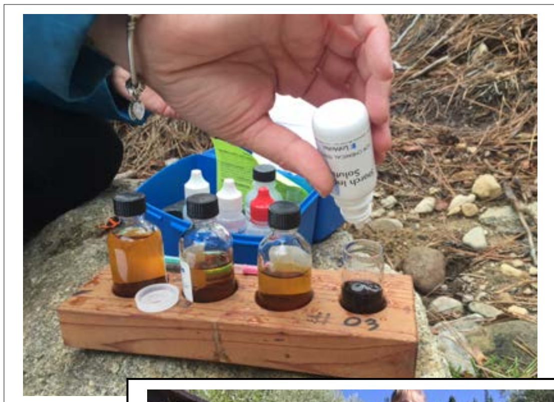
Truckee River Watershed Council
2018 Annual Monitoring Data Report
February 22, 2018



foriver
TRUCKEE RIVER WATERSHED COUNCIL

Executive Summary

The Truckee River Watershed Council (TRWC) has maintained a volunteer-based water quality monitoring program since 1999. The Adopt a Stream program includes physical, chemical and biological monitoring. The purpose of this report is to summarize water quality data for the Truckee River watershed, outline the goals and objectives for the monitoring program, and relate data back to those monitoring objectives.

The primary goals of the Adopt a Stream program are:

1. To assess the condition of the Truckee River ecosystem;
2. To screen for water quality problems typically associated with common land use practices in the Truckee River watershed;
3. To collect data related to the Truckee River Operating Agreement (TROA);
4. To support the Truckee River sediment TMDL monitoring program; and
5. To empower citizens to be responsible stewards and decision-makers.

To address these goals, we developed a set of questions:

- 1a. Are water quality standards being met in the Truckee River watershed?
- 1b. What is the overall water quality in the Truckee River watershed?
- 2. Is there evidence of impacts to water quality at urban sites as compared to non-urban sites?
- 3. How has TROA changed water quality at sites below dams?
- 4. Is there evidence of water quality impairment due to excess sediment?
- 5. What is the level of public engagement in our Adopt a Stream program?

Data collected thus far support the following conclusions:

1a. Are water quality standards met? No, not always. The most readily comparable standards for our region include dissolved oxygen concentration and nitrogen and phosphorus standards.

Our data indicate some monitoring locations have depressed dissolved oxygen concentrations as compared to the standard established by the Lahontan Basin Plan (LRWQCB, 2015). These locations include:

- Donner Creek below the dam (DONN-03);
- Martis Creek above Martis Lake (MART-00);
- Squaw Creek near mouth (SQCR-00); and
- Trout Creek at mouth (TROU-00).

Nitrogen and phosphorus numeric standards have been established for a subset of our monitoring locations:

- Truckee River below Tahoe dam (TR01);

- Bear Creek at mouth (BEAR-00);
- Squaw Creek at mouth (SQCR-00);
- Trout Creek at mouth (TROU-00); and
- Little Truckee River below Boca dam (BOCA-00).

With the exception of the Little Truckee below Boca, all locations regularly exceed standards for some forms of nitrogen or phosphorus.

1b. Overall water quality in the Truckee River watershed? The following streams exhibit degraded water quality across multiple parameters:

- Martis Creek above Martis Lake (MART-00);
- Union Valley Creek at Truckee River (GLEN-00);
- Trout Creek at mouth (TROU-00);
- Squaw Creek at mouth (SQCR-00);
- Donner Creek below dam (DONN-03); and
- Prosser Creek below dam (PROS-01).

Other sites are in generally good condition, such as:

- Sagehen Creek at Highway 89 (SAGE-00);
- Pole Creek (POLE-00); and
- Cold Creek (COLD-00).

Nutrients are an emerging concern in our watershed. Even at sites without established standards, we measure relatively high concentrations of nitrogen and phosphorus. In the past few years, we have seen extreme algal growth at many locations. Although the low flows experienced during the drought have certainly influenced this growth, nutrients are also a contributing factor.

2. Water quality at urban and non-urban sites? Urbanization is potentially a substantial influence on water quality. We find our more urban sites to have higher electrical conductivity as compared to non-urban sites. Temperature and turbidity appear to be slightly elevated at urban locations compared to non-urban locations.

3. TROA effects on water quality? Our data provide an important baseline for assessing impacts of TROA on water quality. TROA went into effect in December, 2015, so 2016 was the first year we monitored under "TROA operations". 2016 was the final year of a severe drought and 2017 was a record precipitation year for the Truckee basin, however 2018 was fairly "normal". Data collected from Prosser Creek below Prosser Dam indicate that the biological community was in worse condition after TROA as compared to before. TROA has had significant impacts on Prosser Reservoir operations.

4. Water quality impacts of excess sediment? The most effective way TRWC has supported the Truckee River sediment TMDL is through our bioassessment data including work performed by subcontractors as well as volunteers. The data we have collected supports that there are impacts to the benthic macroinvertebrate due to excess deposited sediment. We need to expand our current efforts to more fully document the extent and severity of sediment deposition throughout the Truckee River and will work cooperatively with the Lahontan Regional Water Quality Control Board to do so.

5. Level of public engagement? Volunteer participation remained high in 2018. Over the years we have had consistent volunteer involvement and interest in the program.

Contents

List of Tables

List of Figures

Introduction

The Adopt a Stream Program of the Truckee River Watershed Council is a volunteer based water quality monitoring program. The program began in 1999 and has expanded through the present day. The purpose of this report is to summarize water quality data for the Truckee River watershed, outline the monitoring objectives for the monitoring program, and relate data back to those monitoring objectives.

The Truckee River Watershed

The Adopt a Stream program monitors the conditions of the Middle Truckee River. This includes all drainages to the Truckee River, from below the dam at Lake Tahoe to the California/Nevada state line. The watershed includes 26 major sub-basins (or sub-watersheds) and covers an area of 435 square miles. A map of the watershed, including monitoring locations, is included as Figure 1.

The Truckee River watershed has a 170+-year history of significant human disturbance. Timber harvests (including multiple clear cuts) began early to support silver mining and the transcontinental railroad; railroad construction and operation were (and still are) the source of many watershed problems; the native trout species (Lahontan cutthroat trout) was fished to extinction as a food source for California expansion by 1930; gravel mining to support large scale road construction including Interstate 80 have left behind degraded areas; and the largest subdivision in the United States – Tahoe Donner - was built in the 1960s and 1970s before stormwater and erosion regulation. A series of dams in the Truckee River system were established for water supply and flood control.

More recent impacts of concern in the Truckee River watershed include extensive construction particularly in the Town of Truckee and Martis Valley. Ski resorts are expanding to year-round resorts with an increase in golf course use and residential development. Additionally, the flow regime in the Truckee River and key tributaries has seen significant changes with the Truckee River Operating Agreement (TROA) going into effect as of in December of 2015.

The Truckee River and three tributaries (Bronco Creek, Gray Creek, and Squaw Creek) are listed as impaired for excessive sediment under the Clean Water Act. Sediment sources include road and highway salting and sanding, construction, ski runs, and natural sediment sources including landslides and debris flows. Donner Lake is listed as impaired for priority organics, arsenic, and chlordane.

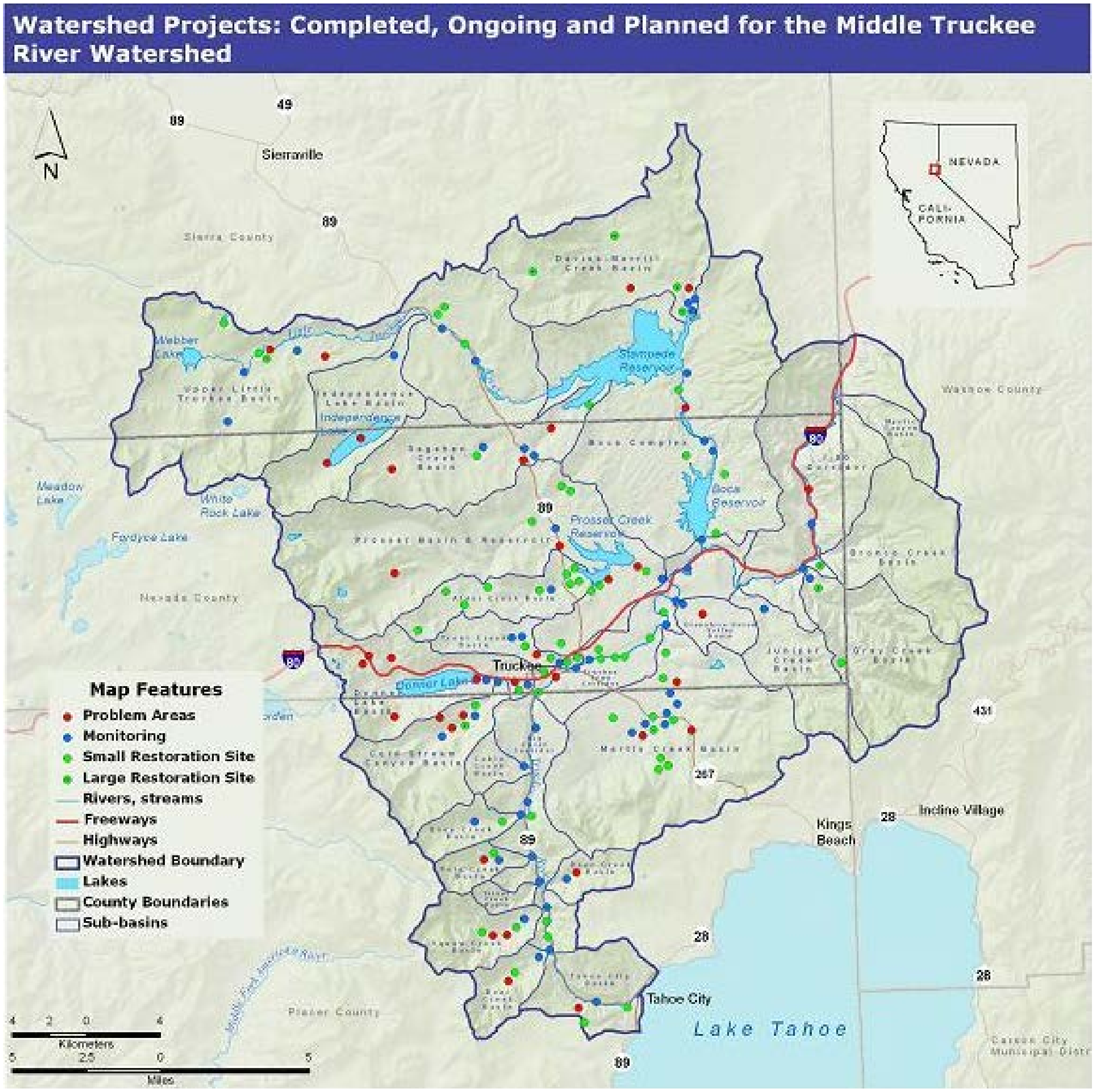


Figure 1. Middle Truckee River watershed with major stream sub-basins outlined. Monitoring locations are indicated by blue dots. Map created by Digital Mapping Solutions.

Monitoring Goals and Objectives

The Adopt a Stream (AAS) program is designed to supplement existing agency monitoring efforts in the Truckee River watershed. The focus of AAS is on measuring physical, chemical, and biological parameters in order to assess water quality and watershed health.

The primary goals of the Adopt a Stream program are:

1. To assess the condition of the Truckee River ecosystem;

2. To screen for water quality problems typically associated with common land use practices in the Truckee River watershed;
3. To collect data related to the Truckee River Operating Agreement (TROA);
4. To support the Truckee River sediment TMDL monitoring program; and
5. To empower citizens to be responsible stewards and decision-makers.

To address these goals, we developed a set of questions:

1a. Are water quality standards being met in the Truckee River watershed?
1b. What is the overall water quality in the Truckee River watershed?
2. Is there evidence of impacts to water quality at urban sites as compared to non-urban sites?
3. How has TROA changed water quality at sites below dams?
4. Is there evidence of water quality impairment due to excess sediment?
5. What is the level of public engagement in our Adopt a Stream program?

The report is organized around these questions.

Funding Sources

Adopt a Stream is currently funded by the donors to the Truckee River Watershed Council and the Martis Fund. Coliform sample analysis was donated by the U.S. Geologic Survey (USGS).

Program Description

The Truckee River Watershed Council (TRWC) has conducted water quality monitoring since 1999. Parameters monitored, timing, and frequency have all changed over the years as the monitoring program has matured. All monitoring activities are contained under the umbrella of "Adopt a Stream"; however there are three primary components to the monitoring program:

1. Snapshot Day. This program has existed since 2001 and is a one-day watershed wide (Lake Tahoe and Truckee River) monitoring event. Basic physical and chemical parameters are measured. The focus of Snapshot Day is to cover as much geographic area as possible in order to capture a "snapshot" in time of water quality for the entire Truckee River/Lake Tahoe watershed. Several different groups are involved in Snapshot Day; TRWC manages the event for the Middle Truckee River watershed. Snapshot Day takes place in the spring of each year during snowmelt run-off (high flow).

2. Adopt a Stream – Stream Teams. Regular monitoring of basic physical and chemical parameters began in 2007. Selected streams are monitored by volunteers four times per year (including Snapshot Day). Any of the streams monitored on Snapshot Day may be monitored throughout the season.

3. Truckee River Aquatic Monitors. This group has collected bioassessment and basic habitat data since 1999. Approximately five streams are monitored each year, with a different selection of streams monitored each year. Streams are only monitored once in any given year.

This report includes data from all three components of Adopt a Stream.

Field and Lab Methods

Monitoring locations and parameters monitored can be found in Table 1 for physical and chemical monitoring and Table 2 for bioassessment sites.

Physical and chemical monitoring includes measurement of water temperature, dissolved oxygen, pH, electrical conductivity, and turbidity. On Snapshot Day, grab samples are also collected and sent to a laboratory for nutrient and coliform analysis. Beginning in 2014, we added one additional nutrient sample collection during low flow conditions. Bioassessment monitoring includes collection of benthic macroinvertebrates following the State Water Resources Control Board 2007 SWAMP protocol (Ode, 2007). Prior to 2007, the California State Bioassessment Protocol was followed (Harrington and Born, 1999).

Nutrient samples are analyzed by either High Sierra Water Lab in Tahoe City (formerly Truckee), or the Tahoe Environmental Research Center in Incline Village. Coliform samples are analyzed by the U.S. Geologic Survey in Truckee (formerly Carnelian Bay).

Benthic macroinvertebrate samples are collected by volunteers and are processed either by volunteers or professional labs. TRWC volunteers identify the samples from 1-2 streams per year and the remainder is sent out for professional identification, either to the California Department of Fish and Wildlife Aquatic Bioassessment Laboratory or Aquatic Biology Associates in Oregon. Samples identified by volunteers are only identified to family level, whereas the professionally processed samples are identified to SAFIT Level II (species or genus; Richards and Rogers 2011). This varying level of taxonomic resolution affects several metrics; therefore data from volunteer- and professionally-identified samples are presented separately where appropriate. Prior to the adoption of the 2007 SWAMP protocol, the number of organisms in a subsample from each stream varied as well. Volunteers counted out and identified 300 organisms from each stream and professional labs counted out and identified 900 organisms. The number of organisms present also skews some metrics.

In 2009 an Index of Biological Integrity (IBI) was published for the Eastern Sierra (Herbst and Silldorff, 2009). An IBI gives each stream a "score" based on the species diversity found in a sample. IBIs are derived from multiple taxonomic metrics. The IBI is designed to use 500 count data (the current 2007 SWAMP standard), and requires genus or species level identification. Therefore, IBI scores can be easily calculated for a subset of TRWC collected data from 2008 forward.

Table 1. Sites monitored for basic physical and chemical parameters (temperature, electrical conductivity, dissolved oxygen, pH, and turbidity). Each year, some of these sites are tested for nutrients and/or coliform bacteria.

Site ID	Site Name
MTR-ALDR	Alder Creek
MTR-BEAR-00	Bear Creek at mouth
MTR-BIGC	Truckee River in Big Chief Corridor
MTR-BOCA-00	Little Truckee below Boca Dam
MTR-BOCA-01	Little Truckee at Boyington Mill
MTR-BOCA-02	Worn Mill Creek
MTR-CABN	Cabin Creek subbasin
MTR-COLD-00	Cold Creek
MTR-DEEP	Deep Creek
MTR-DMCB	Davies Creek
MTR-DONN-00	Donner Creek at mouth
MTR-DONN-01	Donner Creek at Hwy 89
MTR-DONN-03	Donner Creek below Donner Lake
MTR-EMAR	East Martis Creek at bridge
MTR-GLEN-00	Union Creek below Glenshire
MTR-GLEN-02	Union Valley Creek above Glenshire Pond
MTR-GRAY	Gray Creek
MTR-I80C	Truckee River in I-80 Corridor-Floriston
MTR-INDE	Independence Creek
MTR-JUNI	Juniper Creek at Iceland road
MTR-MART-00	Martis above Martis Lake
MTR-MART-01	Martis at COE boundary
MTR-POLE-00	Pole Creek
MTR-PROS-01	Prosser Creek below dam
MTR-PROS-02	Prosser Creek at Highway 89
MTR-SAGE-00	Sagehen Creek at Highway 89
MTR-SAGE-02	Sagehen Creek at Field Station
MTR-SILV	Silver Creek
MTR-SQCR-00	Squaw Creek near mouth
MTR-TOWN	Truckee River in Town Corridor
MTR-TR01	Truckee River near Tahoe City
MTR-TROU-00	Trout Creek near mouth
MTR-TROU-01	Trout Creek in Town
MTR-TROU-02	Trout Creek in Tahoe Donner
MTR-ULTB	Upper Little Truckee at Highway 89 bridge

Table 2. Bioassessment monitoring locations including years monitored.

