REVIEW OF TRUCKEE RIVER SEDIMENT TOTAL MAXIMUM DAILY LOAD

STAFF REPORT

California Regional Water Quality Control Board

Lahontan Region

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Executive Summary

The purpose of this staff report is to document completion of the 10-year review of the Middle Truckee River Total Maximum Daily Load for Sediment (Truckee TMDL) required in Chapter 4, Implementation, of the Water Quality Control Plan for the Lahontan Basin (Basin Plan). The Truckee TMDL was developed to address sedimentation and siltation impairments for the Truckee River, Gray Creek and Bronco Creek first identified during the 1992 update of the Clean Water Act Section 303(d) list of impaired waters. The Truckee TMDL was adopted by the Lahontan Regional Water Quality Control Board (Lahontan Water Board) on May 14, 2008 and approved by the State Water Resources Control Board (State Water Board) on March 17, 2009. To implement the 10-year review, the Truckee TMDL language in the Basin Plan directs staff to examine target and compliance data to determine the need for revision of the TMDL, numeric targets, or the implementation plan.

This report provides background information regarding the Truckee River watershed and describes the information and data reviewed as part of the 10-year review required by the Truckee TMDL Basin Plan language. It includes an evaluation regarding the progress made towards achieving the goal of the Truckee TMDL, which is attainment of the sediment-related water quality target and the protection of aquatic life beneficial uses with a focus on early life stages (e.g., COLD and SPWN). Additionally, this report includes recommendations regarding the need to modify or revise the Truckee TMDL. This staff report also addresses the basin planning project proposed by the Truckee River Watershed Council (TRWC) during the 2015 and 2018 Basin Plan Triennial Review processes to develop additional numeric target(s) for embedded or deposited sediment for incorporation into a revised Truckee TMDL. TRWC supported the completion of several TMDL-related sediment monitoring and bioassessment studies between 2010-2014 that they suggest provide evidence for sediment-related impairment even when the numeric target for suspended sediment in the Truckee TMDL is met.

Completion of the 10-year review followed the guidance in the Basin Plan language and involved assessing water quality data collected since adoption of the Truckee TMDL together with other available information, including reports by responsible parties, state agencies and non-profits, to determine progress towards achieving the TMDL goal and compliance with the implementation targets. As described in the 2008 Truckee TMDL Staff Report, the implementation targets identify activities required by dischargers that are expected to achieve attainment of sediment-related water quality targets. The implementation targets do not require specific reductions in sediment discharge but rather represent progress towards attaining the desired conditions in the watershed. The 2008 Truckee TMDL Staff Report states that this is due to the impracticality of using sediment mass reductions as indicators of beneficial use protection.

The following are the primary conclusions from the review of the available information and data related to the Truckee TMDL.

- Hydrological conditions vary substantially from year to year, and the severe drought that occurred between WY2012-2016 is evident from the low annual discharge volumes and streamflow observed during that time (see Table 1). The highest total discharge in the past 15 years for the Truckee River (measured at Farad) occurred in WY2017 (672,200 acre-feet) and the lowest occurred in WY2015 (81,440 acre-feet).

- The numeric target for suspended sediment concentration (SSC) in the Truckee TMDL, defined as an annual 90th percentile value of less than or equal to 25 mg/L measured at Farad, has been met each year since the TMDL was adopted in 2008.
- Turbidity data provide another way to assess suspended sediment conditions in the Truckee River. The available data collected at Farad show the water quality objective for turbidity, defined as 3 Nephelometric Turbidity Units (ntu) expressed as the Mean of Monthly Means (MoMM), was exceeded during some years (see Table 3). Further data analysis is needed to determine whether the rate of exceedance would result in a 303(d) listing for turbidity impairment.
- Placer County and the Town of Truckee established a comprehensive stormwater monitoring program in 2008 that produces data and information important for documenting progress towards attainment of the TMDL goals. However, there are no discernable trends in sediment discharge over the past 10 years based on data collected as part of this program, which is likely due to variable hydrologic conditions that drive variability in sediment discharge from year to year.
- Annual sediment discharge estimates for sub-watershed areas where data are available were generally lower than the Truckee TMDL target load allocations for those areas (see Figure 4). During WY2011 and WY2017, which were wet years, the target was exceeded for Martis Creek, and during WY2011, the target was exceeded for the Trout Creek sub-watershed.
- The review of available information, including submittals by responsible parties (identified in Table 4), indicates substantial effort has been focused on reducing sediment discharge to the Truckee River since the Truckee TMDL was adopted (see Table 5). Projects completed include extensive dirt road rehabilitation on USFS land, stormwater improvements at Caltrans legacy sites, efforts to reduce erosion for heavily used portions of the Truckee River below Lake Tahoe, and stream channel restoration in Coldstream Canyon, among others.
- Information regarding sediment-related channel conditions is limited to studies conducted between 2010-2014. Rapid Assessment Methodology studies did not find that excess fine sediment in the stream channel was prevalent in the surveyed locations, except for Trout Creek, where high proportions of fine sediment (>50 percent) were observed in some locations. Studies supported by TRWC found that fine sediment increased between 2011 and 2014 due to the low flow conditions in 2014, however the average proportion of fine sediment was still below 20 percent at the locations sampled. The lack of recent studies makes it difficult to assess the current status of sediment conditions in the Truckee River and tributary channels.
- Bioassessment monitoring has shown mixed results, with most sites on the Truckee River showing good biological integrity while locations sampled in 2011 near Juniper Creek, Bear Creek and Squaw Creek did not meet biological integrity goals. Due to the lack of recent habitat assessments or bioassessment monitoring results, the status of aquatic life beneficial uses in the Truckee River is difficult to determine.
- CDFW has conducted periodic fish surveys in the Truckee River (last survey occurred in 2014), which show high temporal variability in estimated fish density, with the lowest values in the early 1980's and the highest observed in 1987. Recent data from a limited fish survey conducted by Trout Unlimited in 2020 at one location suggest

habitat conditions are adequate for fish spawning and rearing, however additional observations are needed to provide greater clarity regarding whether sediment discharge continues to impair the beneficial uses in the Truckee River.

- Re-opening the Truckee TMDL to revise the sediment source analysis, load allocations or TMDL targets is not recommended at this time due to the need for additional information to determine the status of beneficial use protection in the Truckee River. Similarly, adding a new TMDL target for embedded or deposited sediment, as requested by TRWC, is not recommended due to lack of recent information on sediment-related channel conditions.
- Modification of monitoring required in permits issued to dischargers is recommended to improve the collection of data and information regarding habitat and sediment-related conditions in the Truckee River. Additionally, monitoring activities undertaken by other agencies or non-profits may provide additional information to document current conditions in the Truckee River. Since the lack of recent information hampers the ability to make robust findings regarding the status of the beneficial uses, staff recommends revisiting the Truckee TMDL in three to five years after additional monitoring activity can be completed.

Introduction

The Middle Truckee River Total Maximum Daily Load for Sediment (Truckee TMDL) was developed in response to Clean Water Act Section 303(d) impairment listings for sedimentation that were first identified for the 1992 listing cycle. The original listing occurred prior to the State Water Board's 2004 Water Quality Control Policy for California's Clean Water Act Section 303(d) List, which established statewide consistency and standardized data requirements for the 303(d) list. The Truckee River was listed for excess sediment based primarily on a 1990 memo regarding fish habitat conditions submitted by California Department of Fish and Wildlife (CDFW) (Messersmith, 1990) that highlighted impacts to fish habitat in the Truckee River associated with siltation leading to substrate loss, loss of adult habitat and inadequate flows. Other information used to support the 1992 listing is not well documented and consists of observations of high sediment loads during thunderstorms, particularly in Gray and Bronco Creeks, which enter the Truckee River downstream of the confluence with the Little Truckee River. Gray and Bronco Creeks were also listed in 1992 as impaired due to sediment discharge that adversely affected the Reno-Sparks water treatment plant located downstream. The Truckee TMDL addresses the sediment impairments in Gray and Bronco Creeks in addition to the impairment for the Truckee River.

The Lahontan Regional Water Quality Control Board (Lahontan Water Board) adopted an amendment to the Water Quality Control Plan for the Lahontan Basin (Basin Plan) in 2008 to incorporate the Truckee TMDL, which was then approved in 2009 by the State Water Board and the US EPA. The adopted TMDL language includes direction to Lahontan Water Board staff to undertake a review of the Truckee TMDL after 10 years (the halfway point estimated for TMDL attainment, which is expected to occur in 2028). The TMDL language directs staff to examine target and compliance data to determine the need for revision of the TMDL, numeric targets, or implementation plan. It also provides examples of the type of information to review and potential outcomes of the 10-year review, which could include recommendations to reassess sediment sources, revise targets, or adjust the implementation plan. This staff report was prepared in response to the Truckee TMDL 10-year review

directive and includes a review of water quality data and information collected since establishment of the TMDL in 2008.

This report also examines the need for a new TMDL target criterion for deposited or embedded sediment for the Middle Truckee River, a project first proposed by the Truckee River Watershed Council (TRWC) during the 2015 Triennial Review of the Basin Plan. While not ranked as a priority project at that time, this project was again considered during the 2018 Triennial Review process and was ranked at No. 9, which is "above the line," and one that Water Board staff intends to work on as a priority. As stated in the response to comments for the 2018 Triennial Review, Water Board staff will need the assistance from the TRWC to advance the deposited/embedded sediment project because of the Water Board's limited resources. This staff report includes a review of information and data to determine the need for a new Truckee TMDL target for deposited or embedded sediment.

Truckee River Watershed Overview

The following provides an overview of the Truckee River watershed that includes a brief review of the geography and natural history of the area followed by a short discussion of the human history and land uses in the watershed. Information is also provided about activities that are associated with beneficial uses assigned to the Truckee River that address recreation, commercial and sport fishing and aquatic life uses. More extensive treatment of these topics can be found in *Truckee River Chronology: A Chronological History of Lake Tahoe and the Truckee River and Related Water Issues* (Horton, 1997) and the *Coordinated Water Management Strategy for the Middle Truckee River,* prepared by the Truckee River Watershed Council (2004).

Geography, Land Uses, and Human Development

The Truckee River originates upstream of Lake Tahoe as the Upper Truckee River, which is the largest tributary to the lake. It then flows north out of Lake Tahoe near Tahoe City towards the Town of Truckee, after which it flows northeasterly along Interstate 80 through a relatively steep narrow canyon towards Reno, NV and eventually reaches its terminus at Pyramid Lake in the desert plains of Nevada. In the past, enough water flowed through the Truckee River into Pyramid Lake during high-water years to create overflow into Winnemucca Lake, which is now a dry alkali lakebed to the east. Pyramid and Winnemucca lakes are remnants of ancient Lake Lahontan, which once covered much of the Great Basin (Truckee River Watershed Council, 2004).

The Middle Truckee River, which extends between Lake Tahoe and the California/Nevada state line, is the portion of the river that is the focus of this staff report. The Middle Truckee River watershed covers an area of approximately 285,000 acres or 435 square miles. Figure 1 shows the location of the Truckee River and identifies the extent of the watershed and the sub-watershed areas associated with the numerous tributaries that enter the Truckee River downstream of Lake Tahoe. Several of the tributaries have one or more federal reservoirs (Prosser Creek, Little Truckee River and Martis Creek), while Donner Creek has a privately-owned reservoir. Table 1 contains information about the sub-watersheds listed from upstream to downstream.

Figure 1 Map showing middle Truckee River watershed and major sub-watershed areas (taken from Middle Truckee River TMDL Staff Report (2008))

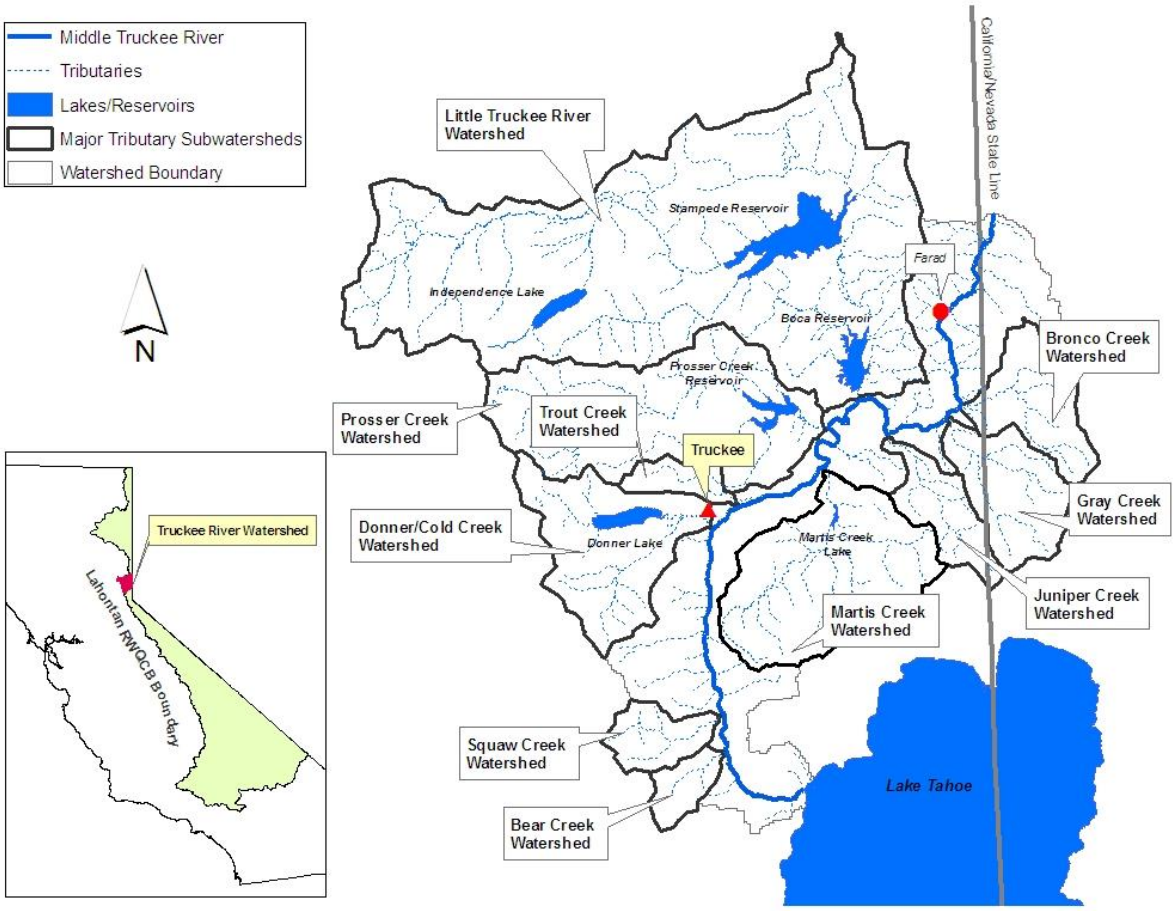


Table 1 Subwatershed areas, level of disturbance, and development and legacy issues

Subwatershed Area	Size	Level of Disturbance	Major Development and Legacy Issues
Bear Creek	5.3 sq. miles	High	Alpine Meadows ski resort, residential and commercial development
Squaw Creek	8.2 sq. miles	High	Palisades Tahoe ski resort, residential and commercial development
Big Chief Corridor	23.4 sq. miles	High	Proximity of Truckee River to Hwy 89, chronic sediment source due to road abrasives used by Caltrans
Deer Creek		Low	Relatively undeveloped sub-watersheds may provide baseline data for comparison with more disturbed sub-watershed areas
Silver Creek		Low	
Pole Creek		Low	
Deep Creek		Low	
Cabin Creek		Low	
Donner Creek	17 sq. miles	High	Residential development, construction of I 80, modified stream channel, road abrasives
Cold Creek (tributary to Donner Creek below Donner Lake)	12.8 sq. miles	High	Legacy impacts include railroad construction, gravel mining and logging.

