer Park (CCH 2017). As a CNPS List 4 species, it is not recorded in the CNDDB.

Austin's Astragalus (*Astragalus austiniae*) – Austin's astragalus is a dwarf, clumped perennial herb in the legume family (Fabaceae) that grows less than 1 foot tall (Wojciechowski and Spellenberg 2017a). It is known only from the Lake Tahoe Basin in rocky soils above the timberline (between approximately 7,800 and 9,700 feet), on exposed ridges, in alpine boulder and rock fields, in subalpine coniferous forest, and in meadows (Wojciechowski and Spellenberg 2017a, CNPS 2017). The CRPR for this species is 1B.3, meaning it is rare or endangered in California and elsewhere, but not very endangered in California (CNPS 2017). Austin's astragalus is known from just nine occurrences in California, most of which are old (1986 or earlier) (CNDDB 2017).

This species may occur in the Bear Creek watershed because there are two recent records within 5 miles (CNDDB 2017), and suitable habitat exists in rocky places at the higher elevations in the watershed.

Davy's Sedge (*Carex davyi*) – Davy's sedge is an erect, clumped, perennial sedge in the sedge family (Cyperaceae) that grows to approximately 10 to 15 inches in height (Zika et al. 2017). It is found in dry and sparsely vegetated meadows and slopes in upper montane and subalpine conifer forests from roughly 4,500 to over 10,800 feet in elevation from the central and northern high Sierra Nevada north through the Cascades into Washington (Zika et al 2017, CNPS 2017). The CRPR for this species is 1B.3, meaning it is rare or endangered in California and elsewhere, but not very rare in California. It is known from 19 occurrences in California, and many of these are old (1969 or earlier) or have inexact location information (CNDDB 2017).

Davy's sedge may occur within the Bear Creek watershed because it has been recorded adjacent to the watershed (CNDDB 2017), and suitable habitat exists in the forests, meadows, and seeps throughout the watershed.

Donner Pass Buckwheat (*Eriogonum umbellatum* var. *torreyanum*) – Donner Pass buckwheat (also known as Torrey's buckwheat) is a named variety of the ubiquitous sulphur buckwheat (*Eriogonum umbellatum*). It is a perennial herb in the buckwheat family (Polygonaceae) that forms large, low mats roughly 4 to 8 inches high and up to 2.6 feet across (Reveal and Rosatti 2017). Donner Pass buckwheat is found growing from roughly 5,900 to 8,600 feet in alpine and subalpine areas within coniferous forests, meadows, and seeps on the east side of the Sierra Crest near Donner Pass, growing in volcanic sand or gravel (Reveal and Rosatti 2017, CNPS 2017). It is known only from Nevada, Placer, and Sierra Counties from 25 occurrences (CNDDB 2017). The CRPR for this species is 1B.2, meaning it is rare or endangered in California and elsewhere, and fairly endangered in California (CNPS 2017). It is also considered a sensitive species by the TNF (USFS 2013c).

Donner Pass buckwheat may occur in the Bear Creek watershed because there are several recent records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in forests, meadows, and seeps throughout the watershed.

Galena Creek Rockcress (*Arabis rigidissima* var. *demota*) – Galena Creek rockcress is a perennial herb in the mustard family (Brassicaceae) that grows as a basal rosette on the ground surface or an elevated woody base; flowering stems may be between 7 and 24 inches tall (Windham and Al-Shehbaz 2017). It grows in rocky, open areas in montane coniferous and broadleaf upland forests from approximately 5,900 to 8,400 feet in elevation in the northern high Sierra Nevada (Windham and Al-Shehbaz 2017, CNPS 2017). Galena Creek rockcress is known from just seven occurrences in El Dorado and Placer Counties (CNPS 2017, CNDDB 2017). The species is included with Trinity Mountain rockcress (*Boechera rigidissima*) in the current Jepson Manual (Jepson Flora Project 2017), which also occurs in the Klamath Ranges, but CNPS recognizes Galena Creek rockcress as a unique variety and it is tracked as such in the CNDDB. The CRPR for this variety is 1B.2, meaning it is rare or endangered in California and elsewhere, and fairly endangered in California (CNPS 2017).

Galena Creek rockcress may occur in the Bear Creek watershed because there are two recent occurrences of the species recorded within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in forests at the higher elevations in the watershed.

Long Petaled Lewisia (*Lewisia longipetala*) – Long petaled lewisia is a perennial, clumped herb in the miner's lettuce family (Montiaceae) that grows just 1 to 2 inches tall (Miller and Dempster 2017). It grows in granitic rocky boulder and rock fields and mesic openings in subalpine coniferous forest at elevations from 8,200 to 9,600 feet in northern and central high Sierra Nevada (Miller and Dempster 2017, CNPS 2017). Long petaled lewisia is known from 14 occurrences in Nevada, Placer, and El Dorado Counties (CNDDB 2017). The CRPR for this species is 1B.3, meaning it is rare or endangered in California and elsewhere, but not very endangered in California (CNPS 2017). It is also listed by the TNF as a sensitive species (USFS 2013c).

Long petaled lewisia may occur in the Bear Creek watershed because there are two recent records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in the rocky habitats and subalpine forests in the watershed.

Munro's Desert Mallow (*Sphaeralcea munroana*) – Munro's desert mallow is a perennial subshrub in the mallow family (Malvaceae) that grows up to 2.5 feet tall (La Duke 2017).

It grows in Great Basin scrub at approximately 6,500 feet in elevation, and is known in California from just 1 location, although it is more common in other western states (La Duke 2017, CNPS 2017, CNDDB 2017). The CRPR for this species is 2B.2, meaning it is rare or endangered in California but more common elsewhere, and fairly endangered in California (CNPS 2017).

Munro's desert mallow may occur in the Bear Creek watershed because the known location is from Squaw Creek (CNDDB 2017), which is within 5 miles of the watershed, and suitable habitat exists in the alpine dwarf shrub habitat in the watershed.

Nuttall's Ribbon-Leaved Pondweed (*Potamogeton epihydrus*) – Nuttal's ribbon-leaved pondweed is an aquatic perennial rhizomatous herb in the pondweed family (Potamogetonaceae) that grows up to 5.5 feet long (Hellquist et al. 2017). It grows in shallow water in ponds, lakes, streams, and freshwater marshes and swamps from approximately 1,200 to 7,100 feet in elevation in the outer North Coast Ranges, high Sierra Nevada, Warner Mountains, and Modoc Plateau (Hellquist et al. 2017, CNPS 2017). The CRPR for this species is 2B.2, meaning it is rare or endangered in California but more common elsewhere, and fairly endangered in California (CNPS 2017). It is known from 25 occurrences in California, although many records are old (1994 or earlier) or have inexact location information (CNDDB 2017).

Nuttal's ribbon-leaved pondweed may occur in the Bear Creek watershed because there is one record of the species within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in lakes, ponds, and streams throughout the watershed.

Scalloped Moonwort (*Botrychium crenulatum*) – Scalloped moonwort is a perennial rhizomatous fern in the adder's-tongue family (Ophioglossaceae) that grows up to 2.4 inches tall (Farrar 2017a). It grows in seeps and stream margins, bogs and fens, montane coniferous forest, meadows, and freshwater marshes and swamps in the high North Coast Ranges, high Cascade Range, high Sierra Nevada, San Gabriel Mountains, San Bernardino Mountains, Warner Mountains, White and Inyo Mountains, and east of the Sierra Nevada in California at elevations from approximately 4,160 to 11,800 feet (Farrar 2017a, CNPS 2017). Scalloped moonwort is known from 125 occurrences in California, many of which are recent (i.e., 2000 or later) (CNDDB 2017). The CRPR for this species is 2B.2, meaning it is rare or endangered in California but more common elsewhere, and fairly endangered in California (CNPS 2017).

Scalloped moonwort may occur in the Bear Creek watershed because there are two records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in seeps, stream edges, forests, and meadows throughout the watershed.

Threetip Sagebrush (*Artemesia tripartita* ssp. *tripartita*) – Threetip sagebrush is a mounded perennial shrub in the sunflower family (Asteraceae) that grows up to 1 foot tall (Shultz 1993). It is found in northern and central high Sierra Nevada at elevations between 7,200 and 8,530 feet in openings in upper montane coniferous forest in rocky, volcanic soils (Shultz 1993, CNPS 2017). Although the current Jepson Manual states that threetip sagebrush does not occur in California (Jepson Flora Project 2017), it is known from four locations in Nevada, Placer, and Plumas Counties according to the CNDDB (2017). The CRPR for this species is 2B.3, meaning it is rare or endangered in California but more common elsewhere, and not very endangered in California (CNPS 2017).

This species may occur in the Bear Creek watershed because there is a record adjacent to the watershed on the southeast slope of Ward Peak, just outside the watershed boundary (CNDDB 2017), and suitable habitat exists in forest openings at higher elevations in the watershed.

Woolly-Leaved Milk-Vetch (*Astragalus whitneyi* var. *lenophyllus*) – Woolly-leaved milk-vetch is a perennial herb that grows to between 2 and 16 inches tall (Wojciechowski and Spellenberg 2017b). It is found in open, rocky places in subalpine coniferous forest and alpine boulder and rock fields at elevations between 4,900 and 10,000 feet in the Klamath Ranges and northern high Sierra Nevada (Wojciechowski and Spellenberg 2017b, CNPS 2017). The CRPR for this species is 4.3, meaning it has a limited distribution in California and is not very endangered in California (CNPS 2017).

Woolly-leaved milk-vetch is known to occur in the Bear Creek watershed; it was collected in 1915 in the "summit of the Craggs" above Deer Park (CCH 2017). As a CNPS List 4 species, it is not recorded in the CNDDB.

Upswept Moonwort (*Botrychium ascendens*) – Upswept moonwort is a perennial rhizomatous fern in the adder's-tongue family (Ophioglossaceae) that grows up to 2.4 inches tall (Farrar 2017b). It is found in moist meadows and open woodland near streams or seeps at approximately 3,600 to 10,500 feet in elevation in the high Cascade Range, central high Sierra Nevada, White and Inyo Mountains, and east of the Sierra Nevada in California (Farrar 2017b, CNPS 2017). The CRPR for this species is 2B.3, meaning it is rare or endangered in California but more common elsewhere, and not very endangered in

California (CNPS 2017). There are 44 occurrences recorded in California, and most of them are recent and have specific location information (CNDDB 2017).

Upswept moonwort may occur in the Bear Creek watershed because there is one record within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in forests, wet meadows, and seeps throughout the watershed.

3.7 Disturbance History

A number of historical events and land-use themes in the watershed appear to play an important role in the current status of natural resources health and integrity, including: road building, residential development, ski area development, and to a lesser extent, livestock grazing and logging. We briefly describe the history of these activities below. Dr. Susan Lindström has provided a full account of cultural and historical land uses in **Appendix B**.

3.7.1 Livestock Grazing

Seasonal, transitory sheep grazing in Bear Creek watershed has been documented back to 1911 (Lindstrom, 2017), but limited to the Five Lakes area and likely areas along Bear Creek in the lower meadow area. The USFS continued to restrict grazing after the passage of the Taylor Grazing Act (1934) in an effort to restore or improve range conditions. By 1970, grazing was excluded from most of the Bear Creek watershed.

Grazing impacts to the stream environment are well documented. High concentrations of suspended solids or other sediment loads, and fecal coliform or fecal streptococci may be associated with grazing, and can alter an existing stream ecosystem or even create an entirely new ecosystem (*cited in* Kauffman and Krueger,1984). At the time of this assessment, no livestock grazing was known to occur and the limited historical grazing does not appear to impact existing conditions.

3.7.2 Logging

Historical records suggest that timber harvesting in the watershed has been limited, as compared to nearby areas. Lindstrom (2017) documented a few accounts of logging in the Bear Creek watershed as early as 1881, with more intensive period of railroad logging occurring 1900 – 1909. Additional timber harvest occurred in limited areas in 1948 and again in 1968 (**Figure 3-16**).

Logging after the 1970s was largely focused on selected areas for thinning, fire management, forest health and ski area development. Logging practices included railroad logging, yarding, tractor logging, with documentation of clear cuts. Tractor logging was reportedly the most destructive with respect to erosion and sedimentation of Bear Creek (Lindstrom, 2017).

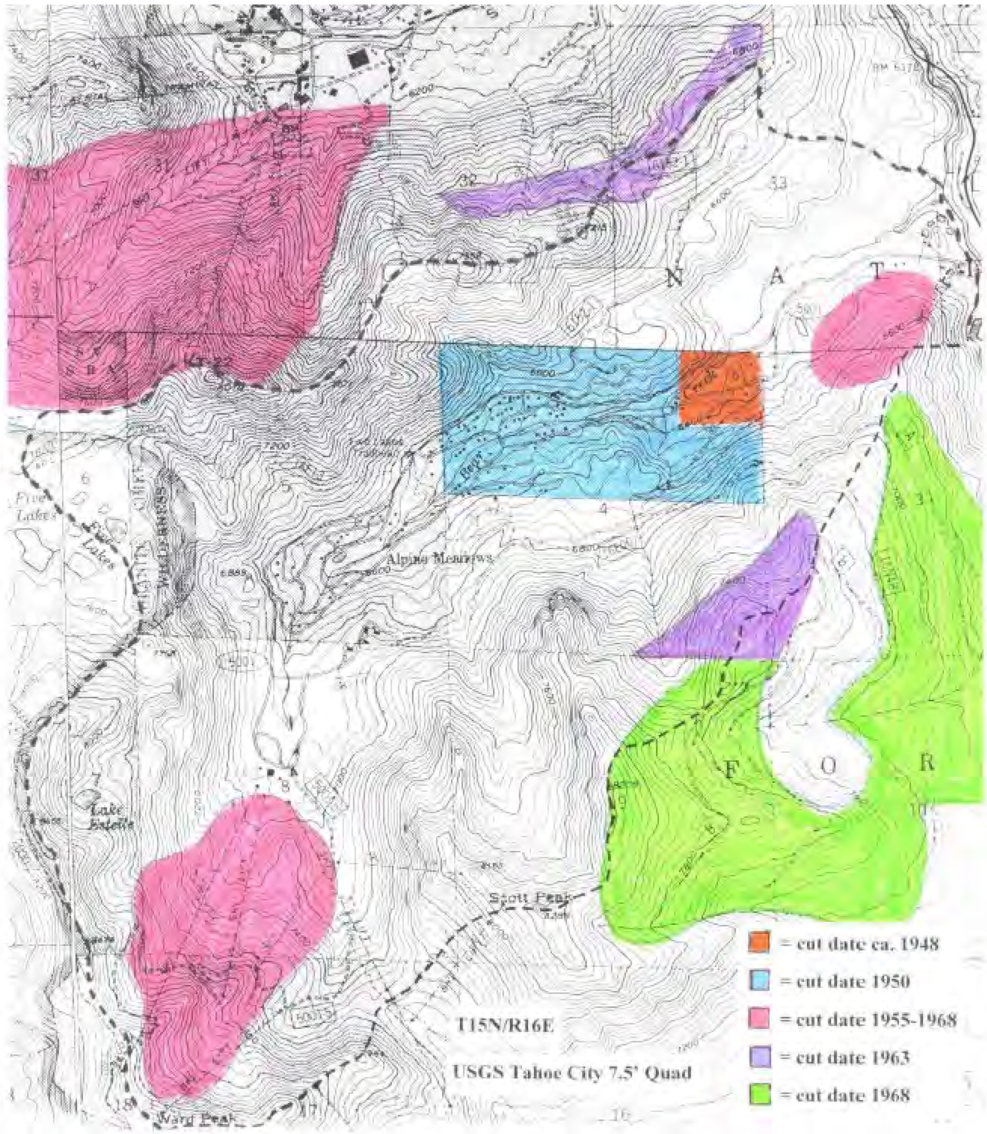

Figure 3-16 Areas of historical logging, Bear Creek watershed, Placer County, California (Lindstrom, 2017).

3.7.3 Roads and Ski Area Development

This assessment's review of roads was limited to those managed by Placer County, USFS, and Alpine Meadows Ski Area.

Roads can be a major watershed disturbance depending on their construction, stream crossing design, drainage patterns, road density (miles of road per square mile), and maintenance. In the northern Sierra Nevada, unpaved roads have shown 12- to 25-fold increases in sediment yield to nearby streams (Coe, 2002). Improper or undersized culverts can lead to channel scour and eventually fish passage barriers, as well as stream diversion (Furniss and others, 1997). Roadcuts along unstable hillslopes can promote excessive sediment to inboard ditches, and eventually the stream. Roadcuts may also trigger landslides or debris flows. Roads can increase hydrologic connectivity with streams—when runoff can accumulate and discharge to the stream more quickly. Increases in volume of runoff entering the streams can, in turn, increase flood magnitude and frequency, and results in channel scour and bank erosion. Maintenance, grading or use of existing dirt roads during wet weather can quickly double the amount of sediment available for delivery to nearby streams (Coe, 2002). Finally, roads can modify channels and sediment supply through the process of stream capture. Stream capture occurs when a culvert at a stream crossing becomes overwhelmed or plugged with sediment resulting in redirection of streamflow. If the road is graded such that it can provide a flow path, the road becomes the active channel. In the Bear Creek watershed, stream capture often occurs at stream crossings when a culvert becomes plugged or at locations where roads intersect first order tributaries.

Road development within the Bear Creek watershed began near the turn of the 20th century, when Scott's Springs Resort (a.k.a., Deer Park Springs) was established as a recreational/tourist destination (see Appendix B; Lindstrom, 2017). A USGS topographic map (Truckee Sheet) from 1889 shows the first road along Bear Creek to Scott's Springs. Logging in the early 1900s used mechanical logging practices that generated multiple skid roads, and even a railroad grade that extended along Bear Creek up through the lower meadow (Lindstrom, 2017).

Sometime in the early 1950s, the lower Bear Creek Valley was developed to support the Powder Bowl Ski Area (a.k.a., Deer Park Ski Resort), with graded trails and paved parking. The 1960 Winter Olympics at Squaw Valley brought additional interest and development in the Bear Creek watershed, including Alpine Meadows Ski Area (formerly known as

Ward Peak Ski Resort) in 1961 with extension of a paved road up the valley and a parking lot for approximately 500 vehicles (Lindstrom, 2017).

By the mid-1960s, additional roads were constructed for housing developments within the valley, as indicated from a 1966 historical aerial photograph. To service the growing community, the Alpine Springs County Water District (ASCWD) was formed to provide water, sewage, garbage, fire, and recreational parks. These services required additional roads for water and sewer line installations and maintenance.

Stormwater management from roads is a challenge in the watershed. The County and others inherited outdated infrastructure and poor road drainage construction built in the 20th century. Snow removal and winter management to maintain access to residential communities and Alpine Meadows Ski resort pose additional responsibilities.

Today, Placer County maintains most paved roads in the Bear Creek Valley, including Alpine Meadows Road and many of the residential streets. Under a recent monitoring program, Placer County mapped most major culverts or stormwater outfalls within their jurisdiction in the watershed **(Figure 3-17**). Many of these culverts discharge stormwater directly to Bear Creek or confine surface runoff to limited crossings under streets and roads.

Squaw Valley/Alpine Meadows maintains and provides snow removal for the parking lots at the old Deer Park Ski Area and Alpine Meadows Ski Area. These impervious surfaces discharge runoff and road sand to Bear Creek directly or via the existing stormwater system. Squaw/Alpine also maintains the unimproved roads and trails within the Alpine Meadows Ski Area boundary under a Special Use Permit. These roads typically require constant maintenance to maintain access to the upper mountain. Maintenance includes grading, unplugging culverts, culvert replacement, and filling of gullies.

The USFS manages most of the uplands and existing unimproved roads/trails in the watershed. In 2016, the USFS completed the Middle Truckee River Tributaries Sediment Source Assessment (USFS, 2016) to identify and prioritize erosion hot-spots and develop a plan prescribing sediment control treatment. In Bear Creek watershed, the USFS identified the former Deer Park Ski Area, Alpine Meadows Ski Area, and road segments along the south side of the middle watershed as high-priority areas or roads with ‘at-risk’ or ‘impaired’ ratings.

Other roads that were not assessment as part of this assessment are privately owned and maintained, including those managed by the Bear Creek Association (HOA), Juniper Mountain Association, Alpine Meadows Estates Association and White Wolf.

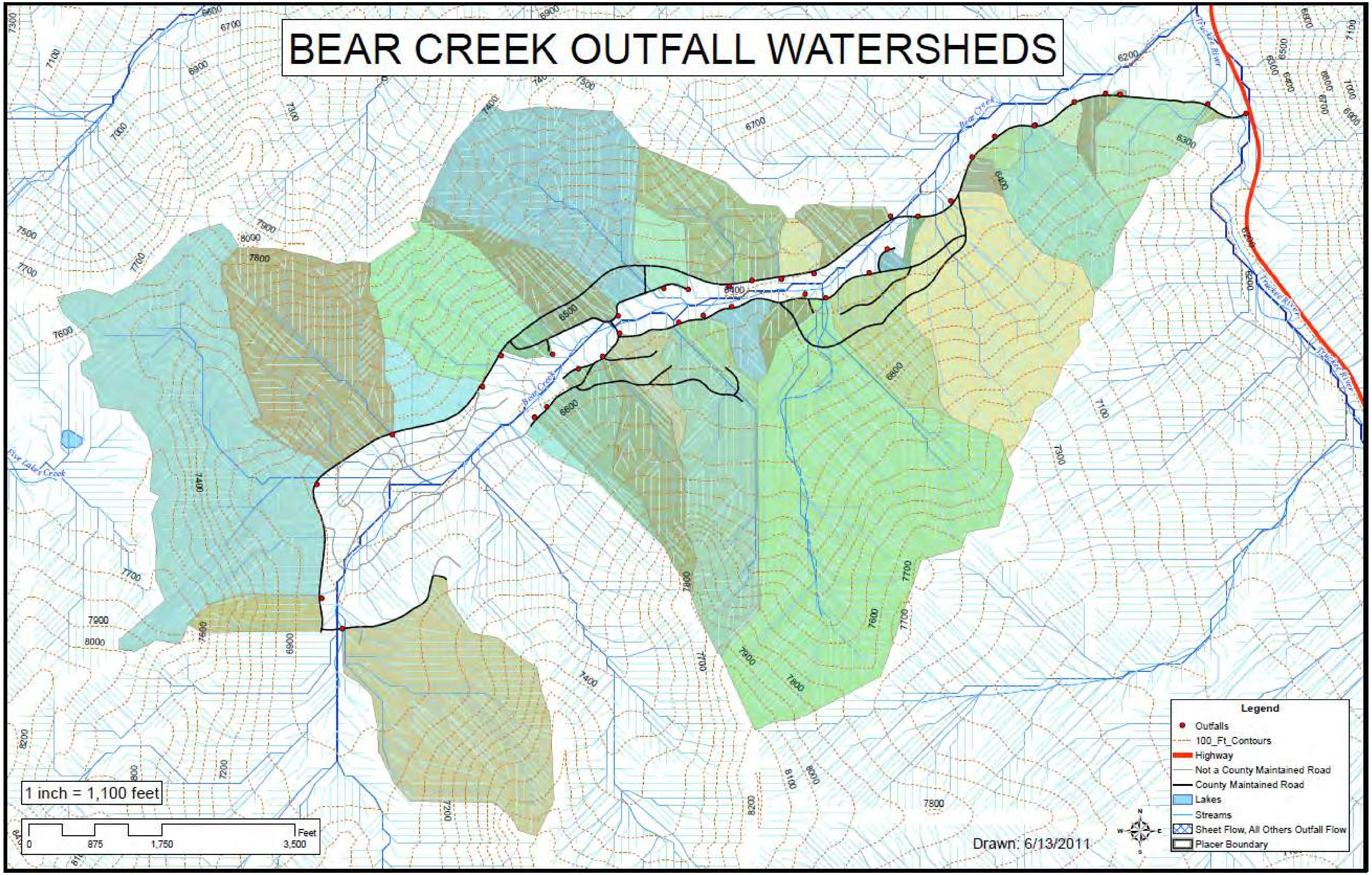

Figure 3-17 Map showing stormwater subwatersheds and major stormwater outfalls, Placer County maintained roads, Bear Creek watershed, Placer County, California (Placer County, 2017).

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4 WATERSHED CONDITION

This section of the report documents watershed conditions, as evaluated using a combination of background research, existing data, and field reconnaissance. This allows for identification of disturbed and impaired areas and associated watershed management strategies, as summarized in Chapter 6. Watershed conditions, including ecosystem functions and values, were evaluated using a reconnaissance of the creek, meadows, spring sources, and uplands, the most recent scientific principles available, professional experience, local knowledge, maps and aerial photographs, and GIS analysis. Our work augmented the USFS assessment of sediment sources within the Bear Creek watershed.

The stream and riparian corridor was evaluated in September and October 2017 following a winter with well-above average precipitation and multiple floods. The uplands were evaluated in August and September 2017, including Alpine Meadows Ski Area, White Wolf, USFS lands, and the former Deer Park Ski Area. Roads and stormwater infrastructure were evaluated in September 2017 with Placer County Public Works staff.

Our field team consisted of ecologists with H. T. Harvey & Associates, and Balance Hydrologics hydrologists, geologists, and geomorphologists. Field activities consisted of stream walks within the meadows and portions of the uplands, and quantitative assessment of channel morphology, aquatic habitat, and hydrology. Where feasible, our team hiked within or along Bear Creek from the confluence with the Truckee River upstream to the Alpine Meadows Ski Area. We also visited all existing road/trail creek crossings. Owner Troy Caldwell provided our team with a tour of the White Wolf property, and we conducted a self-guided tour of Alpine Meadows via its road network. We also documented habitat conditions within the meadow and stream system by traversing the meadows along meandering transects, recording the presence of wildlife and the condition and composition of plant communities.

4.1 Stream, Riparian, and Meadow Corridor Assessment

A stream corridor assessment was carried out in order to make comparisons between intact and impaired channel reaches, document in-channel or near-channel sediment sources, characterize hydrology and channel conditions, riparian and meadow conditions, and evaluate physical and biological aquatic habitat.

4.1.1 HYDROLOGIC ANALYSIS

To better understand fluvial conditions, channel function, and habitat value, we completed several hydrologic analyses. Annual variation in streamflow, baseflow, and peak flows were estimated from adjacent or nearby gaged watersheds and using standard hydrologic methods and regional relationships (McGraw and others, 2001, Gotvald and others, 2006). The USGS manages a streamflow gage on Ward Creek, since WY1973 (USGS 10336676, Ward Creek at HWY 89 near Tahoe Pines, California) and Blackwood Creek since WY1961 (USGS 10336660, Blackwood Creek near Tahoe City, CA).

McGraw and others (2001) developed a regression using these two USGS gages to estimate streamflow in Bear Creek. This regression equation was used in this assessment to estimate average and minimum flows in Bear Creek (**Table 4-1**). We observed approximately 5 cubic feet per second (cfs) in the channel during this assessment, a significantly higher value than estimated using McGraw and others (2001), suggesting a wetter than average year.

Table 4-1 Estimated monthly average and minimum streamflow, Bear Creek, Placer County, California

Month	Average Flow *cfs*	Minimum Flow *cfs*
October	1.1	0
November	4.6	0
December	8.5	0
January	10.2	0
February	9.9	0
March	15.6	0.7
April	33.5	6.9
May	67.5	12.1
June	51.4	1.8
July	14.7	0
August	1.8	0
September	0.4	0

Period of Record: WY1973 - WY2014

Separately, based on unit-discharge from Ward Creek, we applied a standard flood-frequency analysis (Bulletin 17B) to estimate peak flows for common return periods (i.e., 1-year to 100-year flood) for Bear Creek. Ward Creek is a similar sized watershed (9.7

square miles), includes similar elevations and is located south and adjacent to Bear Creek. A secondary method (Gotvald and others, 2006) was also used to arrive at similar return periods and provide a possible range in expected flows (**Table 4-2**).

Table 4-2 Estimated Flood Frequency-Magnitude, Bear Creek, Placer County, California

		Methods	
		Bulletin 17B [1]	*Gotvald and others (2006)* [2]
Return Period	**Probability**	**Streamflow**	**Streamflow**
(years)	*(%)*	*(cfs)*	*(cfs)*
100	1	1,708	1,210
50	2	1,290	981
20	5	852	--
10	10	592	500
5	20	383	336
2	50	170	167
1.5	65	120	--
1	99	20	--

Notes:

1. U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: Reston, Virginia, U.S. Geological Survey, Office of Water Data Coordination, 183 p.
2. Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, C., 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012-5113, 38 p., 1 pl.

From **Table 4-2**, we estimate the annual flood to be roughly 20 cfs, while a 'bankfull' event (1.5-year return period) to be approximately 120 cfs, also the approximate flow that naturally inundates floodplains and some wet meadows. We estimate a 100-year flood to be roughly between 1,200 cfs and 1,700 cfs.

For context, the Bear Creek peak flow in WY2017 (January 8, 2017) was estimated to be between 800 cfs and 1,000 cfs, or between a 20- and 25-year flood using Bulletin 17B (USGS, 1981). Additional analysis of regional gages in the Truckee River Basin also indicates that 2017 peak flows were generally between 15-year and 25-year flood events. In fact, the annual peak flow (January 8, 2017) was the 2nd largest flood on record for Ward Creek; and possibly the flood of record for Blackwood Creek (gage lost power during storm). This event and its relationship to the channel condition is revisited below in relevant reaches.