Stream	Location	Years Monitored
Alder Creek	Above Highway 89	2014, 2018
Bear Creek	Near confluence with Truckee River	2002, 2003, 2004, 2006, 2009, 2012
Cold Creek - lower	Just above confluence with Donner Creek	2008, 2010, 2011, 2012, 2013, 2014, 2016
Cold Creek - upper	Near horseshoe bend in railroad	2000
Cold Stream	0.5 mile upstream of confluence with Little Truckee River	2002
Davies Creek	Just below confluence with Merrill Creek	2003, 2005, 2006, 2008, 2010, 2011
Deep Creek	1.75 miles from confluence with Truckee River	2005
Deer Creek	About 1 mile upstream of confluence with Truckee River	2004
Donner Creek	Immediately downstream of Highway 89	2005, 2008
East Martis Creek	At bridge on Waddle Ranch	2003, 2008
Gray Creek	Near mouth	2001, 2002, 2005, 2006
Independence Creek	Below road crossing, near campground	2007
Independence Creek - lower	On Ranz Property in Meadow	2009
Independence Creek tributary	About 2.5 miles downstream of lake, 1.3 miles upstream of confluence with Little Truckee (at road crossing)	1999, 2001
Juniper Creek	About 1.3 miles upstream of confluence with Truckee River	2004
Little Truckee River	Along highway 89, approximately 0.6 miles downstream of turnoff to Kyburz Flat	1999, 2011
Little Truckee River	Above Boyington Mill	2013, 2014
Little Truckee River	Between Boca and Stampede – downstream of USGS gage	2006, 2007
Little Truckee River – Lower Perazzo	In Lower Perazzo Meadow, downstream most reach	2010, 2011, 2012, 2013, 2015, 2016, 2017, 2018
Little Truckee River – Perazzo Meadows	In Middle meadow restoration site near old road	2009
Little Truckee River – below Middle Meadow	Immediately above Lower Meadow, below Middle Meadow restoration site	2016

Little Truckee River – below Upper Meadow	Immediately below Upper Meadow Restoration site, below confluence with Perazzo Creek	2015, 2016, 2017, 2018
Lower Martis Creek	Near confluence with Truckee River	2006
Martis Creek - Main	In Wildlife Area (upstream of Hwy 267)	2001, 2002, 2003, 2004, 2005, 2007
Martis Creek – Main	Main branch, downstream of highway 267	2000
Martis Creek – West	Below golf course, on USACE land	2003
Perazzo Creek - Upper	About 1.5 miles upstream of confluence with Little Truckee River	2003
Perazzo Creek	Near confluence with Little Truckee River	2005, 2008, 2009, 2014
Pole Creek	About 1.4 miles upstream of confluence with Truckee River	2004
Prosser Creek	Below dam, above USGS gage	2013, 2014, 2016, 2018
Prosser Creek	Below the dam – just upstream of I-80	2003, 2007, 2008
Prosser Creek	Immediately upstream of Highway 89	2012, 2015, 2018
Sagehen Creek	Downstream of Highway 89	1999, 2000, 2010, 2012, 2017
Sagehen Creek	Just downstream of the field station	2004, 2006, 2007
Silver Creek	Approximately 0.1 miles upstream of Highway 89	2011
Squaw Creek	Lower end of Squaw Meadow	2002, 2003, 2007
Trout Creek	At Bennett Flat	2003
Trout Creek	At mouth	2000, 2003, 2007
Truckee River at Granite Flat	Granite Flat Campground	2001, 2004
Truckee River at Horseshoe Bend	Near Hirschdale	2001, 2004

Table 3. Field methods used for each parameter. Analysis location refers to whether the measurement is taken in the field ("Field") or collected and analyzed later ("grab sample").

Parameter	Method	Analysis location
Dissolved Oxygen	Winkler Titration, Chemet, or YSI meter	Field
pH	Meter or pH strips	Field
Conductivity	Hand held conductivity meter	Field
Turbidity	Turbidity Meter – kept in office	Grab sample
Temperature	Thermometer (-5 to 50 °C)	Field
Nutrients	NH_3-N, NO_3 & NO_2-N, SRP, TP	Grab sample
Coliform	Colony forming units/100 mL	Grab sample
Benthic Macroinvertebrates	2007 SWAMP protocol	Grab sample

Results and Analysis

The following parameters have been regularly monitored between 2001 – 2018 and will be reported on:

1. Temperature. To identify areas of concern for thermal pollution.

2. Dissolved Oxygen. To determine health of aquatic ecosystem. Dissolved oxygen is necessary for aquatic organisms like insects and fish. Low levels can be caused by high temperature or excess bacterial activity. Low dissolved oxygen levels are responsible for eutrophication and in extreme cases, fish kills.

3. Conductivity. To determine potential sources of dissolved solids or salts. High conductivity indicates impaired water quality. Common anthropogenic sources in the Truckee River watershed include road salt and sand.

4. pH. To determine if a stream will support aquatic life. pH can be affected by many types of sources, both natural and anthropogenic and indicates whether water is acidic or basic.

5. Turbidity. To identify areas of increased erosion. Turbidity is an indicator of the amount of suspended particles in the water.

6. Nutrients. Nitrogen and phosphorus are used to identify sources of nutrient loading. Excess nutrients, particularly phosphorus, can lead to algal blooms and eventual anoxic conditions.

7. Benthic macroinvertebrates. To determine the ability of the water body to support aquatic communities. Different types of benthic macroinvertebrates respond differently to pollution in aquatic ecosystems.

Data are presented in relationship to the monitoring program goals listed in the Introduction section of this document.

Goal: Assess the condition of the Truckee River ecosystem: Are water quality standards and objectives met in the Truckee River watershed?

The Lahontan Region Basin Plan (Basin Plan; LRWQCB, 2015) is the water quality plan for our region. The Basin Plan outlines several water quality objectives, and some specific standards for streams in the Truckee River watershed. The standards and objectives against which our data can be evaluated are included in the tables below. Table 4 shows water quality objectives that apply to all streams in the Middle Truckee River watershed.

Table 4. Water Quality Objectives for the Truckee River Watershed

Parameter	Standard
Measurements Directly Comparable to Water Quality Objectives	
Dissolved Oxygen	The dissolved oxygen concentration shall not be depressed by more than 10 percent, below 80 percent saturation, or ***below 7.0 mg/l at any time***, whichever is more restrictive.
Measurements Not Directly Comparable to Water Quality Objectives	
Turbidity	The turbidity shall not be raised above 3 Nephelometric Turbidity Units (NTU) mean of monthly means.
Coliform	The fecal coliform concentration during any 30-day period shall not exceed a log mean of 20/100 ml, nor shall more than 10 percent of all samples collected during any 30-day period exceed 40/100 ml. The log mean shall ideally be based on a minimum of not less than five samples collected as evenly spaced as practicable during any 30-day period. However, a log mean concentration exceeding 20/100 ml for any 30-day period shall indicate violation of this objective even if fewer than five samples were collected.

We can readily compare our data to the dissolved oxygen standard of no measurements less than 7.0 mg/l. The turbidity and coliform samples are more difficult to compare against because they are based upon multiple samples collected throughout the month. However, we can use 3 NTU and 20 cfu/100 ml as benchmarks for good water quality – how often do we observe measurements above these thresholds?

The Basin plan establishes numeric nutrient objectives for several locations within the watershed, a subset of which correspond to our monitoring locations (Table 5). We can readily compare our data against these standards.

Dissolved oxygen

For both the Little Truckee River Hydrologic Unit and the Truckee River Hydrologic Unit, the Basin Plan for the Lahontan Basin (LRWQCB, 2015) holds the following standard for dissolved oxygen:

"The dissolved oxygen concentration shall not be depressed by more than 10 percent, below 80 percent saturation, or below 7.0 mg/l at any time, whichever is more restrictive."

Our data are collected and reported as mg/l so we graphed the number of times that we measured dissolved oxygen below 7.0 mg/l. Figure 2 shows those data for all monitoring events.

Most of the monitored streams show at least one measurement lower than 7.0 mg/L, and several locations have more than 10 measurements less than 7.0 mg/l: Donner Creek below the dam (DONN-03), Martis Creek above Martis Lake (MART-00), Squaw Creek near mouth (SQCR-00), and Trout Creek at mouth (TROU-00).

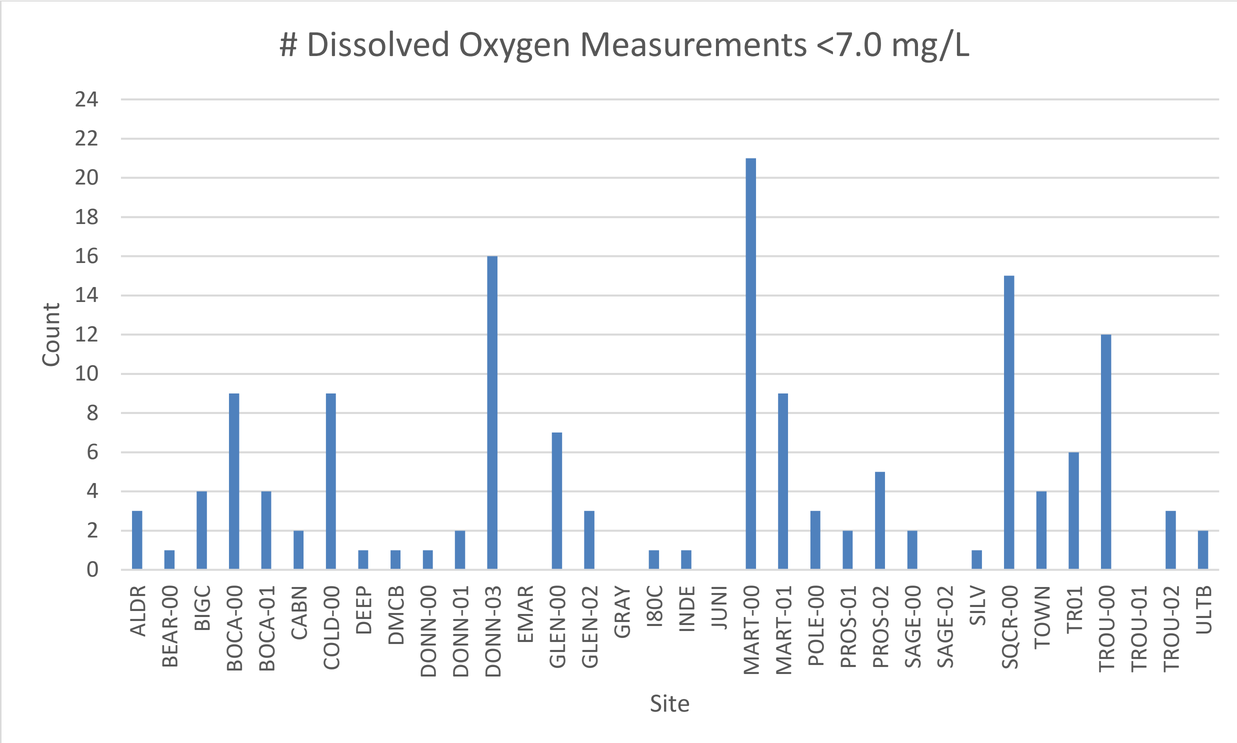


Figure 2. Number of dissolved measurements below 7.0 mg/L collected at each monitoring site.

There is substantial beaver activity at both Martis Creek at Trout Creek immediately upstream of the monitoring locations. Beaver dams pond water, and still water holds less oxygen than running water, so this could one reason for the results at this location. We should collect additional data from near these sites to determine if the depressed dissolved oxygen is localized or more widespread.

Donner Creek below the dam tends to be slightly warmer than other locations, and temperature has a significant impact on dissolved oxygen with warmer water holding less oxygen. Donner Lake has a top release dam, so the water at the outflow is coming from the surface of the lake which is warmer than the deeper water. Additionally, releases from Donner Lake are limited during the summer months in an effort to keep the lake high for recreation. Moving downstream along Donner Creek (DONN-01 and DONN-00), the dissolved oxygen levels seems to recover – this is probably due to the input from Cold Creek to Donner Creek just below the dam.

The lowest reach of Squaw Creek should be fairly well oxygenated. It is mostly forested and fairly steep, which promotes oxygenation as the water flows over the riffles and cascades. However, the meadow reach of Squaw Creek lacks streamside vegetation and is actively eroding. These impacts would raise water temperature, and therefore decrease dissolved oxygen. It is possible that water quality impacts experienced in the meadow reach are still expressed at our monitoring station near the confluence with the Truckee River. A restoration plan is in development for the Squaw Creek Meadow and that should positively affect water quality in the downstream reaches.

Turbidity

Turbidity is highly variable, and can be difficult to measure accurately. Additionally, the Basin Plan water quality objective for both the Little Truckee River Hydrologic Unit and the Truckee River Hydrologic Unit is based upon a measurement of mean of monthly means. We only collect a single sample in any given month. Therefore, our data are not directly comparable to the standard.

However, we can look at the number of times turbidity at each site has measured greater than 3 NTUs (Figure 3). Only sites with more than 5 turbidity measurements were included in the graph. Most sites have measured higher than 3 NTU at some point. Alder (ALDR), East Martis Creek (EMAR), Union Creek below Glenshire (GLEN-00), Martis above Martis Lake (MART-00), and Prosser below the dam (PROS-01) show the greatest number of measurements above 3 NTU.

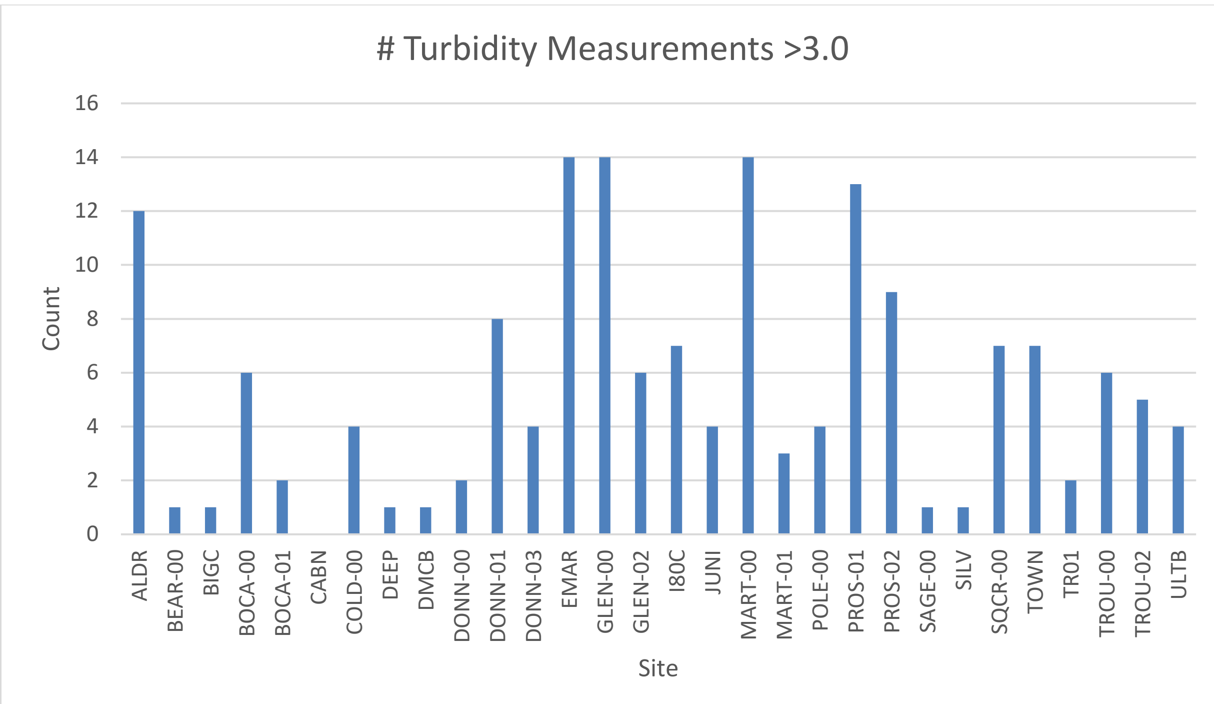


Figure 3. Number of turbidity measurements greater than 3 NTU. Only sites with more than five measurements are included.