Subwatershed Area	Size	Level of Disturbance	Major Development and Legacy Issues
Town of Truckee Corridor	14.1 sq. miles	High	Urbanized residential and commercial development, modified stream channel, roadway impacts from the use of abrasives on I 80, Hwy 267 and Hwy 89
Trout Creek	4.9 sq. miles	High	Medium to high density residential development and recreation facilities with lots of impervious surfaces
Martis Creek	40.9 sq. miles	High	Northstar Ski resort, residential and commercial development, proximity to Hwy 267, Martis Creek Reservoir likely traps sediment upstream of Truckee River
Prosser Creek/Alder Creek	54 sq. miles	Medium	Residential development, Prosser Reservoir traps some sediment, high dirt road density
Little Truckee River	172 sq. miles	Low	Low level of development, legacy impacts from logging and grazing, BOR water storage reservoirs (Stampede and Boca) trap sediment
Juniper Creek	10.8 sq. miles	Medium	Low level of development, high dirt road density and erodible areas in stream zone
Gray Creek	17.8 sq. miles	Medium	Legacy impacts include logging and grazing, dirt roads
Bronco Creek	40 sq. miles	Medium	Legacy impacts include logging and mining,

In addition to the named tributaries, there are also smaller unnamed tributaries that enter the Truckee River between Lake Tahoe and the Town of Truckee. The Little Truckee River is the largest tributary to the middle Truckee River and contains the most water storage capacity in its two reservoirs, Stampede and Boca.

Native American tribes, namely the Paiute, Mono, Shoshone, and Washoe tribes, inhabited or visited the Lake Tahoe basin, and the middle and lower Truckee River prior to the arrival of European settlers, which began in the mid-1800's. In the winter months, the Washoe lived in the Carson and Washoe Valley areas, but as the weather warmed up in the spring, the tribe would return to the shores of Lake Tahoe and the Middle Truckee River watershed. The Pyramid Lake Paiute also long depended on natural resources from the Truckee River and the Pyramid Lake Paiute Reservation was first established in 1859 and includes 470,000 acres around and including the lake. The Truckee River and Pyramid Lake used to provide abundant fish for native people, including Cui-ui (*Chasmistes cujus*), an endemic, omnivorous sucker species, and Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*), an endemic salmonid species that occurred in the Truckee River and Pyramid Lake.

In the past, Lahontan cutthroat trout in Pyramid Lake migrated up the Truckee River to spawn in the colder waters higher up in the watershed (Horton, 1997). The construction of dams on the lower Truckee River associated with the Truckee-Carson Project (now called the Newlands Project), which diverted water at Derby Dam downstream of Reno to locations in the Carson River watershed near Fallon, coupled with overfishing, eventually decimated the fishery. Environmental degradation was also a factor in decline of the fishery due to rampant logging and erosion associated with the development of sawmills that filled the Truckee River with sawdust (Horton, 1997). Ultimately Lahontan cutthroat trout were extirpated in the Lower Truckee River watershed sometime between 1938 and 1944 (Truckee River Watershed Council, 2004).

European explorers began to visit the Truckee River area in the early 1800's, followed by a few parties of early emigrants who traveled through the area, including the tragic Donner Party. After discovery of gold on the South Fork American River in 1848, a growing number of gold-seekers began to arrive, which eventually led to settlers who remained in the Truckee-Donner area. One activity that drove development at the time is logging, which provided timber for the Comstock mines and for construction of the transcontinental railroad that was completed in 1869. Individuals and industries began to locate in the Truckee area that were incentivized by the availability of cheap land. The Homestead Act provided homesteaders who met minimal requirements up to 160 acres of land for free, and some would sell their parcels to timber operators that led to consolidation into larger holdings. This provided the basis for the cattle industry that came later, when homesteads cut over by timber owners were often turned into thriving livestock operations (Truckee River Watershed Council, 2004). Eventually, municipalities including Truckee and Tahoe City became established, and hotels and restaurants were constructed for visitors to Lake Tahoe, which was becoming a popular tourist destination in the late 1800's.

With the advent of modern "all-weather" highways, including the completion of Interstate 80 over Donner Summit in 1957, the focus of development in the Truckee-Tahoe area moved away from resource extraction towards recreation. The relative proximity to major urban areas like Sacramento and the Bay area made the area popular for second-home owners and large residential subdivisions, such as Tahoe-Donner and Northstar, were developed starting in the early 1970s. This changed the historical growth pattern of Truckee and the surrounding area, where growth typically was located around a commercial core, to more widespread developments consisting of single-family residential homes near a ski hill, lake or other recreational facility (Truckee River Watershed Council, 2004).

Fishing and Recreation

Rainbow trout (*Oncorhynchus mykiss*) and Brown trout (*Salmo trutta*) are important sport fish in the Truckee River and are non-native species first introduced to the watershed in the late 1800s. As a result of these introductions, the Truckee River and several of its tributaries (e.g., Donner Creek and Prosser Creek) have become popular fishing destinations with both fly-fishers and lure or bait fishers. A portion of the Truckee River is designated as a Wild Trout Water by the California Fish and Game Commission (CFGC), a designation given to "aesthetically pleasing and environmentally productive" streams and lakes managed exclusively for wild trout, with appropriate regulations. The Wild Trout Water designation applies to the Truckee River from its confluence with Trout Creek (located near Hwy 267) downstream to the CA/NV state line, excluding the property owned by the San Francisco Fly Casters Club (SFFCC). As a private fishing lodge, the 334-acre SFFCC property includes a 3.5 mile stretch of the Truckee River starting near the Glenshire Dr. Bridge that is not open to the public. Overall, 19 miles of perennial stream habitat along the Truckee River are designated as Wild Trout Waters. According to the Wild Trout Policy, Wild Trout Waters must meet the following criteria:

- Open to public angling
- Able to support, with appropriate angling regulations, wild trout populations of sufficient magnitude to provide satisfactory trout catches in terms of number or size of fish.
- Domestic strains of catchable-size trout shall not be planted but suitable hatchery-produced wild or semi-wild strains may be planted in designated waters, but only if necessary, to supplement natural reproduction.

Along with the Wild Trout Water designation, portions of the Truckee River and adjacent state-owned lands are designated as the Truckee River Wildlife Area, which was established by the CFGC in 1996. The wildlife area consists of five noncontiguous units (Canyon, Union Ice, Boca, Polaris, and West River) that together total approximately 5,300 acres. Most of the wildlife area is located along the Truckee River between the Town of Truckee and the CA/NV state line, however a section of the river just downstream of the confluence with Donner Creek is also designated. As described on the CDFW website (https://wildlife.ca.gov/Lands/Places-to-Visit/Truckee-River-WA), this area was acquired primarily for fishing access since natural reproduction supports a good trout fishery in the Truckee River.

In addition to state-owned lands, roughly 50 percent of the land area in the middle Truckee River watershed is federally managed by the U.S. Forest Service (USFS) as part of the Tahoe National Forest (TNF), Truckee Ranger District. A small portion of land along the first few miles of the Truckee River downstream of Lake Tahoe is managed by the USFS Lake Tahoe Basin Management Unit. Recreation is the primary land use in the Truckee Ranger District, where activities like hiking, biking, camping, rafting and kayaking are popular, while skiing, snowboarding, snowmobiling and snowshoeing occur in the winter.

During the summer, rafting is a popular activity on the Truckee River, especially for the segment just downstream of Lake Tahoe, which is heavily used when flows are adequate for rafting. Unguided rafting is the most common but there are licensed rafting companies that operate on this reach. The reach downstream of Donner Creek is more commonly used by experienced rafters and kayakers, with the lower portion of the river below the Little Truckee River popular with commercial rafting companies. Rafting and kayaking may increase sediment discharge to the Truckee River because of the disturbance caused by large number of people accessing put-in and take-out locations along the river. Placer County's stormwater monitoring program includes periodic inspection of sites in the popular upper segment of the Truckee River below Lake Tahoe. During the most recent survey of these sites in 2020, downward trends were assigned to seven sites, indicating the potential for negative water quality impacts has increased since the previous inspection in 2018 (CDM Smith and Balance Hydrologics, 2021).

The large ski resorts, that include Palisades Tahoe (located in the Bear Creek and Squaw Creek sub-watersheds), and Northstar (Martis Creek sub-watershed), and their associated commercial and residential development represent another significant recreation-focused land use in the Truckee River watershed. Additionally, Tahoe-Donner is a smaller ski operation surrounded by 6,500 residential properties located north of I-80 in the Trout Creek drainage. ome have expanded operations to include summer activities like hiking and mountain biking accessed via their lift system.

Approach for Developing the Truckee TMDL

The Lahontan Water Board utilized a variety of data sources and information to develop the Truckee TMDL that included turbidity and SSC water quality data collected by various agencies and scientific literature on biological impacts associated with suspended sediment. In addition, several studies to support development of the Truckee TMDL were completed by the Desert Research Institute (DRI) and Dr. D. Herbst that include the following:

- DRI (2001) Water Quality Assessment and Modeling of the California Portion of the Truckee River Basin

- DRI (2004) Suspended Sediment and Turbidity Patterns in the Middle Truckee River, California, for the Period 2002-2003. (Department of Hydrologic Sciences Publication No. 41196)
- Herbst and Kane (2006) Fine Sediment Deposition and Invertebrate Communities in the middle Truckee River, CA: Development of Criteria for Establishing TMDLs. Sierra Nevada Aquatic Research Laboratory

TMDL Sediment Load Allocations

Estimates for sediment loading for sub-watershed areas within the Truckee watershed were developed using regression equations that describe the relationship between SSC grab sample data and streamflow (Desert Research Institute, 2001). The regression equations were then applied to streamflow data for 1996-1997, an above average water year that included a major flood event. Sediment discharge for intervening zones not within sub-watershed areas was estimated as the difference between the sum of the sub-watershed estimates and the total sediment discharge estimated at Farad. Additionally, event-based sediment loading was estimated using turbidity data and a regression equation that predicted SSC based on turbidity, flow, water temperature and specific conductivity data (Desert Resource Institute, 2004). Event-based sediment loading was then added to the streamflow-based estimates to arrive at a baseline estimate for sediment discharge at Farad of 50,382 tons per year. Although the 2008 Truckee TMDL Staff Report describes concern with potential overlap between the sediment loading captured by the two methods, the Lahontan Board considered them both valid and chose to add them together to arrive at the baseline estimate. The use of an above average water year with an extreme flooding event in January 1997 together with the addition of the event-based loading appears to overestimate annual sediment loading for the Truckee River. This was considered by staff when developing the recommendations presented at the end of this report.

Suspended Sediment Numeric Target Selection

Documentation supporting the TMDL included an examination of the available guidance and scientific literature regarding suspended sediment criteria for the protection of aquatic life beneficial uses COLD and SPWN. The literature review revealed a wide range of recommended SSC values; however, most fell between 25 to 80 mg/L. According to the 2008 Truckee TMDL Staff Report, the lower end of the range in values is meant to protect salmonid juvenile, larval, and egg life stages, while the higher values are protective of adult fish. The review also revealed that various statistical approaches and evaluation periods are used to express SSC target values that include averages and geometric means applied over time periods ranging from daily to yearly, as well as single value maxima and annual 90th or 98th percentile values. Ultimately, the Lahontan Water Board selected an SSC target of less than or equal to 25 mg/L, expressed as an annual 90^{th} percentile applied at the USGS gaging site at Farad to protect early life stage aquatic organisms. The 90th percentile annual target was chosen because it provides for seasonal or short-term variability and the Farad location was selected because it captures cumulative sediment transport conditions since it is located at the downstream end of the project area. It is also the location with the most comprehensive dataset for streamflow and SSC data. By comparison, the Basin Plan water quality objective for suspended sediment for streams that flow into Lake Tahoe is an annual 90^{th} percentile value of less than or equal to 60 mg/L.

Sediment Load Reduction Target

The Truckee TMDL includes a sediment load reduction target of 20 percent of the baseline sediment loading, which leads to an allowable sediment load of 40,300 tons/year at Farad. The 20 percent load reduction is based on SSC data collected at Farad between 1976 and 2005 (n = 434 samples) that showed that the annual 90th percentile 25 mg/L target value was exceeded 6 years out of the 27-year record, or 22 percent of the time. The 20 percent reduction identified in the staff report reflects the proportion of years (rounded down from 22 percent) in the 27- year dataset that the SSC target criteria was not met.