4.1.2 CHANNEL REACH CLASSIFICATION

For the purposes of this assessment, a stream reach classification was completed and channel conditions were assessed by reach through interpretation of historical aerial photographs and stream reconnaissance. Each reach was classified based on several characteristics including: a) approximate channel slope, b) channel planform, c) channel morphology, d) dominant bed material size or influence of bedrock controls, e) dominant sediment transport processes and, f) influence of land-uses or modification of channels or hydrology. Nine distinct reaches were identified (Reaches A through I) in Bear Creek while eight additional tributary reaches were noted and evaluated (**Figure 4-1**).

We summarize each reach with our observations and key characteristics in **Table 4-3**. A single photo depicting each reach is included in this section and additional photos from our assessment are provided in **Appendix C**. Stream reconnaissance field forms are included as **Appendix D.**

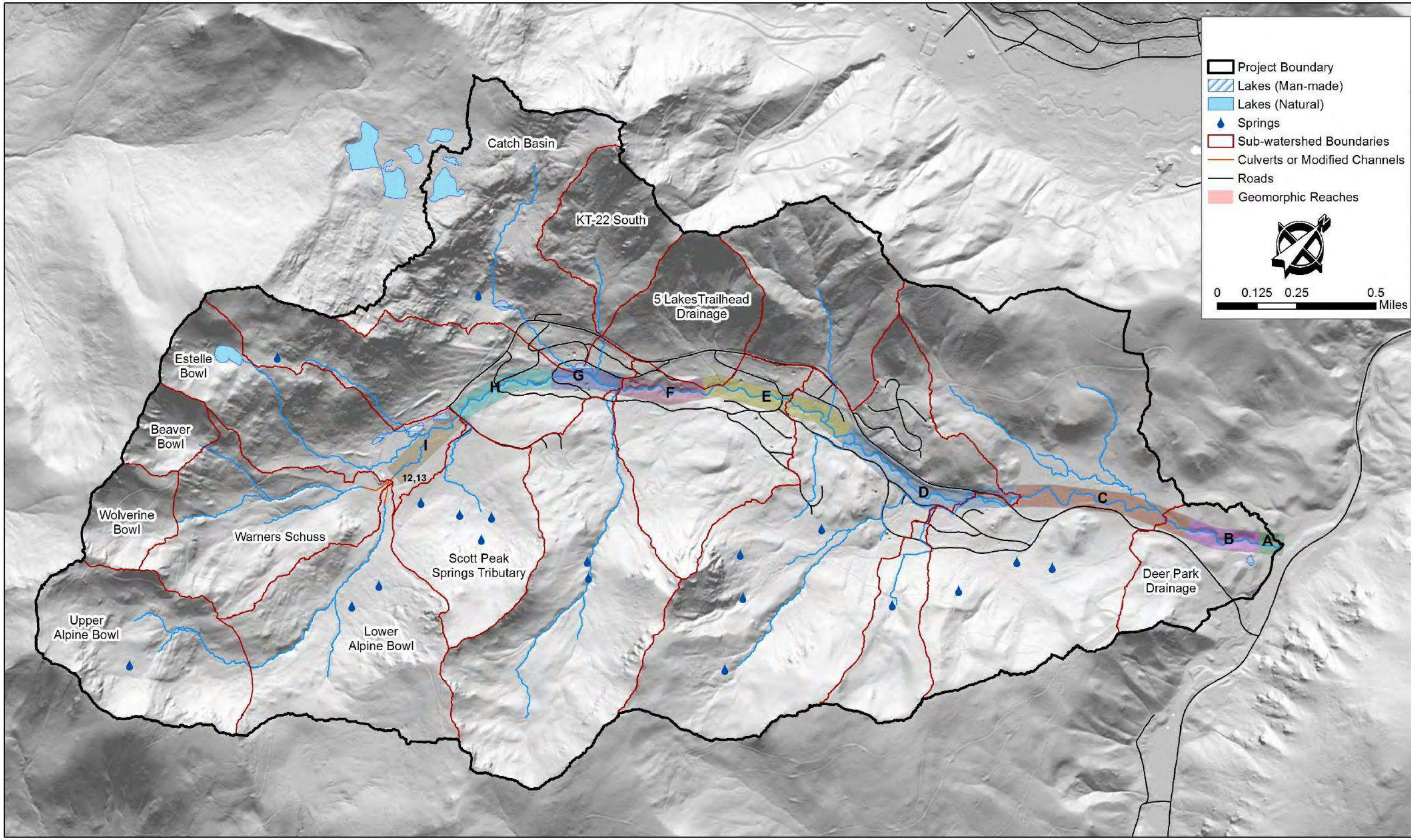

Figure 4-1 **Map showing geomorphic channel reaches, major tributaries, Bear Creek Watershed, Placer County, California.**

Table 4-3 Bear Creek and tributary geomorphology, condition, and general descriptions, Placer County, California

Channel Reach	Planform	Channel Type	Reach Length (approx.)	Reach Slope (approx.)	Geomorphic Setting	Bed Material Source	Condition	Description
			(ft)	*(%)*				
Bear Creek								
Deer Park Drainage	Stormwater ditch and single-thread channel	constructed	*not measured*	*n/a*	Urban	Glacial, urban materials	Eroding	We include this separate catchment within the Bear Creek Assessement because it drains the Deer Park Ski Area and stormwater associated with its parking lot and a portion of Alpine Meadows Road. Discharges to Truckee River roughly 850 feet upstream from the Bear Creek mouth. Drainage also receives runoff from the ASCD pond and recreational fields.
A	Alluvial Fan, distributary	Pool-Riffle	325	0.5	Confluence, Baselevel change	Volcanics, Granitics, glacial moraine	Eroding	Transitional reach between a bedrock/moraine controlled or confined valley and the confluence with Truckee River. Historically, supported a distributary channel system on an alluvial fan. Currently, channel is incised into fan and fixed in place by older growth pines. Abundant algae on bed.
B	Single-Thread	Step-Pool, Cascade	1,600	5.0-15.0	Moraine, bedrock controls	Volcanics, Granitics, glacial moraine	Stable	Confined valley, channel cutting through glacial moriane to bedrock. Steep side slopes and channel slope, absence of floodplain. Cascades may present natural fish passage barriers; abundant algae in pools
C	Single-Thread (formerly Braided)	Pool-Riffle	3,500	1.5-2.0	Former Lucustrine, outwash; fault controlled	Volcanics, granitics, glacial outwash	Transitional	The moraine of Reach B provides grade control for an alluvial valley fill, and the lower gradient system. This reach is an active braided channel, floodplain and meadow with instream wood recruitment. Reach may be bound by faults at either end providing a geologic control on meadow and channel slopes. Channel is incised in segments with eroding banks and sediment sources to downstream habitat and Truckee River. Reach also receives perennial flow from multiple spring-fed channels along south side of meadow. Abundant fines and algae in pools.
D	Single-Thread	Step-Pool	3,300	2.0-3.0	Bedrock controls, bounded upstream by fault	Volcanics, granitics, glacial outwash	Stable	Defined by a valley-confined segment, bedrock controlled. Private property prevented a detailed reconnaissance of this reach. Some sections viewed from road appear to have incurred a period of incision; but willow roots and boulders provide channel stability.
E	Single-Thread	Pool-Riffle, step-pool	3,600	2.0-2.5	Glacial outwash, residential	Volcanics, granitics, glacial outwash	Eroding	Reach receives several smaller tributaries, including 5-Lakes Trailhead drainage. Channel has healthy riparian vegetation, but shows evidence of incision likely associated with stormwater inflows. Road traction sand is visible on bars, floodplain, in pools. Includes Lower John Scott Trail crossing. Placer County reports multiple stormwater issues in this reach.
F	Single-Thread	Step-Pool	1,400	5.0-7.0	Bedrock control, fault bounded	Granitics	Uncertain	Bedrock controlled, valley confined and characterized by cascade and step-pool morphology. Private property prevents a more detailed reconnaissance
G	Single-Thread		1,500	3.0-4.0	glacial moraine	Volcanics, granitics, glacial outwash	Stable	Boulder controlled, supports a willow riparian, flows are diverted to a recreational pond; algae covered bed. Includes Park Drive crossing; downstream end of reach may be bounded by fault. Reach stable and resilient due to boulder substrate.
H	Single-Thread	Step-Pool, Cascade	2,000	7.5-15.0	Bedrock control		Stable	Steep, bedrock controlled reach; includes Upper John Scott Trail crossing; private property prevents a more detailed reconnaissance.
I	Single-Thread	Pool-Riffle, step-pool	1,500	3.0-7.0	glacial moraine, urban	Volcanics, granitics, glacial outwash	Eroding in segments, aggrading in others	Reach defined between Ginzton Access Road crossing upstream to Alpine Meadows Ski Area Base Lodge. Lower gradient slope once supported willow riparian and meadow; Reach receives stormwater runoff from Alpine Meadows Parking lots. Snow removal and storage directly in channel. Receives overflow from snowmaking pond which captures flow from Estelle Lake tributary, wells, and springs. Abundant green filamentous algae reach-wide.
--	CULVERT	--	600	5.0-6.0	glacial moraine	Volcanics, granitics, glacial outwash	--	Headwater tributaries converge at the base of Alpine Meadows Ski Area and are enclosed in a culvert which discharges to Reach I
Headwater Tributaries (White Wolf)								
Catch Basin	Single-Thread	Step-Pool, Cascade	--	>8	Bedrock control	granitics	Stable	Spring-fed tributary, drains a 0.4 square mile subwatershed, also known as White Wolf. Landowner diverts spring flow for domestic use and maintains a small man-made pond. Waters are used for snow making at Alpine Meadows Ski Area.
Headwater Tributaries (Alpine Meadows Ski Area)								
Estelle	Distributary/ Single-Thread	Step-Pool, Cascade	--	>8	Bedrock control, moraine	granitics	Stable/modified in lower reach	This tributary drains a 0.2 square mile subwatershed and supports a tarn lake (Estelle Lake). Area is managed by USFS and Alpine Meadows Ski Area. Lower segment of this tributary has been modified and relocated to accommodate a ski run (Kangaroo Run). The segment was straightened and confined to a ditch but seeps water across ski run. Some waters are diverted to fill a snow making pond. Streamflow under Alpine Meadows Ski Area parking lot is contained in a culvert and discharges to a second snow making pond. Pond overflow is discharged back to Bear Creek within Reach I.
Beaver Bowl			--	*>8*				Not evaluated
Wolverine Bowl	Single-Thread	Step-Pool, Cascade	--	>8	Bedrock control, colluvial, moraine	Metasedimentary/ Volcanics	Eroding	This tributary drains a 0.4 square mile subwatershed and includes many ski runs at Alpine Meadows Ski Area. Steep slopes are subject to natural gullying and rilling from intense rainfall events. Maintenance roads cross the subwatershed and require constant maintenance due to erosion. Flows are also focused along mainteance roads. Tributary supports a small alpine/willow and alder dominated meadow. Tributary also receives streamflow from Beaver Bowl and Warner's Schuss (ski run/drainage). Flows are confined to a culvert at the base lodge and discharges to Reach I.
Alpine Bowl	Single-Thread	Step-Pool, Cascade	--	>8	Bedrock control, colluvial, moraine	Metasedimentary/ Volcanics	Eroding	This tributary drains a 0.6 square mile subwatershed that drains the highest elevations in the Bear Creek watershed. Upper segments support steep alpine/willow-dominated meadows that are spring-fed and generally in stable condition. Maintenance roads and snowmaking water-supply lines cross the subwatershed and exacerbate the natural erosion under intense rainfall events. Lower tributary segment is also known as "Hot Wheels Gully" on ski maps.
Scott Peak Springs	Distributary/ Single-Thread	Step-Pool, Pool-Riffle	--	3- >8	Colluvial, moraine	Volcanics	Stable	Drains a 0.2 square mile subwatershed on the northwest aspect of Scott Peak. Supported by multiple perennial springs which create a discharge slope meadow complex adjacent to Subway Ski Lift and Parking lot at Alpine Meadows Ski Area. Discharges to Bear Creek via culverts within Reach I.

Channel processes can be framed in terms of spatial patterns of sediment production, transport, and deposition. **Figure 4-2** is a longitudinal profile of Bear Creek and shows a somewhat typical concave shape, with steeper gradients (>20 percent) in the upper watershed, and lower gradients (<5 percent) in the lower half of the watershed. Bedrock exposure within the watershed present distinct slope breaks between reaches and function to control sediment transport and deposition in adjoining reaches. Finally, Bear Creek has developed its own distinct characteristics in areas where it has cut through glacial moraines.

Smaller, steeper tributaries (not shown) in the upper zone of a watershed function to erode and transport sediment, while the larger, shallower mainstem channel in the lower zone of a watershed tends to accumulate or deposit sediment. Watershed management strategies should differ where sediment transport processes differ. It is also important to recognize that these zones are not static, and sediment transport processes may change in a particular location following large floods, wildfires, or during extreme droughts.

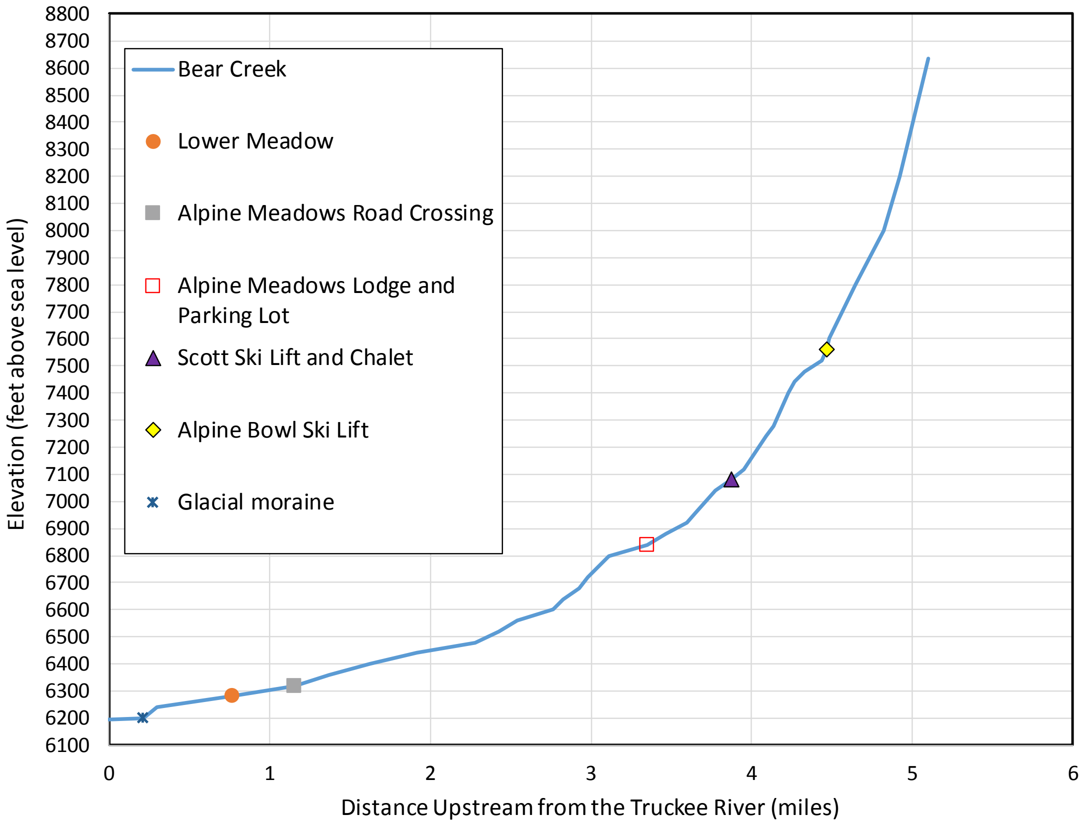

Figure 4-2 Longitudinal Profile of Bear Creek, Placer County, California.

In **Figure 4-3**, we plot Bear Creek by reach based on slopes measured from topographic maps and as compared to the general distribution of alluvial channel types presented by Montgomery and Buffington (1997). Processes such as scour, deposition, and function of large woody debris can be inferred from the graph and applied toward channel restoration planning in specific areas. Alluvial reaches exhibit pool-riffle type morphology, whereas, bedrock controlled reaches typically express cascade and/or step-pool morphology. The predicted channel morphology generally conforms to our observations in the field. Their classifications also help to define future design concepts to maintain geomorphic form and function.

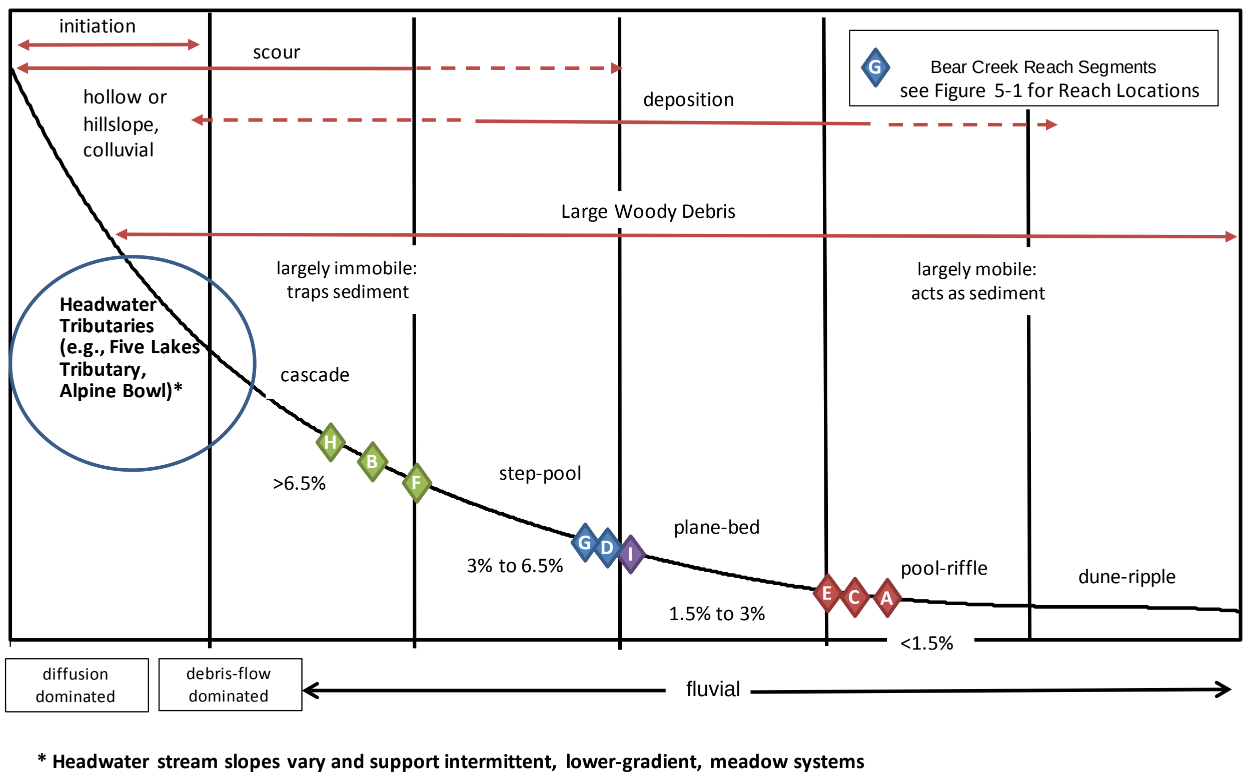

Figure 4-3 Expected channel geomorphology based on slope, Bear Creek watershed reaches, Placer County, California (adapted from Montgomery and Buffington, 1997).

4.1.3 Channel Form and Ecological Function

Some reaches of Bear Creek and its tributaries are functioning relatively well with stable banks, some degree of floodplain connectivity, extensive vegetation cover, and riparian scrub vegetation. Existing riparian zones support a diversity of terrestrial wildlife and provide instream wood, shading, and organic debris that support fish habitat and macroinvertebrate production. Other reaches show evidence of channel degradation, a lack of floodplain connectivity, limited fish habitat, and lack a well-developed riparian corridor.

The following section provides brief assessments of the geomorphology, wildlife and aquatic habitat conditions provided by each identified reach of Bear Creek (see **Figure 4-1**). Where appropriate, observed examples of lower and higher ecological functions are highlighted for each reach. We evaluated channel condition and function using measured channel geometry and high-water marks (e.g., sedimentation and debris lines) from recent floods. Where alluvial reaches and floodplain meadows are present, we set out to understand the relative extent and frequency at which flood waters access or inundate floodplain or meadow surfaces. Typically, streamflow in a pool-riffle channel crossing a meadow system can be expected to overtop its banks or engage its floodplain at least 5 or 6 times in a decade—sometimes referred to as the 1.5-year or 2-year flow or 'bankfull discharge'. Inundation of a meadow surface at these frequencies serves many eco-hydrologic functions, such as depositing fine sediment and nutrients to meadow soils and plants while recharging local groundwater and attenuating peak discharge in downstream areas.

4.1.3.1 Reach A

Reach A forms a deltaic type landform, where Bear Creek encounters a fluctuating base level of the regulated Truckee River. The change in base level and energy forms a depositional zone with dynamic distributary channels, similar to a delta (**Figure 4-19**). Sediment deposition, transported by the steeper Bear Creek, changes location relative to the stage of the Truckee River. For example, during times of reduced Truckee River flow releases from the Tahoe City dam, sediment from Bear Creek actively deposits in the active channel of the Truckee River. In contrast, higher flows in the Truckee River promote overbank deposits and bar development within Bear Creek within this reach.

Figure 4-4 Reach A showing confluence with Truckee River and wet meadow complex, Bear Creek, Placer County, California.

The overbank areas in Reach A are primarily dominated by a wet meadow complex. This meadow, although relatively small, is in excellent ecological condition and dominated by grasses, sedges, and rushes indicative of wetlands and montane meadows with high surface and shallow groundwater availability. Other portions of the meadow are considerably drier and upland plants (e.g., conifers) are more common except along small distributary channels where willows occur. These channels appear to possibly convey higher flows (e.g., during winter floods or snowmelt runoff), down into the wetter portions of the meadow bordering the Truckee River, but these channels are disconnected from the creek at lower flows (e.g., during base flow conditions).

At the time of this assessment, Reach A was characterized by a long, slow glide with some fine sediment deposition and relatively little in-stream habitat diversity or shade to support fish or invertebrate production. Limited areas of bank erosion occur in this reach. Mixed conifer forest occurs along the left bank and provides a source for instream wood as channel patterns migrate and undercut their root mass.

Factors limiting the ecological functions of this reach are the lack of in-stream habitat diversity, shade for fish and benthic macroinvertebrates, and presence of fine sediment and algae on the channel bed. Sources of fine sediment may originate from stormwater, active erosion of upstream reaches, and/or low-flow disturbances in the channel (i.e., upstream horse crossings). The wet meadow complex at the Truckee River confluence, although small, provides high wildlife habitat values within this reach.

Identified Opportunity: Habitat enhancements may include addition of instream wood to encourage sedimentation and more frequent overbank flooding of wet meadow complex.

4.1.3.2. Reach B

In Reach B, Bear Creek cuts through a glacial moraine-dominated landform, where channel slope and morphology is controlled by both bedrock and glacial till. Channel features include cascades and step-pools with alternating plunge pools and small pool-riffle-run complexes (**Figure 4-5**). Steep side-slopes are composed by highly erodible unconsolidated sands, gravels, cobbles and boulders, typical of a moraine. The reach is primarily occupied by mixed conifer forests. Limited willow and alder border segments of the stream channel. In some locations, stands of aspen intermix with conifers. Large numbers of downed trees and other sources of wood appear to be generated within this reach.

Larger boulders provide refuge for fish from higher velocity flows, overhanging conifers provide shade, and some streamside riparian vegetation provide in-stream habitat complexity, resulting in good-quality fish habitat in this reach, although largely for the benefit of nonnative species. Stands of aspen increase structural diversity for terrestrial wildlife and increase foraging opportunities for some species of birds (i.e., foliage gleaning species) for which conifer forests provide lower-quality habitat. Additionally, the juxtaposition of larger aspen, mature conifer forest, and Bear Creek provides suitable habitat for special-status species like the northern goshawk and Sierra marten. Small numbers of fish, largely nonnative rainbow trout, were observed in this reach during a September 2017 reconnaissance survey of the creek.

No restoration actions are recommended for this reach.

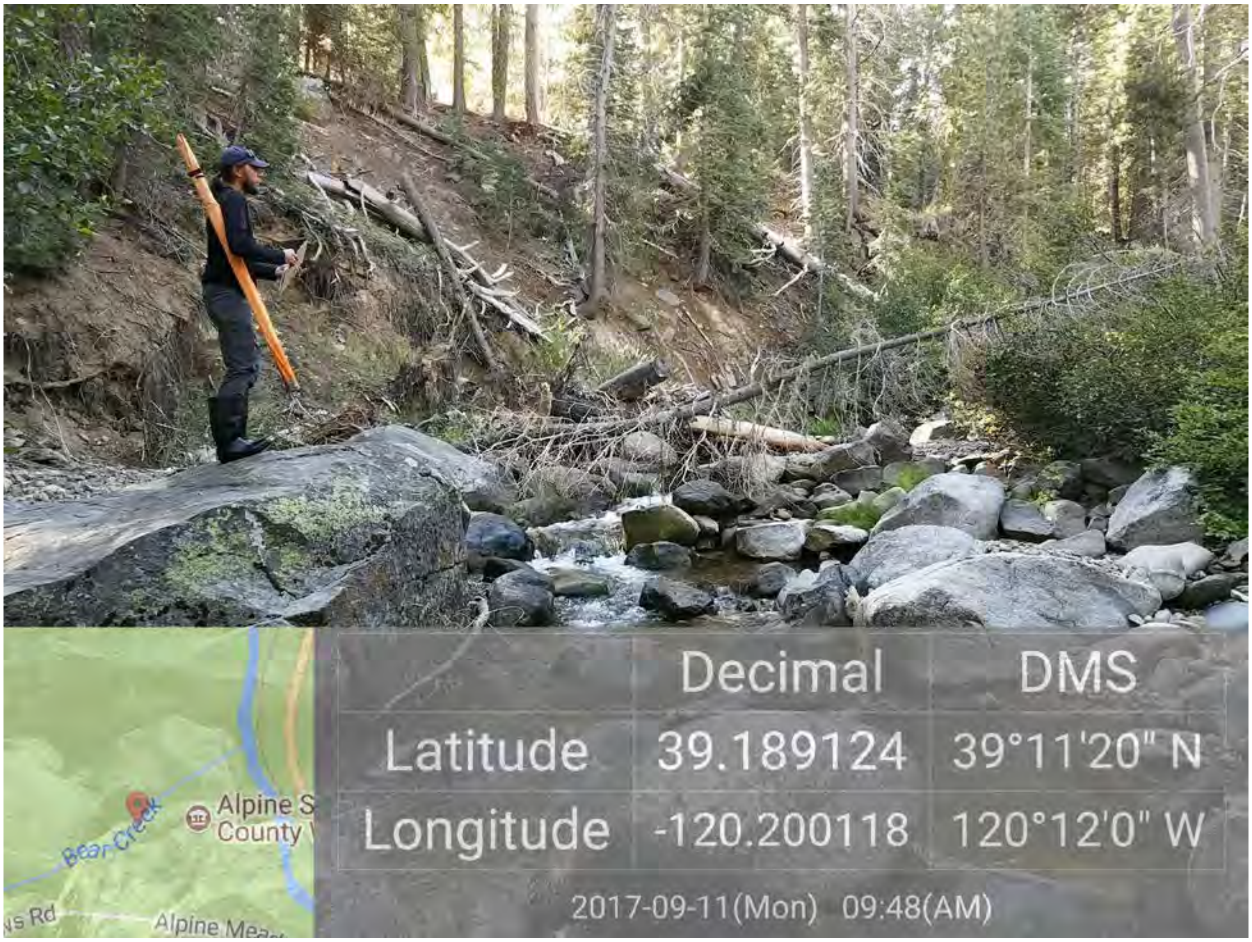

Figure 4-5 Reach B showing boulder-dominated step-pool morphology and steep sideslopes of a channel cutting through a glacial moraine, Bear Creek, Placer County, California.

4.1.3.3. Reach C

Reach C is defined by alluvial valley fill, a lower gradient system influenced by the downstream moraine and possibly structural geology (fault trace). Bear Creek in this reach is a dynamic, meandering channel with active bank erosion and in-channel bar formation with pool-riffle morphology (**Figure 4-6**).

Figure 4-6 Reach C showing a meandering alluvial channel and wet meadow complex, Bear Creek, Placer County, California.

The creek in Reach C is characterized by a series of pools and riffles with long, slow glides. Fine sediment deposition among stream gravels is common in this reach and in-channel structures, such as large wood, beaver dams, boulders and similar features that add habitat complexity, are limited (**Figure 4-7**).

Habitats along Reach C are dominated by meadows, some larger areas of riparian (i.e., willow-dominated) scrub, and aspen and cottonwood intermixed with conifers. The channel corridor exhibits large gravel bars that typically lack vegetation, suggesting that either high velocity flows periodically scour out new vegetation as it recruits (e.g., willow seedlings) or that soil and hydrological conditions are not conducive to the recruitment of new riparian vegetation.