Turbidity measures suspended particles in the water column – both fine sediment and algae cause high measurements. The past several years, extremely low flow and substantial algae growth have been observed at Alder Creek and Prosser Creek below the dam. Both these sites also have inputs from roads and dirt trails. Union Valley Creek (GLEN-00) drains an urbanized watershed. Martis Creek upstream of our monitoring location experiences substantial instream erosion. We are in the process of developing a restoration plan for Martis Creek that would eliminate much of the eroding streambanks. High turbidity in East Martis Creek is somewhat unexpected – this is an undeveloped watershed. However, there are some erosional areas associated with legacy logging sites. TRWC has recently begun restoring some of these sites, which may reduce fine sediment reaching East Martis Creek.

Coliform

The Lahontan region water quality objective for coliform is based on a 30-day log-mean not to exceed 20 colony forming units (cfu)/100 ml sample water. The log mean should be based on 5 samples taken within 30 days. We only have single sampling events for any given year, so our data are not directly comparable to the standard. But, using 20 cfu/100 ml as guidance for a tolerable threshold of coliform, we can determine if that threshold is exceeded. Figure 4 shows the number of times we have measured 20 cfu/100 ml or greater at any of our sites. The State Water Resources Control Board recently proposed raising the standard in the Lahontan region to 100 cfu/100 ml. Only one sample taken during TRWC monitoring has ever exceeded 100 cfu/100 ml – 146 recorded May 2015, at Union Valley Creek above Glenshire pond (GLEN-02). We have sampled this site annually since then. No coliform was detected in 2016 (0 cfu/100 ml), 1 cfu/100ml was detected in 2017, and 16cfu/100ml was detected in 2018.

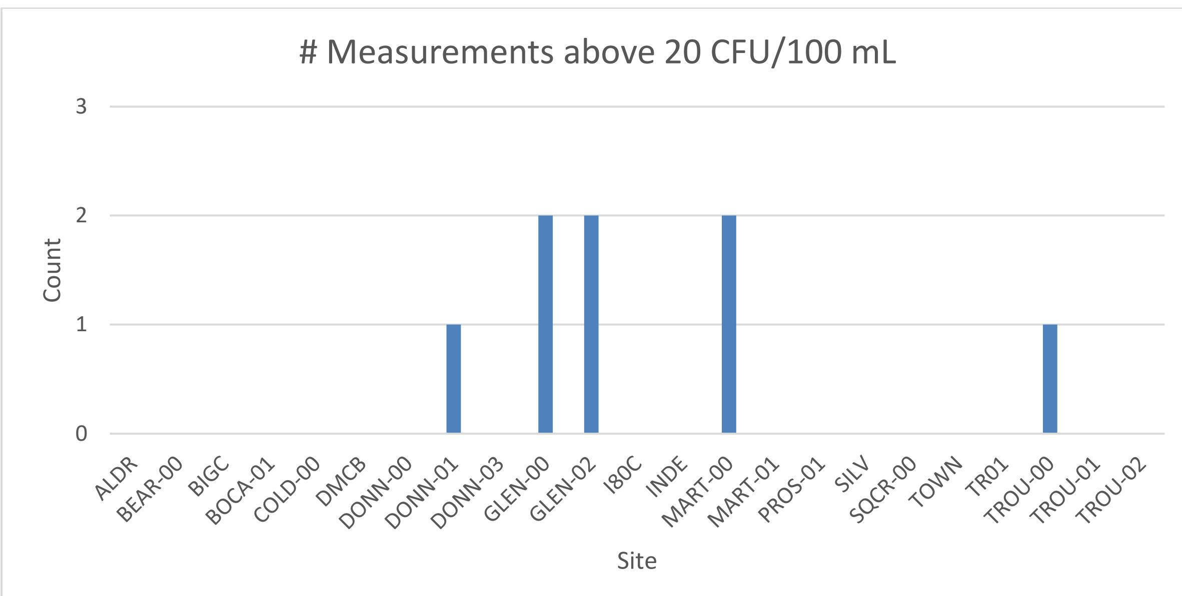


Figure 4. Number coliform measurements above 20 colony forming units (CFU) per 100 milliliters. Only sites that have been monitored for coliform are included in the graph.

We regularly monitor all the sites that have recorded measurements greater than 20 CFU/ml. Martis and the Union Valley locations (GLEN-00 and GLEN-02) are all located in or near popular dog walking areas. Martis and Trout Creek also support a healthy population of beavers. The single high measurement at the Donner Creek site (DONN-01) may have been related to a temporary homeless camp.

Ideally, we would monitor coliform during the summer months. Concentrations are likely to be higher in the summer due to lower flows. Additionally, high coliform presents a greater risk to public health in the summer as that is when people are swimming, boating, and participating in other water-contact recreation.

Lahontan Regional Water Quality Control Board has collected some coliform data in the Truckee River watershed during the summer months (available from www.ceden.org). Their sampling also yielded primarily non-detections or very low levels, so that supports the overall conclusion that coliform is low in our region.

Nutrient standards

The Lahontan Basin Plan (LRWQCB, 2015) includes standards for some forms of nitrogen and phosphorus for a handful of streams in the Middle Truckee River Watershed: Truckee River below Tahoe Dam, Bear Creek, Squaw Creek, Trout Creek, and Little Truckee River below Boca Dam. There are standards for nitrate-nitrite, TKN, total nitrogen, and total phosphorus.

Table 5. California State Water Quality Objectives for nutrients established for specific sites in the Truckee River and Little Truckee River Hydrologic Units.

Surface Water	Site ID	NO3-N (μg/l)	Total N (μg/l)	TKN (μg/l)	Total P (μg/l)
Truckee River at Lake Tahoe outlet	MTR-TR01	20	120	100	10
Bear Creek at Mouth	MTR-BEAR	50	150	100	20
Squaw Creek at Mouth	MTR-SQCR-00	50	180	130	20
Trout Creek at Mouth	MTR-TROU-00	50	150	100	40
Little Truckee River below Boca Reservoir	MTR-BOCA-00	80	400	320	50

<u>Nitrate-Nitrite (NO3/NO2-N)</u>

Nitrate stimulates algal growth, which in turn can lead to eutrophication in aquatic systems. The most common source of nitrate is runoff from fertilized areas such as lawns or other landscaped areas. Nitrate is also a byproduct of septic systems – it is a naturally occurring chemical left after the decomposition of human (and other animal) waste.

Figure 5 shows the sites with established water quality standards for nitrate-nitrite, and the number of times that the established standard has been exceeded. The number of times each site has been monitored for nutrients is included in parentheses after the site code. So, for example, Truckee River below Tahoe Dam (TR01) has been monitored 14 times, but we have never collected a sample that had a higher nitrate concentration than the established standard for that location. The nitrate concentration at Squaw Creek has exceeded the standard several times (8 out of 20).

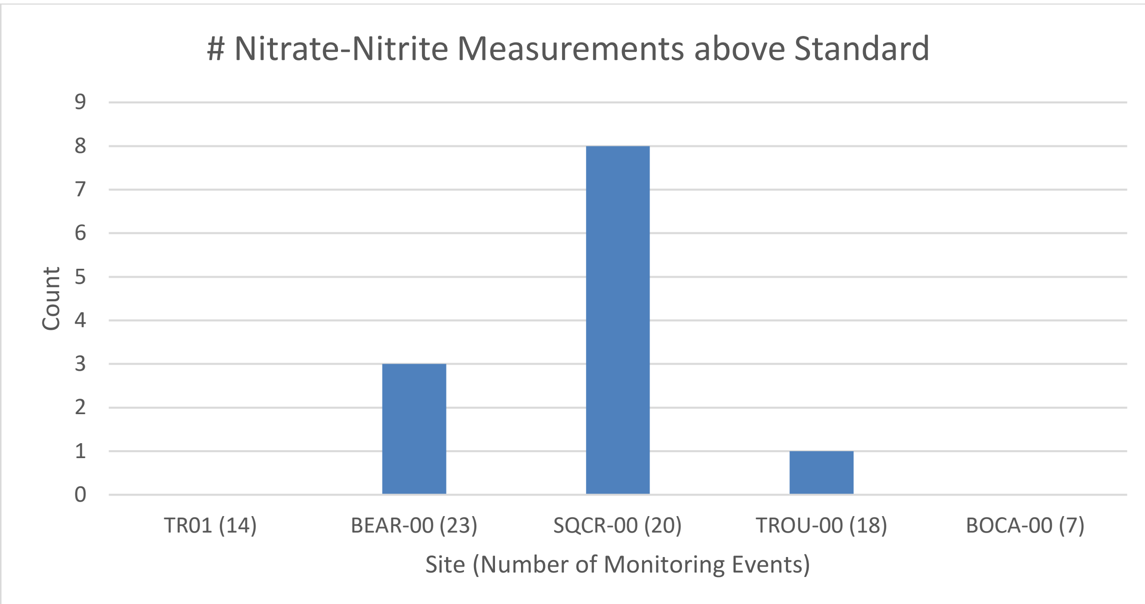


Figure 5. Number of nitrate measurements above standard for sites with established numeric standards.

Total Kjeldahl Nitrogen (TKN)

TKN is the organic portion of nitrogen and can make up a significant portion of total nitrogen. Figure 6 shows the sites with established water quality standards for TKN, and the number of times that the established standard has been exceeded. The number of times each site has been monitored for TKN is included in parentheses after the site code. TKN has been monitored less frequently than the other forms of nitrogen as it is a costlier analysis. To calculate total nitrogen, TKN has to be measured by the laboratory. Once we began looking at both TKN and total nitrogen, we found that several sites had much higher nitrogen content than was indicated by just measuring nitrate and ammonia.

For example, Trout Creek has always exceeded the standard for TKN, while it has almost always met the standard for nitrate. The Truckee River at Tahoe Dam has exceeded the TKN standard seven times out of eleven, but never exceeded the nitrate standard.

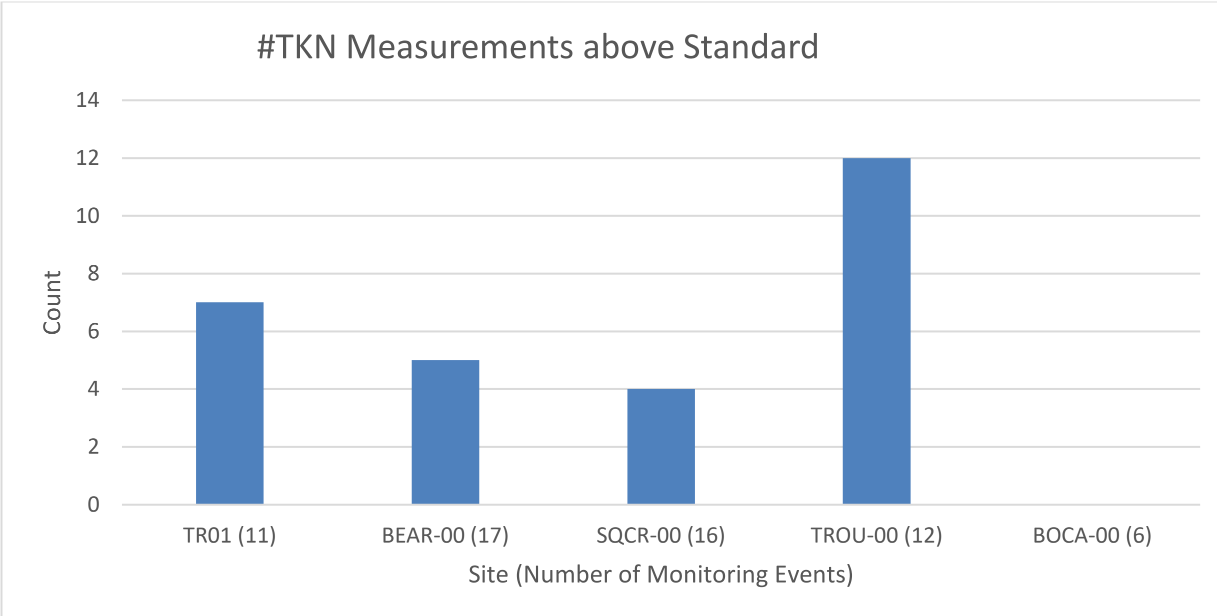


Figure 6. Number of total Kjeldahl nitrogen measurements above standard for sites with established numeric standards.

Total Nitrogen

Total nitrogen includes nitrate-nitrite and total Kjeldahl nitrogen (TKN). Looking specifically at sites for which standards have been established, Figure 7 shows the number of times those standards have been exceeded. The number in parentheses next to the site code is the number of times each site has been monitored for total nitrogen.

Trout Creek (TROU-00) and Truckee River below Tahoe Dam (TR01) have exceeded their standards during many monitoring events – largely due to the contribution of TKN. Bear Creek and Squaw have rarely exceeded the total nitrogen standard. We have very limited data for the Little Truckee River below Boca Dam (BOCA-00) and the standard at this site is quite high (400 μg/L) so although the readings we have observed for this site are fairly high (Figure 19) the standard has never been exceeded.

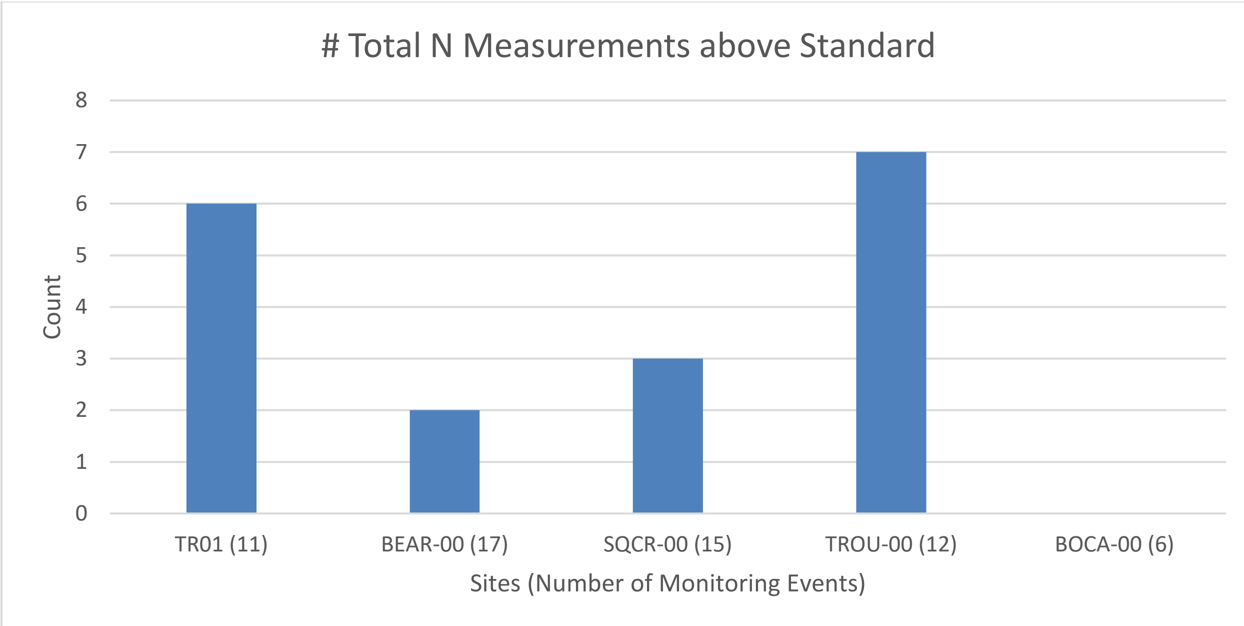


Figure 7. Number of total nitrogen measurements above standard for sites with established numeric standards.

Phosphorus

Phosphorus is also critical for stimulating algal growth in aquatic systems. Phosphorus is naturally present in the environment, in granitic and volcanic rocks. Anthropogenic sources include various soaps and detergents, fertilizers, and other household chemicals.

Phosphorus standards are extremely low for the Middle Truckee River streams (Table 5). Figure 8 shows the number of times those standards have been exceeded. The number in parentheses next to the site code is the number of times each site has been monitored for total phosphorus.

The only site that regularly exceeds the total phosphorus standard is the Truckee River below Tahoe Dam – and the standard for that location is very low, 10 μg/l.