TMDL 10-year Data Review

As directed by the Truckee TMDL Basin Plan language, staff assessed information and data collected since establishment of the TMDL in 2008. The geographic area for which data were examined is generally limited to the watershed areas below the major dams on the tributaries to the Truckee River because the Truckee TMDL is focused on sediment impairment of the mainstem Truckee River, Gray Creek and Bronco Creeks. Tributary areas above the dams typically do not contribute to sediment discharge downstream of the reservoirs. However, due to the extensive dataset available for the Martis Creek sub-watershed above Martis Creek Reservoir, information for Martis Creek is included in this review for comparison purposes. Martis Creek Reservoir is primarily used for flood control and not for water storage and is expected to act as a sediment sink that significantly reduces sediment discharge to the Truckee River from the Martis Creek sub-watershed.

Review of Information Sources and Monitoring Plans

Water quality monitoring data within the Truckee River watershed are collected by various agencies and organizations that include the following local, state and federal agencies, and non-profits:

- Lahontan (R6) and State Water Board Surface Water Ambient Monitoring Program (SWAMP)
- United States Geological Survey (USGS)
- Nevada Division of Environmental Protection (NDEP)
- Truckee River Watershed Council (TRWC)
- Placer County
- Town of Truckee
- California Department of Water Resources (DWR)
- Desert Research Institute (DRI)

The Lahontan Water Board's SWAMP staff conducts monthly and quarterly sampling at locations in the Truckee River watershed, while NDEP conducts monthly water quality sampling at several sites in California. The USGS has collected continuous turbidity data at Farad since 2007 and more recently, DWR established a water quality monitoring program beginning in 2017 related to implementation of the Truckee River Operating Agreement (TROA), which went into effect in 2015. Note that hydrologic and other data is often reported based on Water Year (WY), which is defined by the period from October 1 – September 30. As an example, WY2020 covers the period from October 1, 2019 to September 30, 2020. There is no routine water quality monitoring in Gray and Bronco Creeks.

The Truckee River Water Quality Monitoring Plan (TRWQMP) is a comprehensive monitoring plan developed by Placer County and the Town of Truckee in response to a Lahontan Water Board Water Code Section 13267 order issued to each entity in 2007. The TRWQMP was finalized in 2008 and consists of three implementation phases: Phase 1 involved baseline data collection from WY2009-2013, Phase 2 expanded on monitoring activities from WY2014-2016, Phase 3 began in WY2017 and involves adaptive management of monitoring activities based on Phases 1 and 2. Phase 3 implementation will be ongoing through the final year of TRWQMP implementation (WY2024). Initially the monitoring and reporting was jointly undertaken by Placer County and the Town of Truckee, however beginning with WY2017, Placer County has conducted its monitoring independently and prepared monitoring reports that only include sites in the county. The Town of Truckee has submitted its own stormwater reports in a more limited format since WY2017 to fulfill requirements of the MS4 stormwater permit. Consequently, there is less recent information available for monitoring sites in the Town of Truckee, which includes the Donner and Trout Creek subwatersheds and the Truckee River within the town corridor.

Information about Placer County stormwater management and water quality monitoring activities is available at the following website: https://www.placer.ca.gov/1688/Stormwater-Quality-Management. Information for the Town of Truckee is located at the following website: https://www.townoftruckee.com/government/engineering-and-public-works/clean-water-program/documents

The TRWQMP includes an extensive array of monitoring approaches designed to assess the effectiveness of current strategies to reduce pollutant discharge into the Truckee River and its tributaries. The monitoring strategy is also useful for prioritizing locations that require improvements to reduce stormwater discharge to surface waters. The TRWQMP implemented by Placer County (and the Town of Truckee from WY 2010-2016) includes the following monitoring elements:

- Rapid Assessment Methodology – Characterize distribution of fine sediment on the streambed of surveyed channels in the Truckee River and Squaw, Bear and Martis Creeks, conducted in WY2010, WY2012 and WY2014. This effort was discontinued.
- Bioassessments – Evaluate the health of Squaw and Martis Creeks based on benthic macroinvertebrate communities, conducted biannually since WY2010.
- Community Discrete Samples – Characterize stormwater runoff from catchments in the Martis Creek watershed, conducted annually since WY2011
- Tributary Discrete Samples – Characterize differences in water quality among the Martis Creek tributaries, conducted annually since WY2011.
- Stream Discharge and Turbidity Monitoring – Collect turbidity and total suspended solids (TSS) data at near-continuous turbidity monitoring sites to calculate suspended-sediment loads for Martis Creek and its tributaries, conducted annually since WY2011.
- Rafting Segment Inspection – Document problem sites for pollutant loading along the Truckee River where commercial rafting operations occur in the upper portion of the river below Lake Tahoe, conducted in WY2016, WY2018 and WY2020.
- Field Surveys for GIS Analysis to Develop Recommendations – Identify and prioritize pollutant source areas within developed areas near ski resorts and characterize existing stormwater infrastructure, conducted in WY2016 and WY2019.

Precipitation and Hydrology Data

Most of the runoff in the Truckee River basin originates in the Sierra Nevada in California, however most of the water is allocated for use in Nevada. Runoff in the middle Truckee River is stored in Federal reservoirs (Lake Tahoe, Prosser Creek, Stampede, Boca and Martis Creek Reservoirs) and non-Federal reservoirs (Donner and Independence Lakes), that together can store about a million acre-feet of water. Operation of these reservoirs regulates much of the flow in the Truckee River basin in most years and is governed by the Truckee River Operating Agreement (TROA), which is an agreement negotiated among parties representing the United States, California, Nevada, Pyramid Lake Paiute Tribe, Sierra Pacific, Truckee Meadows Water Authority (TMWA), and other entities in California and Nevada. It was first implemented in December 2015. In general, the reservoirs are operated to capture runoff as available when flow in the Truckee River is greater than needed to serve downstream water rights in Nevada and to maintain prescribed streamflow in the Truckee River, known as Floriston Rates, measured at the Farad gauge near the California-Nevada border (U.S. Department of the Interior and State of California, 2008). According to the TMWA website, TROA increases operational flexibility and efficiency of the reservoirs in the Lake Tahoe and Truckee River basins and provides multiple environmental benefits while protecting existing water rights. It does this in part by allowing for the storage of water and the trading of stored water among the reservoirs.

As is common for the climate in the Truckee River watershed, annual precipitation amounts and run-off are highly variable, as indicated by the USGS hydrologic data summarized in Table 1 for the Truckee River at Farad for the period 2005-2020. Total discharge and streamflow can vary substantially from year to year, and the severe drought that occurred between WY2012-2016 is evident from the low discharge volumes and flows observed during that time. A return to average precipitation occurred in WY2016 that was followed by an historic wet year in WY2017. WY2018 had slightly below average precipitation, and WY2019 was again above average in terms of precipitation and snowfall. WY2020 was another dry water year with below average precipitation that has been followed by an even drier year in WY2021.

Table 2. Annual Total Discharge and streamflow statistics for the Truckee River at Farad for the years 2005-2020

Water Year	WY Type	Annual Total (Acre-feet)	Max Daily Mean Flow (cfs)	Min Daily Mean Flow (cfs)	Peak Flow (cfs)(Date)
2005-2006	Wet	431,786	7,130	277	10,100 (12/31/2005)
2006-2007	Avg	204,745	1,070	345	1,110 (5/18/2007)
2007-2008	Avg	182,194	1,410	291	1,640 (5/18/2008)
2008-2009	Avg	177,571	1,880	191	2,290 (5/5/2009)
2009-2010	Avg	179,934	2,430	75	2,770 (6/6/2010)
2010-2011	Wet	354,618	3,150	275	3,450 (6/23/2011)
2011-2012	Avg	199,291	1,670	393	2,300 (4/26/2012)
2012-2013	Avg	203,267	1,970	333	3,510 (12/2/2013)
2013-2014	Dry	150,900	931	91	1,280 (2/9/2014)
2014-2015	Dry	81,440	1,350	50	2,170 (2/9/2015)
2015-2016	Avg	174,600	2,010	77	2,920 (1/30/2016)
2016-2017	Wet	672,200	6,080	143	9,160 (1/8/2017)

Water Year	WY Type	Annual Total (Acre-feet)	Max Daily Mean Flow (cfs)	Min Daily Mean Flow (cfs)	Peak Flow (cfs)(Date)
2017-2018	Wet	317,000	4,950	365	6,580 (4/7/2018)
2018-2019	Wet	455,300	4,380	287	4,650 (4/9/2019)
2019-2020	Avg	210,500	1,860	243	2,130 (5/18/2020)
2020-2021	Dry	157,900	895	121	1,010 (5/6/2021)

Historical Water Quality Conditions

An early effort to characterize the water quality in the Truckee River occurred in 1972 (Kaiser Engineering, 1973) and combined both the collection of physical and chemical water quality data with surveys for benthic macroinvertebrates (BMI) and attached algae. Data collection occurred in late summer and fall at twelve locations along the Truckee River between Lake Tahoe and Pyramid Lake. A marked difference was observed between water quality in the segment from Lake Tahoe to Farad (near the Nevada border) compared to the lower portion of the Truckee River downstream of Reno, which is described as eutrophic due to the increase in attached algae. Lower numbers of BMI and higher species diversity were observed in the upper portion of the river, with the peak diversity at Farad, with lower species diversity at locations further downstream. In contrast, algal diversity remained stable among the twelve sampling sites. Impairment of the Truckee River due to sedimentation was first identified during the 1992 303(d) listing cycle and the impairment listings apply to the middle Truckee River from Lake Tahoe to the CA/NV border, Gray Creek and Bronco Creek.

Recent Water Quality Conditions

Water quality data collected since establishment of the Truckee TMDL indicate that the numeric target for SSC, defined as an annual 90th percentile value less than or equal to 25 mg/L measured at Farad, has been met each year since 2008. This is based on a review of SSC and Total Suspended Solids (TSS) data collected by multiple agencies as grab samples from the Truckee River at Farad, mostly on a monthly or quarterly basis. The TRWQMP results indicate that the SSC target was also met at locations upstream of Farad at Boca Bridge and above the Town of Truckee through WY2016, which is the last year that data for the Truckee River are reported. TRWQMP results, which utilize near-continuous turbidity data to estimate SSC, found that the small proportion of time that the 25 mg/L SSC target was exceeded generally coincided with rain on snow events or summer thunderstorms. Additionally, the sediment load allocations assigned to specific sub-watershed areas have been met in the years where data are available, except in WY2011, when estimated sediment discharge in Martis Creek and Trout Creek exceeded the load allocations, and in WY2017, when Martis Creek exceeded the allocations. Both of those years were marked by above average annual discharge. Grab sample and near-continuous data for turbidity, which is a measure of transparency in water samples, indicate that the water quality objective for turbidity was exceeded in some years. Additional details regarding the data review are provided below.

Figure 2 displays grab sample TSS data collected at Farad by NDEP, DWR, and R6 SWAMP staff for the period 2000-2021, which shows that only rarely were TSS values at or above 25 mg/L, however this does not include data collected by DRI in 2002-2003 for TMDL development, which did exceed the SSC target. Figure 3 displays NDEP's monthly TSS data collected from 2000-2014 at four locations along the Truckee River from Tahoe City to Farad,

which provides a snapshot of conditions at multiple sites based on samples collected on the same day. Those results indicate that while generally the highest TSS values are observed at the lower end of the project area at the Truckee River at Farad, there are times when the highest TSS concentrations occur upstream near Tahoe City or Martis Creek. More information and analyses are needed to determine the causes of the high TSS concentrations observed at the upstream sites, which may be due to landslides or other episodic sediment discharge events unrelated to streamflow.

Figure 2 Total Suspended Solids (TSS) concentration (mg/L) collected at Farad by NDEP, Lahontan SWAMP (R6) and DWR from 2000 to 2021.