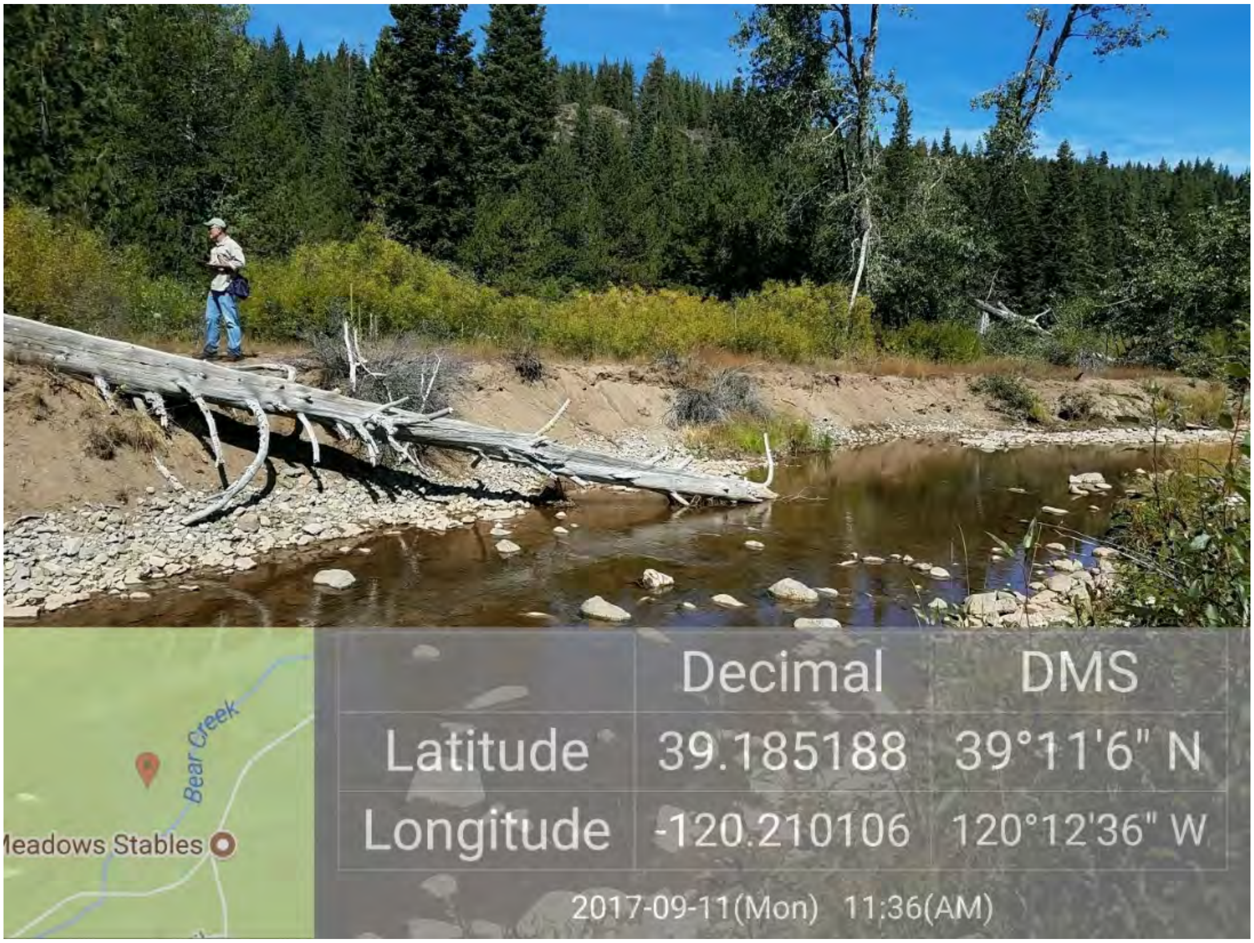

Figure 4-7 Reach C showing an incised channel with active bank erosion, Bear Creek, Placer County, California.

The character of the meadow along Bear Creek through Reach C is markedly different on either side of the creek. On the left bank, the meadow is considerably drier. Old, abandoned meander bends and historic stream channels occur throughout this area. In these topographically lower spots, shrubby willow thickets occur. In higher spots, above these abandoned channel features on the floodplain, annual herbaceous plants and other plants generally indicative of dry meadows (Weixelman et al. 2011) are found. Scattered conifers, mostly lodgepole pine, and a couple of very large black cottonwood trees also occur in these drier meadows. Much of this drier meadow appears to be hydrologically disconnected from the stream due to channel incision.

Conversely, the meadows along the right bank of Bear Creek, in between the creek and Alpine Meadows Road, are considerably wetter and dominated by grasses, sedges, and other deep-rooted plants indicative of mesic and wet meadows, where either groundwater or surface water are more reliably available to support growth of hydrophytic plants. These areas are wetter, in large part, due to supplemental flows provided by hillslope springs that occur along the south side of the watershed. Much of the flow from these springs discharge into Bear Creek via a series of small spring channels that traverse the meadow before reaching the creek. Within the meadow, some of these spring channels are slightly incised, roughly 1 to 3 feet below the meadow surface (**Figure 4-8**), likely the result of concentration of stormwater from Alpine Meadows Road and other neighborhood streets.

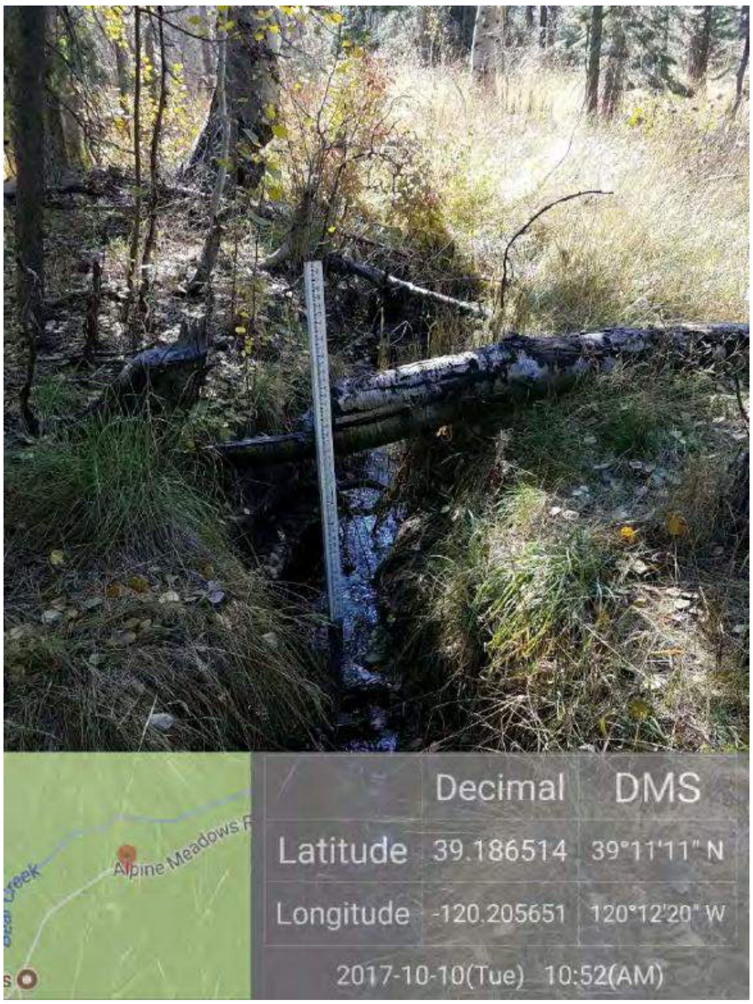

Figure 4-8 Incised spring-fed tributary to Reach C, Bear Creek, Placer County, California.

Aside from hydrophytic grasses and similar herbaceous plants, both aspen and cottonwood, some of which show signs of historic beaver damage, occur throughout the meadow, as do scattered lodgepole pine. Signs of aspen recruitment are present in this area (i.e., a diversity of aspen age classes), but shading from encroaching conifers may be limiting additional aspen regeneration.

Beaver dam remnants are apparent along the stream, and suggest beavers are active within this reach. Floods in 2017 likely removed all beaver dams that once existed. Shade from streamside riparian vegetation likely moderates water temperatures and provide an additional source of habitat complexity is similarly limited in this reach. A small number of rainbow trout were observed in this reach during a September 2017 reconnaissance survey of the creek.

Comparison of historical aerial photographs suggests that this reach of Bear Creek has been altered from a once vegetated anastomosing or multi-channel, wet-meadow system into a single-threaded, incised channel system (**Figure 4-9**). In the 1939 photograph, multiple channels with abundant willow or alder thickets are evident. In subsequent years, a single channel becomes more apparent and willow/alder thickets are replaced with areas of exposed sediment absent of vegetation (e.g., bank erosion, point bars, etc.).

Flooding of meadow surfaces naturally occurs with floods with more frequency (1 to 5-year floods). High-water marks identified along the channel in Reach C suggest that the 2017 peak flow, a roughly 20- to 25-year recurrence flood, was primarily contained within the active channel, likely the symptom of an incised channel system. Incision may be related to the effects of hydromodification —excess runoff from impervious areas. Additional flow provides additional energy acting on the channel bed and banks. The channel responds by widening and deepening to accommodate the modified hydrology. This process results in meadow desiccation, conifer encroachment, and provides a chronic source of fine sediment to the channel from in-channel erosion. Reach C is located downstream from most of the urbanized areas within the watershed and the alluvial characteristics of this reach are more conducive to the impacts of stormwater or hydromodification.

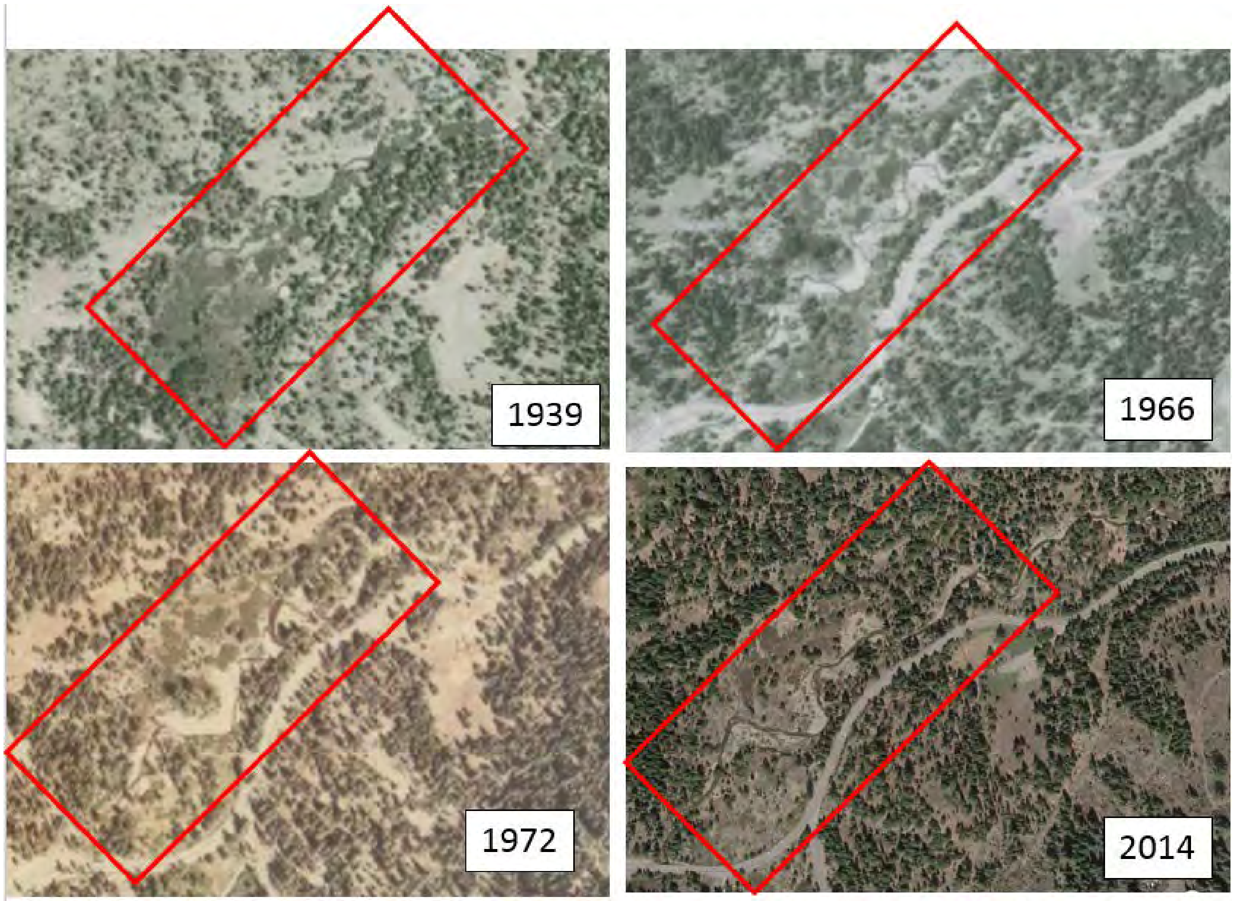

Figure 4-9 Historical conditions, Lower Bear Creek Meadow, Placer County, California.

The ecological functions of this reach are limited by a lack of floodplain connectivity between the creek and its adjacent meadows, caused primarily by incision of Bear Creek. The incision of Bear Creek has also lowered the groundwater table, causing the adjacent meadow to become drier and dominated by conifers and other plants not typically found in wet meadows. Areas of willow scrub, that provide high wildlife habitat values for some species, persist along remnant stream channels in the otherwise drier meadow, but the extent of these habitats is limited and unlikely to persist long-term because current hydrologic conditions do not support recruitment of new willow scrub vegetation to the replace existing vegetation as it gradually dies.

Spring flows that influence the meadows along the right bank of Bear Creek offer resilience against the negative effects of channel incision along this reach. These spring flows provide a reliable source of cold, clean water, and support establishment of higher-functioning mesic and wet meadows in between the creek and Alpine Meadows Road.

This wetter meadow, with its spring channels and matrix of herbaceous plants, aspen, and conifers, provides higher quality habitat for many species of terrestrial wildlife. However, even in these relatively higher-functioning areas, long-term habitat sustainability may be threatened by the incision of spring channels that has resulted from confinement of flows to few culverts under Alpine Meadows Road and addition of stormwater runoff to these channels. A lack of aspen regeneration and increasing conifer encroachment may also impact the ecological functions of this area longer-term.

We observed fine sediment and algae along the wetted bed in Reach C. Reach C receives stormwater runoff and sediment directly from Alpine Meadows Road, and Alpine Meadows Stables which operates adjacent to the meadow with a trail network and several stream crossings. Horse manure was also visible within the wetted channel in this reach, a possible source of nutrients for algae growth.

Identified Opportunity: We identified Reach C for multiple management actions and restoration opportunities to improve channel and meadow functions in these areas, reduce sediment to the Truckee River, and enhance aquatic and meadow habitats. Restoration opportunities in Reach C include augmenting instream wood to encourage sediment deposition and overbank flows, conifer eradication from the meadow, bioengineered check dams to aggrade incised spring tributary channels, and possible beaver dam analogs to encourage in-channel beaver activity. Any restoration actions in Reach C will require coordination with Placer County to improve stormwater management and discourage concentration of flows to a few culverts under Alpine Meadows Road which currently exacerbate incision of spring-fed channels.

4.1.3.4. Reach D

Reach D begins upstream from the Alpine Meadows Road crossing where bedrock constriction forms a narrow canyon reach. Bedrock controls in this reach control channel morphology. The reach is characterized by step-pools and small cascades (**Figure 4-10**). Private property prevented a detailed reconnaissance of this reach. Some sections viewed from Alpine Meadows Road appear to have incurred a period of incision, but appears to be relatively stable today as evidence of a near-continuous riparian corridor along its banks.

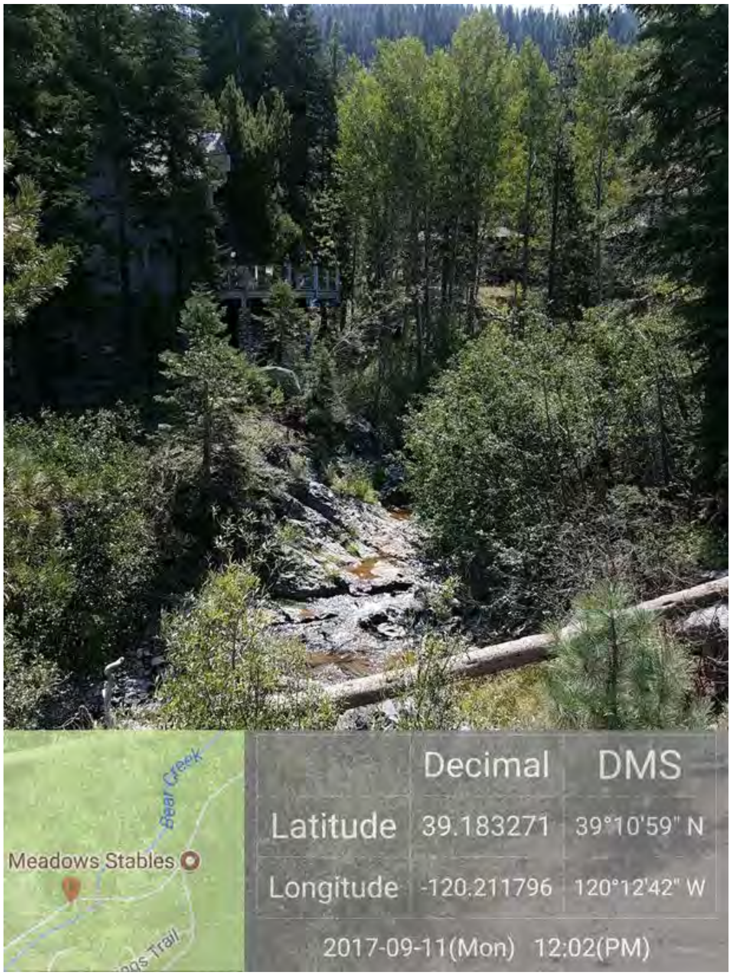

Figure 4-10 Reach D showing bedrock channel and mixed willow-conifer riparian, Bear Creek, Placer County, California.

Habitats are very similar in reaches D through H. Montane riparian scrub and woodland are relatively well-developed in these reaches. These plant communities, which are variously composed of willow, aspen, alder, cottonwood, and dogwood, along with intermixed conifers, provide abundant refugia and breeding substrate for bird prey (i.e., invertebrates), and they provide nesting, foraging, and thermal cover for the birds themselves as well as other species of wildlife. Abundant in-stream habitat structural diversity is provided by boulders, large wood, root wads, and similar features.

Nonnative rainbow trout were more abundant in this reach and reaches E, F, G, and H, suggesting that these reaches likely provide greater aquatic habitat ecological functions than other reaches of Bear Creek. Similarly, the juxtaposition of the stream with riparian scrub, cottonwood, aspen, and conifer forest provides high habitat values for wildlife, which are only reduced by the presence of developed areas (i.e., roads, residences, and vacation cabins).

-Restoration recommendations were not identified within this reach.

4.1.3.5. Reach E

Reach E includes the Lower John Scott Trail crossing at Bear Creek and a confluence with several tributaries including the Five Lakes trailhead tributary. This reach is confined within a narrow canyon, but includes segments of alluvial fill where channel and floodplain features are present. Channel characteristics include pool-riffle morphology with gravels and cobbles dominant (**Figure 4-11**). The channel exhibits active widening and some incision. The coarse texture of the bed provides some resilience to these instabilities. Road traction sand observed in pools and along floodplains is evidence of stormwater runoff and source of possible hydromodification effects. A review of Placer County stormwater culvert locations and flow paths suggest that this reach receives runoff from a significant portion of Alpine Meadows Road and neighborhood streets.

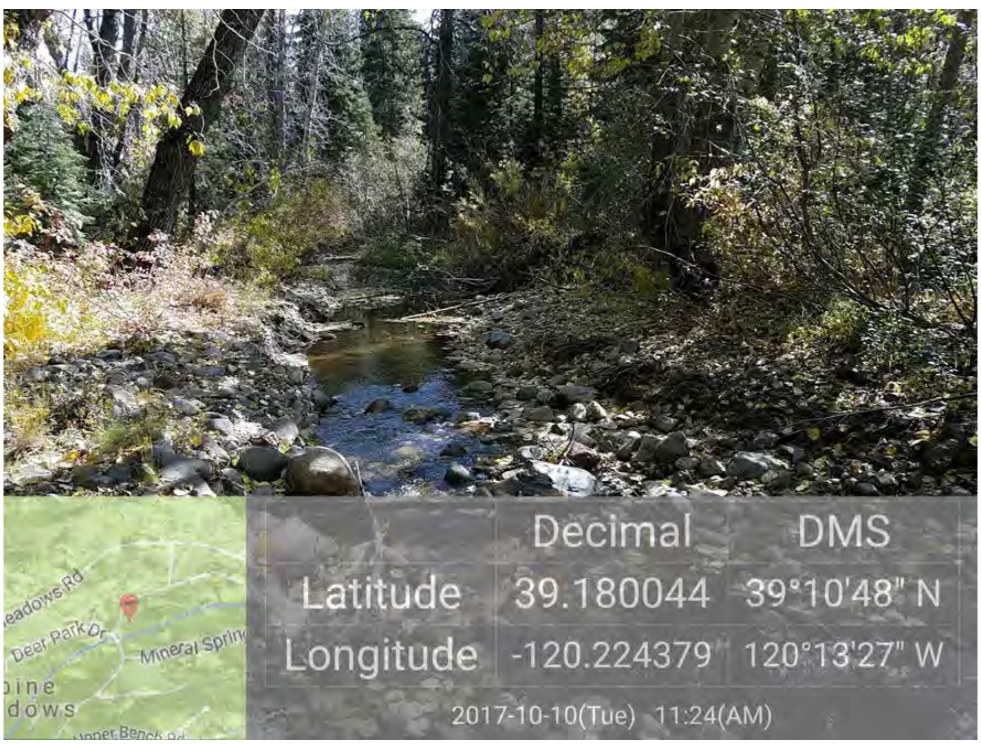

Figure 4-11 Reach E, Bear Creek, Placer County, California.

Stormwater impacts in this reach can be traced up the Five Lakes tributary. This tributary funnels a significant portion of runoff from Alpine Meadows Road. Furthermore, tributaries along this portion of the watershed drain highly erosive geology and in some events, can trigger significant sediment transport to Bear Creek. Frequent culvert plugging from sediment was reported by Placer County under Alpine Meadows Road at the Five Lakes Trailhead. These occurrences have forced stormwater and sediment onto the road and onto private property (Boyer, T., pers. comm., 2017) **Figure 4-12**.

Figure 4-12 Sediment plugged culvert inlet, Alpine Meadows Road at Five Lakes Trailhead, Placer County, California.

Two undersized culverts at the Five Lakes Trailhead conveys runoff from multiple drainages and an inboard ditch under Alpine Meadows Road and discharge to a steep tributary and Bear Creek. The excess stormwater runoff results in channel scour and bank erosion and is a likely sediment source to Bear Creek (**Figure 4-13**).

Figure 4-13 Active channel and bank erosion downstream from Five Lakes Trailhead, Tributary to Reach E, Bear Creek, Placer County, California.

Identified Opportunity: Restoration of channel processes should begin with improved stormwater management or BMPs along Alpine Meadows Road and at the Lower John Scott Trail bridge. Construction of Alpine Meadows Road and John Scott Trail required steep road cuts into native soils and geology. These exposed surfaces provide a chronic source of sediment to in-board ditches and eventually Bear Creek. Slope stability or erosion control measures can be implemented strategically to minimize these sediment sources. Other management actions may include construction of runoff and sediment retention basins, additional culverts to reduce concentration of flow to a single channel, and check dams in the actively eroding channel between Alpine Meadows Road downstream to its confluence with Bear Creek to encourage in-channel sediment storage.

4.1.3.6. Reach F

Reach F was not evaluated in detail due to private property and access; however, a review of aerial photographs, geologic maps, and LiDAR imagery suggests this reach is confined to a narrow canyon with bedrock and boulder controls on channel processes (**Figure 4-14**). Similar to reach E, habitats in these reaches are dominated by montane riparian habitat along the stream channel and by adjacent conifer forests and private residences above the channel.

-No restoration opportunities were identified in this reach.

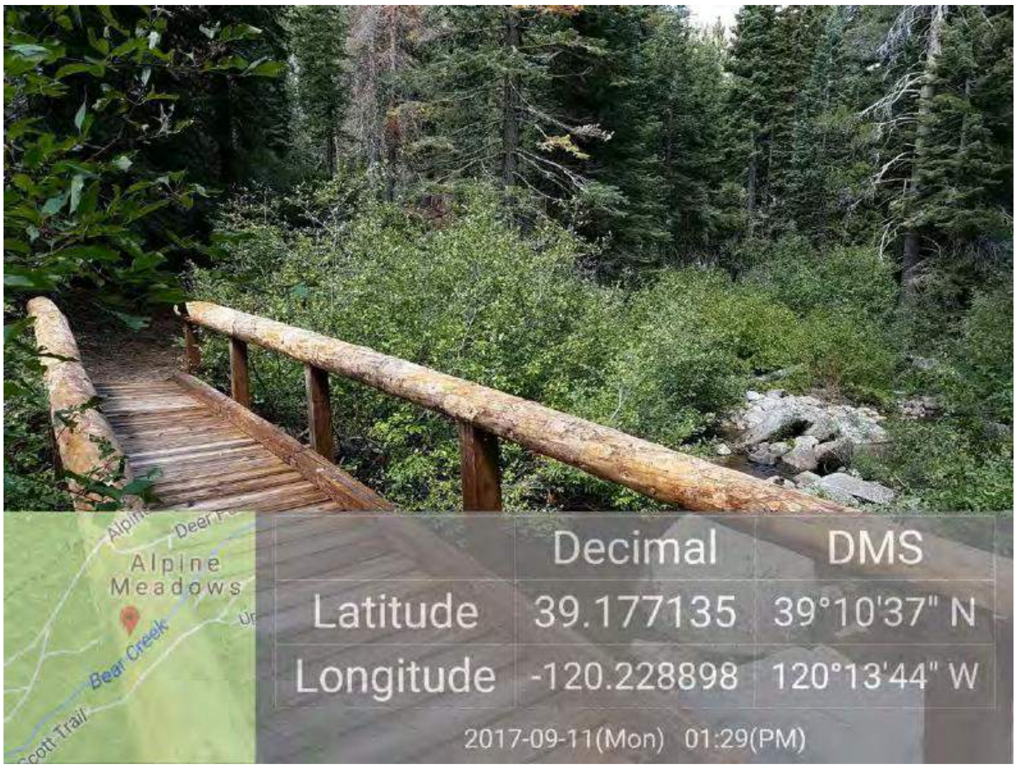

Figure 4-14 Reach F, Bear Creek, Placer County, California.

4.1.3.7. Reach G

Reach G defines the confluence of several large tributaries including Catch Basin and KT-22 South. This reach is also characterized by bedrock and boulder controls on stream processes and a dense willow/alder riparian (**Figure 4-15**).

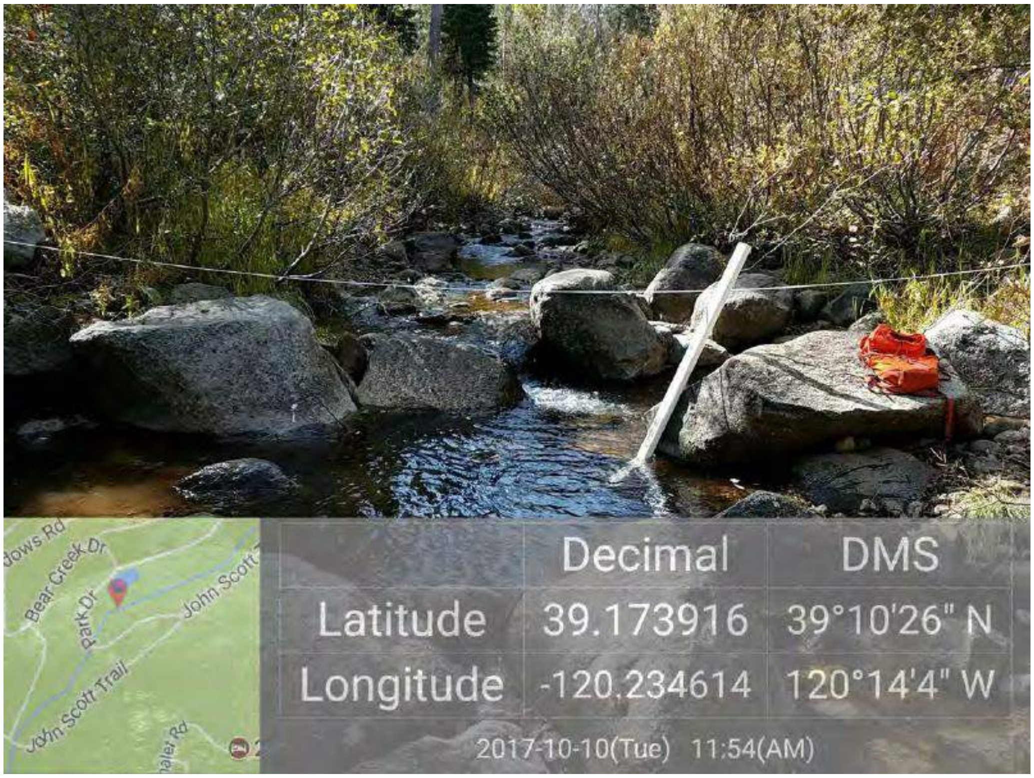

Figure 4-15 Reach G, Bear Creek, Placer County, California.

In this reach, a small diversion dam exists to convey water to a man-made pond used by Bear Creek Valley HOA for recreation. The pond also receives runoff from a small tributary. Dam operations were not evaluated but are believed to function only during the summer season to fill the 0.7-acre pond. The pond discharges back to Bear Creek roughly 400 feet downstream.

-No restoration opportunities were identified for this reach.

4.1.3.8. Reach H

Reach H is delineated from Upper Deer Park Drive bridge, through the Upper John Scott Trail bridge, to the Ginzton Access Road bridge. Similar to reaches below, this reach is bedrock and boulder controlled, but much steeper with cascade-type channel morphology (**Figure 4-16**) Private property prevented a more detailed assessment of this reach. Habitats in these reaches are dominated by montane riparian habitat along the stream channel and by adjacent conifer forests and private residences above the channel. In particular, montane riparian scrub and woodland are relatively well-developed in this reach.