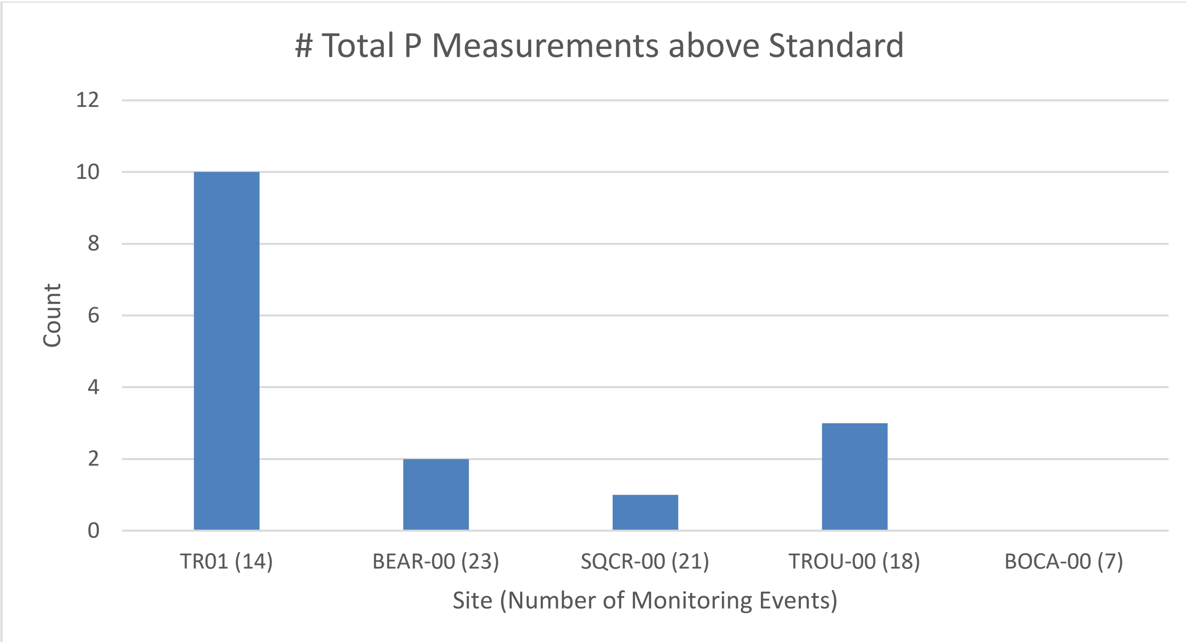


Figure 8. Number of total phosphorus measurements above standard for sites with established numeric standards.

Goal: Assess the condition of the Truckee River ecosystem - What is the overall water quality in the Truckee River watershed?

This section of the report contains box plots of ambient monitoring parameters. These plots show the range of variability and central tendency for the standard parameters of water temperature, electrical conductivity, dissolved oxygen concentration, and pH. Average value is indicated by the "X" symbol and the median is indicated by a diamond. The graphed points correspond to (from highest to lowest) maximum observed value, 3rd quartile value, mean (X), median, 1st quartile value, and minimum observed value.

The value of these graphs is to understand the overall watershed condition, which sites tend to have better or worse water quality, and which sites tend to be more variable. They are not particularly helpful in understand trends – for example, box plots do not indicate if the condition at a specific site is improving, declining, or remaining steady.

Temperature Results

Figures 9a and 9b show water temperature data, separated by flow levels. In unregulated tributaries, high flow corresponds to early season monitoring (May and June) and low flow corresponds to late season monitoring (July, August, and September). Dam regulated tributaries often follow the same pattern, but not always. In the case of dam-regulated tributaries, USGS-reported flow rates for the monitoring date are used to classify the data into high and low flow categories. In general, water temperature is higher during low flow and lower during high flows. There is less variation in the data for low flow events; this is partially due to the fact that the low flow data set is smaller than the high flow data set.

Table 6 shows critical temperature thresholds for critical phases of life for rainbow trout *(Oncorhynchus mykiss)*. The native salmonid in the Truckee River system – Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) – is ecologically similar to rainbow trout in terms of spawning season and thermal tolerance. Therefore, if the watershed can support rainbows, conditions should be sufficient to support Lahontans. Rainbow (and Lahontan cutthroat) trout are most sensitive to water temperature during spawning and embryo survival (Table 6), which take place during the spring and early summer.

Table 6. Temperature ranges required for rainbow trout survival and reproduction. These temperature ranges are representative of those required by most salmonids.

Species	Growth	Maxima	Spawning*	Embryo Survival**
Rainbow Trout	19°C (66 °F)	24°C (75 °F)	9°C (48 °F)	13°C (55 °F)

* The optimum or mean of the range of spawning temperatures reported for the species.
** The upper temperature for successful incubation and hatching reported for the species.
Adapted from EPA's Draft Volunteer Stream Monitoring: A Methods Manual.

Figure 10 shows the number of times that the critical temperature threshold for spawning was exceeded in May at each monitoring location. Not all of these streams support trout spawning, but there are a few troubling sites such as Prosser Creek below the dam (PROS-01) and sites along the mainstem Truckee (below Tahoe Dam - TR01, Big Chief corridor – BIGC, and Truckee at Regional Park – TOWN). Trout Creek once supported trout spawning as well. Prosser Creek and the mainstem of the Truckee River are dam-controlled, so flows can be artificially low in May at these sites due to limited releases from the dams.

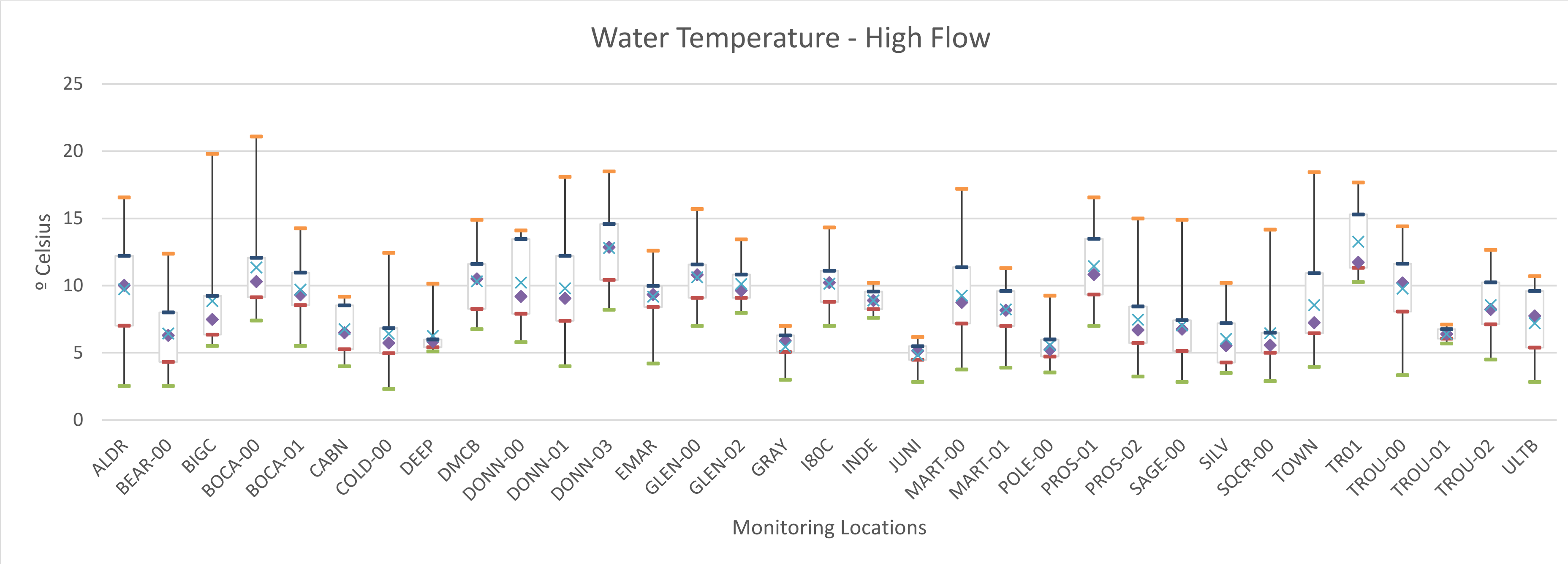


Figure 9a. Water temperature measured during high flows.

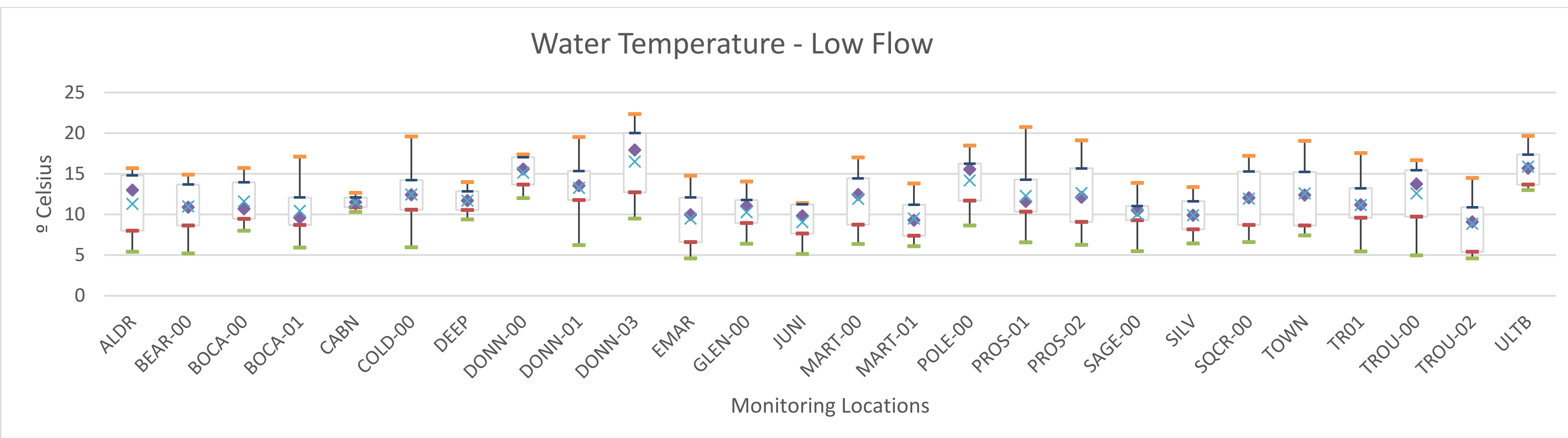


Figure 9b. Water temperature measured during low flows.

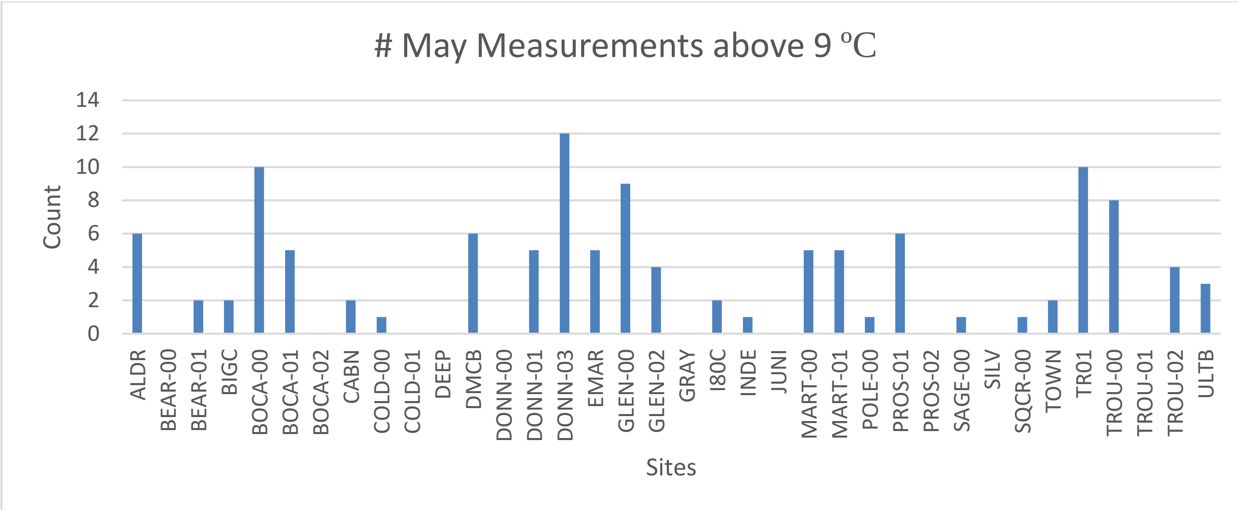


Figure 10. Number of May temperature measurements above 9°C. 9°C is the critical temperature threshold for rainbow trout spawning.

Figure 11 shows the number of times that June temperatures exceeded the threshold for embryo survival at each monitoring location. Overall there are fewer exceedances of the critical temperature than we observe in May, although Alder Creek (ALDR) and Donner Creek below the dam (DONN-03) do show several exceedances.

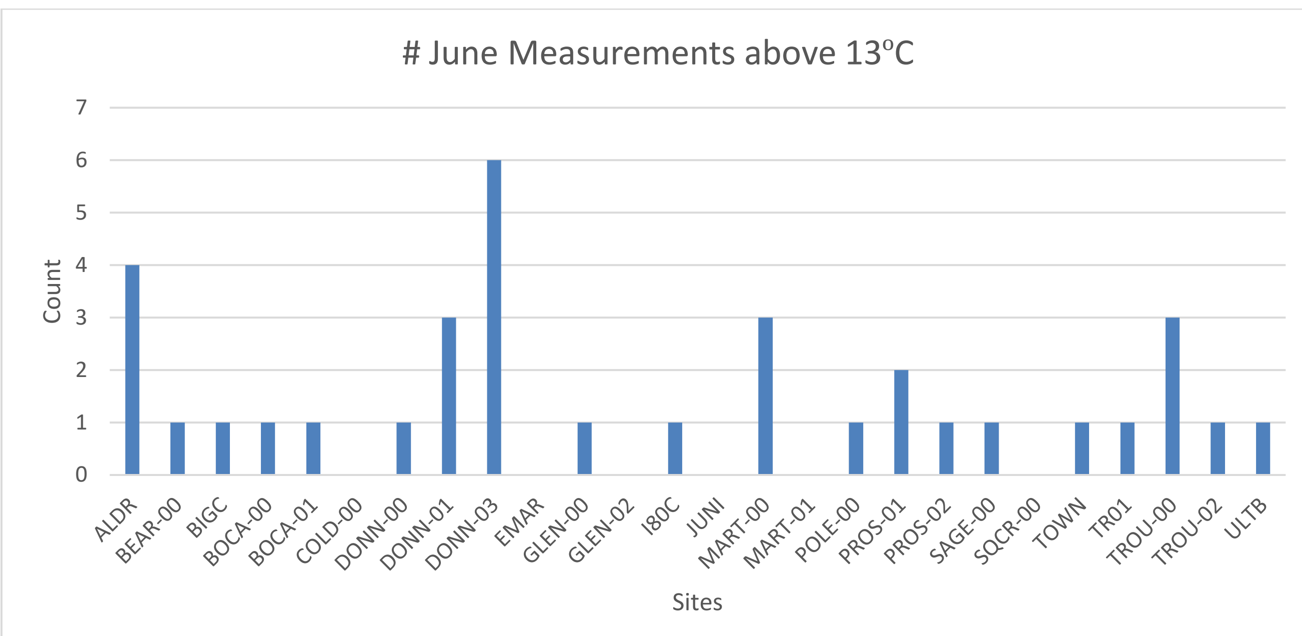


Figure 11. Number of June temperature measurements above 13°C. 13°C is the critical temperature threshold for rainbow trout embryo survival.

Dissolved Oxygen Results

Figures 12a and 12b show dissolved oxygen concentration, separated by flow levels. Dissolved oxygen concentration is related to water temperature. Cold water holds more dissolved gas; therefore dissolved oxygen is expected to be higher at lower water temperature. Comparing data site by site, dissolved oxygen concentration in the Middle Truckee River watershed is lower during the warmer times of year (low flow). See the previous report section on Water Quality Objectives for a discussion of impaired sites.

Electrical Conductivity Results

Figures 13a and 13b show electrical conductivity, separated by flow levels. Electrical conductivity is also sensitive to flows – at high flows, the charged particles that make up conductivity are diluted, and so measured conductivity should be lower. At low flows, the particles are more concentrated, and conductivity measurements will often be higher. Primary sources of charged particles in the Middle Truckee River watershed are road sands, road de-icers, and natural sources. Typically, urban areas or sites adjacent to high traffic roads will show higher electrical conductivity readings (see Figures 27a & b).

At high flow, electrical conductivity is primarily centered between 50-100 microsiemens/cm (μS/cm). During low flow, the distribution of measured values shifts to primarily above 100. This scale of variation is to be expected between flow levels because low flows concentrate the ions. Trout Creek (TROU-00), East Martis Creek (EMAR), Gray Creek (GRAY), Squaw Creek (SQCR-00), Silver Creek (SILV), and Union Valley Creek (GLEN-00) frequently have high conductivity measurements. Trout, Squaw, and Union Valley Creeks are all fairly urbanized watersheds. East Martis and Gray are undeveloped but both have a system of poorly developed historic logging roads and are in naturally erosive areas (NHC, 2006). Silver Creek is mostly undeveloped, although there is a small residential community upstream of the monitoring site.

The two Truckee River sites measured during the summer (TOWN, TR01) expressed very high conductivity in 2015, but were more typical in 2016 and 2017. During the July monitoring in 2015 (when extremely high conductivity was measured at these sites), no flow was coming out of Lake Tahoe, so groundwater was making up much more of the instream flow than surface water. Groundwater has higher conductivity than surface water.