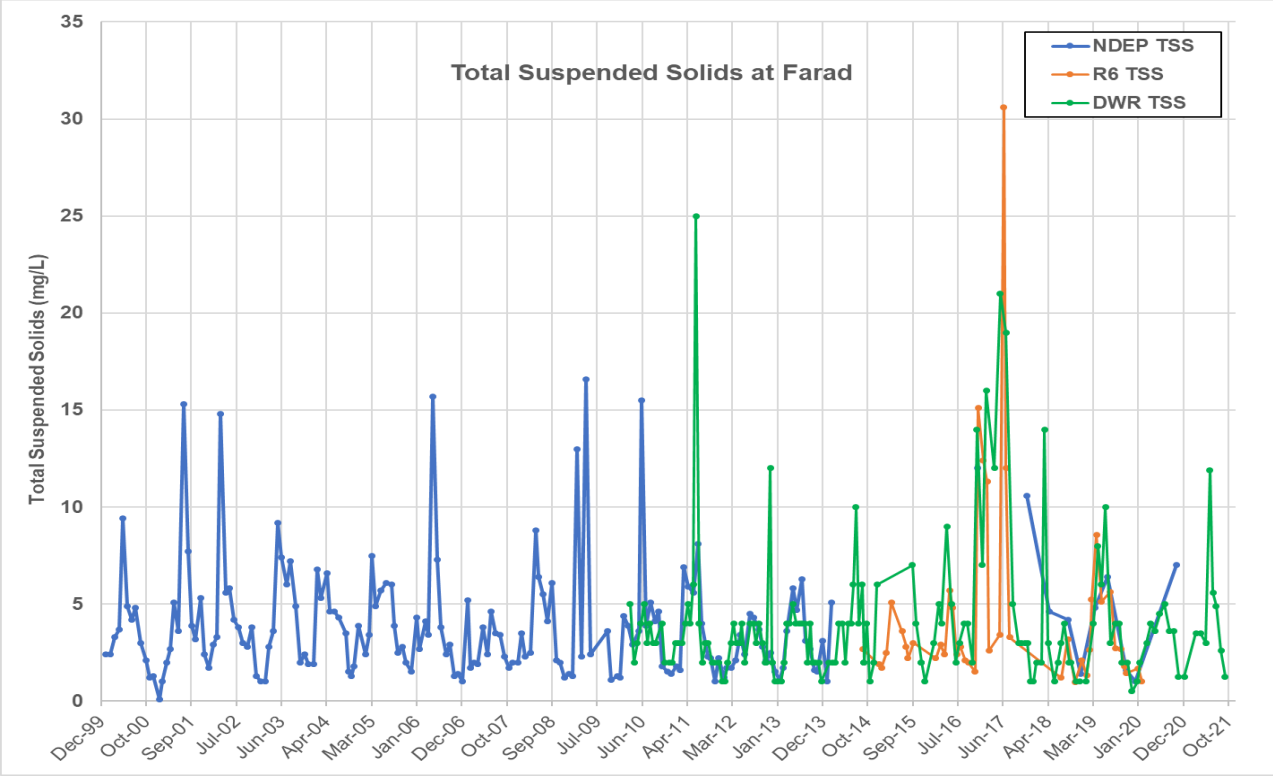
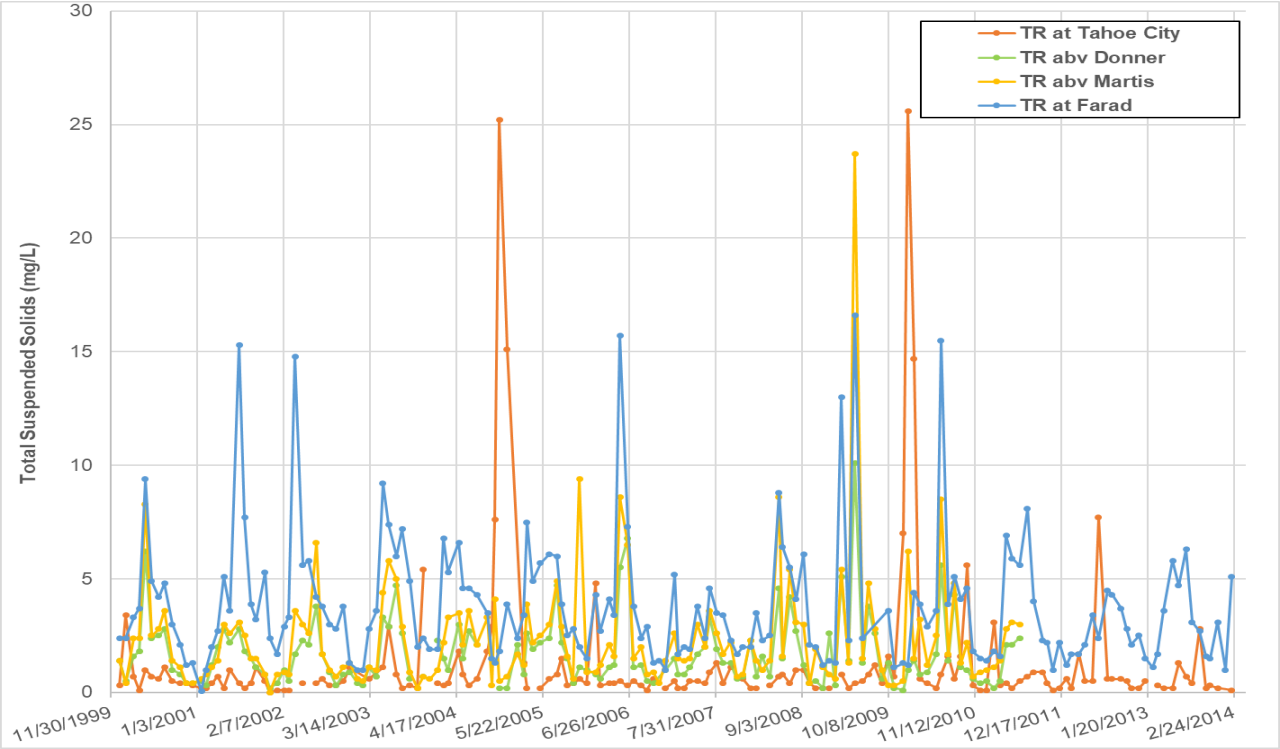


Figure 3 Total Suspended Solids (TSS) concentration (mg/L) collected monthly by NDEP at four locations on the Truckee River from 2000 to 2014.



Turbidity data provide another way to assess suspended sediment conditions in the Truckee River, since turbidity measurements are based on light scattered by particles suspended or dissolved in water. Clay, silt and fine organic matter are examples of particulate matter that increase turbidity. The turbidity water quality objective for the Truckee River is 3 NTU (Nephelometric Turbidity Unit) expressed as the Mean of Monthly Means (MoMM), which for the purpose of water quality assessment is evaluated on an annual basis. NDEP, DWR and R6 SWAMP collect grab-sample turbidity data at Farad, with variable sampling effort, as shown below in Table 3 by the number of samples collected per year (N). Additionally, the USGS began to collect continuous turbidity data at Farad in 2007 and the data can be accessed as the full 15-minute time-series or as daily minimum, maximum and median values.

Table 3 Summary of Mean of Monthly Mean (MoMM) turbidity data and number of samples (N) collected each year by NDEP, DWR, R6 SWAMP and USGS for 2010-2020. The eight exceedances are shown in bold underlined text.

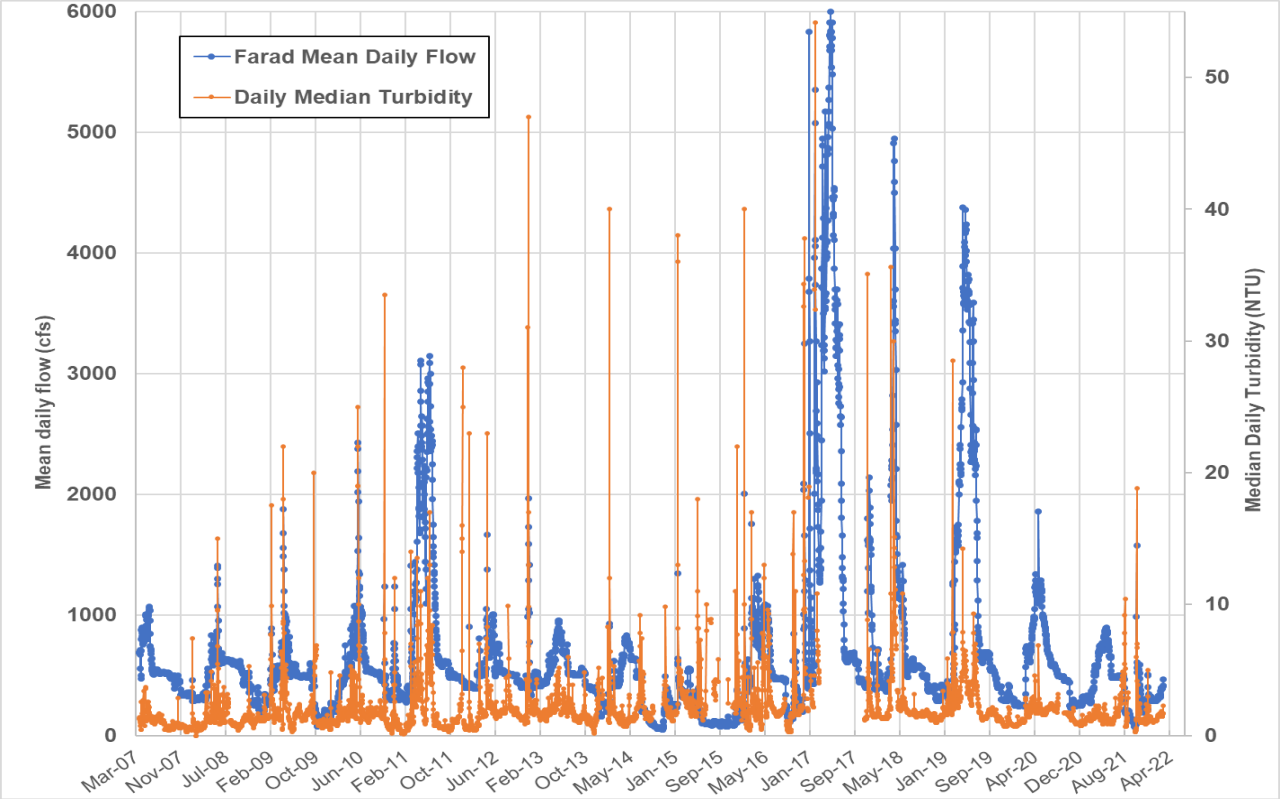
Year	NDEP Annual MoMM	N	DWR Annual MoMM	N	R6 Annual MoMM	N	USGS Continuous Data Annual MoMM
2010	1.75	4	2.62	12			2.12
2011	2.13	12	2.28	17			2.34
2012	1.65	12	1.98	18			2.3
2013	1.53	12	1.63	17			1.94
2014	2.85	3	1.78	17	2.12	4	2.37
2015	**3.13**	4	2.53	5	1.87	12	**3.69**

Year	NDEP Annual MoMM	N	DWR Annual MoMM	N	R6 Annual MoMM	N	USGS Continuous Data Annual MoMM
2016	**6.4**	3	**3.56**	11	1.97	7	**3.17**
2017	**4.23**	3	**5.64**	11	**5.75**	3	2.85
2018	2.01	3	2.49	13	2.57	5	2.49
2019	2.3	3	1.94	11	1.93	3	2.59
2020	1.55	2	1.56	11	0.95	1	1.67
2021			1.04	10			

The turbidity data were assessed against the Truckee River water quality objective by calculating annual MoMM values (based on calendar years), some of which relied on three or fewer samples in a year, as shown in Table 3. The NDEP data exceeded the 3 NTU water quality objective three times over the 2010-2020 period, with two exceedances for the DWR data, and one for the R6 SWAMP data. As a preliminary assessment of the USGS continuous turbidity data, annual MoMM values were calculated using the daily median value reported by USGS derived from the 15-minute data. For the USGS data, the water quality objective was exceeded in 2015 and 2016, although there were gaps in the continuous data record which could bias the outcome of this analysis. When these four datasets are combined and each annual MoMM value is counted as one sample, the rate of exceedance might result in a 303(d) listing for turbidity for the Truckee River. Under the State Water Board Listing Policy, seven exceedances for a sample size of 41 are needed to list for conventional pollutants. Table 3 shows eight exceedances, however additional analysis is needed to confirm whether these data are comparable and would lead to listing for turbidity.

Figure 4 displays the USGS data for daily median turbidity at Farad together with mean daily streamflow, expressed as cubic feet per second, for the period from 2007-2022. There are some gaps in the record for turbidity, particularly in 2017 when streamflow was higher than average. These results show that turbidity values generally remain low (below 3 NTU) in the Truckee River at Farad with occasional spikes that tend to be, but are not always, associated with high streamflow events.

Figure 4 USGS data for mean daily flow and median daily turbidity at Farad from 2007-2022



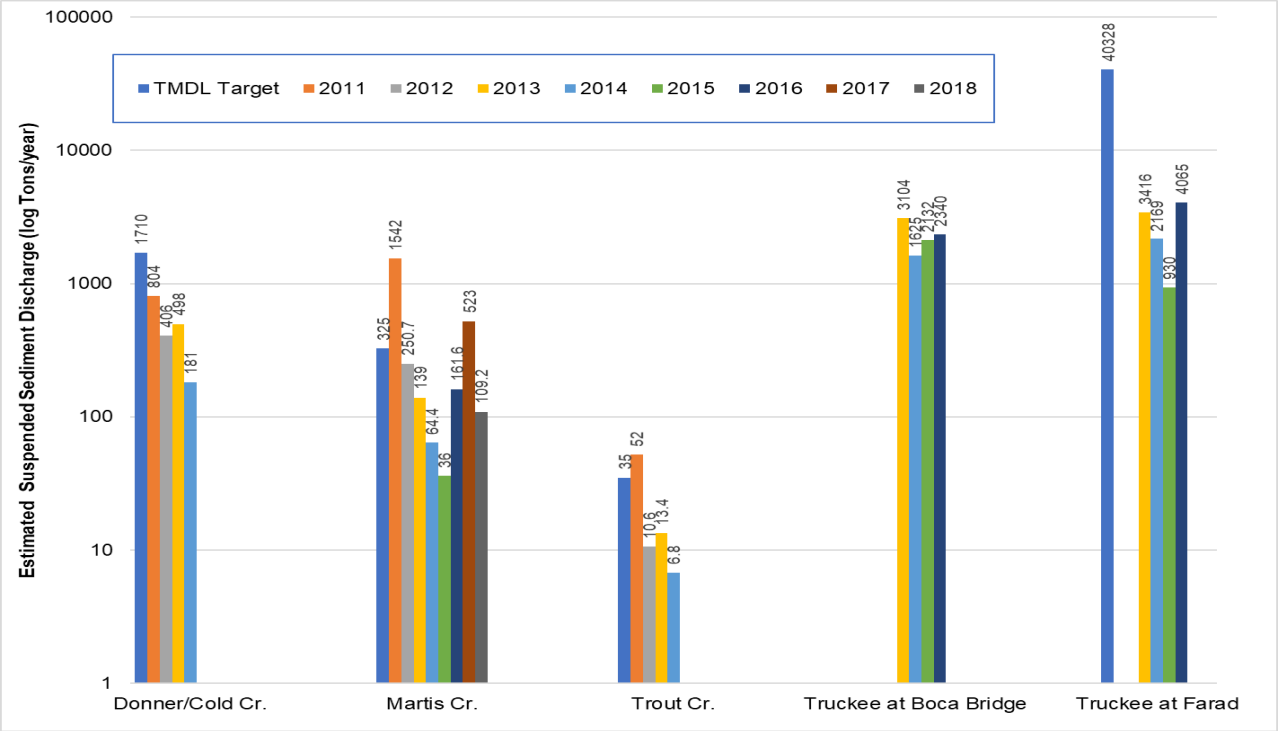
Placer County has implemented annual stormwater monitoring since 2010, which has created a 10-year dataset that can be used to evaluate trends at certain locations in the Truckee River watershed. The WY2020 annual report includes analysis of trends in grab sample data for TSS concentration over time evaluated using the Mann-Kendall test method. For those sites monitored since 2011, which are all in the Martis Creek sub-watershed, the results indicate a decreasing trend in TSS for the mainstem Martis Creek, West Martis Creek and upper Martis Creek sites (CDM Smith and Balance Hydrologics, 2021). Authors of the 2020 report acknowledge the role that hydrology plays in stormwater discharge and suggest the observed trend in TSS may partially be due to differences in hydrologic conditions instead of improvement in stormwater management, a statement that reflects the four years of low precipitation that occurred during the study period. While not the subject of this report, the trend analysis for total phosphorus at those sites also showed a decreasing trend over the past ten years, however mean values for total phosphorus were above the 50 µg/L water quality objective for Martis Creek for most monitoring sites. Martis Creek was first listed as impaired for phosphorus for the 2018 Integrated Report.