-No restoration opportunities were identified for this reach.

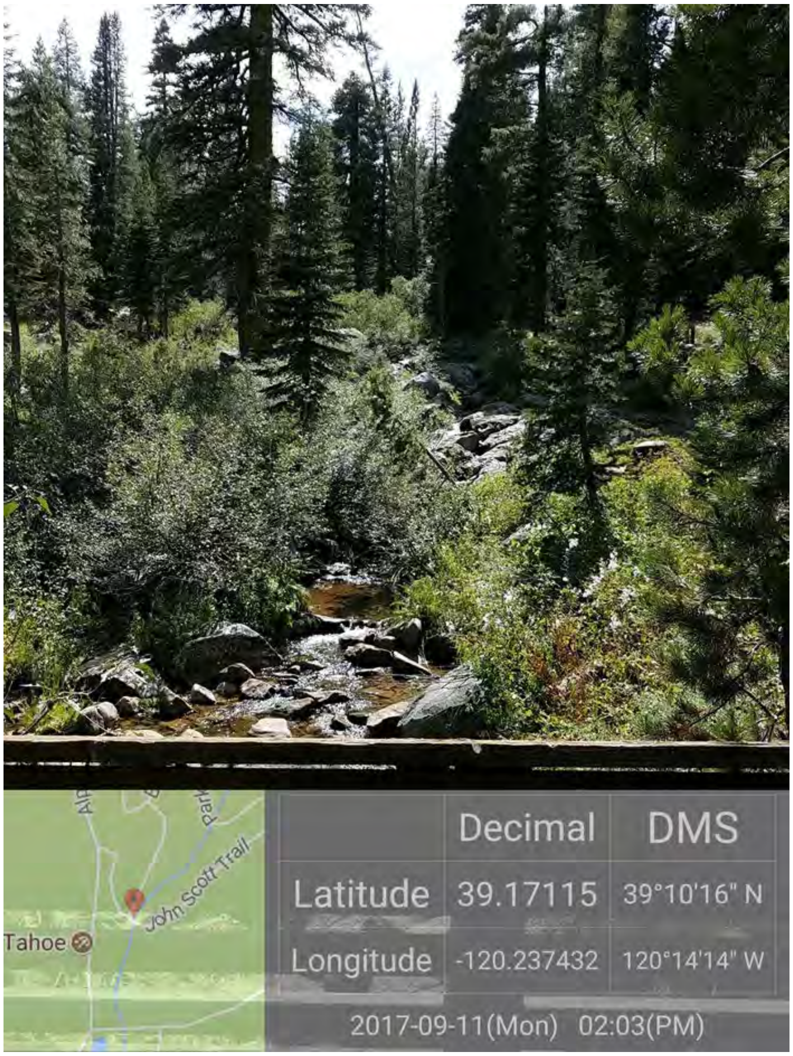

Figure 4-16 Reach H, Bear Creek, Placer County, California.

4.1.3.9. Reach I

Bear Creek, between Alpine Meadows Ski Area base lodge and Ginzton Access Road is identified as Reach I. This reach has a lower gradient than reaches upstream and downstream and is characterized as a single-threaded channel, with pool-riffle and step-pool morphology, and segments with a functioning floodplain. Reach I is also a confluence of many upland tributaries (i.e., Alpine Bowl, Wolverine Bowl, Lake Estelle, Warners Schuss) which discharge to Reach I through culverts and engineered water works.

A review of historical aerial photographs shows conditions in 1939 that supported a wetland meadow complex and continuous stream riparian corridor in reach I (**Figure 4-17**). Reach I was likely impacted from the historic development of Alpine Meadows Ski Area. By 1966, Alpine Meadows Road and a parking lot that accommodated 500 vehicles replaced roughly 4 acres of the original meadow. Bear Creek and several tributaries were enclosed underground in culverts with a loss to stream and floodplain functions for roughly 1,200 feet of channel. Historical aerials from the 1970s show expansion of the parking lot, further encroaching on wet meadow habitat. Within the same decade, ponds were constructed for snowmaking and displaced additional meadow and riparian scrub habitats.

The large contiguous and impervious surfaces modified stormwater runoff and delivery rates to Bear Creek via a stormwater system. Manhole covers suggest underground stormwater chambers exist for stormwater and sediment retention, but we have yet to determine their capacity, functionality, and annual maintenance. Meadow habitat adjacent to the parking lot shows evidence of vegetation buried by road traction sands accumulations deposited from direct parking lot runoff, snowplowing or snow blowing, or discharge from stormwater outfalls from years of parking lot operations.

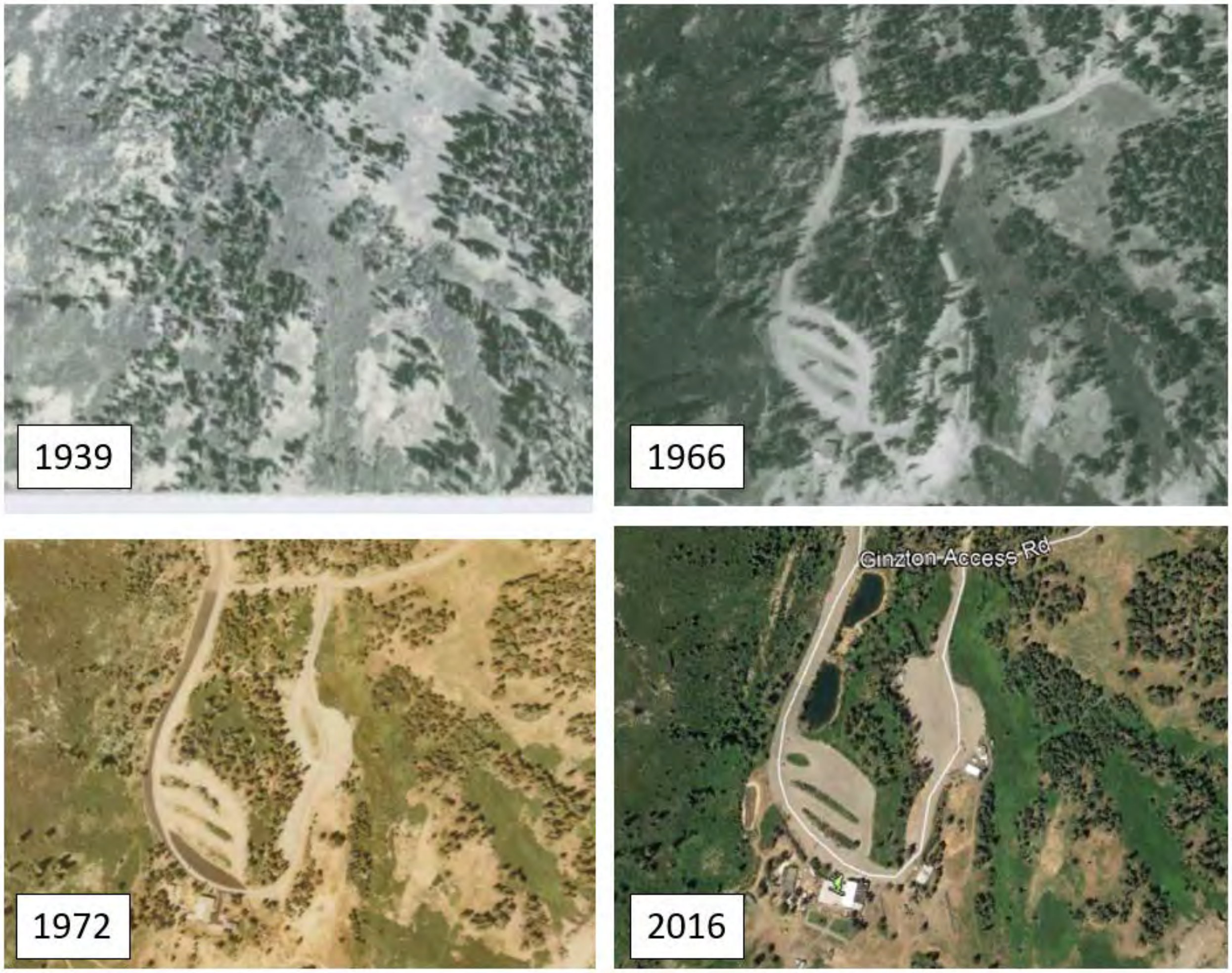

Figure 4-17 Meadow encroachment and stream enclosure in culverts, Alpine Meadows Ski Area, Placer County, California.

Willow and alder riparian adjacent to the parking lot show significantly more denuding and mortality relative to areas distant from the parking lot suggesting affects from snow storage (**Figure 4-18**). Bear Creek is confined between the parking areas with limited buffer width to accommodate floodplain processes and snow storage. In this reach there is limited in-stream habitat complexity. Filamentous algae was observed in the water column across the wetted channel and through most of the reach suggesting excess nutrients.

Relative to other reaches of Bear Creek, this is a very low functioning reach, primarily due to impacts from historic and ongoing operations of Alpine Meadows Ski Area that have altered the hydrology and water quality of the creek, increased sediment inputs to the creek, impacted riparian vegetation, and reduced the extent and quality of meadow habitats. The annual operation of Alpine Meadows Ski Area, including the parking lot and all stormwater discharge, runoff, and snow management, has been under approval and review of the US Forest Service since the 1960s.

Figure 4-18 Riparian mortality from snow storage, Bear Creek (Reach I), Placer County, California.

Identified Opportunities: Restoration and protection opportunities within Reach I include efforts at various levels of complexity and cost. Water quality improvements could involve improving stormwater BMPs and snow storage practices to reduce stormwater runoff and sediment to the channel and meadows. This could be accomplished by Alpine Meadows and the US Forest Service upgrading the current Erosion Control and Stormwater Management Plan. A higher level of effort would entail parking lot modifications, subject to US Forest Service approval, to provide a larger buffer to allow for floodplain processes and snow storage. Reducing impervious surfaces and restoring historical meadow areas would provide the greatest ecological and water quality benefits for meadow and creek restoration. Ski area management could consider relocating skier parking, constructing a multi-story parking structure, or other solutions to achieve these benefits.

4.2 Road Networks, Snow and Stormwater Runoff

Many of the disturbed reaches described in the previous section are impacted by stormwater runoff. In this section, we describe in more detail the urban components of the watershed and how stormwater improvements could greatly improve channel and habitat conditions, and water quality.

Unimproved/dirt maintenance roads, used for Alpine Meadows Ski Area, can be subject to extreme runoff events, debris flows, rock fall, and erosion. While these roads are necessary to maintain mountain operations, additional mitigation measures are proposed to minimize sedimentation of meadow habitat. Road drainage can be improved using more frequent water bars or dips, and some roads can be relocated to avoid wet soils or sensitive habitat.

Most of the paved roads and known stream crossings (culverts) within the Bear Creek watershed are maintained by Placer County (see **Figure 3-10**). We toured the main roads with Placer County staff to confirm their existence, locate problem spots, and discuss maintenance routines. Other unimproved roads, private roads, culverts, outfalls, and stormwater drainage ditches were identified using: a) observations in the field, b) USFS existing information collected as part of the Tributaries Assessment (USFS, 2016), and c) high-resolution aerial photographs. When feasible, these locations were also visited in the field.

Based on our work, the length of roads (paved and unimproved) within the study area is equivalent to 23.5 miles, with a road density of 4.5 miles of road per square mile of watershed, and includes at least 35 stream crossings. Imperviousness (i.e., asphalt roads, concrete, roofs) was estimated to be roughly 3 percent of the watershed (USGS Streamstats, 2017). Most of the estimated imperviousness is located within the valley and adjacent to Bear Creek, while other dirt or unimproved roads are located in the uplands.

While road density and percent imperviousness are important factors, hydrologic connectivity of these features to the channel is a better measure of their potential impacts to Bear Creek. To evaluate hydrologic connectivity, we completed a flow accumulation analysis in GIS using LiDAR-derived topographic information (USFS, 2013) (**Figure 4-19**). The analysis used bare earth topography to generate flow pathways that may be difficult to observe on aerial photos or in the field. The results yielded information on areas where natural drainage patterns and runoff may be altered or focused by roads and/or watershed disturbances. Because this analysis was limited to bare earth topography it does not account for existing culverts under roadways; however, it is useful for evaluating possible areas of road capture, in-board ditches and areas of highly concentrated runoff catchments. While Placer County has mapped many of the existing culverts, they have confirmed more work may be needed. Future in-depth analysis using GPS locations of all culverts can help evaluate if existing roads require additional culverts or drainage improvements.

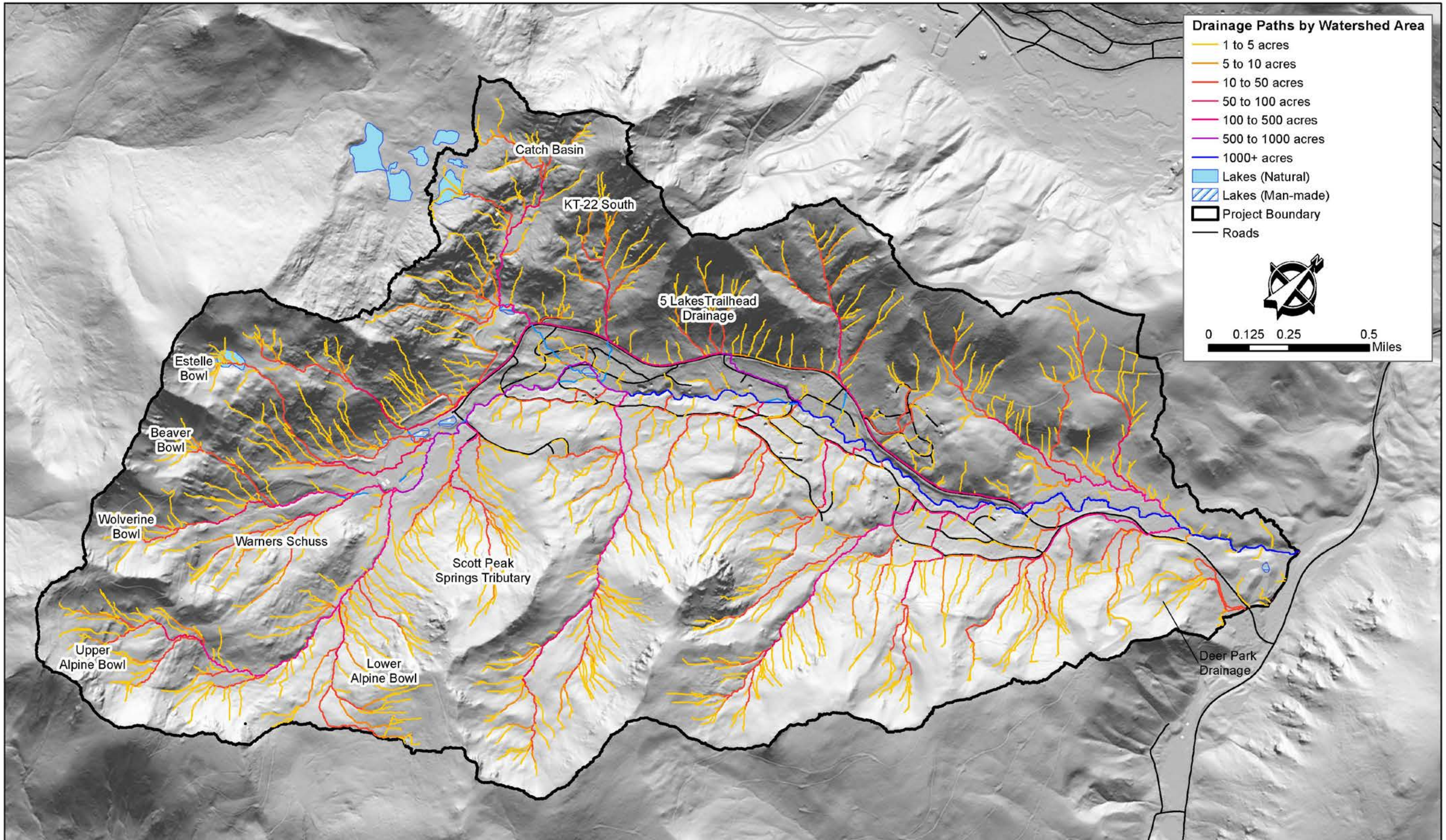

Figure 4-19 Drainage Path Map Bear Creek Watershed, Placer County, California.

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The USFS (2016) identified plugged culverts and stream capture on a dirt road on the south side of the watershed. The road has since scoured and generated measurable runoff and sediment to neighborhood streets and the urban storm drain system (**Figure 4-20**). In **Figure 4-19** and **Figure 4-20**, the flow accumulation analysis shows clearly where the stream is captured by road segments (green circle) and diverts several other smaller drainages into the urban storm drain system.

Figure 4-20 Stream capture from private/USFS road, Road Area #2 (USFS, 2016), Placer County, California.

The flow accumulation analysis shows where roads may be a concern or where they may be impacting the channel. This tool can be further ty66trused to evaluate other specific sites with flow accumulation thresholds modified to adapt to more detailed areas, for example, sites proposed for restoration.

Other issues with stormwater management were identified in the field or with County staff. Grading of unpaved pullouts and wide shoulders and excavation of the in-board ditches are common forms of maintenance along Alpine Meadows Road. (**Figure 4-21**). These in-board ditches can accumulate stormwater runoff and road sand and discharge directly or indirectly to the creek. Erosion of the shoulders and inboard ditch is common and requires annual maintenance.

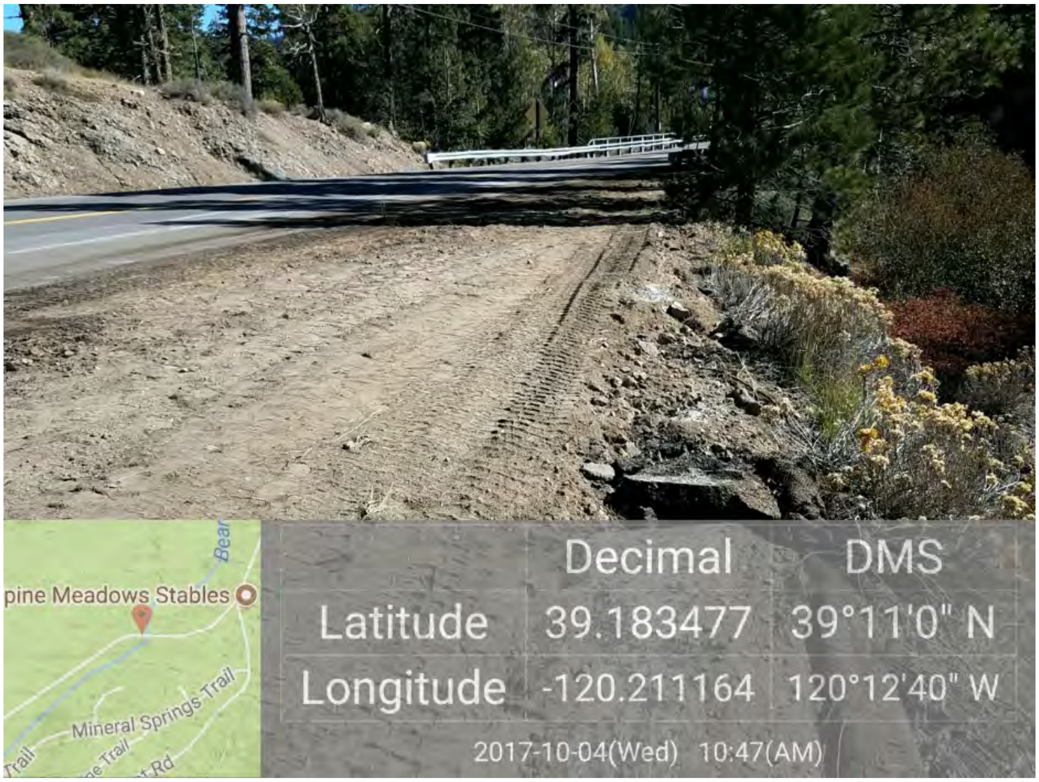

Figure 4-21 Active grading of wide shoulders that drain directly to Bear Creek, Alpine Meadows Road, Placer County, California.

Identified Opportunities: Improved stormwater management watershed-wide would provide many cumulative benefits before other identified opportunities are implemented. Additional culvert assessment may be necessary, including culvert conveyance and sizing, additional culvert installations, and culvert relocation in some cases. The construction of sediment basins to minimize excess sediment to the creek and stormwater retention features designed to reduce and decrease rapid runoff to the channel will improve instream channel conditions and water quality. Finally, re-evaluation of in-board ditch and shoulder maintenance routines may identify alternative solutions or stormwater management BMPs that can be implemented.

4.3 Uplands and Ski Area Development

4.3.1 Deer Park Ski Area

Former ski runs of the Deer Park Ski Area lack sufficient vegetation cover and soil, and exhibit riling and small gully erosion (**Figure 4-22**). The habitat values of these areas are somewhat limited by erosion and by a lack of trees and shrubs that would improve habitat diversity. However, from a habitat standpoint, there are likely fewer opportunities to improve the Deer Park Ski Area relative to other parts of the watershed. Habitat improvement opportunities are limited both due to nearby development (e.g., Highway 89, River Run Condominiums. River Ranch resort) and because conifer forest and upland scrub habitats are generally not limited in the watershed and provide lower-quality habitat values overall (i.e., relative to riparian areas, meadows, and associated wetlands).

Burt and Clary (2015) evaluated multiple former ski areas in the Sierra Nevada, including Deer Park Ski Area, and found that ski runs that were graded have limited recovery over time, but may benefit from restoration activities to improve water quality and provide incidental habitat values. We did identify that runoff and erosion from the Deer Park ski runs are directly connected to the storm drain network and discharge to the Truckee River in the lower Bear Creek Watershed. Similarly, the large parking lots at the former Deer Park Ski Area generate significant runoff with road sand directly to this stormwater system. Manhole covers located in the parking lot suggest underground stormwater chambers for stormwater retention and sediment detention; however, we were unable to confirm their size and whether they are maintained. As such, we have identified this area as a restoration opportunity with a focus on reducing sediment to the Truckee River, consistent with the USFS assessment (2016).

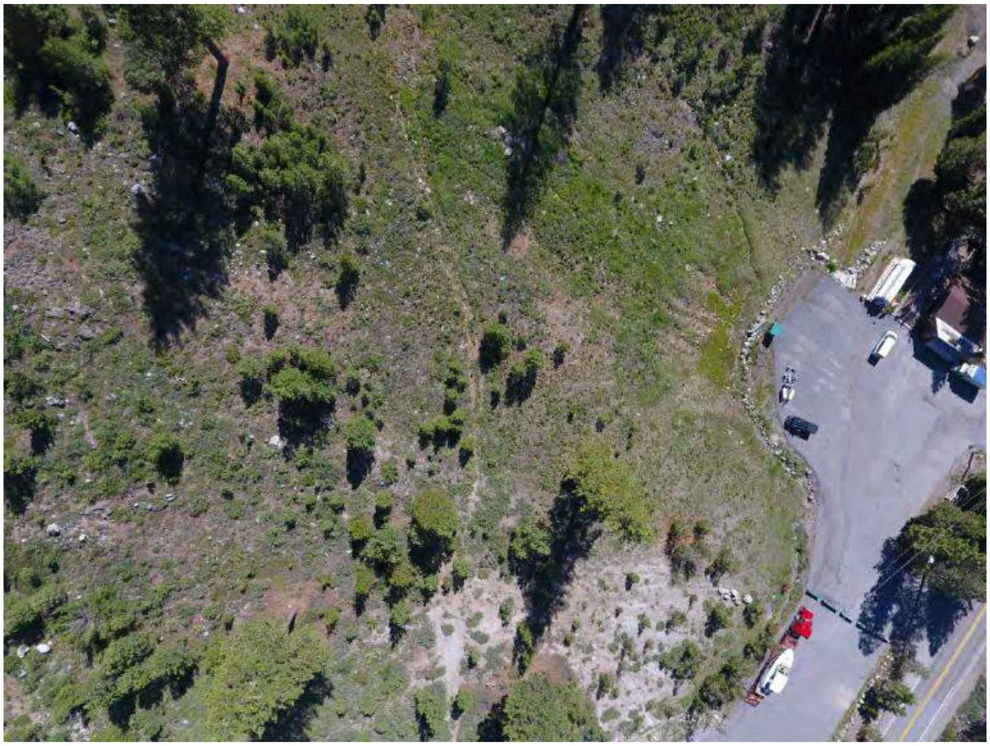

Figure 4-22 Aerial view of former Deer Park Ski Area, showing areas lacking vegetation, hillside rilling, and stormwater ditch, Bear Creek watershed, Placer County, California.

Identified Opportunities: Consistent with the TNF assessment (2016), we identify multiple opportunities at Deer Park to enhance ground cover and forested vegetation, reduce erosion and improve stormwater management. Future improvements may require close coordination with Placer County and Alpine Meadows Ski Resort.

4.3.2 Alpine Meadows Ski Area

Historical ski run development at Alpine Meadows also used grading methods and relocated some spring-fed tributaries to accommodate ski runs, lift infrastructure, and parking facilities. We provide some examples observed from the field:

When Kangaroo Run was created, a perennial channel was relocated to the north into a constructed ditch. Seepage from the ditch continues to support wetland vegetation on the ski run but also contributes to hillside erosion (**Figure 4-23**). A maintenance road used by both Alpine Meadows and ASCWD is located along the run and further exacerbates hillside erosion and habitat degradation.

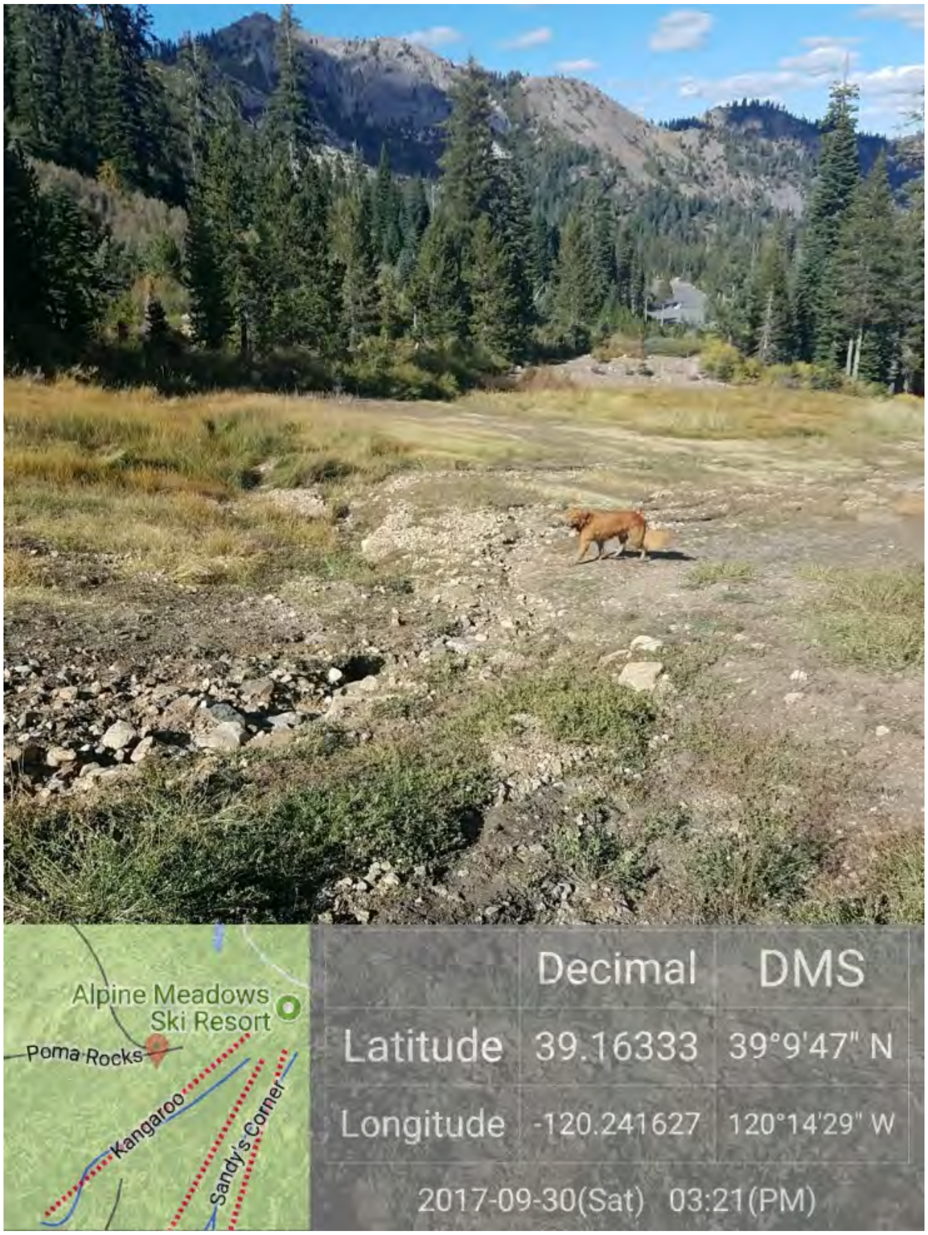

Figure 4-23 Diverted stream and erosion on Kangaroo Run, Alpine Meadows Ski Area, Tahoe National Forest, Placer County, California.

Snowmaking water lines have become exposed at the surface over the years. Once exposed, they act as conduits for runoff interception, concentrating flow and exacerbating hillslope erosion (**Figure 4-24**).

Figure 4-24 Erosion along water lines, adjacent to Meadow Chair, Alpine Meadows Ski Area, Tahoe National Forest, Placer County, California.