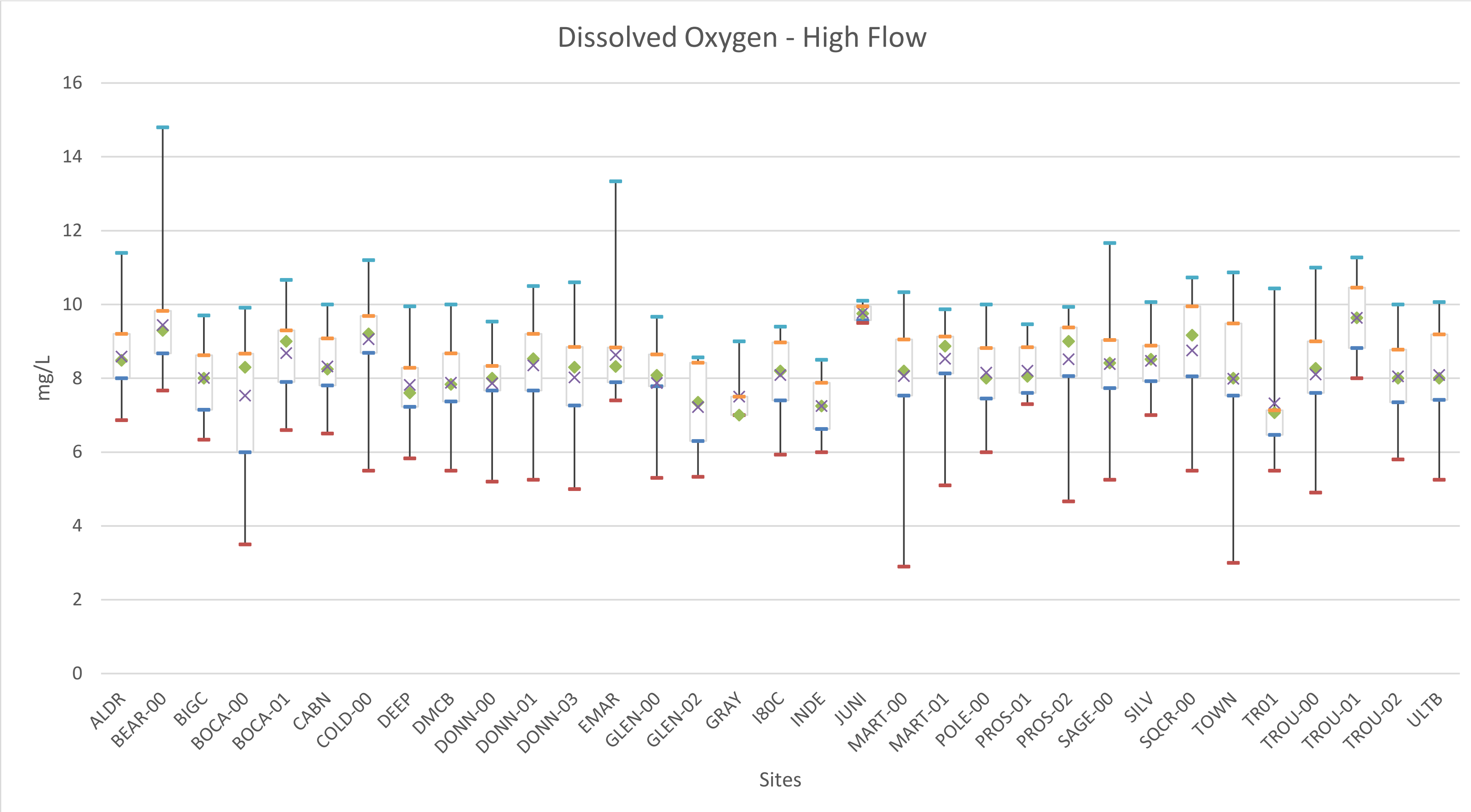


Figure 12a. Dissolved oxygen measured during high flows.

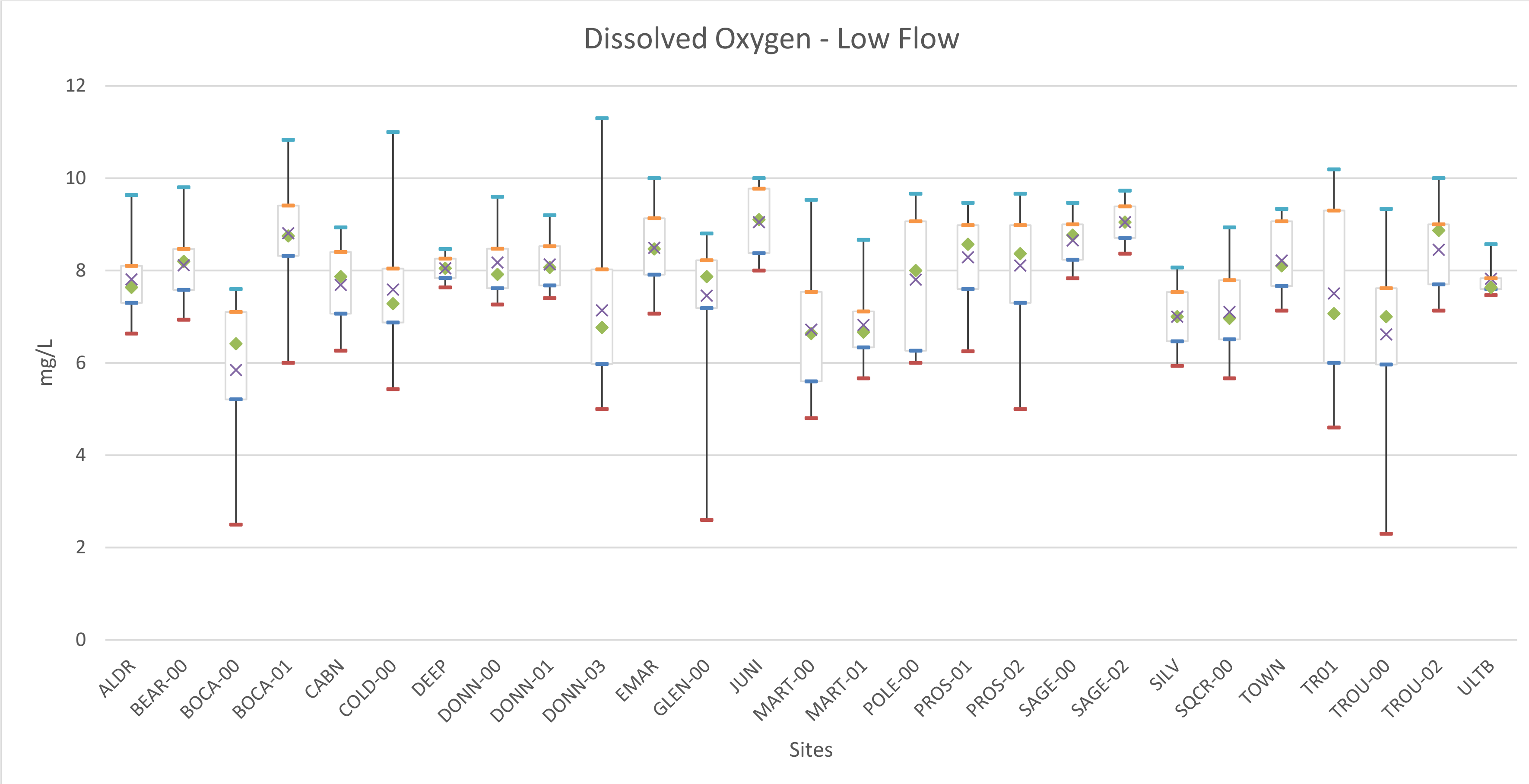


Figure 12b. Dissolved oxygen measured during low flows.

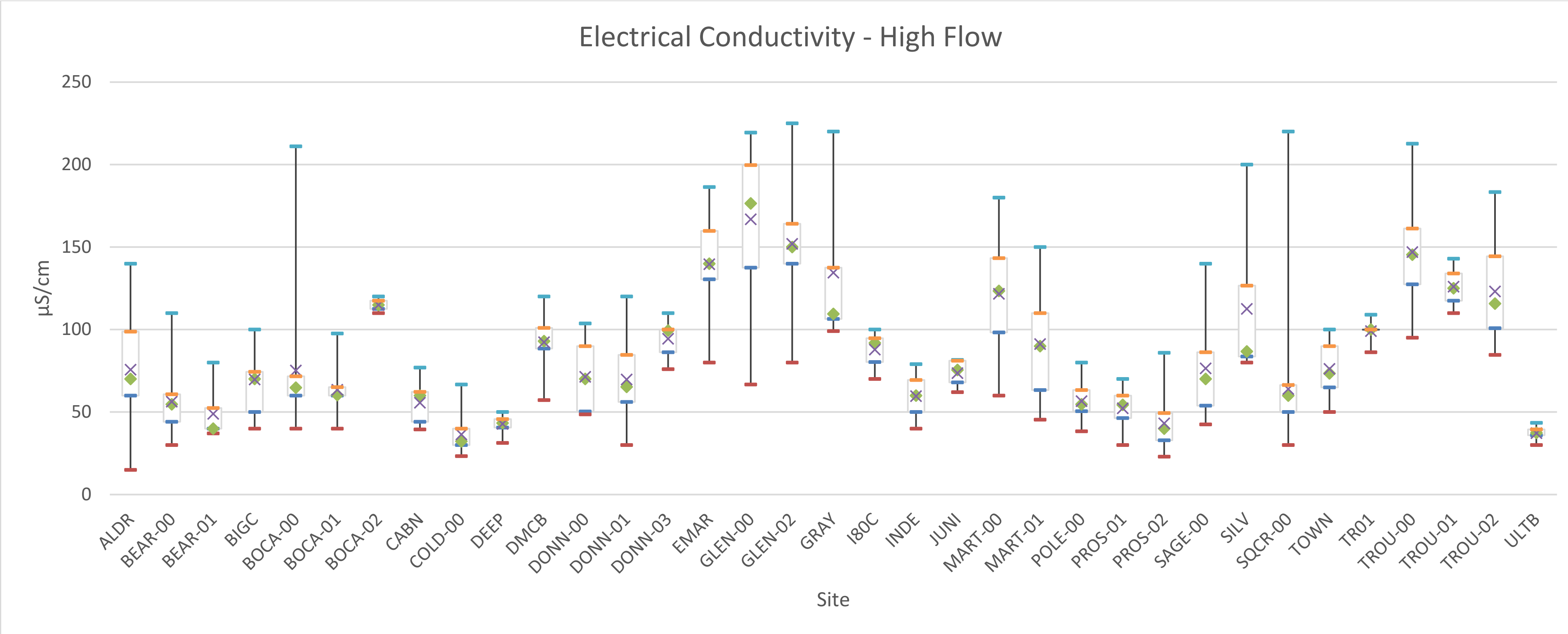


Figure 13a. Electrical conductivity measured during high flows.

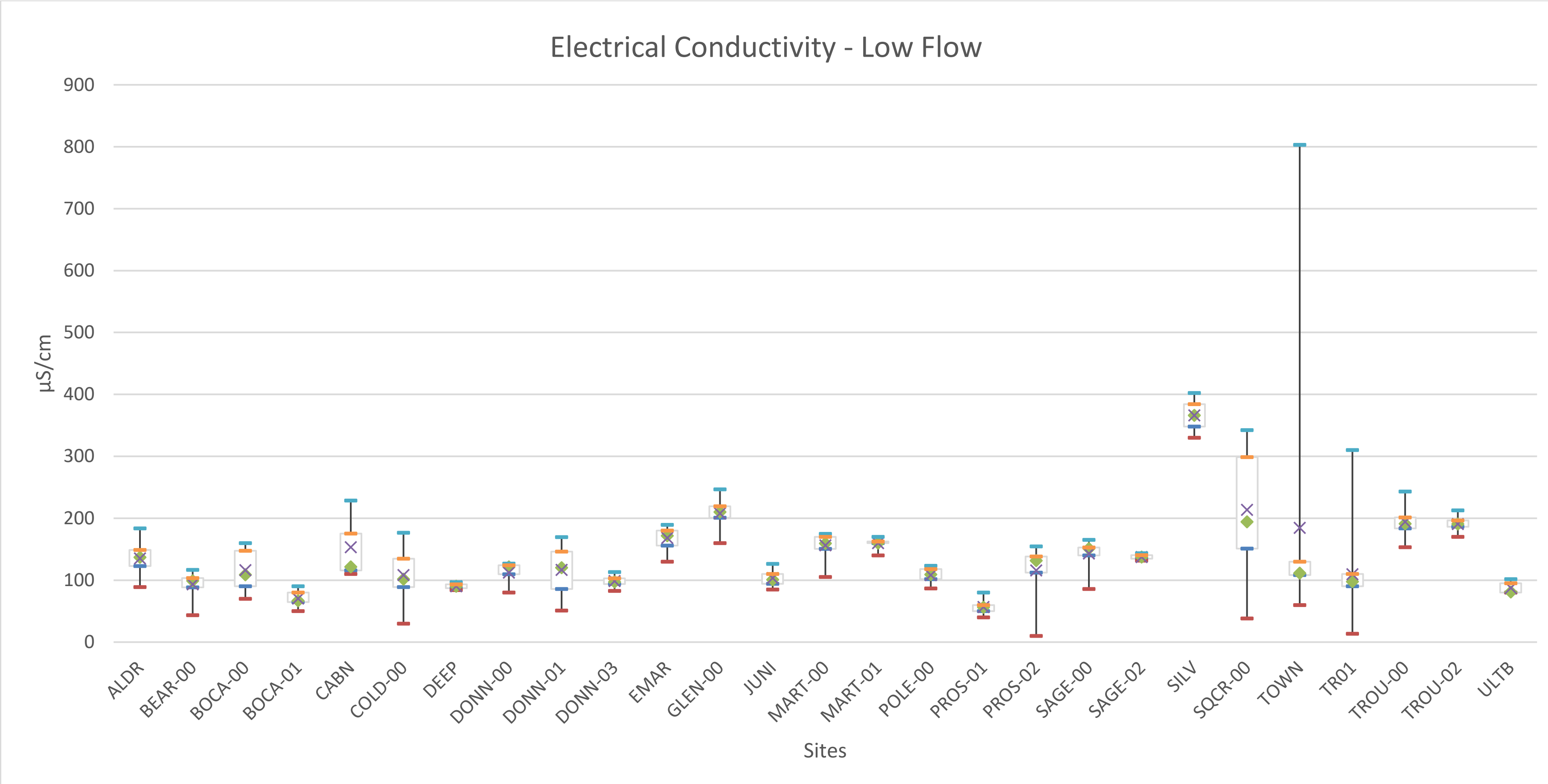


Figure 13b. Electrical conductivity measured during low flows.

pH results

pH is a ratio of ions and is therefore not strongly affected by flow. Therefore, all pH data were graphed together. Low pH indicates acidic water; high pH indicates basic water, with a measurement of 7 being neutral. In the Middle Truckee River watershed, pH is typically very consistent with measurements between 6 and 8 (Figure 14). Very low or very high pH measurements are dangerous for aquatic life. A pH value of 6-8 will support the widest range of biota.

Turbidity

Turbidity is highly related to flow. Turbidity is a measure of the amount of suspended particles in the water. Algae, suspended sediment, organic matter and some pollutants can all increase turbidity in water. Suspended particles diffuse sunlight and absorb heat, which can increase temperature and decrease light available for algal photosynthesis. Turbidity caused by suspended sediment is an indicator of erosion. If sedimentation is extreme, fish and invertebrate populations can be affected. Because erosion is higher during high flows, spring runoff measurements tend to be higher than during low flow.

Figures 15a and 15b show that turbidity is extremely variable, with some sites demonstrating greater variability. Looking at the raw data, while 2017 was a very high water year with many area streams experiencing record flow, there were higher turbidity spikes measured during the 2016 May monitoring event. 2016 was the first average water year after several years of drought – spring runoff during that year likely mobilized sediment that had been deposited on streambeds during the low flow years.