Placer County has also collected nine years of near-continuous streamflow and turbidity data at several locations in the Martis Creek watershed and similar data were collected for WY2011-2014 on Donner Creek and Trout Creek. The monitoring sites on Donner Creek and Trout Creek were established to support sediment studies funded by TRWC and were later discontinued. The turbidity timeseries data were used to develop turbidity-to-SSC correlations that allow the estimation of annual sediment discharge. Sediment discharge was also estimated based on empirical relationships between streamflow and SSC data under different flow conditions that were then applied to a record of streamflow. The results reported by Placer County rely primarily on the turbidity-based method for estimating sediment discharge,

but in some cases both approaches were utilized in combination due to gaps in the turbidity record. In general, the use of near-continuous turbidity monitoring to estimate sediment discharge may better capture sediment discharge events not related to rainfall or fluctuations in streamflow, such as bank failures or illegal discharge, that would not be apparent using the streamflow-based approach (CDM Smith and Balance Hydrologics, 2021).

Estimates for sediment discharge at different locations in the Truckee River watershed are shown in Figure 5 and displayed on a logarithmic scale for the y-axis to better depict the range in values. These results provide insight into the annual variability that exists in estimated sediment discharge and allows comparison with the Truckee TMDL sediment load allocations for individual sub-watersheds. Figure 5 includes estimates for Donner/Cold Creek, Martis Creek and Trout Creek and for the Truckee River at Boca Bridge and at Farad. There is no TMDL target for the Truckee River at Boca. For most years, estimates for sediment discharge are below the TMDL target value, however sediment discharge exceeded the TMDL target for Martis Creek and Trout Creek in WY2011 and for Martis Creek in WY2017. Both WY 2011 and 2017 exhibited above-average annual discharge. Sediment discharge from Martis Creek to the Truckee River is likely much lower than the values in Figure 5 since the measurements are made upstream of Martis Reservoir, which acts as a sediment sink. Another observation is that in WY2015, the estimated sediment discharge was greater at Boca Bridge (2132 tons) than downstream at Farad (930 tons). The authors attribute the higher sediment load observed at Boca Bridge to the urbanized land uses along the Truckee River through the Town of Truckee corridor and suggest that the sediment load may have been deposited in the stream channel before reaching Farad (CDM Smith and Balance Hydrologics, Inc. , 2016).

Figure 5 TMDL target allocations and estimated annual sediment discharge (tons/year) for locations in the Truckee River watershed (x-axis values displayed on a log scale)



Authors of the stormwater monitoring reports make some useful observations regarding sediment discharge in the Truckee River watershed. One is that short-term, high intensity precipitation events, such as rain on snow or summer thunderstorm events, can generate sediment loads an order of magnitude (or more) greater than loads generated by low intensity events, such as spring snowmelt runoff (Balance Hydrologics, Inc., 2014). The original 1992 303(d) listings for sediment in the Bronco and Gray Creeks are based, in part, on observations of high sediment discharge events associated with thunderstorms. Another factor that can influence sediment loading is changes in geology within the watershed, from the glaciated terrain in the upper portion of the middle Truckee River, which tends toward high sediment yield, to the largely bedrock-controlled canyon at the lower end near Farad, characterized by lower yields. Additionally, for the Town of Truckee portion of the river and the developed areas of the Martis Creek sub-watershed near Northstar, fine sediment can be discharged to the Truckee River and Martis Creek from both soil erosion and stormwater outfalls draining areas of high vehicle traffic where traction sand is used. This material may then be transported downstream to lower energy areas where it can settle both in the channel and along the channel fringes where velocities are slow (CDM Smith and Balance Hydrologics, Inc. , 2016). A review of available data and information related to sediment conditions in the stream channel is included later in this report in the section on aquatic and riparian habitat conditions.

Status of TMDL Implementation Measures and Indicator Targets

In addition to the numeric target for suspended sediment at Farad and the load allocations for the sub-watersheds, the Truckee TMDL contains specific implementation measures, each with an associated indicator target, that are meant to reduce sediment discharge to the Truckee River. As described in the 2008 Truckee TMDL staff report, the implementation

targets are meant to express desired conditions in the watershed that involve activities to reduce sediment discharge, rather than specific sediment mass reductions. This is considered appropriate due to the stated impracticality of using sediment mass reductions as indicators of beneficial use protection, which the staff report attributes to the inherent natural variability of sediment delivery and the uncertainties associated with accurately measuring sediment loads and reductions. Some of the implementation measure targets are not well articulated in the adopted TMDL language, but rather direct dischargers to engage in activities related to each measure without providing guidance on the level of effort required. The lack of specificity in the Basin Pan language has led to some ambiguity for staff and creates challenges when assessing compliance with the requirements of the Truckee TMDL.

Some of the implementation measures (e.g., traction sand management, legacy site restoration) are required by MS4 stormwater permits issued to local and state agencies, while the measures related to ski areas are included in Waste Discharge Requirements (WDRs) issued to the resorts. Table 4 contains information regarding each TMDL implementation measure and indicator target, and a review of monitoring and reporting submitted bydischargers. Available information regarding projects implemented to address the Truckee TMDL is presented in Table 5, which includes a short summary of actions completed or in progress since the TMDL became effective. As indicated in Table 5, considerable effort has been applied by multiple entities to complete projects that are expected to reduce sediment discharge to the Truckee River. However, since the implementation targets are not well defined regarding the level of effort required for certain activities, it is difficult to establish if the work that has been completed or is in progress is sufficient for compliance.

Table 4 Summary of Truckee TMDL Implementation Measures and Reporting

Implementation Measure	Evaluation Schedule	Responsible Party	Monitoring and Reports
Road sand application and recovery managed to the maximum extent practicable (MEP)	Annual reporting of sand use and recovery and road sand characteristics	Placer County	Stormwater Monitoring Reports (2009-2020)
		Town of Truckee	Stormwater Monitoring Reports (2009-2020)
		Caltrans	Not required by permit
Ski area Best Management Practices (BMPs) Implementation and maintenance	Annual reporting of inspections, proposed projects to correct deficiencies, and effectiveness of previous projects	Squaw Valley Ski Corporation	Monthly and Quarterly Monitoring Reports
		Northstar-at-Tahoe	Monthly and Quarterly Monitoring Reports
		Alpine Meadows	Annual and Quarterly Monitoring Reports
		Tahoe- Donner Ski Area	Monthly Monitoring Reports
Dirt roads maintained or decommissioned	Annual reporting of dirt road evaluations, proposed and completed	Placer County	SWMP Annual Reports (2009-2020)
		Town ofTruckee	SWMP Annual Report (2009-2020)
		USFS Tahoe National Forest	Letters submitted in 2011, 2013, 2016 and 2020

Implementation Measure	Evaluation Schedule	Responsible Party	Monitoring and Reports
	corrective actions, and effectiveness of	State Parks	Reports not required
Legacy site restoration and Best Management Practices (BMP) implementation	Once candidate sites are identified and prioritized, annual reporting on legacy sites and restoration activities planned or completed.	USFS Tahoe National Forest	Letters submitted in 2011, 2013, 2016 and 2020
		Placer County	SWMP Annual Reports (2009-2020)
		Town of Truckee	SWMP Annual Report (2009-2020)
		State Parks	Reports not required
		Caltrans	Not required by permit

Road Sand Management Activities

The TMDL implementation target related to road sand management requires that road sand be applied using BMPs, that it be recovered to the maximum extent practicable (MEP), and that road sand physical characteristics and recovery rates should be reported annually. The MS4 stormwater permits issued to Placer County and the Town of Truckee include these road sand management requirements and monitoring for this TMDL element is required as part of their stormwater monitoring program. The Town of Truckee has included this information in their annual monitoring reports and their monitoring report for WY 2020 states that the percentage of road abrasives recovered equates to approximately 96% of the total amount applied that year. Placer County has not routinely reported this information, however after a discussion with Lahontan staff on this topic on March 16, they submitted several years of road sand use and recovery data that shows they consistently recover more than they apply.

The statewide Caltrans MS4 stormwater amended permit adopted in 2014 requires measures to address TMDLs, including preparation of a statewide Stormwater Management Plan (SMP) that was completed in 2016. The SMP describes the required reporting by Caltrans, which includes submission of an annual TMDL Status Review Report (California Department of Transportation, 2016). Additionally, Caltrans developed a TMDL monitoring plan in early 2017 that describes the prioritization process used to determine the type of monitoring effort needed for specific watersheds (California Department of Transportation, 2017). Caltrans is supposed to report on traction sand use and legacy site restoration and associated BMP implementation annually. Caltrans submits annual TMDL monitoring reports however those reports do not contain the information specified by the Truckee TMDL, in part because the implementation measures assigned to Caltrans are not identified in their MS4 stormwater permit. Lahontan staff met with Caltrans on March 16, 2022 to discuss TMDL implementation and reporting requirements and Caltrans agreed to submit information on activities taken in the watershed to reduce sediment discharge. Caltrans is not required to implement ambient water quality monitoring in the Truckee River watershed.

According to TRWC, Caltrans tries to reduce the environmental impact from salts and abrasives, either by using natural products in smaller amounts, using brine salts instead of

road sand or through the use of technology, such as road temperature gauges, that can allow treatments to be applied more selectively (Truckee River Watershed Council, 2018). Routine operations also involve sand recovery with street sweeping and annual clean out of sand traps and catch basins.

Ski Area Best Management Practices

The implementation target related to ski resorts in the Truckee River watershed applies to Palisades Tahoe (formerly known as Squaw Valley and Alpine Meadows), Northstar, and Tahoe-Donner ski resorts and requires that ski areas and related facilities be inspected annually to identify areas of erosion. Annual reports should describe the inspection results, proposed measures to correct deficiencies, and the effectiveness of erosion-control projects previously implemented. Compliance with the ski area implementation measures is required by WDRs issued to the ski areas as orders adopted by the Lahontan Water Board.

The WDR for Squaw Valley was adopted in 2009 (Water Board Order No. R6T-2009-0024) and contains requirements for implementation of permanent or temporary stabilization of all disturbed or eroding areas prior to October 15 of each year, in addition to other more detailed requirements for actions to reduce erosion and sediment discharge. Prior to adoption of the 2009 WDR, enforcement actions were taken in the 1990's for noncompliance with prior versions of the WDR, which ultimately led to a judicial consent agreement in 2005 that required development and implementation of a Water Quality Improvement Program, which was completed in 2010. In a 2016 presentation to the Water Board, staff described how cooperative efforts between Water Board staff and Squaw Valley staff have resulted in a shift to embrace environmental stewardship that have resulted in full permit compliance. Squaw Valley and Alpine Meadows, now known as Palisades Tahoe, are currently managed by the same company.

The most recent WDR for the Tahoe-Donner Ski Area, located north of Interstate 80 in the Trout Creek sub-watershed, was adopted in June 2000 (Water Board Order 6-00-45), which is prior to establishment of the Truckee TMDL. The WDR includes measures that directly address the ski area implementation target in the TMDL, such as the requirement to stabilize all disturbed or eroding areas prior to October 15 of each year and to prepare and implement a plan to stormwater controls to reduce erosion at the ski area, lodge and parking areas. The monitoring program requires annual inspections in April and October to identify potential erosion and surface runoff problem areas and the annual monitoring report must describe those areas and the corrective measures that were implemented. Similarly, the WDR for Northstar Ski Area (Water Board Order 6-93-89) was adopted prior to establishment of the Truckee TMDL. It includes required annual inspections and implementation actions to reduce erosion along with monitoring requirements to report on erosion control activities that address the TMDL implementation target for ski areas.

Dirt Road Management and Implementation

The TMDL implementation target for dirt road management requires that dirt roads with inadequate erosion-control structures are rehabilitated and maintained, or decommissioned, with a focus on prioritizing actions for dirt roads located near surface waters. Placer County does not manage dirt roads and the Town of Truckee has municipal ordinances that require erosion control for dirt driveways. With assistance from TRWC, the Tahoe National Forest (TNF) Truckee Ranger District completed a sediment source assessment in key tributaries to the Truckee River, prioritized the sources based on potential for treatment to reduce

sediment production, and developed a plan that prescribes sediment control treatments at selected sites. This effort was completed in August 2016, however the activities outlined in the plan were not necessarily ready for implementation, since portions of the plan require environmental analysis under the National Environmental Policy Act and the California Environmental Quality Act (Truckee River Watershed Council and Tahoe National Forest Truckee Ranger District, 2016).

The Truckee Ranger District has submitted periodic updates that detail the planning efforts and work completed related to road management and restoration in the TNF. These submittals also include projects related to legacy site restoration. Reports were submitted in 2013 (covering 2011-2013), 2016 (covering 2013-2016) and 2020 (covering 2017-2020) and describe activities to reduce sediment discharge projects in watershed areas that discharge to the Truckee River, which are summarized in Table 5. Additional projects have been completed in the Little Truckee River and Prosser Creek sub-watersheds upstream of the tributary reservoirs, however these projects are not shown in Table 5. Much of the activity completed on the Truckee Ranger District involves road rehabilitation in tributary areas along the Hwy 89 corridor upstream of the Town of Truckee (e.g., Pole Creek, Silver Creek and Cabin Creek sub-watersheds).

Legacy Site Restoration

The TMDL implementation target for legacy site restoration specifies that legacy sites should be restored or stormwater BMPs implemented to prevent erosion and sediment discharge to surface waters. As indicated in Table 5, multiple entities have worked to reduce sediment discharge by addressing legacy land uses. The Truckee Ranger District, together with other partners, completed a large restoration project in 2020 to improve the meadows and stream corridor in the Bear Creek sub-watershed. Legacy land uses affecting Bear Creek include historic grazing and logging. Other projects have been completed, are underway or are under development by Placer County and the Town of Truckee that address legacy land uses, such as restoration of the McIver Dairy site near Donner Pass Road and projects to restore Trout Creek. The TRWC has been involved with addressing legacy issues at multiple locations within the watershed, as indicated in Table 5. In particular, the work they have completed in the Coldstream Canyon area is important since the Donner Creek sub-watershed area, which includes Coldstream Canyon, has some of the highest sediment loading observed in the Truckee River watershed. Legacy land uses in Coldstream Canyon include logging, road and railroad construction and gravel mining.