We have described the impacts of the Alpine Meadows parking lot in earlier sections (e.g., Reach I). Over the years, the expansion of the parking lot encroached on what is referred to herein as Scott Peak Springs Meadow. This meadow was likely one of the largest meadows in the watershed before development. It receives hydrologic support from multiple hillside springs along the west aspect of Scott Peak, presumably associated with a mapped fault (Sylvester and others, 2012). While some of the spring flow is diverted by ASCWD, these waters still support a robust meadow and willow riparian adjacent and east of the parking lot and under the Subway Chair.

Finally, the area around the main base lodge has been highly modified over the years. This area was historically a confluence of several upland tributaries. In the 1960s, roughly 1,200 feet of channels was buried in culverts. It's possible that the tributary we refer to as 'Hot Wheels Gully' was diverted into the main channel further upstream of its original confluence, but further investigation may be warranted.

Identified Opportunities: There may be multiple opportunities to improve ecological functions and habitats and reduce erosion with the Alpine Meadows Ski Area. Some segments of the culverted reaches could be 'daylighted' to improve channel and floodplain functions. Improvements or restoration efforts to regain meadow acreage may be feasible, but would require removal of portions of the parking lot. Snowmaking water lines could be relocated or improved to minimize runoff capture and hillside erosion, and road drainage improvements may be adopted to reduce sedimentation of meadow habitats. All of these suggestions will require close coordination with Alpine Meadows Ski Resort such that restoration actions do not disrupt or interfere with ski operations.

Priority of Identified Opportunities: In this section, we have identified multiple opportunities for restoration or management actions to address the goals of this assessment. It is important to consider the order in which restoration or management opportunities are addressed or implemented. When considering restoration of fluvial or river environments, upstream or upland opportunities should always be considered first or priority since these actions may address the sources of the problem or impacts in downstream areas. For example, meadow restoration in lower Bear Creek may only be successful if stormwater issues immediately upstream or watershed-wide are addressed first.

5 ASSESSMENT CONCLUSIONS

Bear Creek is one of many tributaries to the Truckee River that are sensitive to disturbances due to its elevation, geology, soils, and climate. Bear Creek is unique in that it is one of few tributaries that provides cold, clean, spring-derived flows that support baseflow and aquatic habitat in Bear Creek and the Truckee River. Bear Creek is also a watershed with historical land-uses and impacts dating back to the late 1800s. Both legacy impacts and current land-uses have generated cumulative watershed-wide disturbances that have altered some natural processes and ecosystem functions. However, many areas within the watershed are functioning well.

In this chapter, we summarize the assessment findings and provide a basis for future management actions and/or restoration recommendations. Our disturbance inventory and management/restoration recommendations are discussed in the next chapter:

- Much of the Bear Creek watershed is underlain by erodible material that has been disturbed by historical and on-going land-uses. Restoration and management efforts can be prioritized by focusing on these areas and/or impacts.
- Historical land-uses in the Bear Creek Watershed were less extensive than in other Middle Truckee River watersheds, but the watershed has been more recently impacted by road-building, residential development, and recreational infrastructure. Restoration and management recommendations presented herein therefore include stormwater management strategies along with approaches for offsetting hydromodification impacts.
- Conditions during this assessment were observed shortly after extreme floods at the end of a multi-year drought, representing more unstable conditions than may be encountered at other times. Pre- and post-restoration monitoring data may be expected to show some degree of natural recovery from these conditions, as dependent on future hydrologic conditions.
- Multiple unimproved roads and/or road segments constructed during the logging era continue to alter natural channel flow, and are a source of excess sediment. Drainage management strategy recommendations along dirt/unimproved roads include restoration of natural drainage pathways and dispersal of concentrated flows.

- Graded ski runs and ski area maintenance roads altered natural drainage patterns, and require similar approaches to reduce the amount of water and sediment that is generated from these features.

- Six out of 10 native fish species may still occur in Bear Creek. These species include: Paiute sculpin, Lahontan speckled dace, Lahontan redside, Tahoe sucker, mountain sucker, and mountain whitefish. Restoration and habitat enhancement measures will include improving physical habitat for which these species are suited.

- Introduced North American beaver (*Castor canadensis*) likely occur in the watershed and can provide multiple benefits to degraded meadows and aquatic habitat. In-channel restoration strategies will encourage beaver activity.

- Vegetation communities within the Bear Creek watershed are diverse, but primarily dominated by white fir. Existing aspen and cottonwood groves are mapped in few locations of the watershed. Restoration strategies will enhance these areas for habitat benefits.

- Invasive plants mapped within the watershed are mostly located within disturbed areas of the Alpine Meadows Ski Area and in small, localized areas along Bear Creek. Management actions will include efforts to eradicate invasive species.

- Multiple springs and abundant spring flows were observed within Bear Creek watershed. They provide hydrologic support for wet meadow and aquatic habitat and cold, clean baseflow in Bear Creek and the Truckee River. Spring areas are identified and protection and/or enhancements are proposed.

6 DISTURBANCE INVENTORY AND RESTORATION OPPORTUNITIES

The restoration and management opportunities presented in this report have been developed to a) improve ecological function; b) enhance both aquatic and upland habitats, c) improve water quality and maintain cold, clean baseflows to the Truckee River in times of drought, d) contribute to Sierra-wide efforts to enhance and restore montane meadows, which have been identified as key ecological units for habitat and ecosystem services, and e) support the local economy through long-term sustainable support of nature-based recreational assets. While land ownership in the watershed is diverse, many landowners and stakeholders have similar management goals and resource objectives, or are bound by a regulatory framework to maintain or improve the ecological health of the watershed. For the purposes of these recommendations, the term “restoration” can mean a watershed-scale approach in which management strategies target watershed processes, or targeted actions at a particular location, either of which will improve downstream conditions.

Key management actions and/or restoration opportunities that address disturbances or impacts in the watershed are identified in **Table 6-1** and located in **Figure 6-1**. High priority projects were further developed into Project Sheets (**Appendix F**). In coordination with TRWC and stakeholders, the Lower Bear Creek Meadow Restoration in Reach C was selected for design. Remaining opportunities will also be given consideration as additional funding becomes available. Recommendations assume coordination with existing stakeholders for further input, design and implementation.

Table 6-1 Management actions and restoration opportunities, Bear Creek watershed, Placer County, California

Management Actions and Restoration Opportunities, Bear Creek Watershed, Placer County, California, 2017

Project ID	Project	Location	Stakeholders/Landowners	Watershed Benefits	Sources of Degradation	Objectives to Restore Process(es)	Constraints	Opportunities	Priority
(Multiple)	Stormwater BMPs	Multiple outfalls in watershed (see map), includes project #11	Placer County	Reduced sediment to Bear Creek	Inadequate stormwater detention and conveyance; high connectivity of impervious surfaces; concentration of runoff in single channel-incision	1) Implement additional stormwater BMPs; 2) Increase number of culverts to reduce stormwater concentration at a point	Steep slopes, avalanche zones	Stormwater runoff may be the most important factor in channel degradation; reducing and treating stormwater will provide other benefits and aid in enhancing other projects.	HIGH
1	Bear Creek alluvial fan meadow	Reach A	USFS	Increased meadow wetting, function and integrity	stormwater runoff incising through fan	Instream wood placement to spreadflow and encourage sediment deposition on fan	access		LOW
2	Deer Park Stormwater Management	Deer Park Drainage	USFS, Squaw Valley Ski Holdings, Inc.	Reduced sediment to Truckee River, improved stormwater quality and aquatic habitat	Concentration of flow from parking lots to drainage ditch	Stormwater and sediment detention; check dams in gully to reduce further incision and encourage sedimentation	Existing parking lot, Apline Meadows Drive	Stormwater BMPs could be implemented with little or no loss to parking capacity	HIGH
3	Deer Park Ski Area: Materials Management	Deer Park Drainage	USFS, Squaw Valley Ski Holdings, Inc.	Reduced sediment to stormdrain and creek	Improper storage; lack of BMPs	BMPs education and implementation	None	Low-cost	MOD
4	Deer Park Ski Area: Ski run rehabilitation/revegetation + road decommissioning	Deer Park Drainage	USFS, Squaw Valley Ski Holdings, Inc.	Reduced runoff and erosion; enhanced native vegetation and terrestrial habitat	Historical grading to create ski runs	Decommision roads	Steep slopes, erosion control in first 1-3 years	1) access; 2) reduce sediment sources to Bear Creek; 3) restore upland habitat	HIGH
5	Lower Bear Creek Meadow-Horse Crossings	Reach C	USFS, Alpine Meadows Stables	Reduced sediment and organic matter inputs to stream, improved water quality and aquatic habitat	Horse trail captures runoff and erodes to creek; horse manure in active channel	Possible trail crossing relocation; armour trail, horse manure management	Impacts to existing Alpine Meadows Stables operations		HIGH
6	Lower Bear creek Meadow Restoration	Reach C	USFS	Increased meadow health and integrity, improved water retention in meadow and reduced bank erosion and sediment to Truckee River, improved aquatic habitat	Stormwater runoff, incision of channel through meadow; lack of large instream wood;	Combine with stormwater management (under other proposed projects) to reduce runoff; add instream wood, strategically place wood to reconnect backwater channels			HIGH
7	Lower Bear Creek Meadow	Reach C	USFS	Improved terrestrial wildlife habitat values	Beaver activity, conifer encroachment	1) remove conifers; 2) beaver deterrence; 3) protect spring source waters		Combine with Project #6	HIGH
8	Spring flow channel incision	Reach C, Tributary subcatchment	USFS, Placer County	Encouraged dispersion of spring flow onto meadow surface; reduced erosion, enhanced meadow terrestrial and aquatic habitat	Limited # of culverts under Alpine Meadows Road, below Mineral Springs Trail, stormwater runoff	Increase number of culverts; sod/wood check dams in existing incised channel	Multiple stakeholders		MOD
9	Area #2, Middle Bear Creek Section	Tributary Subcatchment	ASCWD, USFS, Private	Restored drainage patterns and reduced hillside erosion	Stream capture by old roads and ski trails	Decommission roads/skid trails, relocate recreational trails	Lower portion of road-private; Buried utilities (water line)	Improve recreational access (trail used by locals for hiking, biking)	HIGH
10	White Wolf, road runoff erosive geology/soils	Tributary Subcatchment	White Wolf	Reduced sediment to Bear Creek	Road and road maintenance	Relocate road or improved drainage	topography, bedrock	Hillslope retention, distance from creek	LOW
11	Five-Lakes Trailhead	Five Lakes Tributary	USFS, White Wolf, Placer County	Reduced sediment sources	Runoff management of Alpine Meadows Road, confluence of major natural drainages; trail runoff management	Sediment/runoff retention, upgrade culverts, improve trail drainage;			HIGH
12	Alpine Meadows Parking Lot Snow storage management	Reach I (Subway Lift Parking Lot + Main Lodge lot)	USFS, Squaw Valley Ski Holdings, Inc.	Reduced sedimentation and mortality of willow in meadow, Improved riparian habitat	Snow storage; stormwater discharge (absence of treatment, BMPs)	Provide buffer for snow storage betweeen parking lot and creek; sediment BMPs	Requires reduction in some parking or asphalt areas		HIGH
13	Alpine Meadows Parking Lot Runoff and Sediment Management	Reach I (all parking lots)	USFS, Squaw Valley Ski Holdings, Inc.	Reduced sediment sources to meadow and Bear Creek, Improved water quality	Contiguous impervious area; inadequate runoff detention, direct discharge to meadow and creek; willow riparian impacts	1) Underground stormwater/meltwater + sediment retention; 2) Daylight drainages through parking lot-relocate parking spaces to non-sensitive areas 3) provide wider buffer for stream/riparian	Possible reduction in asphalt/parking areas	1) Improve meadow condition, 2) mitigate runoff magnitude and frequency, 3) reduce sediment to Bear Creek	HIGH
14	Alpine Meadows Maintenance Road Management for runoff and sediment to meadows	Reach I	USFS, Squaw Valley Ski Holdings, Inc.	Reduced sediment sources to meadow and Bear Creek, Improved water quality and meadow function	Runoff captured by maintenance roads, road erosion,	1) Increase number of water dips/bars; 2) Asphalt chipping; 3) road outsloping		Decrease long-term maintenance	HIGH
15	Road cut, sediment source reduction	John Scott Trail /Alpine Meadows Road	Bear Creek HOA/Placer County	Reduced sediment from erosion of road cut	direct runoff of road cut onto road to stormdrain or in-board ditch	1) erosion control, 2) stone wall or slope protection			MOD
16	Reduce erosion and meadow loss	Kangaroo Run	USFS, Squaw Valley Ski Holdings, Inc., ASCWD	Reduced erosion of discharge-slope wetland (former channel)	Road and road maintenance	Abandon road and restore slope; relocate road		Minimize sedimentation of snow making ponds	MOD

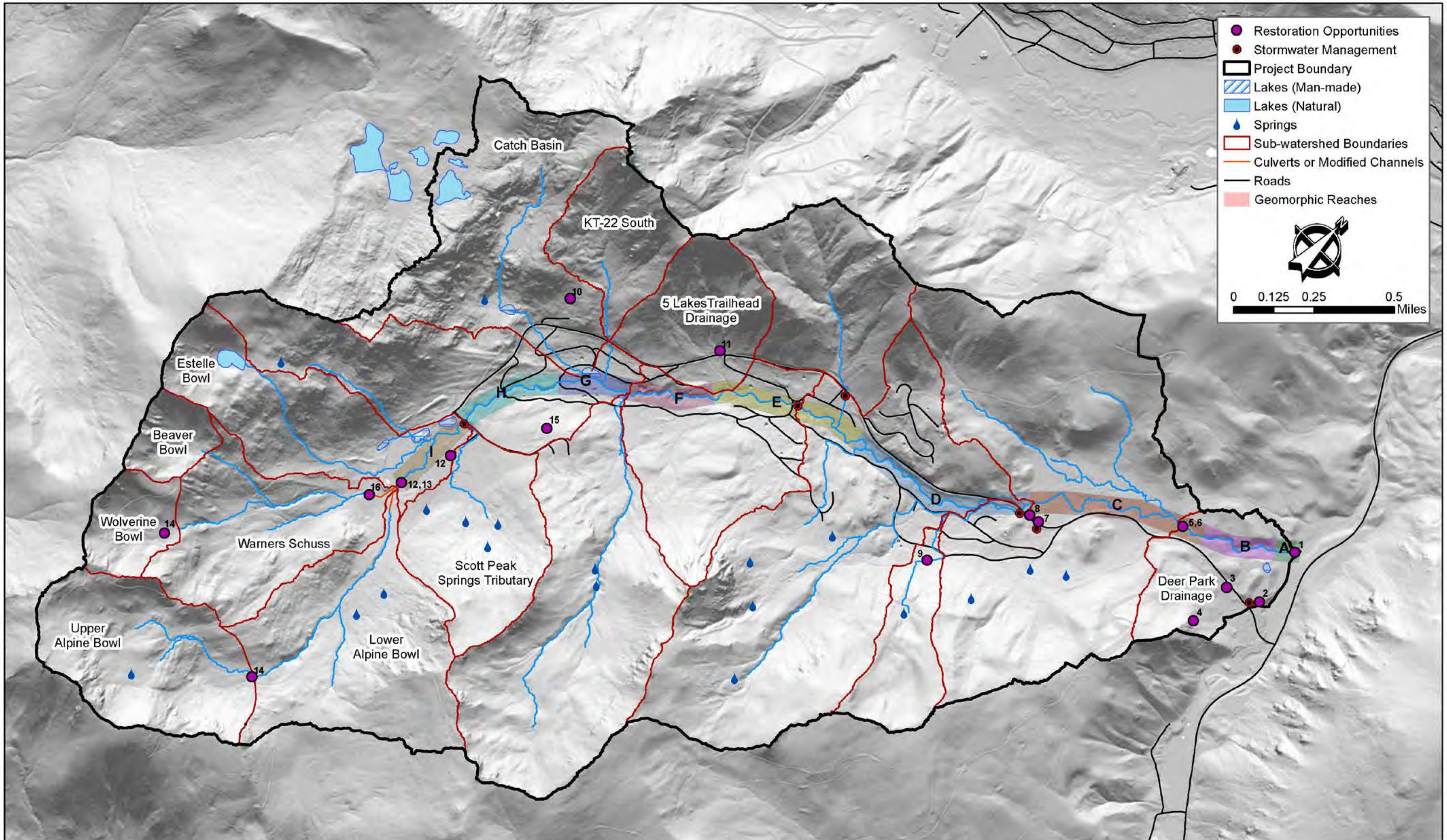

Figure 6-1 Management actions and restoration opportunity locations, Bear Creek watershed, Placer County, California.

7 LIMITATIONS

As stated in the introduction to the report, the objectives of this study are to provide the Truckee River Watershed Council with a characterization of the hydrologic and geomorphic processes that support habitat and water quality in the Bear Creek watershed. This is a reconnaissance report, intended to bracket likely historical and potential future conditions, to identify certain hydrologic or geomorphic factors which must be better known, and to help guide initial planning. This report is not intended to serve as a basis for flood management or detailed floodplain planning, both of which are conducted by well-defined and separate procedures, and which frequently require multiple lines of evidence. Use of these results for purposes other than those identified above can lead to significant environmental, public-safety or property losses. Balance Hydrologics should be contacted for consultation prior to considering use of this analysis for any purposes other than the reconnaissance, watershed-scale analysis specified above in this paragraph.

The application of geomorphic history to inferring future channel and corridor change has a long and respected record in the earth sciences. As with all historical or archival analysis, the better the record is known and understood, the more relevant and predictive the analysis can be. We do encourage those who have knowledge of other events or processes which may have affected the site or channel system to let us know at the first available opportunity.

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APPENDICES

APPENDIX A

Invasive and Sensitive Species

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings	Ecology Threat
Hoary alyssum *Berteroa incana*	Cal-IPC: NL CDFA: B	Annual to short-lived perennial 1-3 feet tall; most prolific on dry, disturbed, open sites; reproduces from seed bank. Observed along lower Bear Creek below Alpine Meadows Road and by TNF botanists in Alpine Meadows ski resort.
Spotted knapweed *Centaurea stoebe* ssp. *micranthos*	Cal-IPC: H CDFA: A LTBWCG Top Priority TRWC Species of Interest	Biennial to short-lived perennial 3-4 feet tall; reproduces vegetatively or by seed; found in disturbed, open areas or rangeland on light and well-drained soils. Observed in watershed by TNF botanists.
Yellow star thistle *Centaurea solstitialis*	Cal-IPC: H CDFA: C LTBWCG Top Priority TRWC Species of Interest	Winter annual or sometimes biennial 6-7 feet tall; reproduces by seed and can form dense and impenetrable stands; found in many habitat types following disturbance
Bull thistle *Cirsium vulgare*	Cal-IPC: M CDFA: C LTBWCG Top Priority TRWC Species of Interest	Biennial, annual, or short-lived perennial 6-7 feet tall; found in disturbed areas; reproduces from seed.
Orchardgrass *Dactylis glomerata*	Cal-IPC: L CDFA: NL	Perennial, cool-season bunchgrass 1-2 feet tall; pasture grass that has escaped in many locations; reproduces from seed. Observed in meadows along Bear Creek below Alpine Meadows Road.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings	Ecology Threat
Klamathweed *Hypericum perforatum*	Cal-IPC: M CDFA: C LTBWCG Top Priority TRWC Species of Interest	Erect perennial to 4 feet tall; reproduces from seed and vegetatively from rhizomes; found in rangeland and open, disturbed areas such as roadsides and logged sites; plant populations cycle in relationship to populations of leaf-feeding beetles that can produce excellent control of Klamath weed, particularly below 5,000 feet elevation. Observed along Bear Creek below Alpine Meadows Road and by TNF botanists in Alpine Meadows ski resort.
Perennial pepperweed *Lepidium latifolium*	Cal-IPC: H CDFA: B LTBWCG Top Priority TRWC Species of Interest	Erect and vigorous spreading perennial up to 6 feet tall; reproduces vegetatively, including from root fragments, and from seed; found in disturbed areas on moist or seasonally-wet soils; tolerates alkalinity and salinity. Observed in watershed by TNF botanists.
Reed canary grass *Phalaris arundinacea*	Locally invasive in Bear Creek Watershed	Vigorous, long-lived, perennial, sod-forming, rhizomatous grass between 6 and 8 feet tall; many cultivars and hybrids recorded throughout its range, making native status questionable; can become weedy or invasive in wetland habitats. Observed in watershed by TNF botanists.
Sheep sorrel *Rumex acetosella*	Cal-IPC: M CDFA: NL	Erect or ascending perennial 1-2 feet tall; can form dense stands in disturbed sites within natural communities; reproduces from creeping rhizomes and seed
Woolly mullein *Verbascum thapsus*	Cal-IPC: L CDFA: NL	Erect biennial or annual 1-7 feet tall; invades disturbed or barren soil in montane meadows and forests; reproduces prolifically from seed. Observed along Bear Creek below Alpine Meadows Road and in scattered locations in the White Wolf property.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings	Ecology Threat

Sources: Cal-IPC 2017, CalWeed Mapper 2017, CDFA 2016, USFS 2017, LTBWCG 2017, USDA 2017, USFS 2013a.

Key: Cal-IPC = California Invasive Plant Council; CDFA = California Department of Food and Agriculture; LTBWCG = Lake Tahoe Basin Weed Coordinating Group; NL = not listed (species not included in the Cal-IPC California Invasive Plant Inventory Database and/or CDFA Noxious Weeds list); USDA = U.S. Department of Agriculture.

Notes:

[1] Rating Codes

California Invasive Plant Council (Cal-IPC)

H: High	These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
M: Moderate	These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
L: Limited	These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

California Department of Food and Agriculture (CDFA)

A	A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. If found entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.
B	A pest of known economic or environmental detriment and, if present in California, it is of limited distribution. If found in the state, they are subject to state endorsed holding action and eradication only to provide for containment, as when found in a nursery. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.
C	A pest of known economic or environmental detriment and, if present in California, it is usually widespread. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.

LTBWCG Top Priority: Weed species at risk of introduction and spread into the Lake Tahoe Basin Region based on historical survey and mapping data gathered by cooperating partners in and around the Basin.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings	Ecology Threat

TRWC Species of Interest: Weeds included in the Invasive Weeds Guidebook available on the Truckee River Watershed Council website: https://www.truckeeriverwc.org/get-involved/weed-warriors/.

Table 4-2. Special-Status Wildlife, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Name	Source	Status[1]	Habitat	Potential for Occurrence
Amphibians				
Foothill yellow-legged frog *Rana boylii*	USFS	SCT, CSSC, USFS-S	Partly shaded shallow streams, riffles, and pools with a rocky substrate in a variety of habitats from approximately sea level to 6,000 feet.	Unlikely to occur. The watershed is generally above the elevational range of the species.
Sierra Nevada yellow-legged frog *Rana sierrae*	CNDDB	ST, FE, USFS-S	Streams, lakes, and ponds in montane riparian, lodgepole pine forest, subalpine conifer, and wet meadow habitats. Elevation range is 2,040-12,070 feet.	Known to occur. This species has been detected in alpine lakes within and adjacent to the watershed.
Southern long-toed salamander *Ambystoma macrodactylum sigillatum*	CNDDB	CSSC	Alpine meadows, alpine lakes, and ponds.	Known to occur. The species has recently been observed in the Five Lakes area and in a pond northeast of Lake Estelle within the watershed.
Birds				

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Bald eagle *Haliaeetus leucocephalus*	USFS	SE, FP, USFS-S	Requires large bodies of water, or free flowing rivers with abundant fish, and adjacent snags or other perches. Nests in large, old-growth, or dominant live tree with open branchwork and medium canopy. Typically selects largest tree in stand usually near a permanent water source. Ponderosa and sugar pines often used. In winter, roosts in dense, sheltered, remote conifer stands.	Unlikely to occur. Suitable nesting and foraging habitat is not present on the watershed.
California spotted owl *Strix occidentalis occidentalis*	USFS	CSSC, USFS-S	Mature mixed coniferous forest with large diameter trees and high canopy closure, multiple canopy layers, and downed woody debris. Also forages in more open stands.	Potential to occur. The species is not known from within 5 miles of the watershed; however, suitable habitat is present in the northeast and southeast portion of the watershed. Recent CNDDB records indicate several nesting territories in proximity to the watershed (but greater than 5 miles distant).
Greater sandhill crane *Grus canadensis tabida*	USFS	ST, FP, USFS-S	Marshes and meadows adjacent to grassland or other short vegetation uplands. Nearby montane dry or wet meadow.	Unlikely to occur. Lacey Valley, approximately 25 miles north of the watershed, is known to be the most southerly breeding area for this species in California and suitable habitat for the species is not present on the watershed.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Great gray owl *Strix nebulosa*	USFS	SE, USFS-S	Mature forests surrounding meadows with high density of large diameter snags and high canopy closure and cooler sub-canopy microclimate. Meadow-mature forest zone.	Unlikely to occur. Mainly occur in the meadow-mature forest zone on the western slope of the Sierra Nevada. Suitable meadow habitat is not present in the watershed.
Long eared owl *Asio otus*	CDFW, eBird	CSSC	Riparian or other thickets with small, densely canopied trees. Hunts in open areas, occasionally in woodland and forested habitat	Potential to occur. Marginally-suitable habitat exists on the watershed. Known to occur in the Tahoe Basin.
Northern goshawk *Accipiter gentilis*	CNDDB, eBird	CSSC USFS-S	Mature coniferous forest with large diameter trees and high canopy closure. Frequently forages along meadow edges or in aspen/willow shrub communities.	Known to occur. Alarm calls heard during a site visit in September 2017, and eBird records show the species as occurring along Bear Creek near Alpine Meadows Drive in 2016. Numerous TNF and CNDDB records in and near the watershed.
Short-eared owl *Asio flammeus*	CDFW	CSSC	Open treeless areas with elevated sites for perches and dense vegetation, tall grasses, brush, ditches, and wetlands.	Unlikely to occur. Suitable grassland habitat not present in the watershed.
Willow flycatcher *Empidonax traillii*	CNDDB	SE, USFS-S	Medium to large meadows with extensive areas of montane wet meadow, emergent vegetation and large stands of willow or other riparian deciduous shrubs.	May occur. Suitable habitat is present on the watershed, and the species has been observed within 5 miles of the watershed.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Yellow warbler *Setophaga petechia*	CNDDB	CSSC	Meadows, riparian areas, or recent burned areas with large stands of willow or other deciduous shrubs.	May occur. Suitable habitat is present on the watershed, and the species has been observed within 5 miles of the watershed.
Fish				
Lahontan cutthroat trout *Oncorhynchus clarkii henshawi*	CNDDB, USFWS	FT	Small cool-water streams with riffle-runs, rocky substrates, and pools with vegetated and stable stream banks.	Unlikely to occur. Species extirpated from this reach of Truckee River and its tributaries.
Lahontan mountain sucker *Catostomus lahontan*	CDFW	CSSC	Shallow (< 6ft deep), clear, cool, low-gradient, low- velocity streams with diverse substrates with dense cover (emergent macrophytes, logs, undercut banks).	Potential to occur. Species occurs in Truckee River system, but limited suitable habitat is present in Bear Creek.
Mountain whitefish *Prosopium williamsoni*	CDFW	CSSC	Clear, cold streams with deeper pools and runs.	Potential to occur. Species occurs in Truckee River system, but limited suitable habitat is present in Bear Creek.
Lahontan Lake tui chub *Gila bicolor pectinifer*	USFS	CSSC, USFS-S	Large, deep lakes.	Unlikely to occur. Suitable habitat is not present on the watershed.
Invertebrates				

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Black juga *Juga nigrina*	USFS	USFS-S	Perennial flowing streams, seepages, springs and creeks with substrates including boulders and cobble, gravel, sand, and mud.	Potential to occur. Suitable habitat is present in Bear Creek; however, the species has not been observed within 5 miles of the watershed.
California floater *Anodonta californiensis*	USFS	USFS-S	Primarily found in lakes, reservoirs, and slow-moving streams with mud or sand substrates. Occasionally found in creeks and rivers with gravel substrates.	Potential to occur. Suitable habitat is present on the watershed; however, records of the species in the general region are from prior to 1985.
Great Basin rams-horn *Helisoma newberryi*	CNDDB	USFS-S	Large lakes and slow rivers with soft mud bottoms, including large spring sources and spring-fed creeks.	Unlikely to occur. Historically, the species has been observed on slow segments of the Truckee River directly downstream of Lake Tahoe in the Tahoe Basin Management Unit; however, it has not been observed on the Tahoe National Forest. The gravelly substrate of Bear Creek does not provide suitable habitat for the species.
Mammals				

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
American pika *Ocnotona princeps schisticeps*	CNDDB	None[2]	Alpine and sub-alpine slopes in the Sierra Nevada from about 7,000 to 12,000 feet elevation. Broken rock habitats such as montane talus fields, old lava flows, old ore-dumps, construction rubble, eroding bedrock outcrops, crevices and cracks in bedrock, lava cones, rip-rap, and abandoned stone houses. Vegetation communities include conifer stands, shrub patches, and meadows.	Known to occur. Suitable habitat exists in the watershed. CNDDB records show occurrence with an accuracy of 1 mile in the Ward Peak area; however, the record is from 1937. CNDDB predicted habitat models rank the high altitude areas of the watershed as high habitat suitability.
California wolverine *Gulo gulo luteus*	CNDDB	ST, FPT, USFS-S	Lodgepole pine forest, mixed conifer, red fir, montane chaparral, and montane wet meadow. Elevation range is 4,300-7,300 feet.	Unlikely to occur. USFS remote sensor cameras detected one individual near the Webber Lake area in 2008, 2009, and 2010, approximately 20 miles northwest of the watershed. One individual was observed in the Truckee area in 2016. This species is known to have a large home range; however, the species' rarity and its sensitivity to human disturbance makes it unlikely that the species would occur in the watershed. CNDDB record from Squaw Valley is from 1950s and is now located in a heavily developed resort area.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Fisher, West Coast DPS *Pekania pennanti*		SCT, FPT, CSSC, USFS-S	Mixed conifer with closed canopies and complex understory structure, montane riparian scrub. Elevation range is 4,000–8,000 feet.	Unlikely to occur. The fisher population has been reduced to two native populations in the southern Sierra and the Klamath-Siskiyou region. All CNDDB records in the general vicinity of the watershed are from prior to 1980.
Fringed myotis *Myotis thysanodes*	USFS	USFS-S	Crevice-rooster in caves, mines, and buildings associated with foothill hardwood, pinyon-juniper, and hardwood-conifer habitats from approximately 4,000 to 7,000 feet.	May occur. Suitable habitat exists within the watershed. CNDDB predicted habitat models rank the open areas east of the Five Lakes as high habitat suitability.
North American porcupine *Erethizon dorsatum*	CNDDB	None[2]	Most common in montane conifer, Douglas fir, alpine dwarf-shrub, and wet meadow habitats. Less common in hardwood, hardwood-conifer, riparian, aspen, pinon-juniper, low sage, sagebrush, and bitterbrush habitats.	Known to occur. CNDDB records report occurrence on watershed in 2011 and 2016. Suitable habitat is present on the watershed.
Pallid bat *Antrozous pallidus*	USFS	CSSC, USFS-S	Roosts in natural crevices in rock outcrops, caves, mines, trees (including bole cavities of oaks, exfoliating ponderosa pine and valley oak bark, and deciduous trees in riparian areas), and various human structures, such as bridges, barns, and vacant buildings.	Potential to occur. Suitable habitat exists in the watershed. CNDDB predicted habitat models rank the open areas east of the Five Lakes as high habitat suitability and east of Juniper Mountain Road as moderate.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Sierra marten *Martes caurina sierrae*	CNDDB	USFS-S	Old growth fir forests and high elevation riparian lodgepole pine associations. Elevation range is 3,400-10,400 feet.	Known to occur. Detected by camera trap on the south side of Bear Creek in the watershed in 2010. Suitable habitat is present on the watershed.
Sierra mountain beaver *Aplodontia rufa californica*	CNDDB	CSSC	Open and intermediate-canopy coverage in riparian-deciduous vegetation with a dense understory near water. Deep, friable soil for burrowing. Elevation range is 5,800-7,600 feet.	Known to occur. One individual was observed near a burrow south of Bear Creek in 2004 and numerous CNDDB records reported from watershed vicinity. Suitable habitat is present on the watershed.
Sierra Nevada snowshoe hare *Lepus americanus tahoensis*	CNDDB	CSSC	Montane riparian scrub, mixed conifer, lodgepole pine forest, aspen, chaparral, montane meadow. Elevation range is 4,850-8,600 feet.	May occur. One individual was observed by camera trap within 5 miles of the watershed in 2013. Suitable habitat is present on the watershed.
Townsend's big-eared bat *Corynorhinus townsendii*	USFS	CSSC, USFS-S	Roosts in caves or cave-like features, including rock outcrops, mines, natural cavities, and occasionally hollow trees. May use separate sites for night, day, hibernation, or maternity roosts. Prefers mesic habitats.	May occur. Found throughout California. CNDDB predicted habitat models suggest that habitat within the watershed is ranked as moderately suitable for the species.
Western white-tailed jackrabbit *Lepus townsendii townsendii*	CNDDB	CSSC	Sagebrush, early successional stages of various conifer habitats, juniper, alpine dwarf-shrub, perennial grassland, and wet meadows.	Unlikely to occur. Only record within 5 miles of the watershed is from 1920. Habitat is marginal within the watershed.