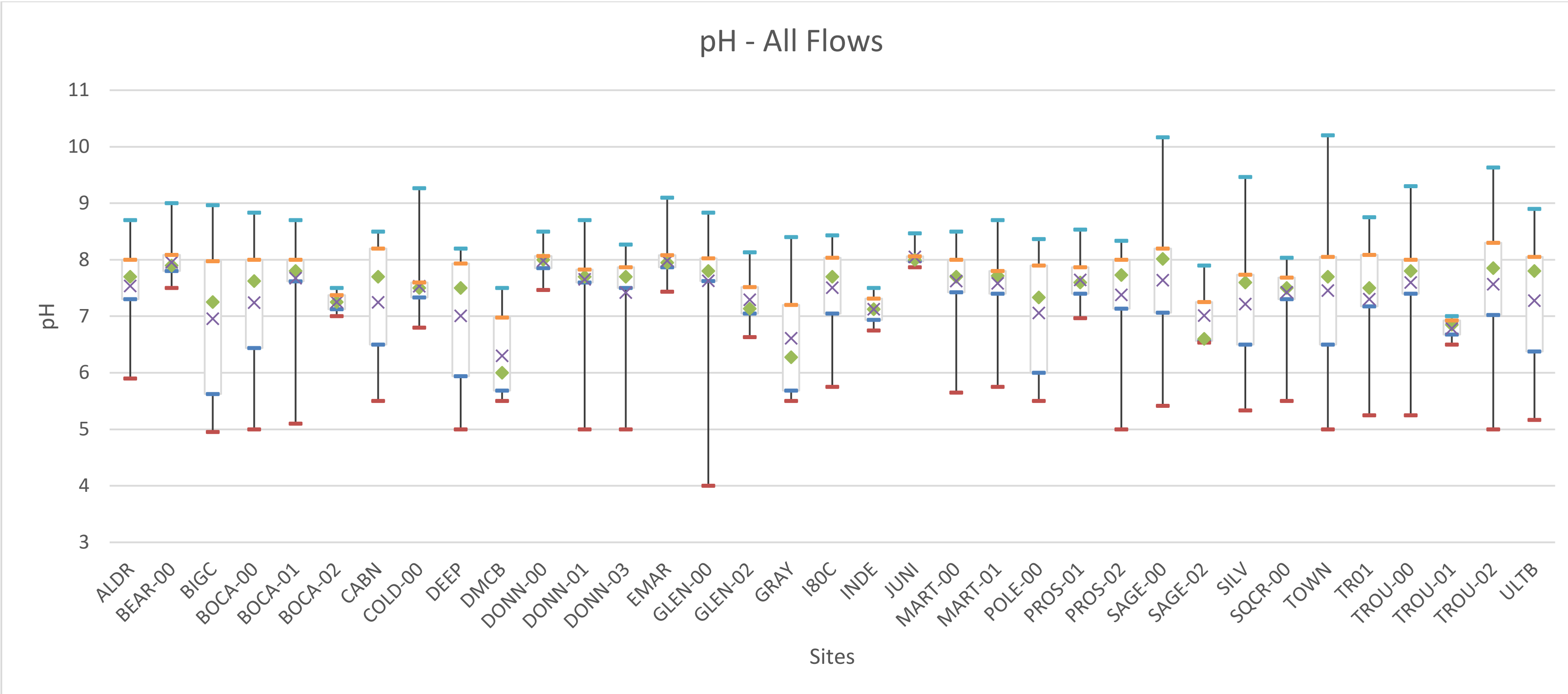


Figure 14. pH measurements.

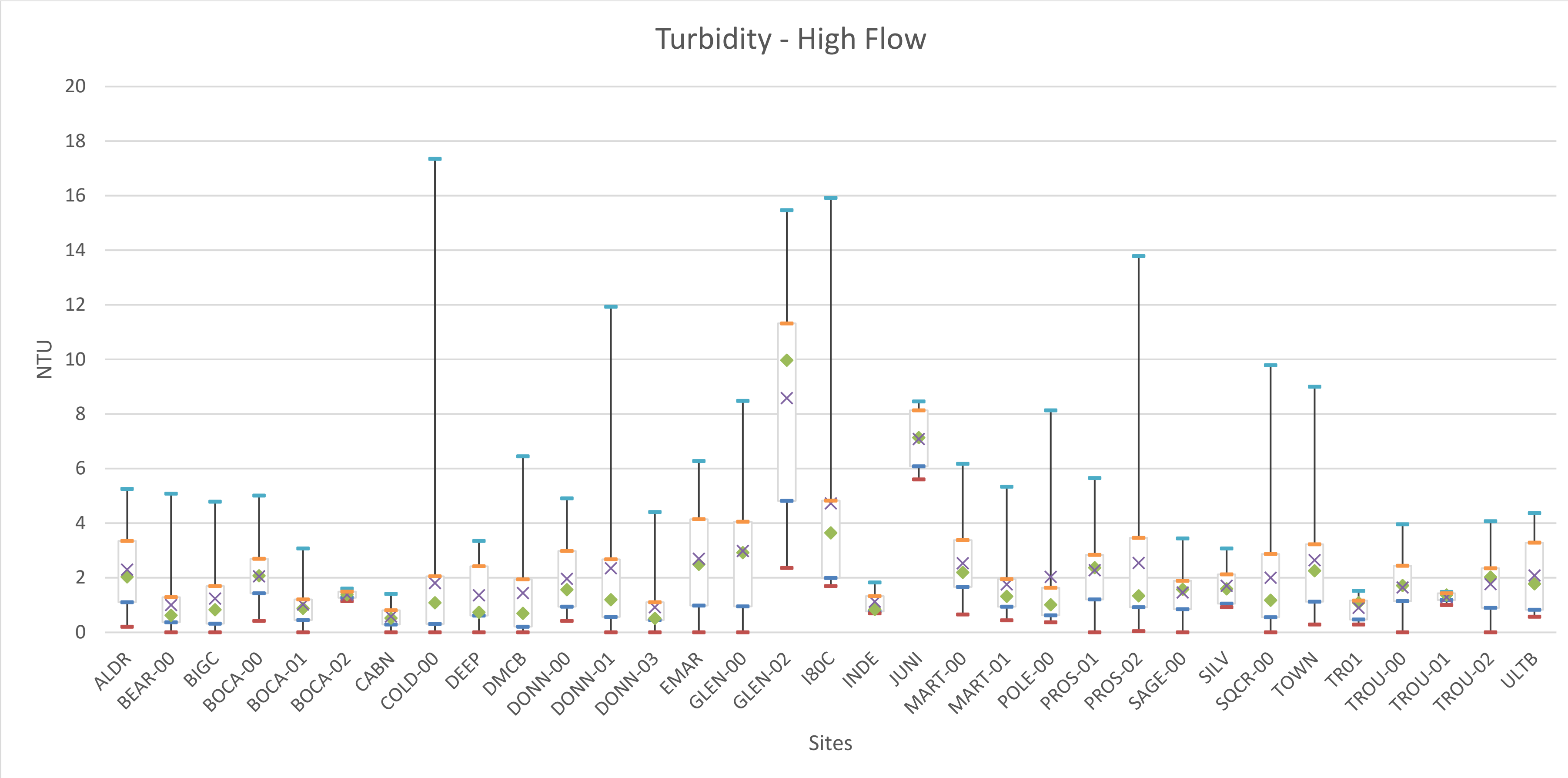


Figure 15a. Turbidity measured during high flows.

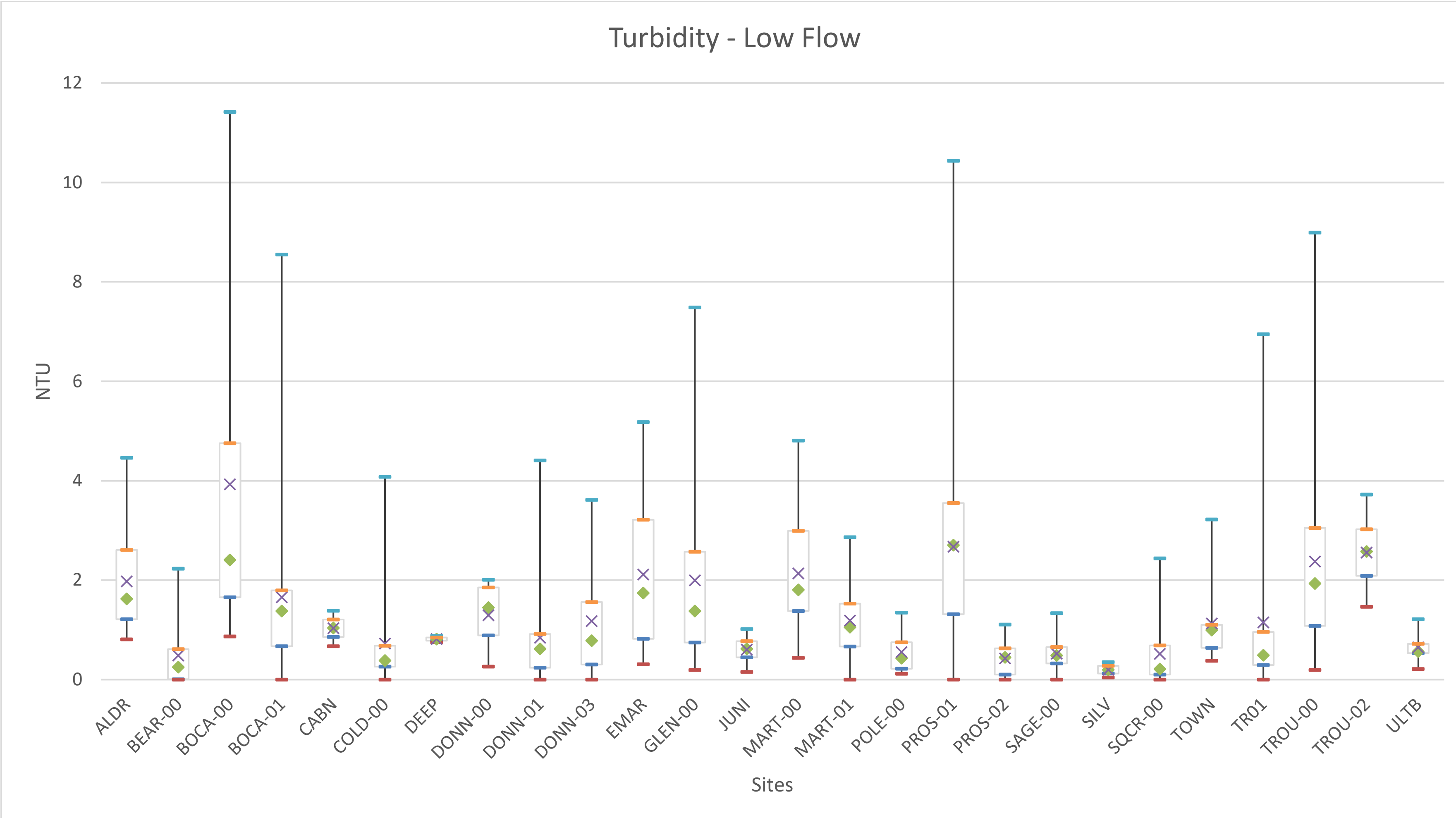


Figure 15b. Turbidity measured during low flows.

Nutrient results

Each year, samples are taken from selected sites and analyzed for forms of nitrogen and phosphorus. Prior to 2014, samples were only taken on Snapshot Day during spring runoff. Starting in 2014, we added one additional nutrient sample taken later in the summer. Nitrogen and phosphorus are necessary to support aquatic life, however high concentrations of either of these nutrients have negative impacts on water quality. Nutrient data are presented in more traditional bar graphs with error bars indicating the standard error as opposed to the "box and whiskers" plots used for other ambient measurements. We have many fewer data points for nutrients than other parameters, so the box and whiskers plots are generally more complicated and harder to interpret with these small data sets.

Nitrogen

Nitrogen occurs in several different forms: nitrate, nitrite, ammonia, and TKN or Total Kjeldahl Nitrogen. Funding has not been consistently available to analyze samples for all forms of nitrogen; therefore we only have total nitrogen data for a subset of years (2006, 2007, 2009-2017).

Figures 5 – 7 and the associated text address established standards for nitrogen and generally discuss sources of nitrogen pollution.

Nitrate-Nitrite (NO3/NO2-N)

Figures 16a – 16b shows nitrate measurements for all streams. Union Valley Creek (GLEN-00 and GLEN-02) stands out as having extremely high nitrate measurements (Figure 16b). In 2016, the Little Truckee River at Boyington Mill (BOCA-01) had very high nitrate measurements as well during both monitoring events (Figure 16a). Nutrients have not been regularly monitored at this site, on the few other occasions, nitrate readings were very low. Flows were quite low in this reach of the Little Truckee during 2016 and there was excessive algae and plant growth. In 2017, nitrate was a little bit high during the September sampling period, but not nearly as high as in 2016 (42 μg/l vs. 185 μg/l) and in 2018, nitrate was fairly low (14 μg/l). We will continue to monitor this site to assess if there is regular water quality impairment due to high nitrogen concentrations or if conditions in 2016 were unusual.

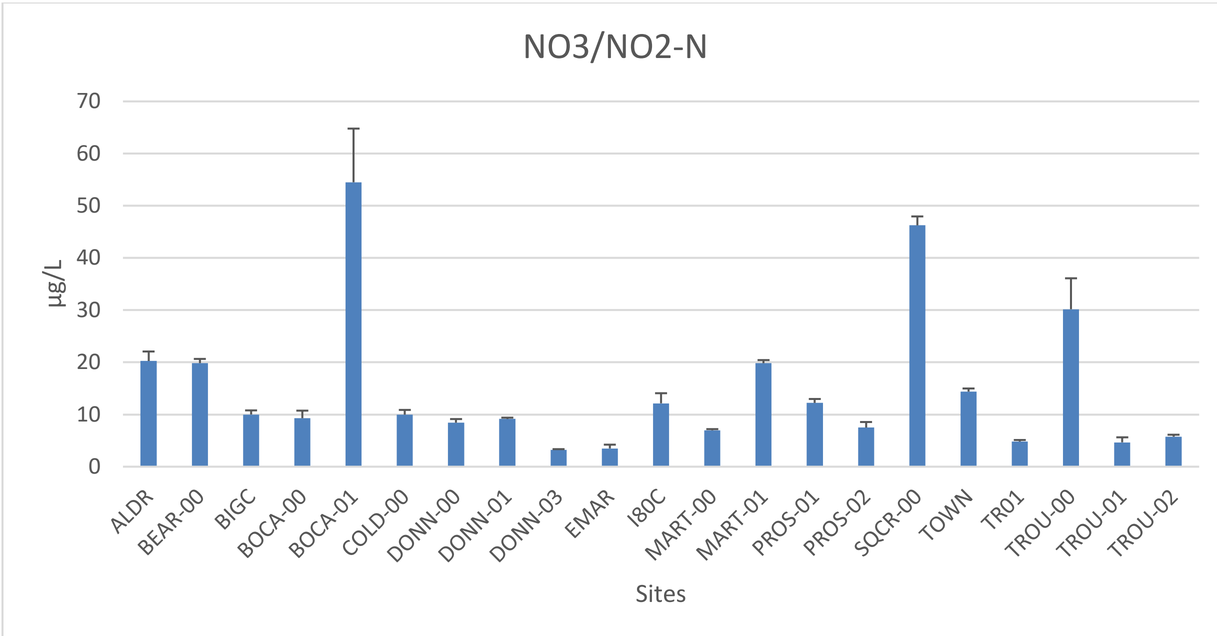


Figure 16a. Nitrate measurements.

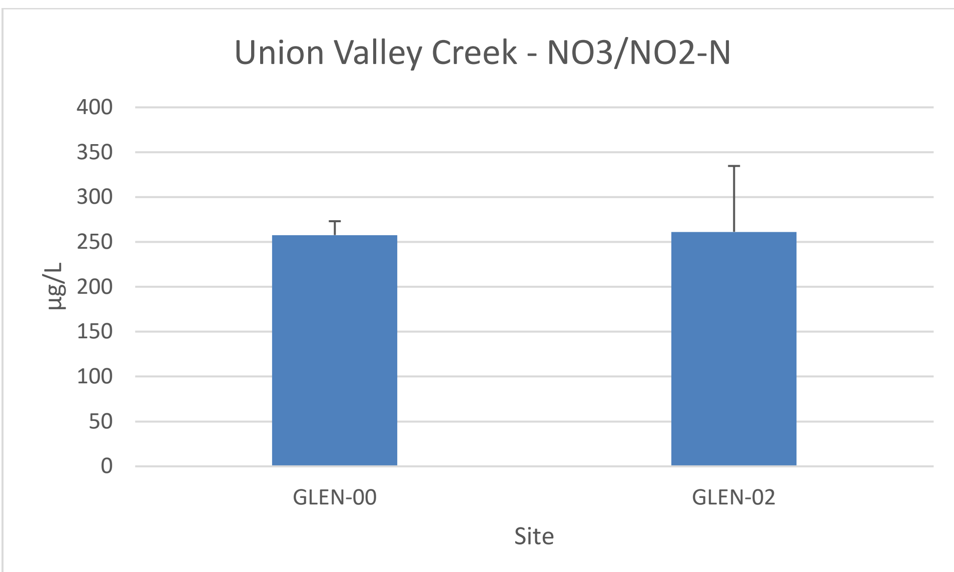


Figure 16b. Nitrate measurements for Union Valley Creek.

Ammonia

Ammonia is a reduced, toxic form of nitrogen and is usually associated with the decomposition of organic matter and wastes. Total ammonia consists of the un-ionized (NH_3) plus the ionized (NH_4^+)

forms. Ionized ammonia is relatively nontoxic while un-ionized ammonia is toxic to fishes and aquatic invertebrates, even in low concentrations. We measure the un-ionized form.