The TMDL implementation plan also highlights efforts by grant-funded non-profits and land trusts that are engaged in restoration activities in the Truckee River watershed. It should be noted that TRWC and their partners have completed several projects to restore meadow and stream habitat at locations above tributary impoundments in the Martis Creek and Little Truckee River sub-watersheds. These projects will reduce erosion and sediment discharge in the watershed, however due to the presence of impoundments that tend to trap sediment, these projects are not included in Table 5. Martis Creek and the Little Truckee River are not expected to contribute significantly to sediment discharge to the Truckee River, although there is little information or data available for tributary locations below the impoundments to confirm this.

Table 5 Summary of projects implemented to address the Truckee TMDL requirements for reduction in sediment discharge.

Tahoe National Forest, Truckee Ranger District (and other local partners)			
Project Name	**General Location**	**Actions Completed**	**Completion Date**
Bear Creek Restoration Project	Bear Creek (near Alpine Meadows)	This project restored 30 acres of meadow and 3,000 feet of stream with assistance from Truckee River Watershed Council	2020
Deer Park Ski Resort Rehabilitation	Bear Creek (near Alpine Meadows)	This project involved recontouring and replanting an abandoned ski hill in the Bear Creek sub-watershed to reduce sediment sources into Bear Creek.	2020
Highway 89 Corridor Tributaries Project	Various tributary drainages along Hwy 89	• Completed approximately 12.7 miles of road work within the Deer Creek, Pole Creek and Silver Creek drainages. • Assessment of Pole and Cabin Creek sub-watershed • Completed implementation in partnership with the TRWC of nearly 18 miles of road improvements. • 16.9 miles of road were treated to improve water drainage and watershed function • 12.5 miles of road treated to improve water drainage and watershed function • 5 miles of off highway vehicle (OHV) trails were treated to improve water drainage in the Pole Creek and Cabin Creek areas	2020 2020 2019 2012 2011 2011
Stockrest Spring Restoration Project		Approximately 35 acres of watershed function was improved, 7 acres of wet meadow were re-watered, and 3000 feet of intermittent stream were restored.	2011
East Zone Connectivity and Restoration Project	Various areas	Project involves road and trail management and includes identifying sediment delivery issues, remediating those through re-routes, decommissioning, and restoration of hydrologic connectivity	Approved 3/21
Alpine Meadows Ski Area	Bear Creek (near Alpine Meadows)	Work with Alpine Meadows ski areas to assess sources of erosion and plan for remediation of roads and other infrastructure, as needed.	Under Development

Placer County (and other local partners)			
Project Name	**General Location**	**Actions Completed**	**Completion Date**
Truckee River Recreational Access Plan	Hwy 89 Corridor, Squaw Valley Rd. to Truckee	Key elements of the plan include restoration of eroded or degraded areas to minimize sediment and pollutants discharge to the Truckee River.	Under Development, CEQA Scoping
Town of Truckee (and other local partners)			
Coldstream Culvert Replacement	Coldstream Canyon	Replacement of an aging box culvert under Coldstream Road with a new bridge across Donner Creek to increase flood capacity and improve fish passage.	2020
McIver Dairy Restoration	Town of Truckee	This project removed a large amount of artificial fill, reconnected the creek with its floodplain and restored 4 acres of meadow. Project implemented with assistance from Truckee River Watershed Council.	2019
Trout Creek Restoration Reach 3	Town of Truckee	This project improved floodplain quality, increased riparian habitat, improved flood capacity and improved water quality by managing stormwater runoff	2012
West River Street Project	Town of Truckee	This project will improve stormwater capture and treatment while providing pedestrian connections that may reduce automobile use.	Under Development
Church Street Extension	Town of Truckee	Extend Church Street from the “Railyard Redevelopment” area west to Glenshire Drive. This project includes restoration of the creek upstream and downstream of a new bridge, which will replace the currently undersized culvert.	Under Development
Truckee River Legacy Trail Phase 4	Town of Truckee	The project consists of 1.9 miles of multi-use trail that crosses both public and private property, and includes a 400-foot bridge across the Truckee River located on USFS property	Under development
Trout Creek Restoration Project	Town of Truckee	Restore Trout Creek from its I-80 undercrossing to the confluence with the Truckee River	Under development

Truckee River Watershed Council (and other local partners)			
Project Name	**General Location**	**Actions Completed**	**Completion Date**
Coldstream Ponds and Roads	Cold Creek above Donner Creek	The project included drainage improvements along 7 miles of dirt road, decommissioning 1 mile of dirt road, creation of 1/2 acre of wetland habitat on pond fringe, additional work taking place in 2021; completed in partnership with California State Parks	2021
Truckee River BMP retrofit program	Truckee River watershed	Residential BMPs implemented on 150 private residential properties	2014-2018
First 4-mile restoration	Truckee River between Lake Tahoe and Alpine Meadows road	Streambank stabilization at three locations, improved access point, revegetation. Total of 1,200 feet streambank treated, 0.9 acres floodplain and meadow restored/enhanced. Completed in partnership with Tahoe City PUD.	2016
Coldstream Floodplain	Cold Creek above Donner Creek	The project included creation of 0.8 acres of floodplain and riparian habitat, erosion remediation along 1,000 feet of stream, 1,200 feet streambank restored; completed in partnership with California State Parks	2012
Caltrans			
Truckee Maintenance Station	Town of Truckee	Improvements were made to provide treatment for discharges leaving the site that include treating runoff at three discharge points at the station with storm water vault systems.	2012
Floristan Sand and Salt House	I-80 east of Truckee	The Floristan Sand and Salt house was relocated to move it away from the Truckee River and the existing structure was demolished.	2017

Other Factors Affecting Water Quality

Climate change is an important factor that affects hydrology, and by extension also impacts water quality in the Truckee River both now and in the future. A comprehensive assessment of projected impacts to water supply in the Truckee Basin associated with various climate change scenarios was completed in 2015 (Bureau of Reclamation, 2015) that provides insight into how Truckee River hydrology may change in the future. The study's central tendency, which depicts the average of the scenarios examined, projects a slight increase for inflow to Lake Tahoe and at the Farad gage location (2-3 percent) over the reference condition, while the range of uncertainty related to future climate scenarios could result in either increases or decreases in inflow of up to 18 percent. Additionally, increases in mean annual temperature are likely to change the timing and intensity of runoff, with more precipitation falling as rain instead of snow and peak flows occurring earlier in the year. These changes could lead to increased erosion and sediment transport in the Truckee River watershed and underscore the need to continue to undertake wetland, meadow and stream corridor restoration projects.

Another factor that may impact water quality is the continued development occurring in the Truckee River watershed. The Town of Truckee increased by over 1,000 residents between the 2010 and 2020 census and the Town's website lists a number of new developments that are either already approved or are in the planning phase. Presumably, all new developments are required to abide by the Town's municipal code section for stormwater quality, which requires that public and private development projects reduce stormwater pollution and erosion both during construction and after the project is complete. Measures required by the Town's municipal code include the use and maintenance of BMPs to reduce pollutants in stormwater and the requirement that property owners near watercourses not remove healthy bank vegetation in such a manner as to increase the vulnerability of the watercourse to unnaturally high rates of erosion. New housing and commercial developments are also occurring in unincorporated areas of Placer County, which has similar requirements that address impacts to water quality associated with development.

TMDL Compliance Summary

The review of available information and data, including the submittals by permit holders, indicates that there has been substantial effort to reduce sediment discharge during the 12 years since the Truckee TMDL was fully approved in 2009. The tables above that summarize projects completed during this time indicate that this effort has occurred throughout the middle Truckee River watershed. It is difficult to estimate the magnitude of the reduction in sediment discharge resulting from completion of these projects in relation to the load allocations identified in the Truckee TMDL. As noted in the 2008 Truckee TMDL Staff Report, the implementation targets are meant to express desired conditions in the watershed, rather than numeric sediment mass reductions. This is primarily due to the difficulty in quantifying reductions in sediment discharge because of the variable climate and hydrology that characterize the Truckee River watershed, which can lead to episodic events resulting in high sediment discharge (e.g., rain on snow events, thunderstorms) and large variability in streamflow from year to year. The review of available water quality data indicates the numeric target for suspended sediment concentration has been met since establishment of the Truckee TMDL. However, the available turbidity data collected at Farad indicate there are years when the annual MoMM water quality objective for turbidity is exceeded.

There are still areas in the watershed where additional effort may be needed to reduce the discharge of fine sediment to the Truckee River. Those areas are generally associated with developments near ski resorts, locations along major roadways, and in the Town of Truckee corridor where run-off from roadways and other paved areas may discharge into tributary streams and the mainstem Truckee River. The use of abrasives for traction control creates chronic sources of fine sediment in these areas. Placer County and the Town of Truckee, via their stormwater monitoring and reporting programs, continue to identify areas where improvements are needed in stormwater infrastructure and implement projects as resources allow. Caltrans is also actively maintaining and improving stormwater infrastructure associated with roadways under its responsibility. Recommended areas for water quality improvements focus on road shoulder areas, culvert and outfall locations, and implementation of strategies such as soil stabilization and installation of green stormwater infrastructure (e.g., infiltration and bioretention BMPs) (CDM Smith and Balance Hydrologics, 2021).

Similarly, although the TNF Truckee Ranger District has only submitted periodic reports regarding actions taken to address sediment discharge from dirt roads, they continue to plan and implement projects related to dirt road management to rehabilitate the road network and reduce erosion and sediment discharge. Legacy site restoration continues to occur throughout the watershed and is often implemented through partnerships with multiple entities that include local organizations not mentioned in the Truckee TMDL, such as community service districts, homeowner's associations, and public utilities. Although there are no numeric targets associated with the implementation targets, taken together the multiple actions and reporting completed by the responsible parties are evidence of the efforts made to maintain compliance with the Truckee TMDL. While there have been some gaps in reporting certain TMDL measures, based on the information available, staff concludes that the implementing parties identified in the Truckee TMDL have complied with the requirements.

Truckee River and Tributary Aquatic Habitat Conditions

Another factor to consider in determining whether the Truckee TMDL has led to attainment of the sediment-related water quality objectives is to examine whether current habitat conditions support the beneficial uses. The Basin Plan identifies the aquatic life and habitat-related beneficial uses assigned to the middle Truckee River and its tributaries. The definitions for those beneficial uses are provided below:

- Cold Freshwater Habitat (COLD): Beneficial uses of waters that support cold water ecosystems including, but not limited to, preservation and enhancement of aquatic habitats, vegetation, fish, and wildlife, including invertebrates.
- Wildlife Habitat (WILD): Beneficial uses of waters that support wildlife habitats including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl.
- Rare, Endangered or Threatened Species (RARE): Beneficial uses of waters that support habitat necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened or endangered.

- Migration of Aquatic Organisms (MIGR): Beneficial uses of waters that support habitats necessary for migration, acclimatization between fresh and saltwater, or temporary activities by aquatic organisms, such as anadromous fish.
- Spawning, Reproduction, and Development (SPWN): Beneficial uses of waters that support high quality aquatic habitat necessary for reproduction and early development of fish and wildlife.

The mainstem of the middle Truckee River is designated for the following beneficial uses: COLD, WILD, RARE, MIGR and SPWN. The tributaries to the middle Truckee River are also designated for the same beneficial uses, except for Cold Creek, Trout Creek, Juniper Creek, Gray Creek and Bronco Creek, which are not designated for MIGR.

Historic and Recent Aquatic and Riparian Habitat Conditions

As mentioned briefly in the introduction, the Truckee River watershed has been subjected to many damaging human activities and legacy land uses that have degraded habitat conditions over time. Early on, water quality issues arose from the dumping of sawdust and other material into the Truckee River and from sedimentation due to eroding hillsides left bare after timber was clear-cut in the area. A USGS 1902 report on the condition of forests in the northern Sierra Nevada indicated that by 1902, nearly 59% of the forest land in the Truckee basin had been "logged clean or culled" (Truckee River Watershed Council, 2004). In addition to sawdust, timber harvesting had other impacts due to the use of rivers and streams for transporting logs to the mill, which often included efforts to widen and/or deepen stream channels to allow easier movement of the logs. Other historic land use practices that impacted the Truckee River watershed include ice harvesting activities in the late 19th and early 20th centuries, cattle and sheep grazing, and railroad and road construction (Truckee River Watershed Council, 2004). Altogether, these activities transformed the de-forested landscape as the associated infrastructure, such as roads, flumes, and diversions, created flow paths resulting in erosion, and fine sediment delivery to tributary streams and the Truckee River (Truckee River Watershed Council, 2018).

In the mid-1990's, CDFW conducted habitat assessments and instream flow studies in the mainstem Truckee River and some tributaries to develop streamflow recommendations for TROA (California Department of Fish and Game, 1996). At that time, Truckee River spawning and fry rearing habitat were described as degraded, and pool habitats critical to juvenile survival had been lost. The authors also observed that habitat for spawning, incubation, and rearing of salmonid adults was restricted during severe drought and that negative effects could occur due to fluctuating flows downstream of Lake Tahoe. Similarly, the assessment for Donner Creek and Prosser Creek indicated that channel and habitat conditions were severely degraded, and that flow was highly variable, with minimum streamflow that was too low in both tributaries. Donner Creek and Prosser Creek were identified in the CDFW report as the only tributaries with potential for increasing spawning and rearing habitat in the Truckee River (California Department of Fish and Game, 1996). The 1996 CDFW-recommended streamflows developed for TROA for the Truckee River and its tributaries were designed to meet two primary objectives: 1) maintain self-sustaining Brown and Rainbow trout populations, and 2) provide recruitment to other tributary trout populations. Ultimately, implementation of TROA didn't begin until January 2016 and the coordinated streamflow management under TROA is expected to improve Truckee River

water quality, enhance instream flows and recreational opportunities (U.S. Department of the Interior and State of California, 2008).