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings		Ecology	Threat
Reptiles				
Western pond turtle *Actinemys marmorata*	USFS	CSSC, USFS-S	Slow-moving rivers, streams, lakes, ponds, wetlands, reservoirs, and brackish estuarine waters with deep pools and rocks, logs, and other exposed surfaces for basking. Elevation ranges from sea level to 6,696 feet but are generally below 4,980 feet.	Unlikely to occur. Western pond turtles are typically found below approximately 7,000 feet in elevation.
Critical Habitat Occurring in the Bear Creek Watershed				
Sierra Nevada yellow-legged frog critical habitat	Critical habitat for the species is found within a large portion of the Bear Creek Watershed.			

Notes: CDFW = California Department of Fish and Wildlife; CNDDB = California Natural Diversity Database; DPS = Distinct Population Segment; HTH = H. T. Harvey & Associates; USFS = U.S. Forest Service; USFWS = U.S. Fish and Wildlife Service.

[1] Status Codes

U. S. Fish and Wildlife Service

FE: Federally listed as endangered

FT: Federally listed as threatened

California Department of Fish and Game

SE: State listed as endangered

ST: State listed as threatened

Table A1. Invasive Plants with Potential to Occur in the Bear Creek Watershed

Species	Ratings	Ecology Threat

SCT: State candidate for threatened status

CSSC: California Species of Special Concern

FP : California Fully Protected Species

Region 5, Tahoe National Forest

USFS-S: U.S. Forest Service Sensitive Species (USFS 2013b)

[2]Species without Designated Status: These species were included because distribution and abundance is currently being monitored by CDFW in the CNDDB due to the species' declining population size, previous listing petitions, or lack of scientific data on habitat use or population status. Some of these species may be designated as California Species of Special Concern by CDFW in the future.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Alder buckthorn *Rhamnus alnifolia*	Perennial deciduous shrub	CRPR 2.B2	Meadows and riparian areas in conifer forests, elevation 4,521 to 7,029 feet	Alpine County, Tahoe/Truckee, Lake Almanor vicinity; known along upper Little Truckee River and along Truckee River just east of the watershed. Observed near intersection of Squaw Creek Road and Highway 89 in 2009 and 2015 and on the west side of Highway 89 northwest of Goose Meadow campground in 2009.	Known to occur; recorded along Bear Creek but not observed recently (CNDDB occ. no. 3). Suitable habitat exists in meadows and riparian areas throughout the watershed.
American manna grass *Glyceria grandis*	Perennial rhizomatous grass	CRPR 2B.3	Bogs, fens, wet meadows, seeps, marshes, swamps, streambanks, and lake margins, elevation 3,445 to 6,725 feet	North Coast Range, Sierra Nevada, and east of the Sierra Nevada in the Great Basin	May occur. Recorded just outside the watershed, approximately 650 feet below confluence of Bear Creek and Truckee River (CNDDB occ. no. 11). Suitable habitat exists in wet meadows and along Bear Creek, other streams, and lakes throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Amethyst stickseed *Hackelia amethystina*	Perennial herb	CRPR 4.3	Openings and disturbed areas in lower and upper montane coniferous forest, meadows, and seeps, elevation 5,085 to 7,150 feet	Northern Coast Range, northern Sierra Nevada	Known to occur; recorded in the watershed in 1912 (CCH 2017), but no recent records exist. Suitable habitat exists in forests, meadows, and seeps throughout the watershed.
Austin's astragalus *Astragalus austiniae*	Perennial herb	CRPR 1B.3	Rocky habitats in alpine boulder and rock fields and subalpine coniferous forests, elevation 7,610 to 8,825 feet	Known only from the Lake Tahoe Region	May occur. Two recent records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in rocky habitats in the higher elevations of the watershed.
Bolander's bruchia *Bruchia bolanderi*	Moss	CRPR 4.2 USFS – S	Damp soil in lower and upper montane coniferous forest, meadows, and seeps, elevation 5,740 to 7,875 feet	Widely distributed but uncommon throughout Sierra Nevada; may be found in meadows and seeps	Potential to occur. No records within 5 miles of the watershed. Suitable habitat present in forests, meadows, and seeps throughout watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Clustered-flower cryptantha *Cryptantha glomeriflora*	Annual herb	CRPR 4.3	Granitic, volcanic, or sandy soils in Great Basin scrub, meadows, seeps, subalpine coniferous forest, and upper montane coniferous forest, elevation 7,315 to 11,320 feet	High elevations in the Sierra Nevada and east of the Sierra Nevada in the Great Basin	Potential to occur. No records within 5 miles of the watershed. Suitable habitat present in forests, meadows, and seeps throughout watershed.
Davy's sedge *Carex davyi*	Perennial herb	CRPR 1B.3	Subalpine and upper montane conifer forest, elevation 4,950 to 10,560 feet	Yosemite north through Truckee/Tahoe Basin	May occur. Recorded in meadows along the Truckee River adjacent to the watershed, but record is from 1897 (CNDDB occ no. 19). Suitable habitat exists in forests throughout the watershed.
Donner Pass buckwheat *Eriogonum umbellatum* var. *torreyanum*	Perennial herb	CRPR 1B.2 USFS -S	Openings in upper montane coniferous forest on rocky, volcanic soils, meadows and seeps, elevation 6,122 to 8,646 feet	Tahoe Basin and Donner Pass	May occur. Several recent records within 5 miles of the watershed, and suitable habitat in forests throughout the watershed.
Felt-leaved violet *Viola tomentosa*	Perennial herb	CRPR 4.2	Gravelly soils in subalpine coniferous forests, and in lower and upper montane coniferous forests, elevation 4,755 to 8,235 feet	High elevations in the northern to central Sierra Nevada	Potential to occur. No records within 5 miles of the watershed. Suitable habitat exists in forests throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Fresno ceanothus *Ceanothus fresnensis*	Shrub	CRPR 4.3	Openings or clearings in cismontane woodlands and lower montane coniferous forests, elevation 4,755 to 8,235 feet	Northern and central Sierra Nevada	Potential to occur. No records within 5 miles of the watershed. Suitable habitat exists in forests throughout the watershed.
Galena Creek rockcress *Arabis rigidissima* var. *demota*	Perennial herb	CRPR 1B.2	Sandy or rocky soils in broadleaf upland forest and upper montane coniferous forest, elevation 7,398 to 8,399 feet	Tahoe Basin	May occur. Two recent records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in forests in the higher elevations of the watershed.
Hiroshi's flapwort *Nardia hiroshii*	Liverwort	CRPR 2B.3	Moist soil, meadows, and seeps with underlying granitic bedrock, elevation range unknown	Only known from Nevada County	Unlikely to occur. No records within 5 miles of the watershed and not known to occur in Placer County, but species could be more widespread than currently known. Suitable habitat exists in meadows and seeps in the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Long petaled lewisia *Lewisia longipetala*	Perennial herb	CRPR 1B.3 USFS – S	Alpine boulder and rock, granite soils, subalpine conifer forest, elevation 6,235 to 8,760 feet	Known from El Dorado, Placer, and Nevada Counties; Emigrant Pass to Donner Pass	May occur. Two recent records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in rocky habitats and subalpine forests in the watershed.
Marsh skullcap *Scutellaria galericulata*	Perennial rhizomatous herb	CRPR 2B.2	Lower montane coniferous forest, meadows, seeps, and marshes, elevation 3,280 to 5,875 feet	Tahoe Basin and the Modoc Plateau	Potential to occur. No records within 5 miles of the watershed. Suitable habitat in forests, meadows, and seeps throughout the watershed.
Mingan moonwort *Botrychium minganense*	Rhizomatous fern	CRPR 2B.2	Mesic habitats in lower and upper montane coniferous forests, and around the edges of meadows and seeps, elevation 5,185 to 10,105 feet	High elevations in the Cascade and Sierra Nevada	Potential to occur. No records within 5 miles of the watershed. Suitable habitat in forests, meadows, and seeps throughout the watershed.
Mud sedge *Carex limosa*	Perennial grass-like rhizomatous herb	CRPR 2B.2	Bogs, fens, meadows, and seeps in conifer forests, elevation 5,085 to 7,840 feet	Central Sierra Nevada, South Lake Tahoe/Emigrant Pass, Cascades	Potential to occur. No records within 5 miles of the watershed. Suitable habitat in forests, meadows, and seeps throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Munro's desert mallow *Sphaeralcea munroana*	Perennial herb	CRPR 2B.2	Great Basin scrub	Only known from Squaw Creek, Placer County	May occur. One record within 5 miles of the watershed is from 1920 (CNDDB 2017). Suitable habitat exists in alpine-dwarf shrub habitat in the watershed.
Nevada daisy *Erigeron eatonii* var. *nevadinicola*	Perennial herb	CRPR 1B.2	Volcanic and rocky soils, meadows and seeps, upper montane coniferous forest, elevation 6,235 to 8,565 feet	Sierra Nevada in Sierra, Placer, and Nevada Counties	Potential to occur. No records within 5 miles of the watershed. Suitable habitat exists in forests, meadows, and seeps throughout the watershed.
Nuttall's ribbon-leaved pondweed *Potamogeton epihydrus*	Perennial herb	CRPR 2B.2	Shallow water, ponds, lakes, and streams. elevation 2,495 to 8,565 feet	Outer North Coast ranges, high elevation Sierra Nevada, and the Modoc Plateau	May occur. One record from within 5 miles of the watershed is from 1932 (CNDDB occ. no. 22). Suitable habitat exists in lakes, ponds, and streams throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Oregon fireweed *Epilobium oreganum*	Perennial herb	CRPR 1B.2	Bogs, small streams, elevation 2,590 to 8,495 feet	Outer North Coast ranges and Klamath range. Also recorded in Sierra Nevada	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017); closest records to the watershed are from 1985 or earlier (CCH 2017). Suitable habitat exists in small streams in the watershed.
Plumas ivesia *Ivesia sericoleuca*	Perennial herb	CRPR 1B.2 USFS – S	Seasonally wet, volcanic soils in Great Basin scrub and lower montane conifer forest, elevation 4,690 to 7,185 feet	Eastern Sierra Valley north to Janesville	Unlikely to occur. No records within 5 miles of the watershed (CNDDB 2017). Species range restricted in/around the Sierra Valley and suitable habitat largely absent from watershed.
Robbins' pondweed *Potamogeton robbinsii*	Perennial rhizomatous herb	CRPR 2B.3	Deep water, lakes, elevation 5,150 to 10,825 feet	Sierra Nevada, Cascades, North Coast Range; could be found within lakes and ponds	Unlikely to occur. No records within 5 miles of the watershed (CNDDB 2017 and suitable habitat generally absent.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Santa Lucia dwarf rush *Juncus luciensis*	Annual grass-like herb	CRPR 1B.2	Chaparral, Great Basin scrub, meadows, vernal pools, elevation 1,085 to 6,365 feet	Martis Valley north through Cascades, Central and Southern Coast Range	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in montane chaparral, alpine-dwarf shrub habitat, and meadows in the watershed.
Scalloped moonwort *Botrychium crenulatum*	Perennial rhizomatous herb	CRPR 2B.2 USFS – S	Bogs, fens, seeps, meadows, elevation 4,184 to 10,824 feet	Distributed throughout Sierra Nevada, populations known from Tahoe NF and Sagehen Creek	May occur. Two records within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in seeps, stream edges, forests, and meadows throughout the watershed.
Sierra starwort *Pseudostellaria sierrae*	Perennial rhizomatous herb	CRPR 4.2	Meadows and dry understory of mixed oak or conifer forest, elevation 4,135 to 6,760 feet	North and central Sierra Nevada high	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in meadows and forests throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Slender-leaved pondweed *Stuckenia filiformis* ssp. *alpina*	Perennial herb	CRPR 2B.2	Shallow, clear water of marshes, swamps, lakes, and drainage channels, elevation 984 to 7,053 feet	San Joaquin Valley, San Francisco Bay area, and the central high Sierra Nevada	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in meadows, lakes, and drainages throughout the watershed.
Starved daisy *Erigeron miser*	Perennial herb	CRPR 1B.3 USFS – S	Granite outcrops in upper montane coniferous forest, elevation 6,072 to 8,646 feet	Nevada and Placer Counties, Lake Tahoe Basin Management Unit, Bridgeport vicinity, Donner Pass, Lake Almanor vicinity	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in higher elevation forests throughout the watershed.
Stebbin's phacelia *Phacelia stebbinsii*	Annual herb	CRPR 1B.2 USFS – S	Cismontane woodland, lower montane coniferous forest, and meadows and seeps, elevation 3,480 to 6,560 feet	El Dorado, Placer, and Nevada Counties; American and Yuba River drainages	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in forests, meadows, and seeps throughout the watershed.
Tahoe yellow cress *Rorippa subumbellata*	Perennial rhizomatous herb	CRPR 1B.1	Decomposed granite, lower montane coniferous forest, meadows and seeps, elevation 6,200 to 6,825 feet	Known in CA only from Lake Tahoe; many historical occurrences extirpated	Unlikely to occur. Range is restricted to shoreline of Lake Tahoe.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Three-ranked hump moss *Meesia triquetra*	Moss	CRPR 4.2 USFS – S	Meadows and seeps, bogs and fens, subalpine coniferous forest, mesic upper montane coniferous forest, elevation 6,235 to 7,415 feet	Widely distributed but uncommon in Sierra Nevada, Cascades, North Coast; known from Tahoe NF in fen-like wet meadows and similar habitats	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in forests, meadows, and seeps throughout the watershed.
Threetip sagebrush *Artemisia tripartita* ssp. *tripartita*	Perennial shrub	CRPR 2.B3	Openings in upper montane conifer forest on rocky, volcanic soils, elevation 7,260 to 8,580 feet	Tahoe Basin and Plumas County.	May occur. Observed adjacent to the watershed on the southeast slope of Ward Peak in 2005 (CNDDB occ. no. 1). Suitable habitat exists in forests at higher elevations in watershed.
Water awlwort *Subularia aquatic* ssp. *americana*	Annual herb	CRPR 4.3	Lake and wetland margins, streambanks, wet sedge meadows, muddy flats, and salt marshes in upper montane coniferous forest, elevation 6,300 to 9,710 feet	Yosemite north to Cascades; could occur along lake margins	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists along lake shores, wet meadows, and streambanks in the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Western goblin *Botrychium montanum*	Rhizomatous fern	CRPR 2B.1	Mesic habitats, lower montane coniferous forest, meadows and seeps, upper montane coniferous forest, often in association with incense cedar, elevation 5,280 to 5,415 feet	Cascade Range, Sierra Nevada, and the Warner Mountains.	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists in forests, meadows, and seeps in the watershed.
Woolly-fruited sedge *Carex lasiocarpa*	Perennial, grass-like, rhizomatous herb	CRPR 2B.3	Bogs, fens, marshes, swamps, and freshwater lake margins, elevation 2,100 to 6,430 feet	Klamath Range, Cascade Range, and the Sierra Nevada (Plumas County).	Potential to occur. No records within 5 miles of the watershed (CNDDB 2017). Suitable habitat exists along lake shores and in wetlands throughout the watershed.
Woolly-leaved milk-vetch *Astragalus whitneyi* var. *lenophyllus*	Perennial herb	CRPR 4.3	Alpine boulder and rock field, and rocky subalpine coniferous forest, elevation 4,265 to 9,350 feet	Klamath Range and the northern Sierra Nevada; Tahoe Basin, Donner Pass, Butte, Plumas and Alpine Counties	Known to occur; recorded in the watershed in 1915 (CCH 2017), but there are no recent observations. Suitable habitat exists in forests throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence
Upswept moonwort *Botrychium ascendens*	Rhizomatous fern	CRPR 2B.3	Mesic, lower montane coniferous forest, meadows and seeps, elevation 5,710 to 9,480 feet	Southern Cascade Range, central Sierra Nevada, and east of the Sierra Nevada.	May occur. One record within 5 miles of the watershed (CNDDB 2017), and suitable habitat exists in forests, wet meadows, and seeps throughout the watershed.

Table A2. Special-Status Plants, Their Status, and Their Potential to Occur in the Bear Creek Watershed

Species	Lifeform	Status[1]	Habitat	Distribution	Potential for Occurrence

Notes: CNDDB = California Natural Diversity Database; occ. no. = occurrence number in the CNDDB.

[1] Status Codes:

California Native Plant Society

CRPR (California Rare Plant Ranks):

1A. Presumed extinct in California

1B. Rare or Endangered in California and elsewhere

2. Rare or Endangered in California, more common elsewhere

3. Plants for which we need more information - Review list

4. Plants of limited distribution - Watch list

Threat Code extensions and their meanings:

.1 - Seriously endangered in California

.2 – Fairly endangered in California

.3 – Not very endangered in California

Note that all List 1A (presumed extinct in California) and some List 3 (need more information- a review list) plants lacking any threat information receive no threat code extension

Region 5, Tahoe National Forest

USFS – S: U.S. Forest Service Sensitive Species (USFS 2013c)

APPENDIX B

History, Culture, and Historical Land-Use (Lindstrom, 2017)

APPENDIX C

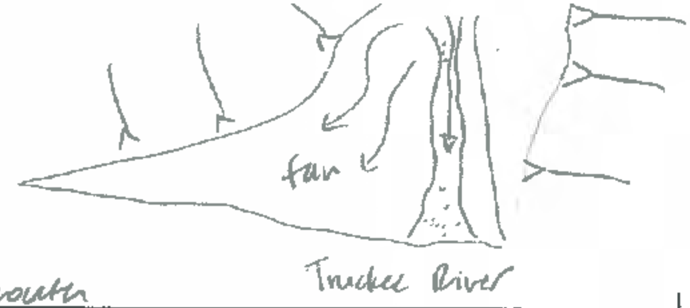
Representative Photographs of Bear Creek by Reach with GPS Location Coordinates (Transmitted Separately)

APPENDIX D

Stream Reconnaissance Field Forms

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet



Project:	217121
Date:	10/10/17
Staff:	BKH

General Location Description: Reach A – 100' u/s of mouth

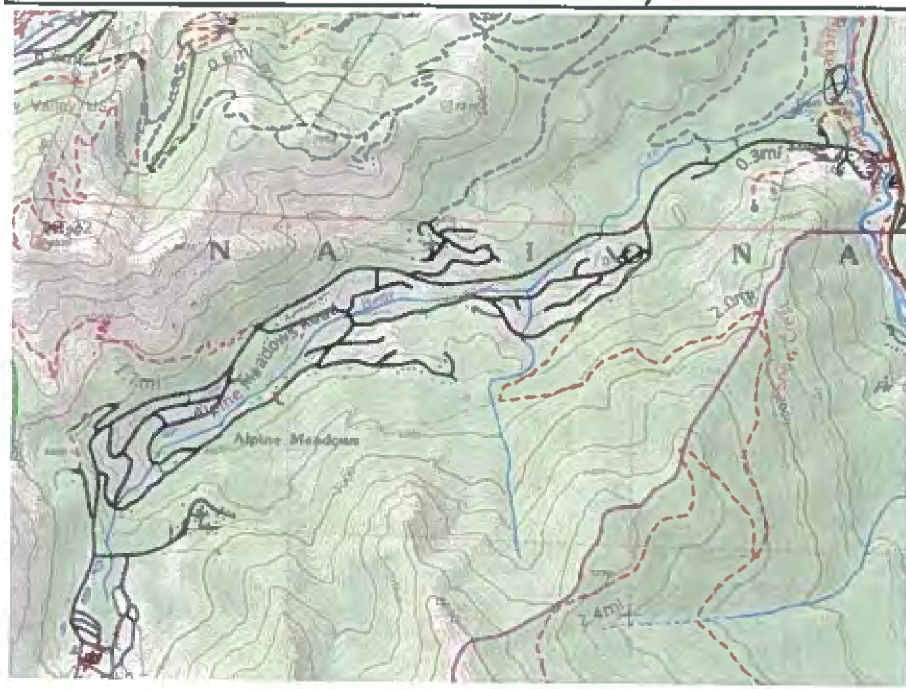
2nd biggest flood of record!

Site Information		Geomorphology						Channel Geometry					Habitat						
								Incised channel			Bankfull' Channel								
GPS I.D	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
179		spr	s, d	g, s	23mm	al	s+e	yes	3.0	55	2.0	37	yes	?	?	?	No	<15	yes

Describe your observations, conditions:

beaver activity; channel appears locked in w/ old pines 3'D BH
bed conditions rich in algae even though scoured this winter

[shallow pool]



Plan view and Cross-section sketches:

HWM = Jan 8, 2017?

possible backwatering from TR

* Not sure if restoration is realistic here — access, integrity

1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©.
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles.
4. Geological Environment: Glacial till, moraine or outwash (gl), lacustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Access → spider excavator from bike path across TR. Use local trees?
Some dead and down can be moved strategically.

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

General Location Description:

Project	217121
Date	10/10/17
Staff	BKH

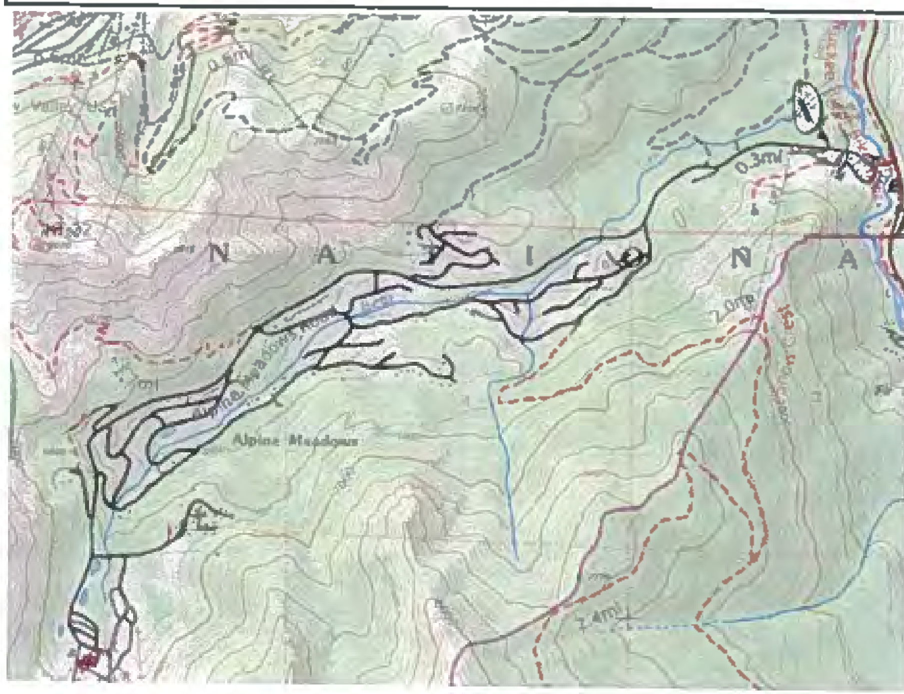
Site Information | Geomorphology | Channel Geometry | Habitat

GPS I.D.	Photo I.D	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Incised channel: Maximum bank height (bed to terrace surface)	Incised channel: Maximum Channel Width (terrace to terrace)	Bankfull Channel: Active Channel Depth	Bankfull Channel: Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
180		spr	s	s, g, c, b	45mm	al	s+e	yes?	3.5	40	2.5	28	yes	50/50	40	30	yes	20	yes

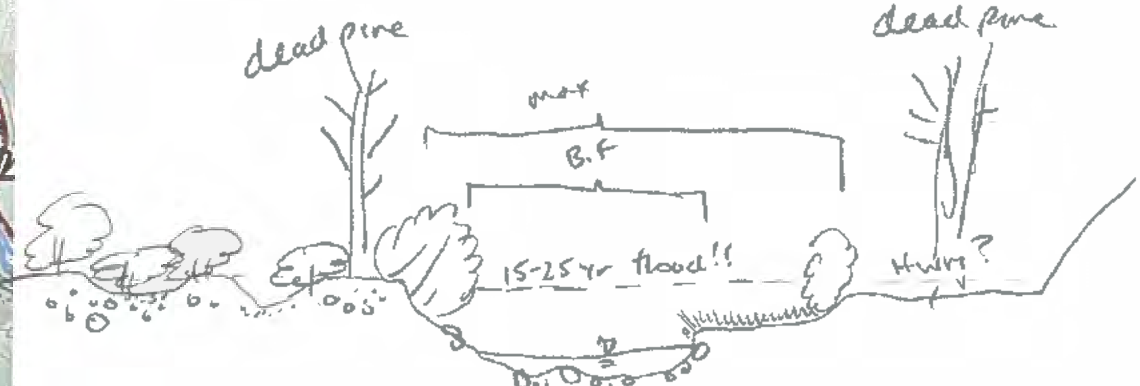
Describe your observations, conditions:

Channel seems fixed in by pines – but old/dead abundant willow on fan/delta

*abundant algae on bed.



Plan view and Cross-section sketches:



– could we load up channel w/ boulders/LWD → kick flow sed to fan?