Generally, ammonia is very low in the Truckee River watershed, as can be seen in Figure 17. Prosser Creek below Prosser Dam (PROS-01) stands out as having fairly high levels. This has varied year by year. In 2015 we recorded extremely high ammonia at this site (58-70 μg/l), but then concentrations were lower in 2016 and 2017 (14 μg/l and 5 μg/l). In 2018, we recorded a fairly high concentration in September (26 μg/l). Prosser Reservoir has been kept at a relatively low level periodically since 2015 and this may be one factor in the high ammonia concentrations measured.

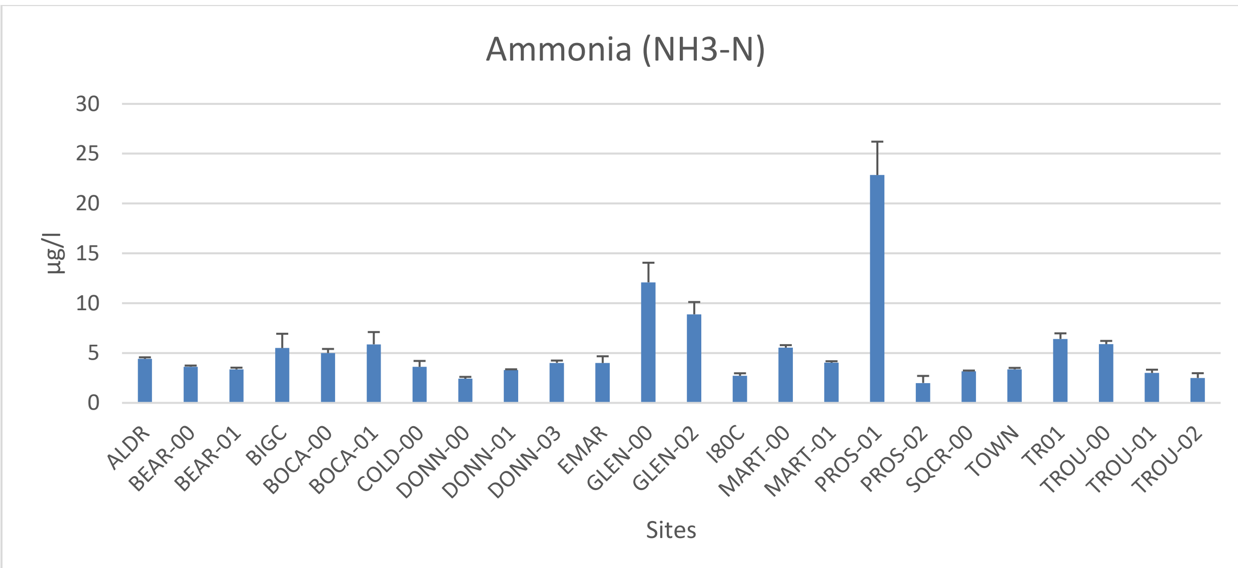


Figure 17. Ammonia measurements.

The water quality objective for ammonia in the Lahontan region is dependent upon pH and temperature. For example, at pH 7 and 10°C (relatively average conditions) the water quality objective is 46 μg/l for one-hour concentrations (most comparable to single point measurements). Figure 17 shows that most measurements are well below that level.

Total Kjeldahl Nitrogen (TKN)

Four sites stand out as exhibiting high levels of TKN (Figure 18): Little Truckee River below Boca Dam (BOCA-00), Little Truckee River above Boyington Mill (BOCA-01), Union Valley Creek at mouth (GLEN-00), and Prosser Creek below the dam (PROS-01). Of these sites, only BOCA-00 has an established standard for TKN – 320 μg/l. Although our monitoring indicates relatively high levels of TKN at BOCA-00, the standard has not been exceeded (Figure 6). We have limited data from BOCA-01 and PROS-01 but the high TKN levels may be related to low flows and excess plant growth in these reaches in 2016, although TKN was still fairly high in 2017 and 2018. We will continue to monitor these sites.

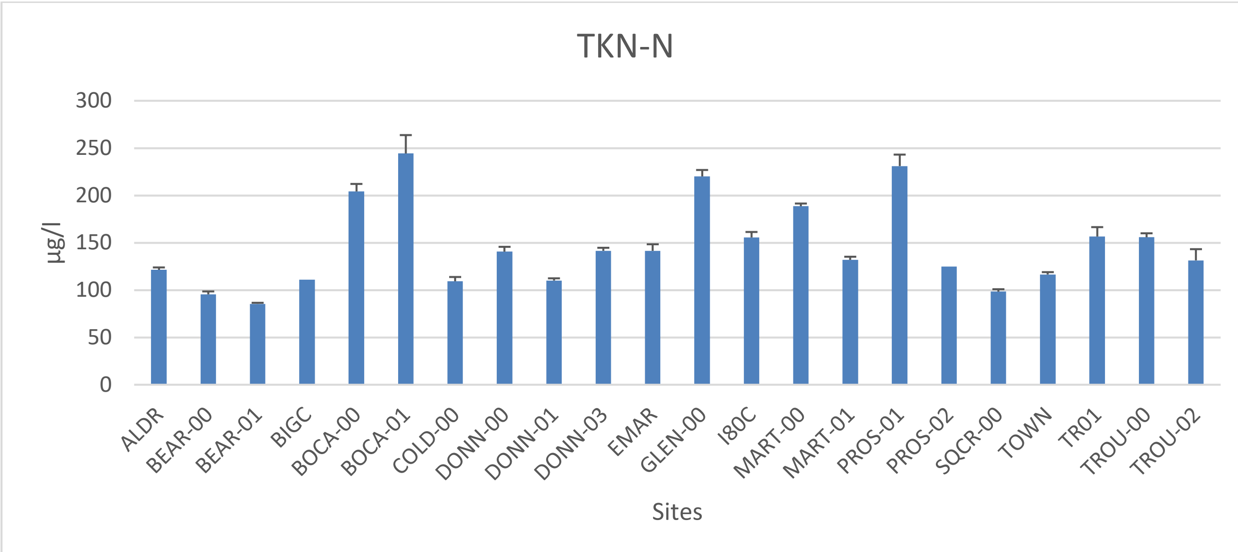


Figure 18. Total Kjeldahl nitrogen measurements.

Total Nitrogen

Figure 19 shows total nitrogen for all sites for which we have data, with the exception of Union Valley Creek at Glenshire Drive (GLEN-02) – measured nitrogen levels for this site (described below) are too high to fit on the same axis as the other sites. As previously noted, total nitrogen standards have only been established for a subset of streams (Table 5). However, several of our sites without numeric standards regularly measure total nitrogen levels greater than the threshold of 150 µg/l or even 180 µg/l established for other tributary streams. BOCA-01, DONN-00, GLEN-00, MART-00, PROS-01, and TROU-00 are all sites with relatively high total nitrogen.

Union Valley Creek at Glenshire Drive (GLEN-02) has only been monitored five times for nitrogen, and each time the total nitrogen has been extremely high – 662.5 µg/l in May 2013, 18,311 µg/l in May 2015, 754 µg/l in May 2016, 231 µg/l in May 2017, and 514 µg/l in May 2018. This site only flows in the spring, but as it is a direct input to the Glenshire Pond, we collect samples when we are able to. The Glenshire Pond has significant problems with excess plant and algae growth. The Glenshire Homeowner's Association has started to develop a plan to improve water quality of the pond.

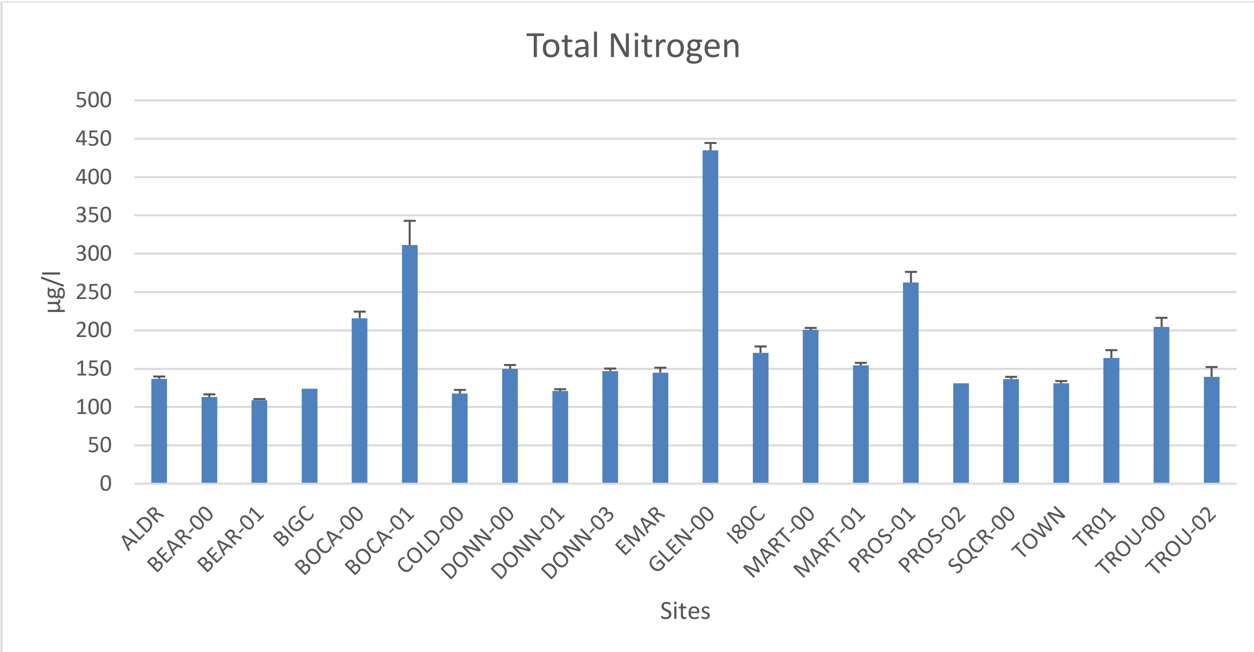


Figure 19. Total nitrogen measurements.

<u>Phosphorus</u>

Background phosphorus levels in the Truckee River are expected to be low. Figure 20 shows results from 2001-2018. For example, established standards are between 10 – 50 µg/L (Table 5). Using 40 µg/L as a "high" value for phosphorus, several sites regularly have levels higher than that: GLEN-00, GLEN-02, and MART-00.

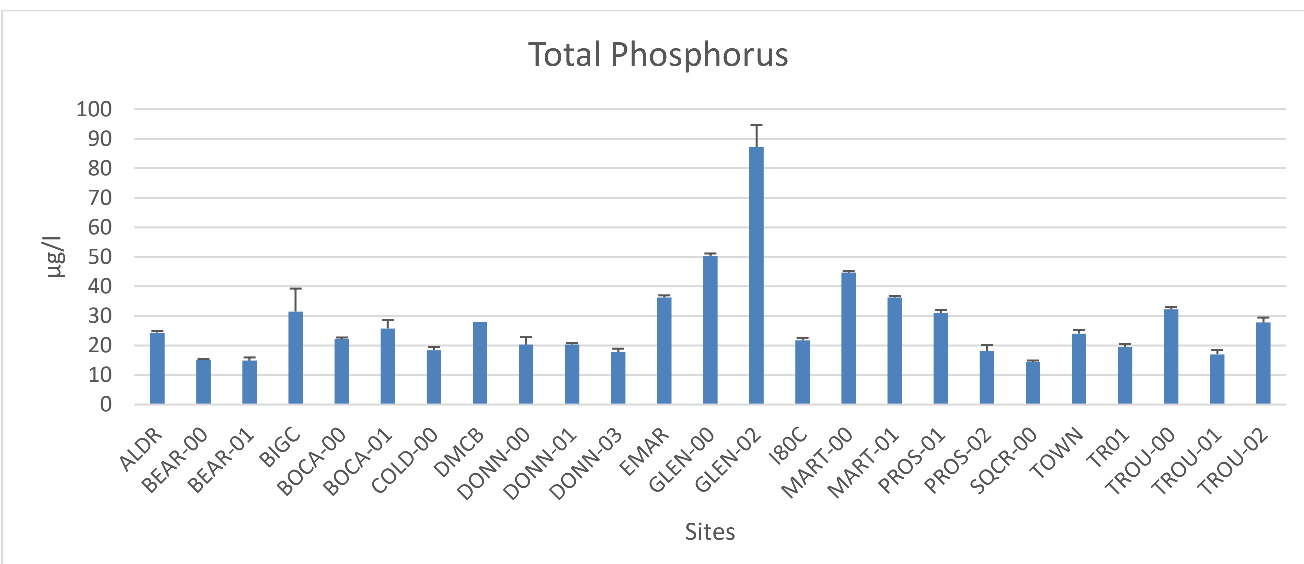


Figure 20. Total phosphorus measurements.

Bioassessment Results

Bioassessment data can be evaluated in a number of ways to demonstrate overall water quality in the watershed. Here we present data related to overall pollution and the aquatic food web.

General Pollution – Index of Biological Integrity

In 2009 an Index of Biological integrity (IBI) for the Eastern Sierra was published (Herbst and Silldorff, 2009). An IBI allows for the comparison of the biological condition of streams based on a single score. An IBI is an index composed of multiple metrics that can be used to accurately and cost-effectively assess stream health.

IBIs are region- or even watershed-specific. To generate an IBI, data must be collected from many different streams of varying "known" condition. Streams are separated into reference and test streams with reference streams being relatively high quality, and test streams of varying quality. Many different metrics are typically considered for evaluation, and a subset are selected for inclusion in the IBI.

For the Eastern Sierra IBI, component metrics were selected for inclusion based on performance indicators such as sensitivity in response to disturbance stressors, high signal-to-noise ratio (strong response to stress with low variation), and little redundancy with other metrics. Thresholds for assessment of biological impairment were based on reference streams of the region, defined as those least influenced by land use disturbances. To identify reference streams, the developers of the IBI used criteria such as low levels of exposure both to the density of upstream road crossings in the watershed, and local reach-scale bank erosion. Streams not conforming to the reference site selection criteria were designated as test sites. The IBI scores of test sites were evaluated relative to the distribution of IBI scores for reference sites to determine whether biological integrity was impaired (according to 5 condition classes). A detailed description of the Eastern Sierra IBI development is included in Herbst and Silldorff, 2009.

Figures 21a – 21b show IBI scores for all streams analyzed to the 500-count standard. Due to the large number of samples, the data from the Little Truckee River sub-watershed are presented separately in Figure 21b.

Scores derived from the Eastern Sierra IBI can be ranked in tiers or classes based on statistical criteria described in detail in the IBI report (Herbst and Silldorff, 2009). Table 7 outlines the scoring tiers.

Figure 22 is a pie chart showing the relative percent of IBI scores in each of the condition categories. While very few streams yield scores in the lowest category during any one year, less than half the streams monitored in any year are fully supporting of aquatic life uses. Figure 22 includes TRWC data as well as data collected by Placer County on Squaw Creek and Martis Creek since 2010.[1]

Table 7. Tiers of the Eastern Sierra IBI.

Tier	IBI Score	Designation
5/A	>89.7	Very Good – Supporting beneficial uses
4/B	80.4 - 89.7	Good – Supporting beneficial uses
3/C	63.2 -80.4	Fair – Supporting but uncertain
2/D	42.2 – 63.2	Poor – Partially supporting beneficial uses
1/F	<42.2	Very Poor – Not supporting beneficial uses

<u>General Pollution - Tolerance Measures</u>

Each taxon of aquatic invertebrate is assigned a tolerance value which is an indication of the amount of pollution that it can survive. Taxa with high tolerance values are able to live in more degraded water (can tolerate more pollution) and taxa with a low tolerance values are less able to live in degraded streams (are intolerant of pollution). Tolerance values range from 0-10, with organisms like stoneflies on the low end and organisms like leeches on the high end. "Tolerant" taxa have tolerance values of 8-10 and "Intolerant" taxa have tolerance values of 0-2.

[1] In 2010, Placer County implemented bioassessment monitoring as part of the Truckee River Water Quality Monitoring Plan (TRWQMP, 2ND Nature, 2008). Prior to the development and implementation of the TRWQMP, TRWC had monitored both Martis and Squaw. To avoid excess impacts to the instream fauna of the streams and maximize limited monitoring resources, TRWC has not monitored Martis or Squaw while Placer County continues to implement the TRWQMP. The Placer County data are collected and analyzed using the same protocols as TRWC uses, therefore all the data are comparable. Additionally, they are readily available in the annual monitoring reports produced by the County (e.g. CDM Smith, 2017).