When considering habitat conditions, it's important to also consider the great diversity found in riparian and upland vegetation along the Truckee River that is important for aquatic and terrestrial wildlife. Riparian vegetation creates shade to cool water temperatures, traps sediment from the watershed, and provides cover and substrate for organisms and eggs (U.S. Department of the Interior and State of California, 2008). As with instream habitat, riparian areas along the Truckee River and its tributaries have been affected by a wide variety of human activities and habitat modifications including urban and industrial development, clearing for agricultural uses, and invasion by nonnative plant species. These habitat modifications have also resulted in sediment discharges to the Truckee River, and an overall reduction in habitat quality and related beneficial uses. TRWC completed a recent assessment and planning exercise related to conditions along the Town of Truckee portion of the Truckee River (Truckee River Watershed Council, 2018). This assessment describes riparian habitat along the Truckee River as having a very narrow land area and patchy distribution that is limited by natural river constraints or land use, which reduces its current habitat value. Floodplains are also important habitat features that can store sediment during high flow events and mitigate downstream flooding. Floodplains in portions of the Town of Truckee section of the river are limited by the railroad tracks located directly adjacent to the river, fill placement, modifications previously made for ice harvesting, or other changes made due to legacy land uses (Truckee River Watershed Council, 2018).

Sediment-related Channel Condition Studies

TRWC supported the completion of several studies on sediment loading and streambed conditions in the Truckee River watershed between 2010 and 2014 to track compliance with the TMDL and to assess the effectiveness of erosion control and watershed management measures to reduce fine sediment loading (Balance Hydrologics, Inc., 2012; Balance Hydrologics, Inc., 2012; Balance Hydrologics, Inc., 2014; Balance Hydrologics, Inc., 2014). This effort included establishing continuous turbidity monitoring stations on Cold Creek, Donner Creek and Trout Creek and measurement of changes in streambed conditions, such as pebble counts to document bed texture and cross-sectional surveys of streambed elevations and sketch maps to identify changes in stream features, such as pools or riffles (Balance Hydrologics, Inc., 2014). Conclusions drawn from these studies are that, at times, there is excess sediment transfer from some tributaries into the Truckee River and that Donner Creek exhibits higher yields and loads normalized by watershed area compared to Cold Creek. These results may be linked to predominantly urban land-uses in the Donner Creek watershed with high amounts of impervious surfaces (Balance Hydrologics, Inc., 2014). Another observation is that the magnitude and duration of annual high flows directly impact the quantity and size of sediment transported and deposited within channel reaches. For example, during WY2011, high streamflow led to changes in bed texture, with a coarsening of the streambed and reduced amounts of deposited sand (Balance Hydrologics, Inc., 2012). In contrast, during WY2014, a period of below-average precipitation and low streamflow, higher amounts of sand were observed in the streambed likely due to settling of suspended sediment from upstream sources (Balance Hydrologics, Inc., 2014). These observations underscore the variability that exists in streambed conditions from year to year and their close association with hydrology.

As part of the TRWQMP, monitoring for fine sediment (<2mm diameter) using a Rapid Assessment Methodology (RAM), was conducted by Placer County in Martis, Squaw and Bear Creeks during WY 2010, 2012 and 2014. RAM surveys involve observations of five particle size classes recorded along the wetted width of transects spaced between 30 meters (in WY2010) or 15 meters (in WY2012 and 2014) apart along a 150-meter stream reach. The particle size measurements are then used to estimate the percentage of the channel bottom covered with fine sediment less than 2mm in diameter. For WY2014, the RAM results revealed an average of 11 percent of the surveyed reaches for Squaw Creek and 10 percent for Bear Creek had a channel substrate comprised of fine sediment (CDM Smith and Balance Hydrologics, Inc., 2014). West Martis Creek had higher proportions of fine sediment in the surveyed channels, with an average of 23 percent, which is likely due to its proximity to Hwy 267. On average fine sediment was lower in WY2014 than in WY2010 in the surveyed stream channels for all three creeks.

RAM surveys were also conducted in WY2010 and WY2012 in the Town of Truckee in Trout Creek, Donner Creek, and in the Truckee River at the confluences with Donner, Trout and Martis Creeks and at Glenshire Bridge. The monitoring effort in the Truckee River focused on reaches upstream and downstream of key stream confluences and road crossings, however there was no clear association found between these potential sediment sources with fine sediment in the river. Donner Creek and the sites on the Truckee River both had an average of 13 percent of the surveyed channels comprised of fine sediment in WY2012. In contrast, Trout Creek had the highest levels of fine sediment, with an average of 52 percent in the surveyed stream channels, although fine sediment in the portion of Trout Creek where a restoration project had been recently completed was much lower (CDM Smith, 2013). The surveyed portion of Trout Creek is adjacent to commercial and industrial areas, roadways and the railroad tracks, which are likely sources of fine sediment. The Town of Truckee is currently planning further restoration of Trout Creek and staff recommends that post-project monitoring include sediment surveys to document the resulting channel conditions.

Target metrics for fine sediment in the channel are included in some San Francisco Bay Regional Board sediment TMDLs and are based on substrate composition measured using bulk core samples. For example, the Pescadero/Butano Creek Sediment TMDL target for fine sediment (<6.4 mm) is less than 30% and for particles < 0.85 mm, the target is less than 14%. However, the target values derived using the bulk core methodology are likely not comparable to the RAM results reported above, which are based on observations of particle sizes for sediment at the surface. Still, the results of the RAM surveys in WY 2010, 2012 and 2014 did not indicate that excessive fine sediment was present in the surveyed stream channels, except for Trout Creek, where high proportions of fine sediment were observed. Unfortunately, as a result of the adaptive management component of the TRWQMP, the RAM surveys of streambed sediment distribution were discontinued after WY2014. According to the WY2016 monitoring report, the RAM results and the baseline data collected had limited value and were replaced with a GIS Source Area Prioritization Analysis that is used to inform the prioritization of efforts related to stormwater infrastructure improvement in the subject watersheds.

Summary of Available Bioassessment Data

Significant effort has gone into collecting aquatic bioassessment data and information in the Truckee River watershed since establishment of the Truckee TMDL, however few recent observations are available for the mainstem Truckee River. Bioassessment is an evaluation

of the condition of a waterbody based on the organisms living within it, with a focus primarily on aquatic insects. Placer County conducts bioassessment monitoring at multiple locations in the Martis Creek and Squaw Creek watersheds biannually as part of its stormwater monitoring program, with the Squaw Creek monitoring designed to assess compliance with the Squaw Creek Sediment TMDL. The Squaw Creek TMDL uses a novel indicator index defined as the Biological Condition Score (BCS) which is derived from the sum of seven component metrics (Herbst D. , 2002) together with sediment size distributions and trends to assess desired conditions. Placer County's bioassessment results for both Martis Creek and Squaw Creek are also assessed using the Eastern Sierra Index of Biological Integrity (ES IBI) (Herbst & Silldorff, 2009). Lahontan and State Water Board SWAMP staff both conduct bioassessment monitoring in the Truckee River watershed, although few monitoring events have occurred in the mainstem Truckee River, likely due to streamflow conditions that are often unsafe for wading. Bioassessment results for SWAMP sampling efforts are assessed using the California Stream Condition Index (CSCI), a statewide biological scoring tool developed in 2015 to assess the health of California freshwater streams (Rehn, Mazor, & Ode, 2015).

CSCI scores are divided into four categories of biological condition as follows: ≥0.92 = likely intact condition; 0.91 to 0.80 = possibly altered condition; 0.79 to 0.63 = likely altered condition; ≤0.62 = very likely altered condition. Generally, most of the CSCI bioassessment scores for sites in the Truckee River watershed fall in the "likely intact" or "possibly altered" category based on the available data reported for the SWAMP program. There are a few sites that have had notably low CSCI scores in the past that include the Truckee River below Bear Creek, where a CSCI score of 0.36 was recorded in 2009, and two sites in the Squaw Creek watershed that had scores of 0.64 and 0.59 recorded in 2000. The CSCI score recorded for Donner Creek in 2014 was very low in 2014 (0.28), while the score in at a site further upstream 2017 (0.95) showed improvement and was in the "likely intact" category. The Truckee River above Martis Creek was sampled in 2013 and had a CSCI score of 0.8 (possibly altered). Due to the lack of recent data for the mainstem Truckee River, it is difficult to draw conclusions about current habitat conditions from these bioassessment results.

The TRWC conducts bioassessment monitoring at multiple locations within the watershed, though no recent sampling events have occurred in the mainstem Truckee River (Truckee River Watershed Council 2018). Bioassessment monitoring results are expressed in terms of the ES IBI. A review of TRWC's bioassessment results collected between 2008 and 2018 shows that the sampling location at Prosser Creek below the dam has consistently poor scores for biological integrity, with all five sampling events scoring below the ES IBI 42.2 value that indicates very poor condition. In contrast, sampling events on Bear Creek (in 2012) and Cold Creek (in 2008 and 2011-2014) resulted in ES IBI scores above 80, which indicate conditions that support biological integrity. TRWC has also conducted extensive bioassessment monitoring in the Little Truckee River watershed above the tributary dams.

Monitoring conducted by Placer County occurs in the Squaw Creek and Martis Creek sub-watersheds, where bioassessment data have been collected every two years since 2010. Placer County's report for WY 2020 summarizes the results for all the monitoring events. Conditions in Squaw Creek in 2020 met some, but not all, of the targets in the Squaw Creek TMDL, which are evaluated at three sites in the Squaw Creek meadow reach (identified as Upper, Middle and Lower). The percentage of particles <3 mm in diameter and the median

particle size (D50) are the two parameters identified as indicator targets for physical habitat suitability in the Squaw Creek TMDL. The numerical target for D50 is an increasing trend approaching 40 mm or greater, while the target for percent fines and sands is a decreasing trend approaching 25 percent or less in the Squaw Creek meadow reach. Neither target was met in 2020 or in previous monitoring events, except in 2010, when the D50 value met the target at all three sites. The indicator target for biological health is a BCS of 25 or more and attainment is assessed as a rolling average of the three previous sampling events. Two of the three sites in Squaw Creek met the minimum target of 25 in 2020, which is an improvement over past sampling events, however the three-sample rolling average did not meet the TMDL target. The 2020 monitoring report suggests that mild winters with fewer flood disturbances lead to more robust and well-developed benthic communities. The ES IBI results for the Squaw Creek sites also showed two sites that were supporting of the biological condition and one site that was partially supporting. The lower scoring sites were not the same for the two indices, with the low BCS at the Upper site and the low ES IBI at the Lower site. Additionally, CSCI scores were calculated using the Squaw Creek bioassessment data collected from 2012-2016, with the three-sample average scores for the three sites falling into the “possibly altered” category.

The most recent ES IBI results for the Martis Creek sub-watershed varied considerably among the seven sampling locations, two of which were new for the 2020 monitoring effort. The upper portions of the Martis Creek tributaries are less disturbed and had the highest ES IBI scores, with scores greater than 80, which is the threshold score considered to be “supporting”. Five of the seven sites sampled in 2020 had ES IBI results greater than 80. In contrast, the lower mainstem Martis Creek site had a score of 58.1 in 2020, which is below the threshold of 62.2, and is considered to be not supporting biological stream health. The lower mainstem Martis Creek site recently underwent restoration and bank stabilization and 2020 was the first year that bioassessment monitoring took place post-construction. Disruption of channel habitat due to the restoration activity likely contributed to the low scores observed there. In general, it is difficult to identify trends over the past 10 years in the bioassessment results for the Martis Creek sub-watershed, since some sites had lower values in 2020 compared to previous years, while other sites have shown gradual improvement over time (CDM Smith and Balance Hydrologics, 2021).

TRWC commissioned bioassessment studies and other investigations to assess the impact of deposited sediment on BMI communities that were conducted by Dr. David Herbst and co-investigators from Sierra Nevada Aquatic Research Laboratory. This work was cited to support the request made during the Triennial Review process in 2015 and 2018 to undertake a basin planning project to develop an embedded/deposited sediment target to add to the Truckee TMDL. The first bioassessment study was conducted in late September 2010 and took place at two sites along the Truckee River: 1) San Francisco Fly Casting Club, and 2) Horseshoe Bend (between Prosser Creek and the Little Truckee River) (Herbst, 2011). Additionally, reference locations were selected in four other Sierra Nevada rivers to allow for comparison with results from the Truckee River that included the following: 1) East Carson River (below Monitor Creek), 2) Markleeville Creek (below Markleeville), 3) West Carson River (below Willow Creek, Hwy 88/89 junction), and 4) West Walker River in the middle area of Walker Canyon. Each sample reach was selected to conform to a similar range of channel gradient (<2%), and the reaches in the Truckee River were further divided into segments that were identified as either mobile or immobile, based on geomorphic stability. Two different sampling protocols were employed at each location that included the

Reach-wide Benthos (RWB), which is the standard method used by the SWAMP Bioassessment Program, and the Targeted Riffle (TR) approach that was used to develop the ES IBI. The study results revealed low ES IBI scores for four of the eight sample reaches on the Truckee River (three low scores for the Club site and one for the Horseshoe Bend site) that indicate poor conditions not supporting reference-class biological integrity. The remaining scores were considered "fair". The Truckee River results contrasted with results for the reference locations, where scores ranged from fair to good and none were in the impaired category. The authors acknowledged that interpretation of the study results is limited by the small spatial extent of the surveyed reaches on the Truckee River.

Herbst and co-investigators conducted a follow-up study in 2011 (Herbst, et al., 2013) that examined in greater detail the relationship between fine sediment deposition and BMI community composition by assessing patch-scale distribution of fine sediment and sand in relation to the biotic response of the BMI community. The study involved the use of various sampling methods at ten locations along the Truckee River situated below tributary confluences from Bear Creek to Bronco Creek. Additionally, the study included targeted riffle sampling at eight locations that were previously surveyed in 2004 to compare the 2004 and 2011 ES IBI results. The 2011 study results indicated that as fine sediment coverage increases on the streambed, the BMI community composition shifts from grazers towards a higher prevalence of collector/gatherers and more tolerant species. The authors suggest a mechanism for this change is that algae growing on rock surfaces become buried or inhibited by sediment, which reduces food resource for grazers. High levels of fine sediment were also associated with reduced BMI density and body size, with potential implications for higher trophic levels, such as fish and riparian birds, due to impacts to the food web through reductions in food quantity (density) and quality (size, variety, and nutritional value). Additionally, BMI communities with low levels of fine sediment coverage (less than 20 percent coverage) were more diverse and abundant with a mixture of functional groups, including grazers and filterers. In contrast, high sediment coverage (greater than 80 percent) led to BMI communities dominated by detritus gatherers, mostly small midge larvae, and reduced abundance and diversity of other taxa. For the 1000 quadrants examined to assess sediment coverage at the ten locations surveyed during the study, 17 percent of the streambed had sediment coverage greater than 80 percent (Herbst, et al., 2013). The authors conclude that reducing the occurrence of habitat patches in the high sediment coverage category would lead to the greatest gains in species diversity of sensitive BMI taxa. The comparison between the 2011 ES IBI results and the results from 2004 revealed that five of the eight locations sampled along the Truckee River met the supporting standard in both years, however sampling locations near Bear, Squaw and Juniper Creeks were not supporting of the reference condition in either year.