1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr), planebed (pb); step-pool (sp); cascade ©;
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles, bedrock (br)
4. Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

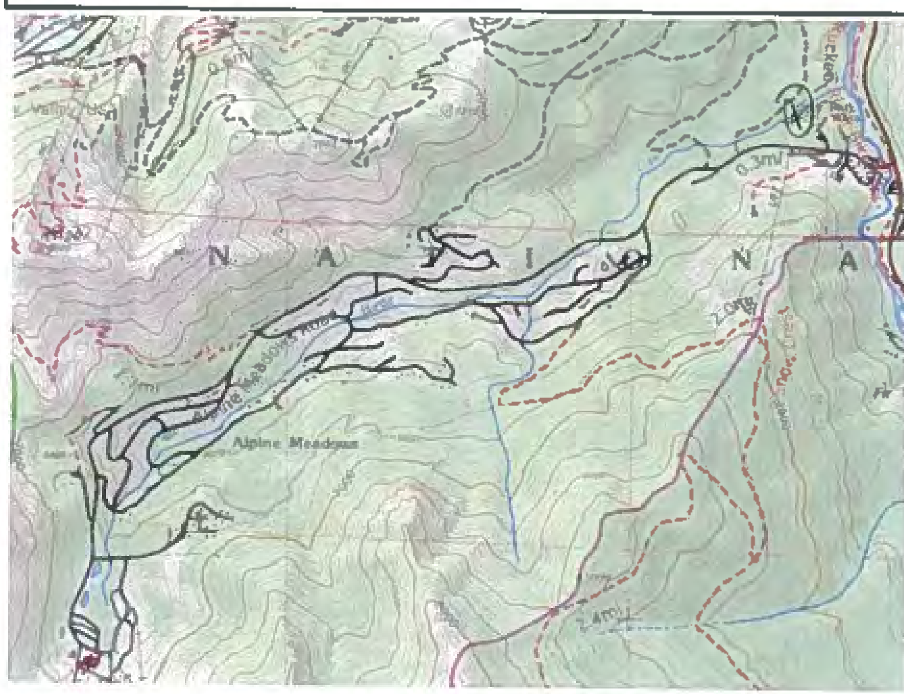
Project:	217121
Date:	10/12/17
Staff:	RKH

General Location Description: cut canyon — thru moraine Tioga?

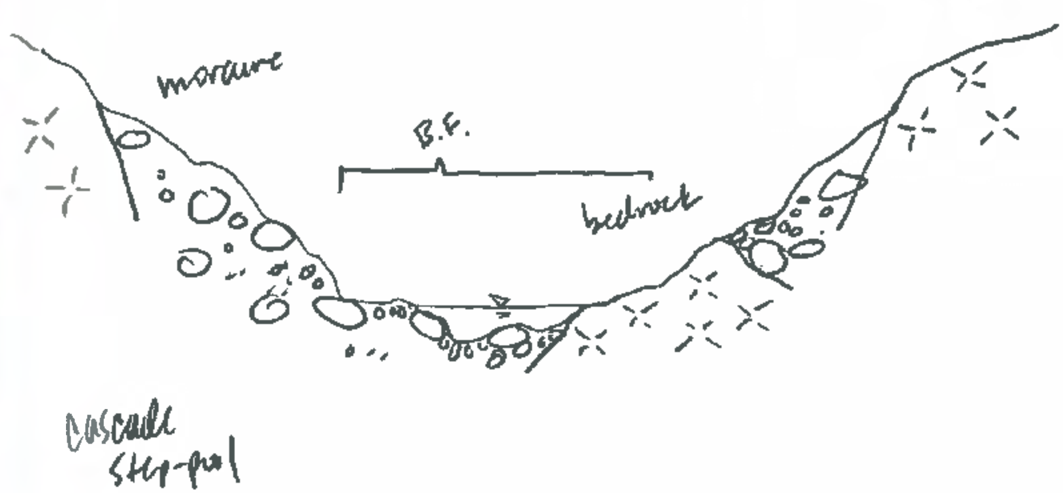
Site Information		Geomorphology						Channel Geometry						Habitat					
									Incised channel		Bankfull* Channel								
GPS I.D	Photo I.D	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
		sp,c	s	c,b	>256	m	s	No	—	—	3.0	25-35	—	—	—	—	yes	25	No

Describe your observations, conditions:

No restoration recommended in this reach



Plan view and Cross-section sketches:



1 Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©;
2 Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3 Bed composition: clay, silt, sand, gravels, cobbles,
4 Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

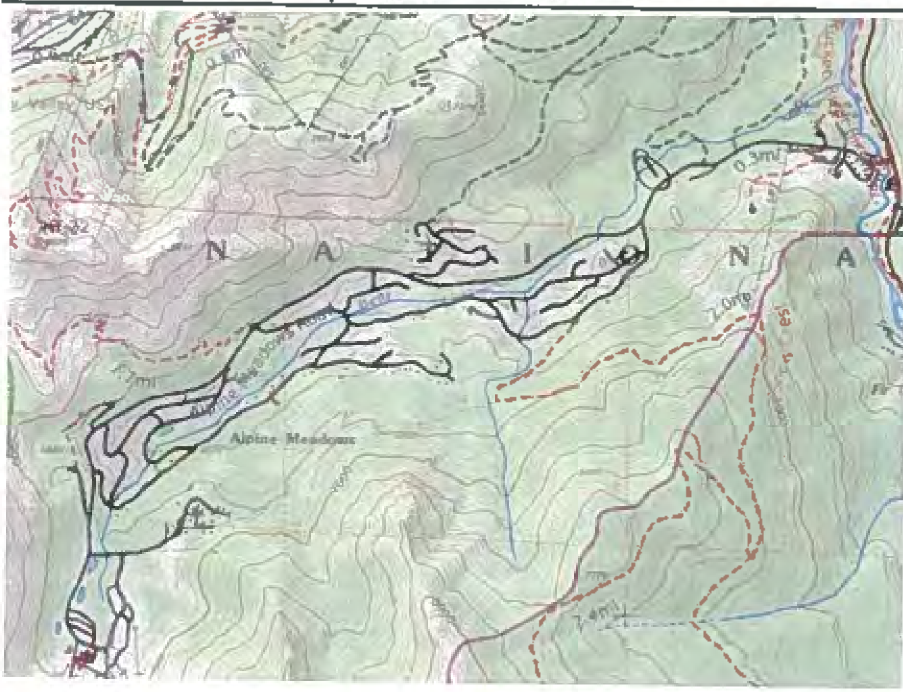
Project:	217121
Date:	10/10/17
Staff:	RKH

General Location Description: "Middle section of Lower Bear Creek Meadow"

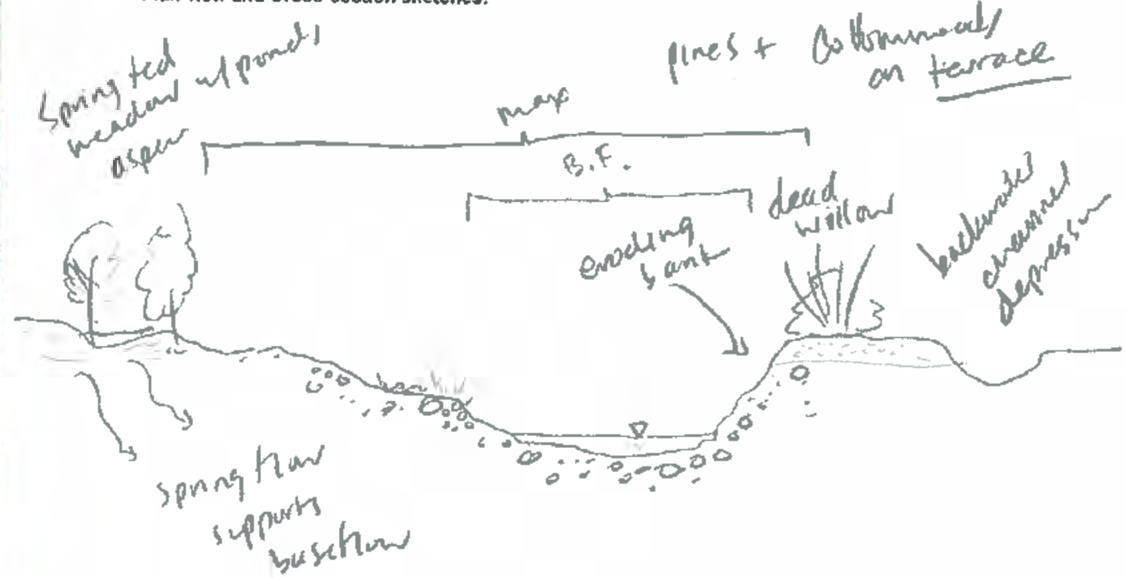
Site Information		Geomorphology						Channel Geometry						Habitat					
									Incised channel		Bankfull Channel								
GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?	?	(ft)	(ft)	yes/no	%	yes/no
181	✓	mpr	s, b	g, c	45	gl, al	e	yes	5'-8'	~~[illegible]~~ 60+	3.0	22	yes	50/50	65	75	yes	< 15	yes

Describe your observations, conditions: → historically braided, today incised

definitely need to evaluate meadow stressors → stormwater? Evaluate historical aerials, oral accounts. → Susan?



Plan view and Cross-section sketches:



1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©;
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles.
4. Geological Environment: Glacial till, moraine or outwash (gl) lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

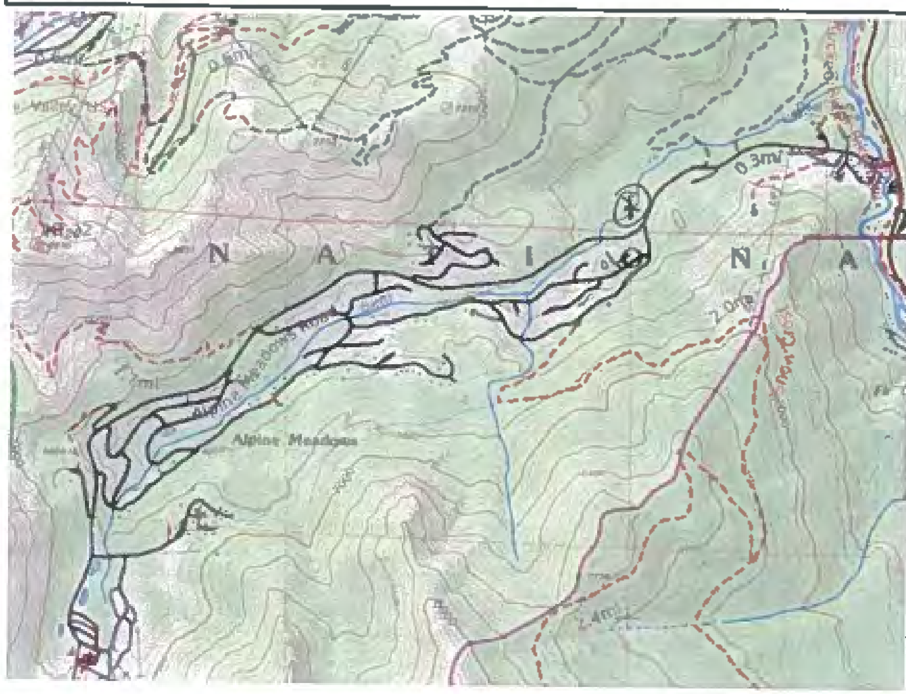
General Location Description: showing silts + algae in pools

Project	217121
Date	10/10/17
Staff:	BKH

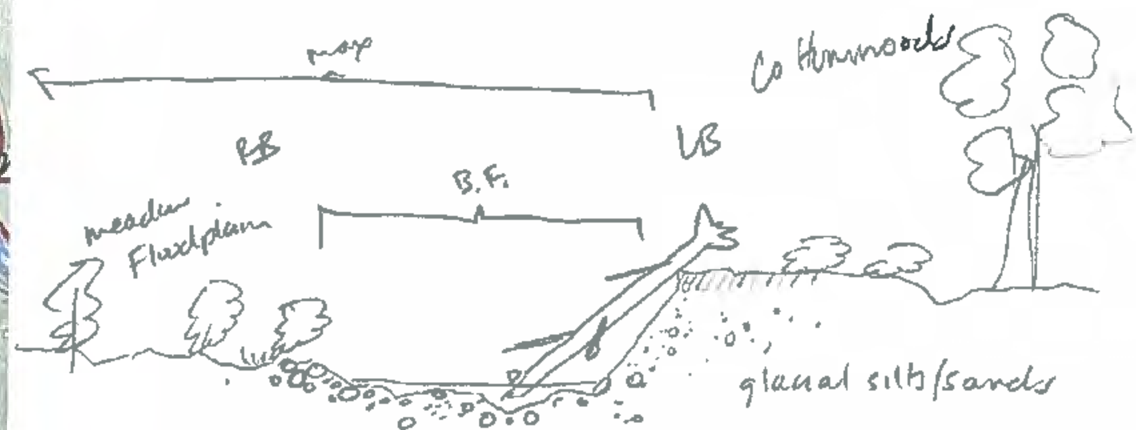
Site Information		Geomorphology						Channel Geometry						Habitat					
								Incised channel			Bankfull Channel								
GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
182	✓	mpr	s, b	s, s, g, c	16	gl, al	e	yes	6-7'	50+	2.5	30	yes/no!	60/40	30	60	yes	<15	yes

Describe your observations, conditions:

* see other notes in notebook



Plan view and Cross-section sketches:



1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©.
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles.
4. Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

General Location Description: Reach D

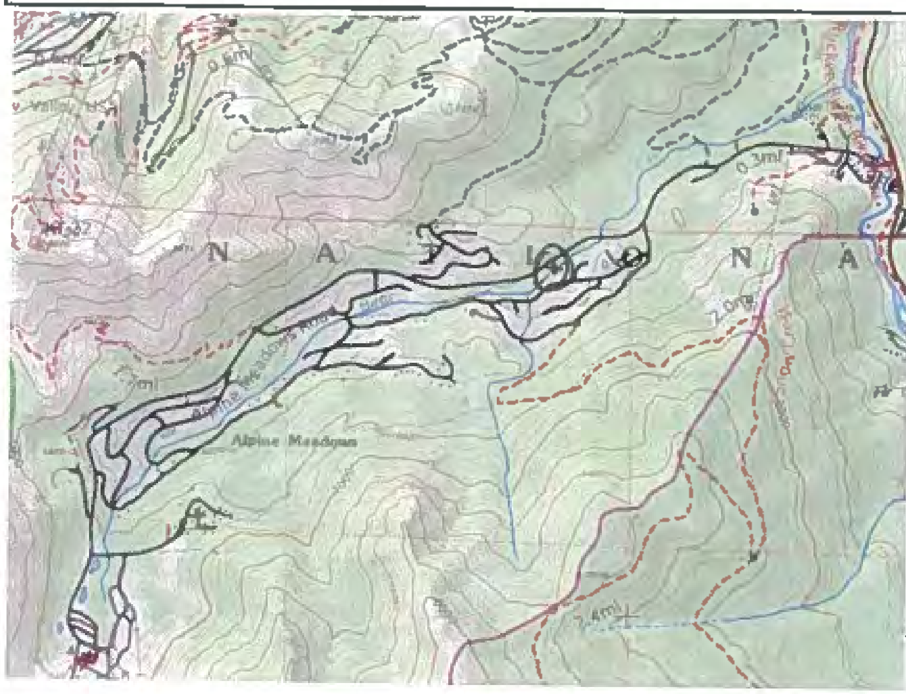
*appears reach episode of scouring/incision – willows and boulders maintain form

Project	217121
Date	10/10/17
Staff	BKa

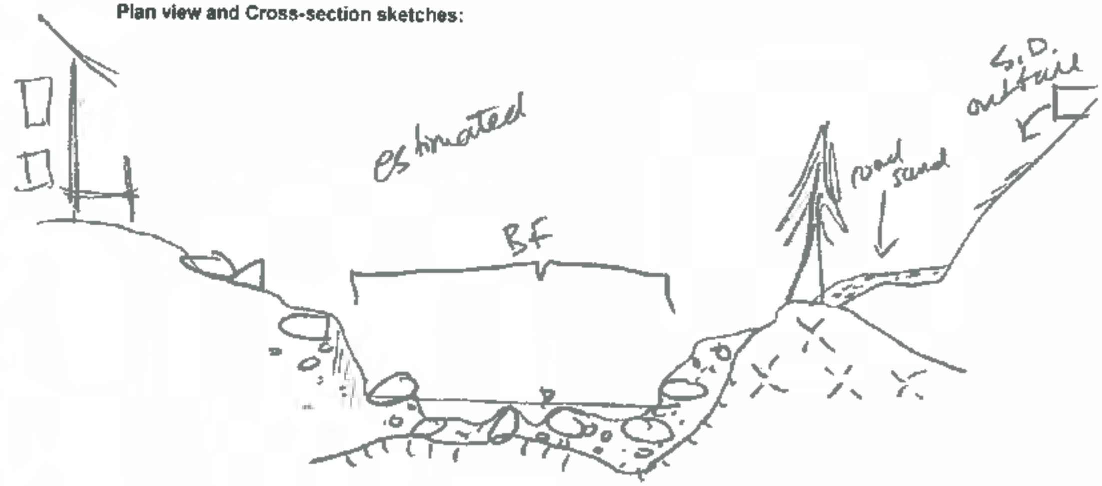
Site Information		Geomorphology						Channel Geometry	Incised channel		Bankfull' Channel			Habitat					
GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2017 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
	✓	sp ~~[illegible]~~	S	S,G,b, br ~~[illegible]~~	>256	gl, br		yes*	?	?	3.0	~25	?	—	—	—	yes		yes

Describe your observations, conditions:

private property on right bank — Placer County left bank?



Plan view and Cross-section sketches:



1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb), step-pool (sp), cascade ©,
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles,
4. Geological Environment: Glacial till, moraine or outwash (gl), lacustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Multiple fish in pool under bridge 2"–6"

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

Project	217121
Date	10/10/17
Staff	BKH

General Location Description: ~200–250' d/s of bridge crossing, Reach E

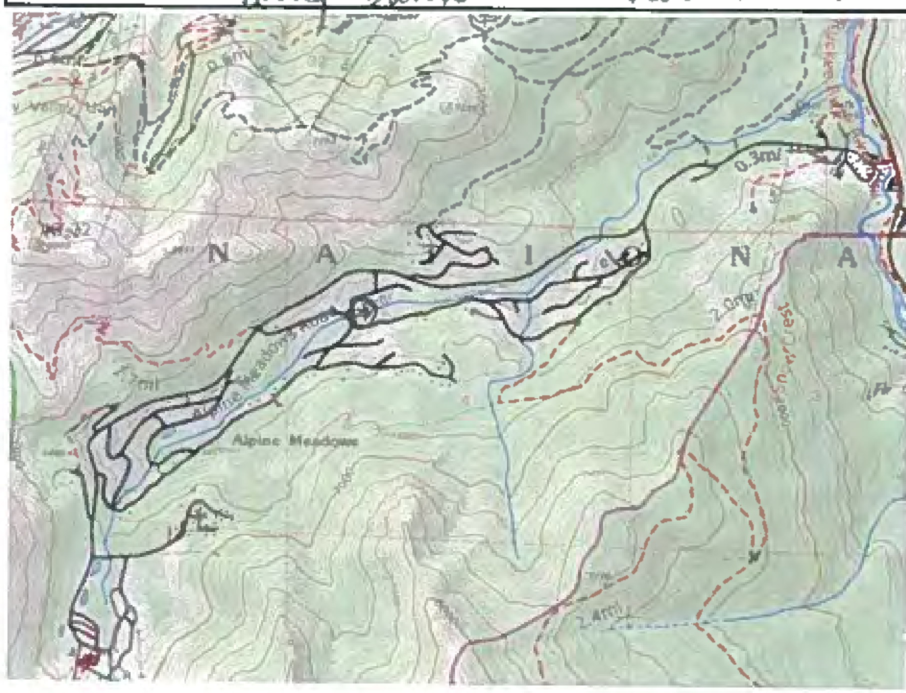
Site Information **Geomorphology** **Channel Geometry** (Incised channel; Bankfull' Channel) **Habitat**

GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2016 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
187	✓	spr	s	S g, c	23	al	eroding	~yes	3.0	50+	2.0	15	yes	50/50	25	20	yes	50	yes

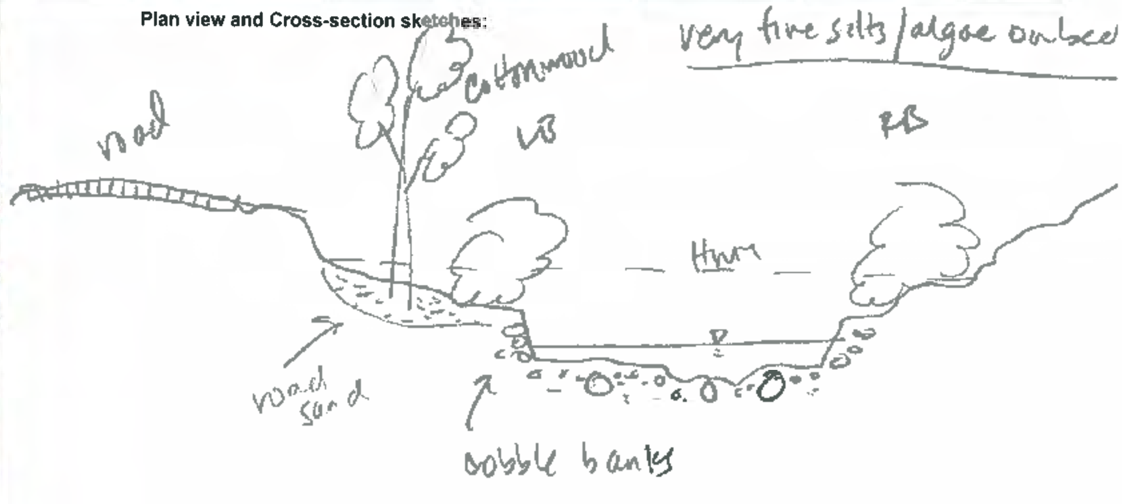
Describe your observations, conditions:

→ intermittently — likely cause — stormwater

visible road sand in channel and along banks → road runoff discharge @ bridge and d/s points.



Plan view and Cross-section sketches:



— recommend stormwater detention/sed detent along bridge crossing

1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©;
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles,
4. Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

Project	217121
Date	10/10/17
Staff	BKH

General Location Description: 200' d/s of diversion for pond, Reach G

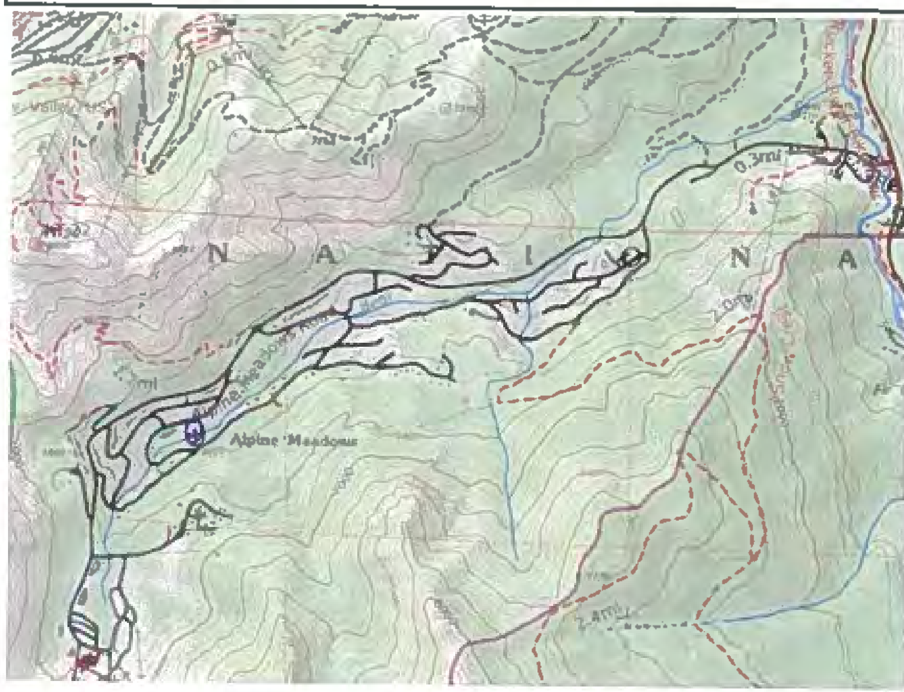
Site Information | **Geomorphology** | **Channel Geometry** | **Habitat**

GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Incised channel: Maximum bank height (bed to terrace surface)	Incised channel: Maximum Channel Width (terrace to terrace)	Bankfull* Channel: Active Channel Depth	Bankfull* Channel: Active Channel Width	Did WY2016 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
184	✓	SP	S	g,c,b	>256	gl	S	no	[illegible]	[illegible]	3.0	25	?		—	10	no	70	NO

Describe your observations, conditions:

water clear — slimy algae on rocks. ; no evidence of road sand in channel

resilient reach due to boulders, willow lined banks



Plan view and Cross-section sketches:

1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb); step-pool (sp); cascade ©;
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d), engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles,
4. Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

Balance Hydrologics, Inc.

Stream Reconnaisance Field Sheet

historically?

General Location Description: Reach I

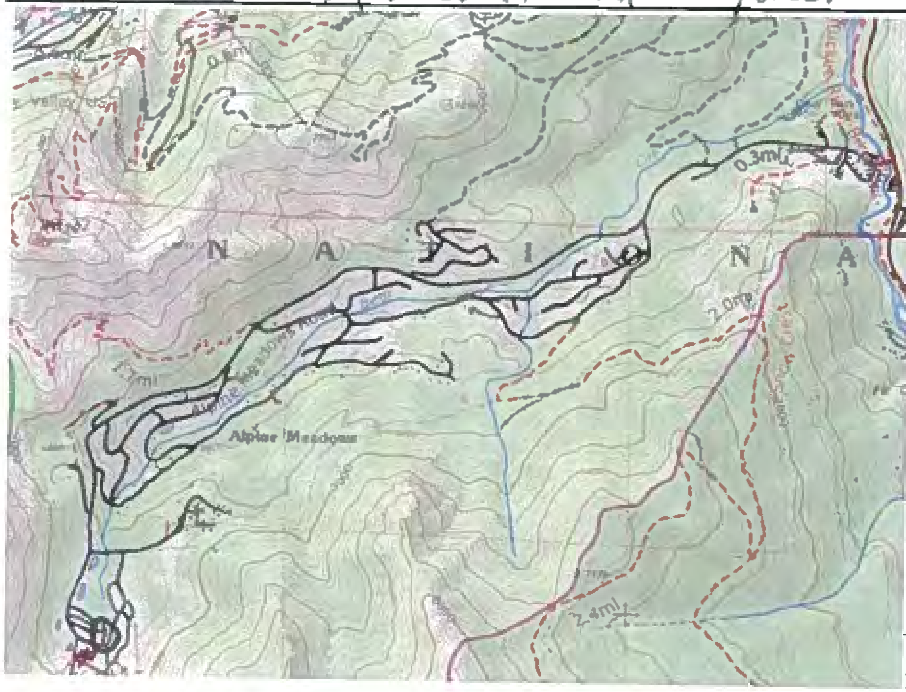
Project	217121
Date	10/10/17
Staff	BKH

Site Information		Geomorphology						Channel Geometry: Incised channel		Bankfull Channel			Habitat					
GPS I.D.	Photo I.D.	Channel Bedform[1]	Channel Planform[2]	Bed Composition[3]	Estimated D_{50}	Geological Environ[4]	Bank conditions (stable or eroding)	Incised?	Maximum bank height (bed to terrace surface)	Maximum Channel Width (terrace to terrace)	Active Channel Depth	Active Channel Width	Did WY2016 Peak flow access meadow or floodplain?	Pool/riffle ratio (in reach)	Riffle length	Pool length	Instream wood?	Riparian Cover (in reach)[4]	Beavers or evidence of ?
					(mm)			yes/no	(ft)	(ft)	(ft)	(ft)	yes/no?		(ft)	(ft)	yes/no	%	yes/no
185	✓	spr sp	s	g, c	23–45	gl	e	yes	3.5	20	2.0	14	yes	40/60	25	15	limited	50	No

Describe your observations, conditions:

abundant green filament algae in creek (photos), deposits of silts/sands on bar

snow is pushed into riparian/creek —— some bank erosion; willow mortality



Plan view and Cross-section sketches:

1. Channel Bedform: meandering pool riffle (mpr); straight pool riffle (spr); planebed (pb), step-pool (sp), cascade ©.
2. Channel Planform: single threaded channel (s), braided channel (b), distributary system (d) engineered channel €
3. Bed composition: clay, silt, sand, gravels, cobbles,
4. Geological Environment: Glacial till, moraine or outwash (gl), lucustrine (lc), alluvial (al), bedrock (br), artificial (A)

Identify general location on map

APPENDIX E

Spatial Data in GIS
(Transmitted Separately)

APPENDIX F

Project Sheets

Lower Bear Creek Meadow, Placer County, California, Project #1

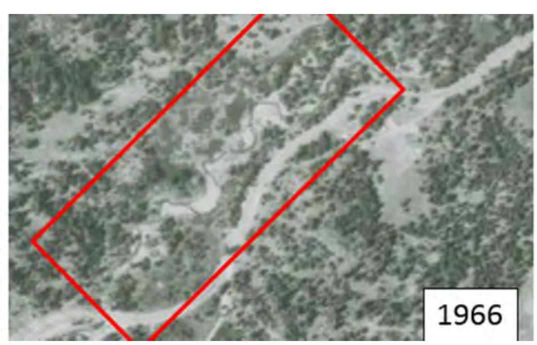
Problem: Hydromodification, channel incision and widening; loss of floodplain/meadow function
Project: Meadow restoration (contingent on County stormwater improvements)
Location: Reach C, Tahoe National Forest and Placer County

General Description of Problem:
The Lower Bear Creek Meadow is defined by alluvial valley fill, a lower gradient system that once supported a multi-threaded wet-meadow system. Its location in the lower reaches of the watershed provide for sediment deposition functions, and aquatic and wildlife habitat. Today, many of these functions and habitats are impaired by an eroding, unstable channel. Instabilities were likely introduced from road construction in the watershed from the 1960s onward. Impervious surfaces generate rapid runoff to the channel, and result in more flashy and higher magnitude peak flows (hydromodification). The modified hydrology increases the stream's ability to erode and over time has deepened and widened Bear Creek through the former meadow. The impaired condition results in less frequent inundation of the meadow surface, in turn, reduces groundwater recharge, and increases meadow desiccation and conifer encroachment due to a lowered groundwater table. Higher magnitude floods are now contained in the channel and exacerbate sediment delivery to the Truckee River from chronic bank erosion. Stormwater ditches along Alpine Meadows Road contribute additional sediment to Bear Creek from erosion of in-board ditches and application of road traction sand during the winter. Other stormwater culverts under Alpine Meadows Road focus spring-fed tributaries to fewer channels, resulting in tributary incision that furthers meadow desiccation.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Restore stream-floodplain/ meadow functions and habitat	Stormwater, absence of stormwater BMPs and infrastructure	Reduce stormwater runoff and sediment inputs to channel; fill channel or encourage channel sedimentation and overbank flows; Increase # of culverts under Alpine Meadows Road.

***Cost Estimate:**

Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +



Restoration or Management Approach:
Meadow restoration may be possible for this roughly 30 acre wet meadow. In-channel and meadow restoration strategies may include, but not limited to, channel fill, introduction of large wood debris, conifer thinning, aspen/cottonwood enhancement and beaver protection; sod check dams in spring-fed tributaries in combination with additional culverts under Alpine Meadows Road. Success of restoration is contingent on stormwater management. While watershed wide stormwater improvements are recommended, stormwater management along Alpine Meadows Road may provide the most benefits.

**cost estimate includes implementation of non-stormwater project elements.*

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Lower Bear Creek Meadow, Placer County, California, Project #1

Target Conditions/Success Criteria:
1) Increased wet meadow vegetation/habitat
2) Restored channel-meadow connectivity
3) Higher groundwater levels
4) Reduced bank erosion

Meadow Restoration Design Alternatives

1. Introduction of large instream wood structures to encourage sediment deposition and overbank flows
2. Channel fill: import materials consistent with local alluvial texture to increase grade of channel
3. Engineered check dams to encourage deposition of sediment delivered to reach

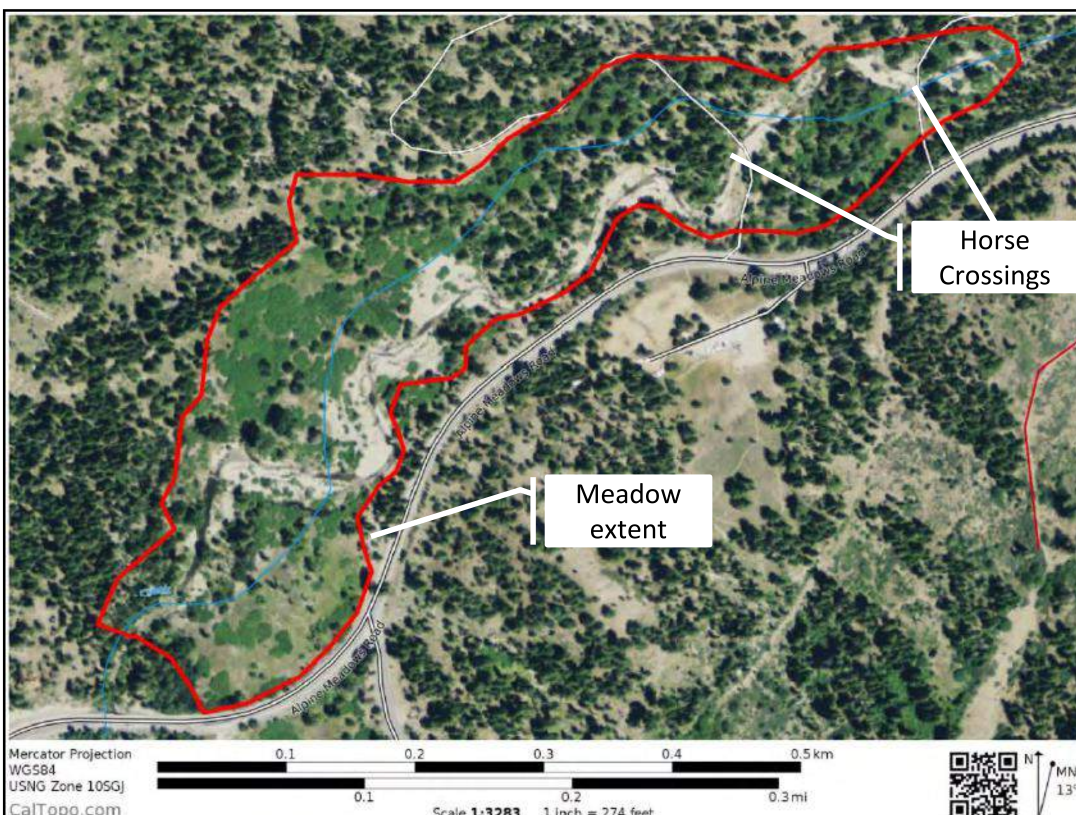
Implementation Timeframe

60% Design (4-6 weeks)
90% Design (4-6 weeks)
Permitting (6-12 months)
Implementation (2 months)
Monitoring and adaptive management (5+ years)

Pre- and Post-project monitoring recommendations:
1) Vegetation/meadow condition surveys
2) Repeat x-section channel surveys
3) Streamflow and sediment transport gaging
4) Observations of channel conditions
5) Groundwater monitoring

Phasing or Order of Implementation:

Stormwater management should be implemented prior to or in concert with meadow restoration or in-stream channel projects.



Lower Bear Creek Meadow showing approximate area proposed for meadow restoration

Deer Park Ski Area Upland Restoration, Placer County, California, Project #2

<u>Problem</u>: Hillside erosion from old graded ski runs and roads
<u>Project:</u> Road decommissioning, revegetation and erosion control
<u>Location:</u> Tahoe National Forest, Former Deer Park Ski Area

<u>General Description of Problem:</u>
Development of Deer Park Ski Area (formerly Powder Bowl) in the 1950s included grading of ski runs and roads for lift operations. Runs were regraded in the early 1980s further removing vegetation and exacerbating hillside erosion. Previous erosion control efforts have largely failed (USFS, 2016). Hillside runoff and sediment are conveyed to a stormwater ditch along the base of the ski slopes. The same ditch receives stormwater runoff from a parking lot which conveys flows directly to the Truckee River. Burt and Clary (2015) evaluated Deer Park Ski Area, and found that graded ski runs may slowly recover over time, but may benefit from restoration activities to improve water quality and provide incidental habitat values.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Reduce hillside erosion; reduce runoff to ditch	Historical ski run grading	Road decommissioning; regrading to restore flow paths, revegetation and erosion control elements

Aerial image showing active rilling, sparse vegetation, and an old road that captures and concentrates hillslope runoff.

<u>Restoration or Management Approach</u>:
The remediation plan for this site was developed by the USFS (2016) and includes: 1) road decommissioning by re-contouring, 2) restore hillslope infiltration by re-incorporating rock and roughness elements to ski slopes, 3) re-grading of heavily rilled or gullied areas to restore flow paths, 4) revegetation, 5) erosion control BMPs, and 6) remove any remaining ski lift infrastructure (e.g., concrete pads, pipelines, etc).

***Cost Estimate:**

Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +

Deer Park Ski Area Upland Restoration, Placer County, California, Project #2

Target Conditions/Success Criteria:

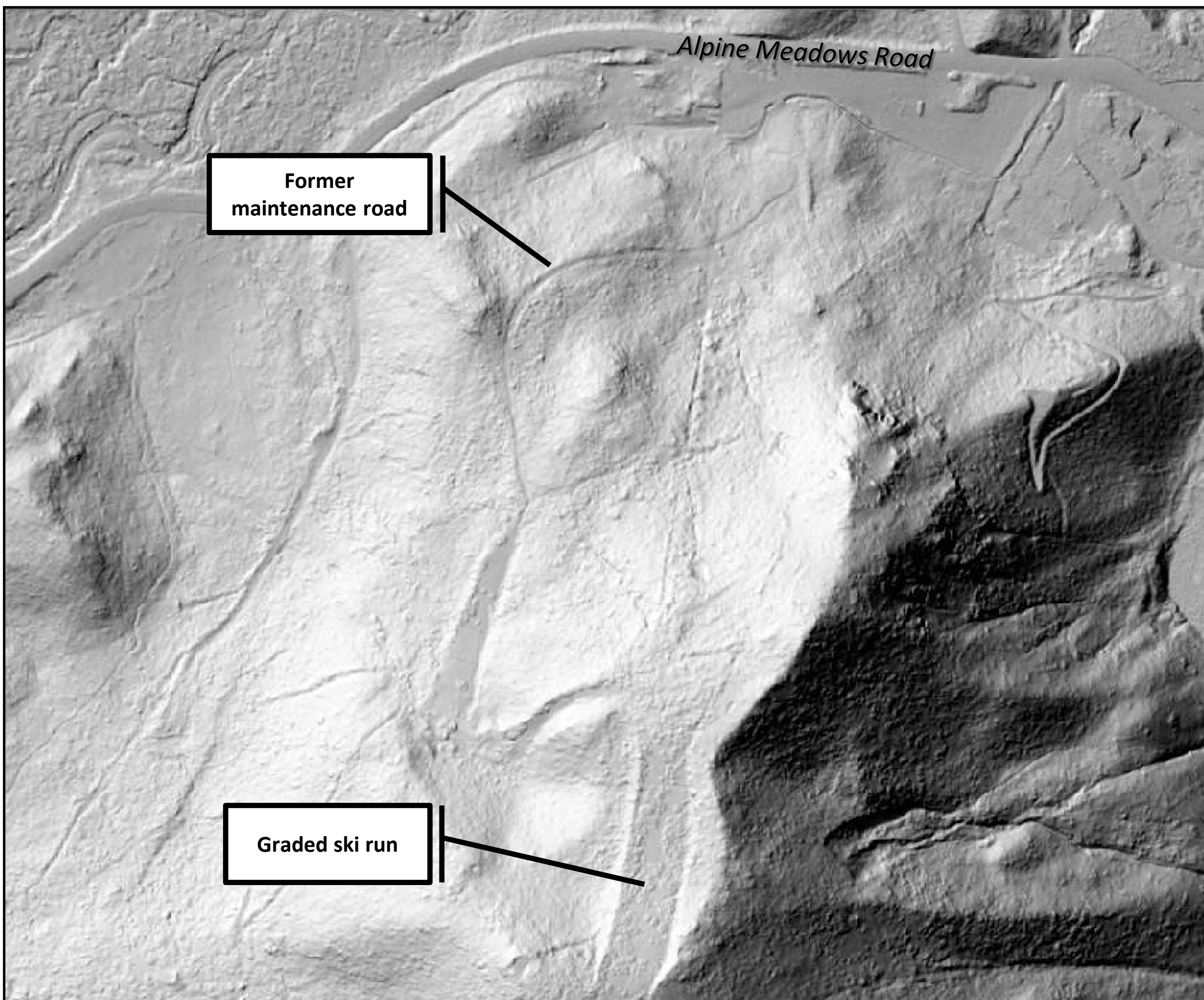
1) Reduced hillside runoff and erosion
2) Increased vegetation cover
3) Enhanced upland or terrestrial habitats

Implementation Timeframe

60% Design (2-4 weeks)
90% Design (2-4 weeks)
Permitting, CEQA (3-6 months)
Implementation (1 month)
Monitoring and adaptive management (5+ years)

Pre- and Post-project monitoring recommendations:

1) Vegetation transects
2) Photo documentation (aerial and ground)



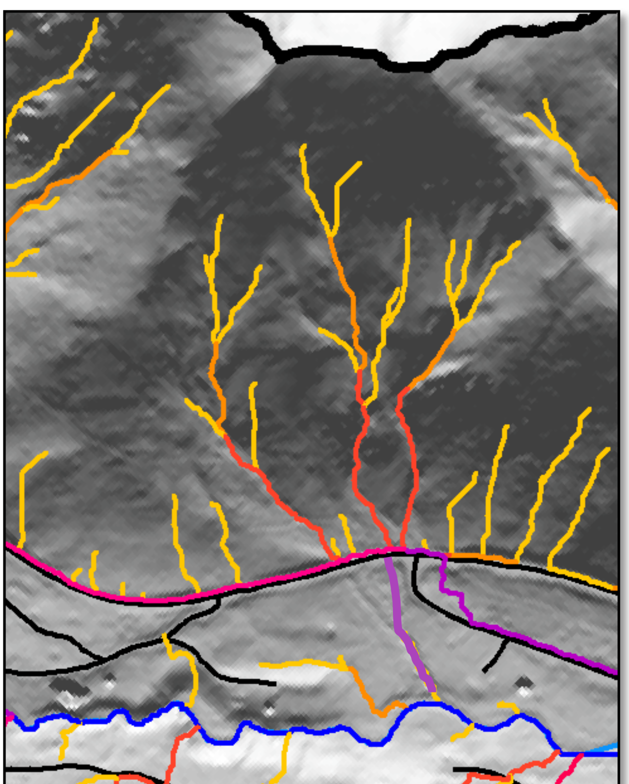
Bare earth image from LiDAR showing graded ski runs, roads, and gully erosion, former Deer Park Ski Area.

Five Lakes Trailhead Improvements, Placer County, California, Project #3

Problem: Inadequate drainage, erosion and excess sediment to Bear Creek
Project: Sediment reduction (contingent on County stormwater improvements)
Location: Tahoe National Forest, White Wolf

General Description of problem:
The Five Lakes Trailhead is a focal point for runoff from both an upland watershed and Alpine Meadows Road drainage. The tributary watershed drains highly erosive geology and in some events, can naturally trigger significant sediment transport. Stormwater runoff from Alpine Meadows Road increases and focuses flows to 2 undersized culverts which discharge to a single channel downstream of Alpine Meadows Road. The culverts frequently become plugged with sediment and force runoff and sediment onto the road and private property. The receiving channel shows evidence of scour and bank erosion and is a likely sediment source to Bear Creek.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Reduce excess sediment to Bear Creek	Stormwater and inadequate drainage infrastructure	Improved stormwater drainage; runoff and sediment detention basins, check dams to encourage channel fill and minimize further erosion.



Flow accumulation analysis showing concentration of watershed and road runoff

Restoration or Management Approach:
Reduction of sediment to Bear Creek from the Five Lakes Trailhead tributary requires County improvements to stormwater drainage and infrastructure as well as some in-channel restoration.

Five Lakes trail drainage could be improved to reduce stream capture. Check dams could be constructed in the tributary channel, downstream of Alpine Meadows Road, to encourage channel fill and reduce further erosion.

Cost Estimate:

Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +

**cost estimate will depend on stormwater engineering required and number of BMP facilities added.*

Five Lakes Trailhead Improvements, Placer County, California, Project #3

Target Conditions/Success Criteria:
1) Reduced sediment to Bear Creek
2) Restored drainage connectivity
3) Reduced flooding of Alpine Meadows Road

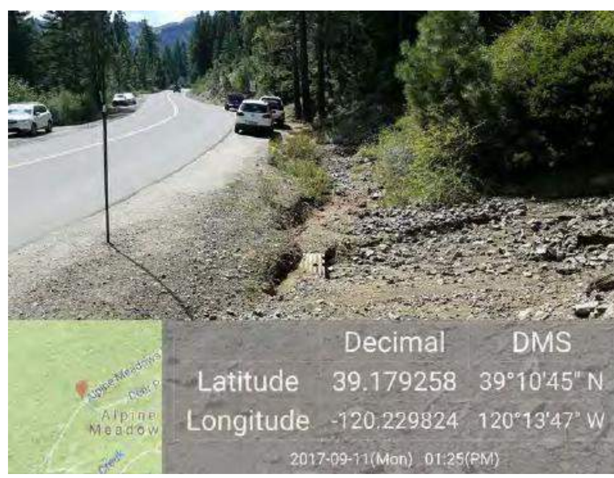
Implementation Timeframe
60% design (4-6 weeks)
90% design (2-4 weeks)
Permitting (3-6 months)
Implementation (2-4 weeks)
Project monitoring (1-3 years)

Pre- and Post-project monitoring recommendations:
1) Repeat x-section channel surveys
2) Observations of culvert and channel conditions
3) Quantify sediment removed from detention basins.

Phasing or Order of Implementation:
Stormwater management should be implemented prior to or in concert with channel restoration or in-stream channel projects.

Stormwater Improvements
1. Runoff and sediment retention basins to capture road runoff prior to discharge into Bear Creek (utilize wide pull-outs for construction of basins)
2. Replace existing culverts with properly sized culverts at existing trailhead
3. Reduce in-board ditch runoff accumulation by constructing additional culverts under Alpine Meadows Road at points where natural swales or channels exist
4. Erosion control or slope stability measures along Alpine Meadows Road road-cuts.

Eroded tributary channel below Alpine Meadows Road



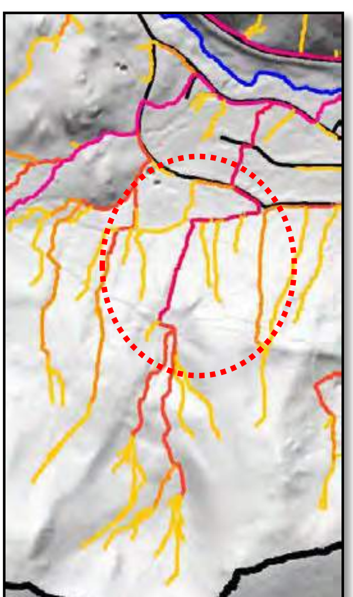
Existing culvert and sedimentation at Five Lakes Trailhead; photo also shows extent of road east of culvert that captures stormwater runoff

Road Area #2 (USFS, 2016), Placer County, California, Project #4

Problem: **Stream capture by unimproved roads, sediment source to Bear Creek**
Project: **Road drainage improvements and natural flow path restoration**
Location: **Tahoe National Forest and Private Property.**

General Description of problem:
Spring-fed channels and sheet flow are captured by unimproved roads. USFS (2016) used WEPP modeling to identify improvements to 0.62 miles of road and 0.45 miles of trails to reduce sediment to Bear Creek. The road is maintained for access to water lines by Alpine Springs County Water District (ASCWD) but is currently impassable for most vehicles. The road directs runoff and sediment onto neighborhood streets and Bear Creek via a stormwater system.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Reduce sediment to Bear Creek; Improve drainage to maintain road	Ineffective drainage; road grading	Restore drainage flow direction; Introduction of water bars/dips; re-contouring some roads with outsloping surfaces; armoring drainage crossings



Restoration or Management Approach:
Drainage improvements could be completed to restore drainage flow direction into existing natural channels. Reduction of road runoff can be alleviated by outsloping the road and/or introducing additional dips. Where natural channels cross the road, 'Arizona crossings' (rock-lined water dips) or additional culverts can be installed to replace undersized or sediment plugged culverts. The USFS assessment (2016) provide additional options and details. Additional considerations of downslope drainage and property flooding require evaluation.

Cost Estimate:

*Cost Estimate
Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +

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Road Area #2 (USFS, 2016), Placer County, California, Project #4

Target Conditions/Success Criteria:

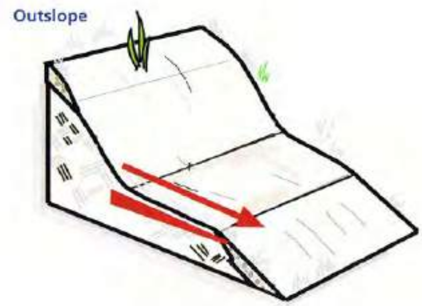
1) Reduced sediment to Bear Creek
2) Eliminate stream capture by roads
3) Reduced flooding/sediment of neighborhood streets

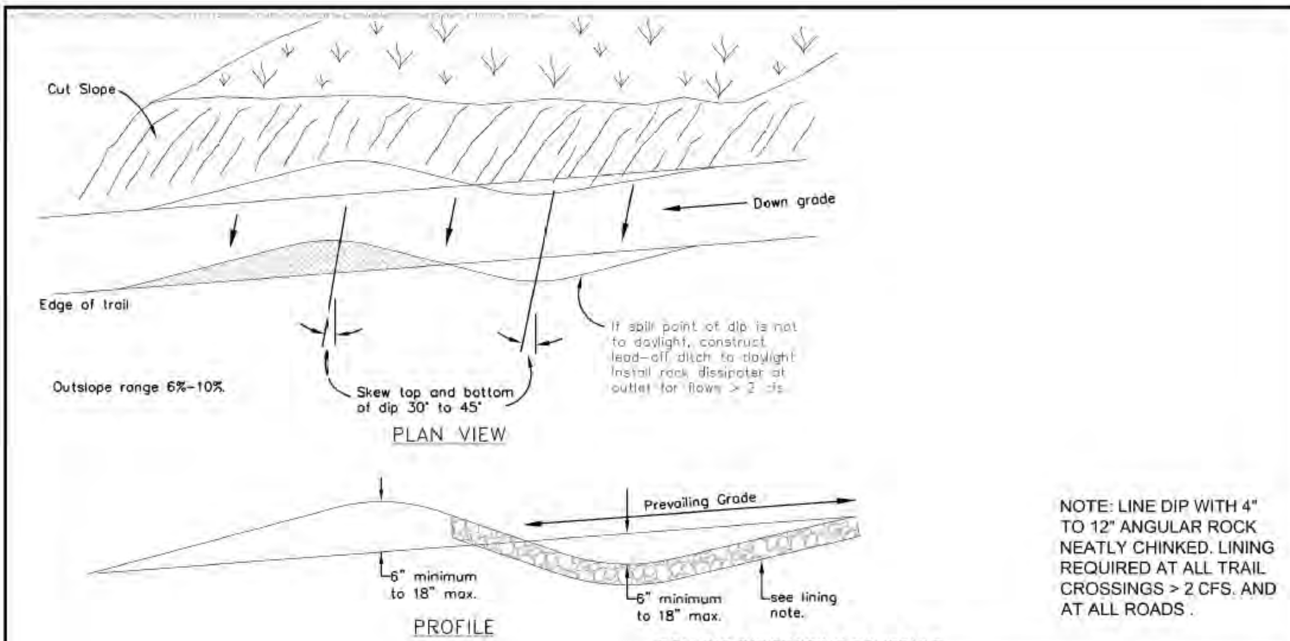
Implementation Timeframe

60% design (2-4 weeks)
90% design (2-4 weeks)
Permitting (3-6 months)
Implementation (2-3 weeks)
Project monitoring (1-3 years)

Pre- and Post-project monitoring recommendations:

1) Observations of hillslope erosion and runoff
2) Vegetation transects and surveys





ROLLING DIP SPACING SCHEDULE:

TRAIL/ROAD MATERIAL TYPE	GRADE						
	2%	4%	6%	8%	10%	12%	15%
LOAM	350'	150'	100'	75'	50'	*	*
CLAY-SAND	500'	350'	200'	150'	100'	50'	*
CLAY OR CLAY-GRAVEL	-	500'	300'	200'	150'	100'	75'

PROVIDED BY KING ENGINEERING INC.

TAHOE DONNER	TAHOE DONNER 5 YEAR IMPLEMENTATION PLAN TYPICAL DETAILS TOWN OF TRUCKEE NEVADA COUNTY, CALIFORNIA	DETAIL 8 ROLLING DIP SOURCE: USFS (MODIFIED)

Example of improving road drainage that could be applied in Road Area #2.

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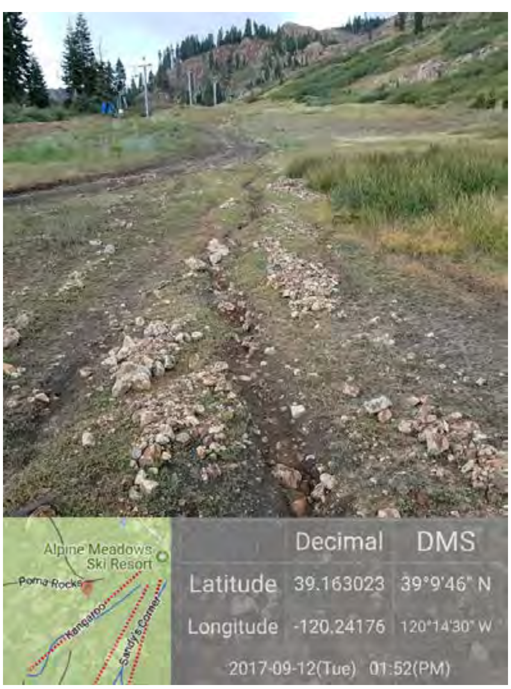
Alpine Meadows Ski Area Roads and Ski Runs, Placer County, California, Project #5

Problem: Erosion and sedimentation of meadow habitats
Project: Ski area road and infrastructure improvements
Location: Tahoe National Forest, Alpine Meadows Ski Area

General Description of problem:
Alpine Meadows Ski Area includes steep terrain with poor vegetation and exposed soils; disturbance of these soils allows for increased slope runoff and erosion. Historical ski area development and on-going ski area operations create challenges for hillslope runoff and sediment management. Current issues include maintenance roads, water lines, and ski runs where former grading practices were used to develop ski runs. Maintenance roads can be subject to extreme runoff events, debris flows, rock fall, and erosion. Buried water lines, used for snowmaking, have become exposed at the surface over time and act as conduits for runoff interception, concentration of flow and hillslope erosion. Historical grading of ski runs removed vegetation and topsoil which increases runoff and erosoin. Finally, some stream segments have been relocated into constructed ditches and culverts to accommodate runs and lift infrastructure.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Reduce hillslope erosion and sedimentation of meadow habitats	Historical ski area development	Improved road drainage; provide buffer zone to protect aquatic and meadow habitats; relocation or deeper burial of water lines.



Hillside seepage from relocated tributary and hillside erosion along maintenance road

Meadow sedimentation from road runoff and erosion.

Cost Estimate:

Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +

Alpine Meadows Ski Area Roads and Ski Runs, Placer County, California, Project #5

Restoration or Management Approach:
The USFS (2016) also identified this area in their sediment source assessment and include many recommendations. Overall, efforts to increase vegetation and/or ground cover will help reduce runoff and sediment entrainment. Road maintenance may be decreased if additional water bars, dips, and outsloping of roads are implemented. In areas where roads convey runoff and sediment to sensitive meadow habitats, roads should be either relocated to provide buffer zones or drainage improved with sediment detention basins. Water lines should be buried deeper (where feasible) or constructed with water spreading structures in frequent intervals to reduce concentration of flow along lines. Finally, where historical grading and channel relocation occurred, maintenance roads should be relocated to avoid seepage areas and erosion. In an effort to better outline these improvements, the USFS can work with their permittees to develop a Natural Resources Management Plan.

Target Conditions/Success Criteria:
1) Reduced hillside and road erosion
2) Reduced sedimentation of meadow habitats

Implementation Timeframe
60% Design (4-6 weeks)
90% Design (2-4 weeks)
Permitting (3-5 months)
Implementation (1-2 months)
Monitoring and adaptive management (annually)

Pre- and Post-project monitoring recommendations:
1) Vegetation/meadow condition surveys
2) Observations of hillside and road conditions

Restoration treatment following installation of a water line (IERS, 2009)

The ski run on the left was graded, while the ski run on the right was cleared (IERS, 2009).

Scott Peak Springs Meadow Restoration, Placer County, California, Project #2

Problem: Loss of wet meadow area and habitat
Project: Meadow restoration
Location: Tahoe National Forest, Alpine Meadows Ski Area

General Description of Problem:
Development of the historic parking lot for Ward Creek Ski Area (Alpine Meadows) in the 1960s impacted an area that once supported a large contiguous wet meadow complex. Expansion of the parking area in the 1970s resulted in further filling of the meadow that derives its source water from springs on the slopes of Scott Peak. Today, stormwater runoff, road traction sands and refuse are discharged to the meadow. Furthermore, snow storage occurs in and near the remnant meadow and riparian corridor, further impacting habitat values and ecological functions. Meadow drainage is confined to a ditch alongside the parking lot and access road and discharges to Bear Creek via one or more culverts.

Goal(s)	Sources of degradation	Objectives to achieve goal(s)
Restore meadow area and habitat	Historical parking lot development for ski area	Modify or relocate asphalt parking areas;

Historical aerial photography illustrating the dissection of a large wet-meadow complex in the Upper Bear Creek Watershed. Red box approximates the same area in both photographs.

Restoration or Management Approach:
The USFS (2016) also identified this area as impairing Bear Creek and tributaries and proposed several remedial actions. In addition to these actions, we encourage consideration of meadow restoration. While full-scale meadow restoration may not be immediately feasible, some modifications to the existing parking lot may provide a wide range of benefits to meadow function and habitat including enhancing groundwater discharge areas, flood water retention, water quality improvements, and willow riparian and wet meadow habitats. Removal of some of the asphalt and restoration of wetland soils, hydrology, and vegetation may provide the greatest benefits. Other management actions may include additional stormwater BMPs including underground stormwater chambers, sediment detention basins, and daylighting of drainage channels at culvert(s).

***Cost Estimate:**

Less than $10K
$10K-$100K
$100K-$500K
$500K-$2M
$2M +

**cost estimate may be reduced with a more defined restoration strategy.*

Scott Peak Springs Meadow Restoration, Placer County, California, Project #2

Target Conditions/Success Criteria:
1) Increased wet meadow area
2) Restored channel-meadow connectivity
3) Reduced sediment and refuse in meadow
4) Enhanced wet meadow vegetation and habitat

Implementation Timeframe

Dependent on project complexity

Pre- and Post-project monitoring recommendations:
1) Vegetation/meadow condition surveys
2) Wetland acreage evaluation
3) Geomorphic surveys of channel conditions
4) Piezometers for groundwater response
5) Photo documentation (ground and aerial)

Project Benefits
1. Montane meadow ecosystems are the most botanically diverse in the Sierra Nevada, and they have high wildlife values because of their abundance of food and cover.
2. Montane meadows also play a unique and crucial role in the ecology of many bird species found in the Sierra Nevada
3. These ecosystems also store water, recharge local groundwater, and provide a perennial source of baseflows to Bear Creek and the Truckee River.

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