There are challenges in reaching conclusions regarding the health of benthic communities in the middle Truckee River and tributary locations below the dams. One challenge involves the observed variability in fine sediment deposition in the Truckee River associated with changing hydrologic conditions and how that impacts the biological community. Another is that bioassessment results are reported using two different indices of biological integrity that are not directly comparable. Currently, the statewide CSCI is the metric used for establishing whether waterbodies are impaired for purposes of the CWA 303(d) list however most of the available bioassessment data for the Truckee River watershed are reported using the ES IBI. Effort should be applied towards calculating CSCI scores from the raw BMI data used to calculate ES IBI scores to align with current assessment standards. While

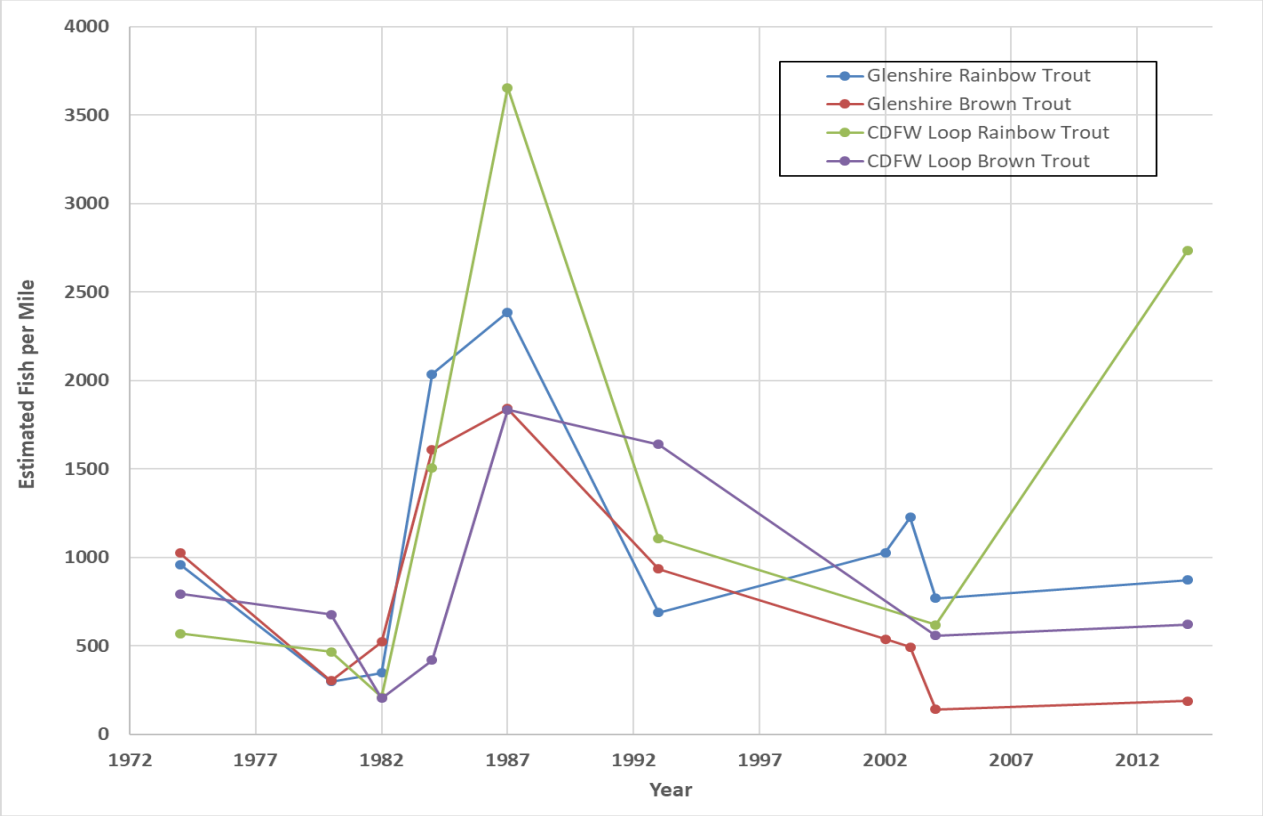
there are few recent observations for the mainstem Truckee River, the available data suggest there are some problem areas where conditions did not support biological integrity in the past. Future bioassessment effort should include revisiting those locations, such as sites near Bear Creek, Squaw Creek and the San Francisco Fly Casting Club.

Aquatic Life Beneficial Use Assessment

The mainstem of the middle Truckee River is designated for multiple aquatic life beneficial uses (see Pages 30-31) and as such, aquatic and riparian habitat along the Truckee River should be of sufficient quality to allow organisms to complete their life cycles with adequate resources and physical habitat conditions to maintain biotic communities. Assessing whether the river supports the beneficial uses goes beyond simply reviewing the water quality and sediment discharge data and information discussed previously. The Truckee River is described as a “blue ribbon” wild trout stream by several organizations (e.g., California Trout, Trout Unlimited), and is designated as a Wild Trout Water by the CFGC. Though this designation alone does not mean that the aquatic life beneficial uses are fully supported, the presence of a robust fish community in the Truckee River would suggest adequate habitat is available or has been available in the past when the Wild Trout Water designation was made.

Observations regarding the resident fish community and habitat quality are factors to consider in determining the status of the aquatic life beneficial uses. The CDFW Wild Trout program conducted electrofishing surveys periodically between 1974-2014 at sampling locations on the Truckee River and Trout Creek. Figure 6 shows estimated fish density (number of fish per mile) for the Glenshire Bridge, a popular fishing spot located about four miles downstream from the Town of Truckee, and CDFW Upper Loop, located downstream of Prosser Creek. The results show high temporal variability in estimated fish density for both locations with the lowest values in the early 1980’s and the highest observed in 1987. Trout densities decreased in subsequent surveys but rebounded somewhat for the 2014 sampling event, although Brown trout numbers remained low at the Glenshire Bridge location. In addition to non-native trout, the most recent survey revealed high estimated numbers per mile of native fish species at both sites that included Speckled dace, Mountain sucker and Paiute sculpin. The high abundance of native fish suggests there is good habitat quality at the locations surveyed. CDFW is expected to conduct fish and habitat surveys in 2022, which would provide valuable insight into the current health of the fish community in the Truckee River.

Figure 6 Electrofishing survey results for 1974-2014 for Rainbow and Brown Trout at two locations on the Truckee River



More recent information for trout numbers is available for 2020 when Trout Unlimited (TU) completed a snorkel survey for a segment of the Truckee River upstream of Glenshire Bridge in August in conjunction with a habitat improvement project. Snorkelers counted fish by species and size class over a total reach length of 550 meters and observed 547 Rainbow trout and 186 Brown trout. Numerically, young of the year fish (e.g. less than six inches) were the most abundant size class across species, and abundance decreased as fish size increased. These smaller fish were mostly found among heavily vegetated banks and large woody debris jams. Larger Rainbow and Browns (greater than six inches) were mostly found in the middle of the channel or in deep eddies behind large boulders. Although the methods differed between the TU and CDFW surveys, a rough comparison can be made with the earlier CDFW surveys by extrapolating TU's snorkel results to fish per mile, which leads to 1600 Rainbow and 544 Brown trout per mile for the segment surveyed. A notable observation from the TU survey is that 15 Lahontan Cutthroat Trout (LCT) were counted during the survey, all of which were in the young of the year size category, which suggests that adult fish are reproducing in the Truckee River. The LCT is listed as threatened under the federal Endangered Species Act. While TU's fish survey results only represent a small section of the river, the presence of the small size class of fish suggests that spawning, incubation and rearing habitat is available and of adequate quality to maintain fish populations.

The Truckee River appears to provide habitat quality that supports the aquatic life beneficial uses, at least in the locations where recent observations are available. However, more information is needed to reach a sound conclusion regarding this question. Aside from the

fish survey discussed above, there are few other recent observations that provide similar insight into aquatic habitat conditions. The most recent bioassessment results for the mainstem Truckee River are from 2013 for one location above Martis Creek that scored at the lower end of the "possibly altered" category, which may not reflect current conditions. Consequently, as detailed below, while changes to the body of the TMDL are not recommended at this time, more effort should be devoted to conducting habitat assessments that would better document current conditions. This could involve modification of the monitoring requirements associated with the implementation targets (which may involve modifying permits).

TMDL Recommendations

This report provides an overview of the information and data sources that were reviewed as directed by the Truckee TMDL Basin Plan language in addition to a discussion of what this information reveals about current conditions along the Truckee River and compliance with the TMDL requirements. The Basin Plan language states that potential outcomes of the 10-year review could include recommendations to reassess sediment sources, revise targets, or adjust the implementation plan. As described in earlier sections of this report, since the TMDL was adopted by the Lahontan Water Board in 2008, considerable effort has gone into activities to address the TMDL. This includes monitoring programs to collect data on conditions in the watershed and the implementation of projects by multiple entities that are expected to reduce sediment discharge to the Truckee River. More projects are currently in the planning phase that will be completed in the coming years that also would be expected to improve habitat conditions. Based on the current analysis, staff concludes that dischargers are making progress on reducing sediment discharge. However, the available data does not show clear trends in sediment discharge over the past ten years, which is likely due, in part, to hydrologic variability that can lead to vastly different streamflow conditions from year to year.

While the Basin Plan TMDL language regarding the implementation targets may not be precise as to how much effort is required to fulfill TMDL requirements, it does not necessarily follow that the targets need to be modified. It would be difficult to develop numeric targets for sediment reduction or other indictor criteria for the various TMDL implementation measures. This was acknowledged in the original Truckee TMDL staff report, which states "because the load allocations presented here are broad estimates, they are not appropriate for use as discharge specifications in waste discharge requirement or permits". Year-to-year variability in hydrological conditions leads to large variation in annual sediment discharge and would make it difficult to assign numeric sediment reduction targets.

A review of sediment TMDLs adopted by other Regional Water Boards did not provide examples of specific sediment reduction targets associated with implementation measures, except for some targets associated with dirt road management in agricultural lands included in the Pescadero/Butano sediment TMDL. Moreover, assuming it is possible to develop numeric targets for sediment load reduction, the effort and resources needed to accomplish the task of translating the implementation targets into more precise measurements of required reductions may not be a good use of staff time. Similarly, it is not clear that there is a need to reassess the sediment sources or TMDL allocations for the same reason. These tasks would require considerable commitment of staff resources that might better be devoted to other priority basin planning projects. Establishing new targets or updating the

sediment sources and allocations in the TMDL do not necessarily lead to improvements in water quality. Instead, those improvements are achieved by implementation actions undertaken by the multiple entities who have been and continue to complete projects that can reduce sediment discharge in the Truckee River watershed. It is worth noting that the TMDL target for SSC has been met in recent years, however that does not mean that the implementation actions should no longer be required, since presumably those actions are needed to continue meeting the target.

TRWC concluded, based on Herbst's studies discussed above, that adverse biological impacts from excess sediment deposited on the streambed continue to occur in the Truckee River and that a new target should be added to the TMDL related to sediment deposition. However, while Herbst's results show that excess sediment coverage (defined as > 80 percent coverage) has adverse impacts on BMI communities, it is less clear what proportion of the Truckee River streambed falls into the excess sediment category. The RAM monitoring conducted through 2014 as part of the TRWQMP that assessed fine sediment in the stream channel did not indicate that excess sediment coverage was prevalent at the locations sampled. Additionally, sediment transport processes are driven in large part by hydrologic conditions that change from year to year that lead to high spatial and temporal variability in streambed conditions. For example, studies supported by TRWC showed that a coarsening of the stream bed occurred after a year with high streamflows. Considering the variability that exists in sediment transport and the lack of recent observations of sediment coverage and streambed conditions, it is not recommended to pursue the development of a new target for fine sediment or embeddedness for the Truckee TMDL at this time.

One part of the Truckee TMDL that could be improved is to expand on the monitoring program contained in the TMDL to include more habitat and biological assessments along the mainstem Truckee River and tributaries other than Martis Creek and Squaw Creek. This would provide a better understanding of the status of aquatic life beneficial uses in the watershed. The studies completed by TRWC that concluded that biological resources continue to be impaired due to fine sediment are not recent and updated information is needed to assess current conditions. Therefore, staff recommends pursuing opportunities for focused monitoring that better documents aquatic habitat conditions. The information needed includes surveys that document fine sediment coverage in the Truckee River channel to provide insight into the extent of sediment impairment. Additional bioassessment monitoring is also needed to document the health of the benthic macroinvertebrate community, which is particularly sensitive to excess sediment. Attention should be focused on sampling locations where previous bioassessment data were collected, such as near Martis Creek, Squaw Creek, Bear Creek and the San Francisco Fly Casting Club.

Lahontan Water Board TMDL program staff will coordinate with regulatory staff to develop recommendations for updated monitoring to obtain the information needed to document aquatic habitat conditions. Examples include requiring additional monitoring that focuses on habitat conditions and bioassessment observations at locations on the Truckee River. Ideally, this would include collecting information on fine sediment distribution in the Truckee River and tributary channels. Staff have also discussed the need for new data with the TRWC and it is possible they may be able to expend resources to undertake monitoring activities. Additionally, staff recommends updating the Waste Discharge Requirements for Tahoe Truckee Sanitation Agency to modify the monitoring requirements related to benthic macroinvertebrate data collection and assessment, which in the current version utilizes

outdated monitoring protocols that make it difficult to interpret the data produced. Staff should also consider adding habitat monitoring in new or updated permits for projects that take place along the Truckee River.

The lack of recent information hampers the ability to make robust findings regarding the status of the beneficial uses. Staff plans to revisit the Truckee TMDL in three to five years when additional monitoring data is available. Staff expects the recommended changes to current monitoring requirements, together with information collected by other entities such as CDFW, will allow staff to better determine the status of the beneficial uses and the need for changes to the Truckee River TMDL.

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