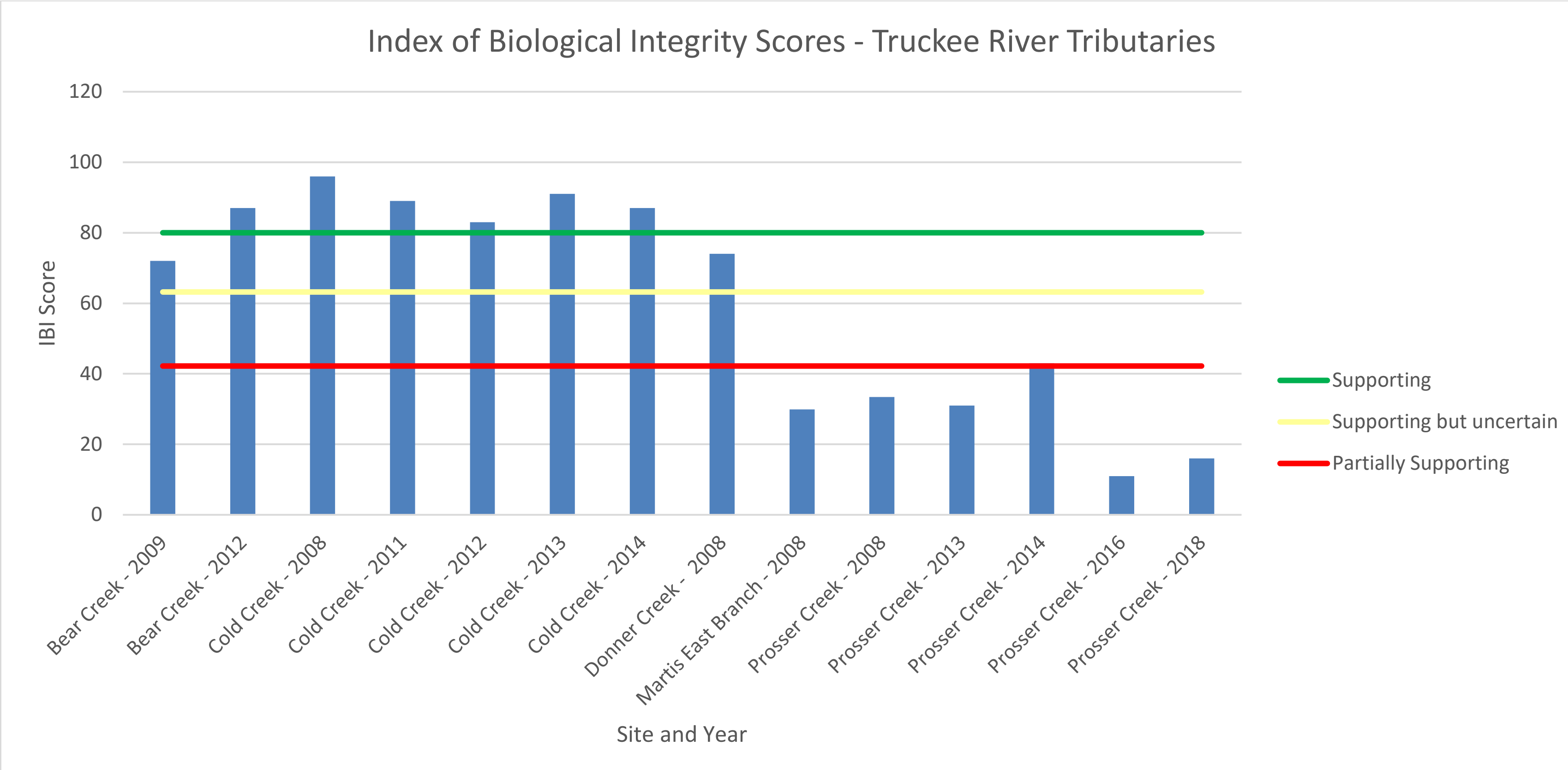


Figure 21a. IBI Scores for Truckee River tributary streams. Sites scoring 80.4 or higher (above green line) are in good condition. Sites scoring between 63.2 and 80.4 (between yellow and green line) are in fair condition. Sites scoring between 42.2 and 63.2 (between red and yellow line) are in poor condition. Sites below 42.2 (below red line) are in very poor condition.

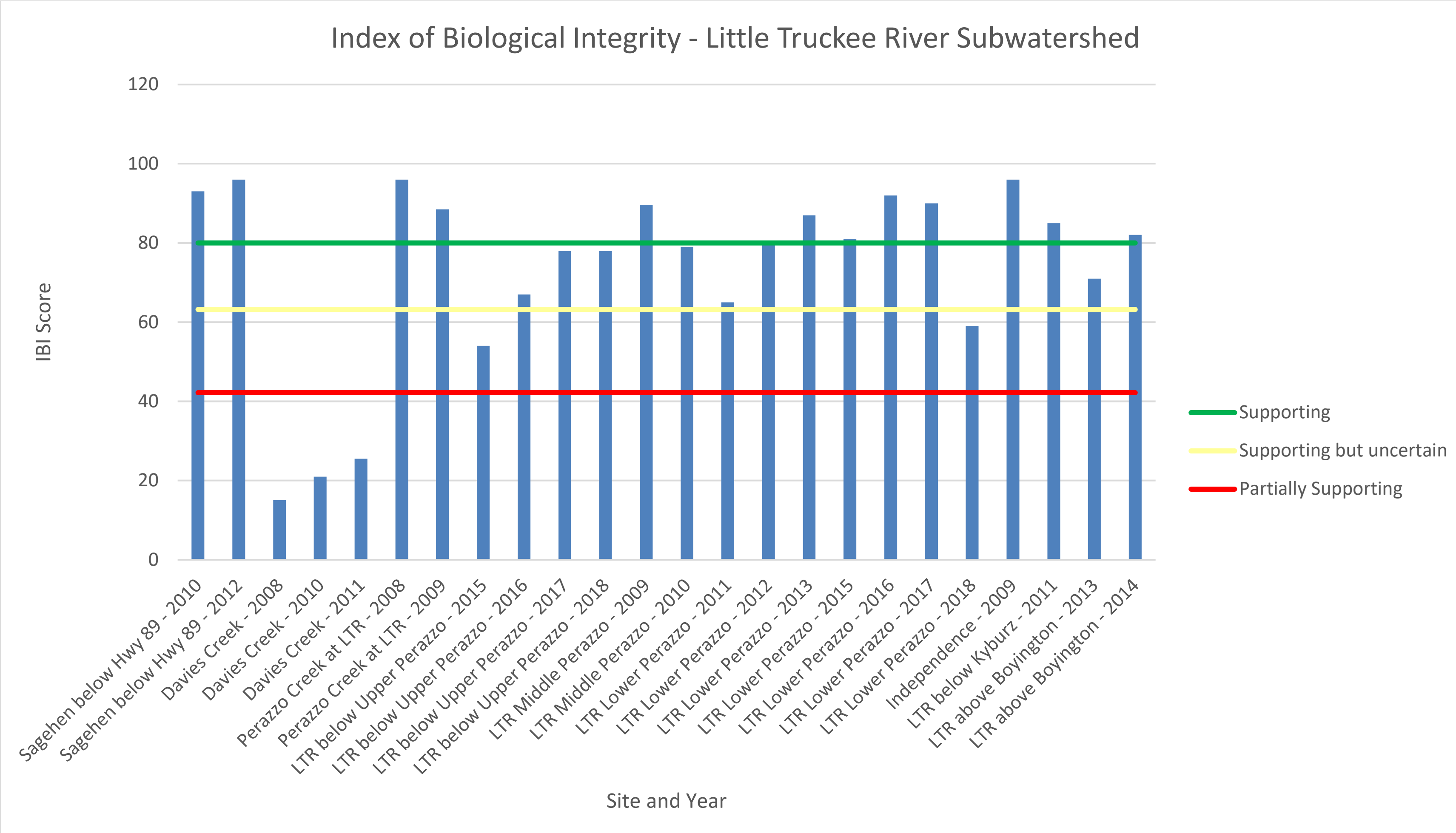


Figure 21b. IBI Scores for sites tributary to or located on the Little Truckee River.

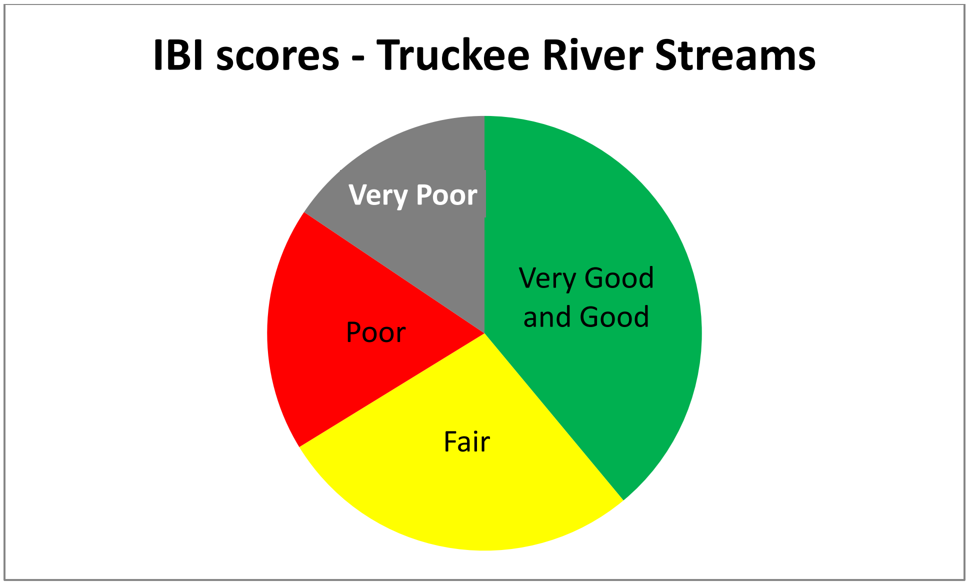


Figure 22. IBI scores for all TRWC and Placer County data by condition score category (Table 7). This pie chart includes IBI data shown in Figures 21a-b and Placer County data as reported in their annual water quality monitoring reports: (https://www.placer.ca.gov/Departments/Works/StrmWtr/StmWtrMonitoring.aspx). In more than half the streams and years sampled, beneficial uses are not fully supported.

The Community Tolerance metric is a weighting of all the organisms in the sample by tolerance value. A high tolerance value means that in general, more tolerant taxa are found in that stream. The community tolerance metric includes all individuals in a sample, not just the highly tolerant or intolerant.

The Eastern Sierra IBI incorporates a number of tolerance metrics, and the aim of the IBI is to give an overall indication of pollution. Additionally, the IBI provides easy to understand output in that it gives a score that directly relates to overall water quality. However, due to differences in collection methodology (see Methods), we can only run the IBI on data collected 2008 or later and analyzed by professionals. For data collected prior to 2008 and volunteer analyzed samples, we can get a general indication of overall pollution by looking at these specific tolerance metrics (% tolerant, % intolerant, community tolerance).

For the samples not included in the IBI graphs, volunteer-analyzed and professionally-analyzed tolerance data are presented together in Figures 23a – 23d, with volunteer-analyzed data marked with an asterisk. Although there are slight differences in metric calculations between professional and volunteer data, the overall results are similar.

Figures 23a-d show the tolerance metrics. Due to the large number of samples, the data have been split into four graphs, organized by position in the watershed. In general, the biological condition of area streams is fairly good when looking at just these metrics. Percent Tolerant is generally low, and Percent Intolerant is generally high. A few streams stand out: West Martis, Trout at Bennett, Prosser Creek, Truckee at Horseshoe, and Davies Creek. West Martis and Trout at Bennett drain fairly developed areas. Davies Creek is a seasonal stream, so it may not be directly comparable to our other sites that are perennial. Prosser Creek is located below a dam, see the section of this report on TROA for further discussion of water quality at this site.

Several streams such as Independence Creek, Sagehen Creek – at the upper sampling location, Prosser at 89, Deep creek, Deer Creek, Cold Creek, and Pole Creek all have low community tolerance values and high percent Intolerant – indicative of good water quality.

Functional Feeding Groups

Available food sources in a stream vary depending upon the distance from the headwaters. The River Continuum Concept addresses how this different availability of food sources will affect the types of organisms found at different points along a stream. In headwater streams, the input of organic matter is primarily from terrestrial sources, these streams tend to be small and shaded, so very little sunlight can reach the stream to stimulate primary productivity (plant and algae growth). Leaves falling from streamside vegetation will provide the majority of the food base to these types of stream. Therefore, we predict to see many "shredders", organisms that feed off of leaves or other types of terrestrial inputs. Some scrapers, collectors, filterers, and predators will also be present.

Further down the stream in "mid-reach" sections, the streams are larger and solar radiation can reach the water. The food base becomes a mix of terrestrial and in-stream primary productivity. Aquatic plants and algae form a significant part of the food web. More medium and fine particulate matter is present in the mid-reach streams than in the headwaters. Shredders are found in much lower abundance, and a small number of predators will be present.

The main types of functional feeding groups found in these mid-reach streams are scrapers that feed on the algae and plants, collectors that gather fine organic matter from stream bottom sediments, and filterers that consume fine organic matter from the water column.

In very large river systems (like the lower Mississippi) the energy base for the food web is primarily leakage from upstream. In these systems, fine particulate organic matter collectors dominate the species assemblage, and a small number of predators will be present.

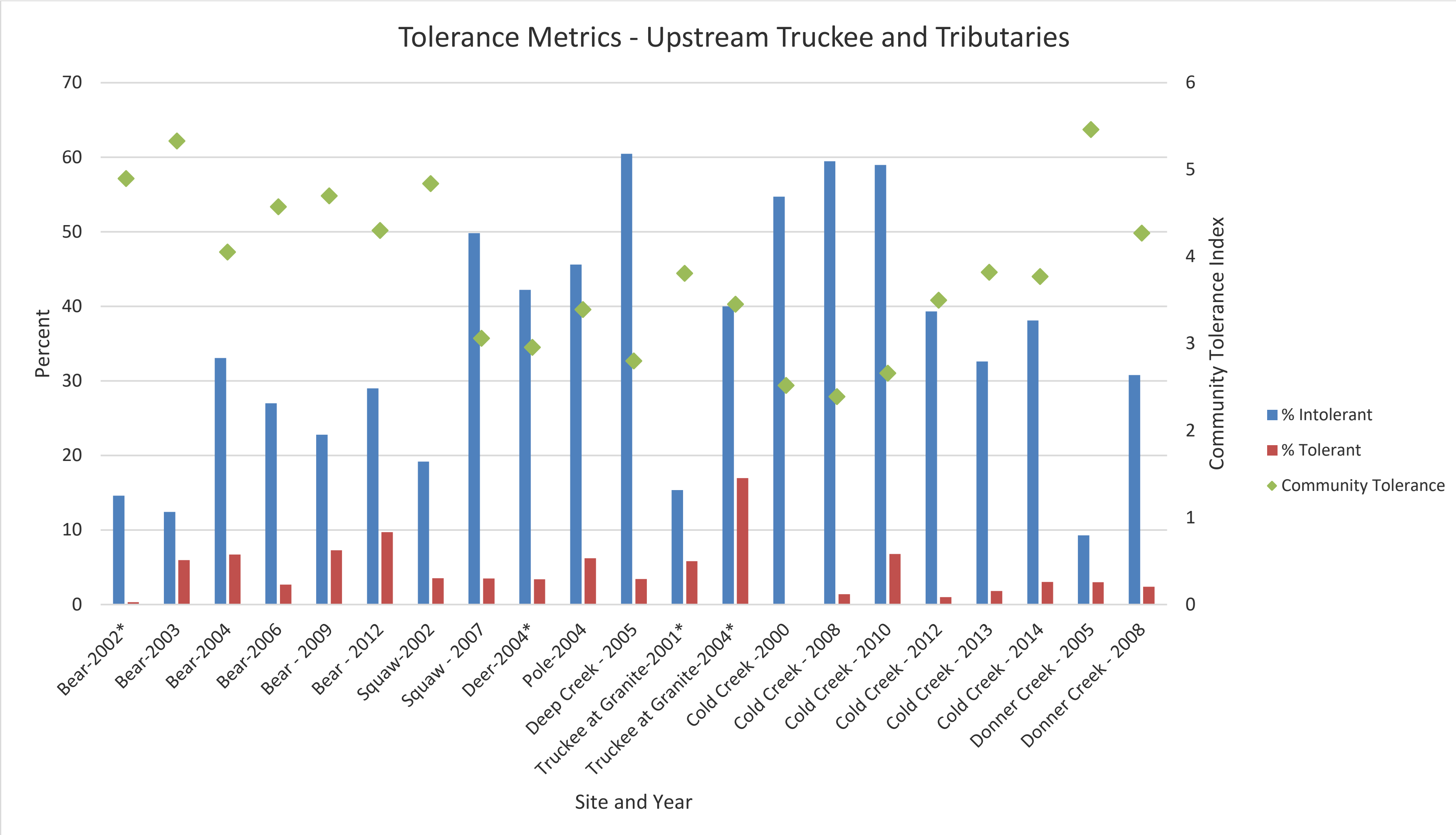


Figure 23a. Tolerance metrics, Truckee River tributaries and Truckee River sites above the Town of Truckee. Data analyzed by volunteers are denoted with an asterisk.

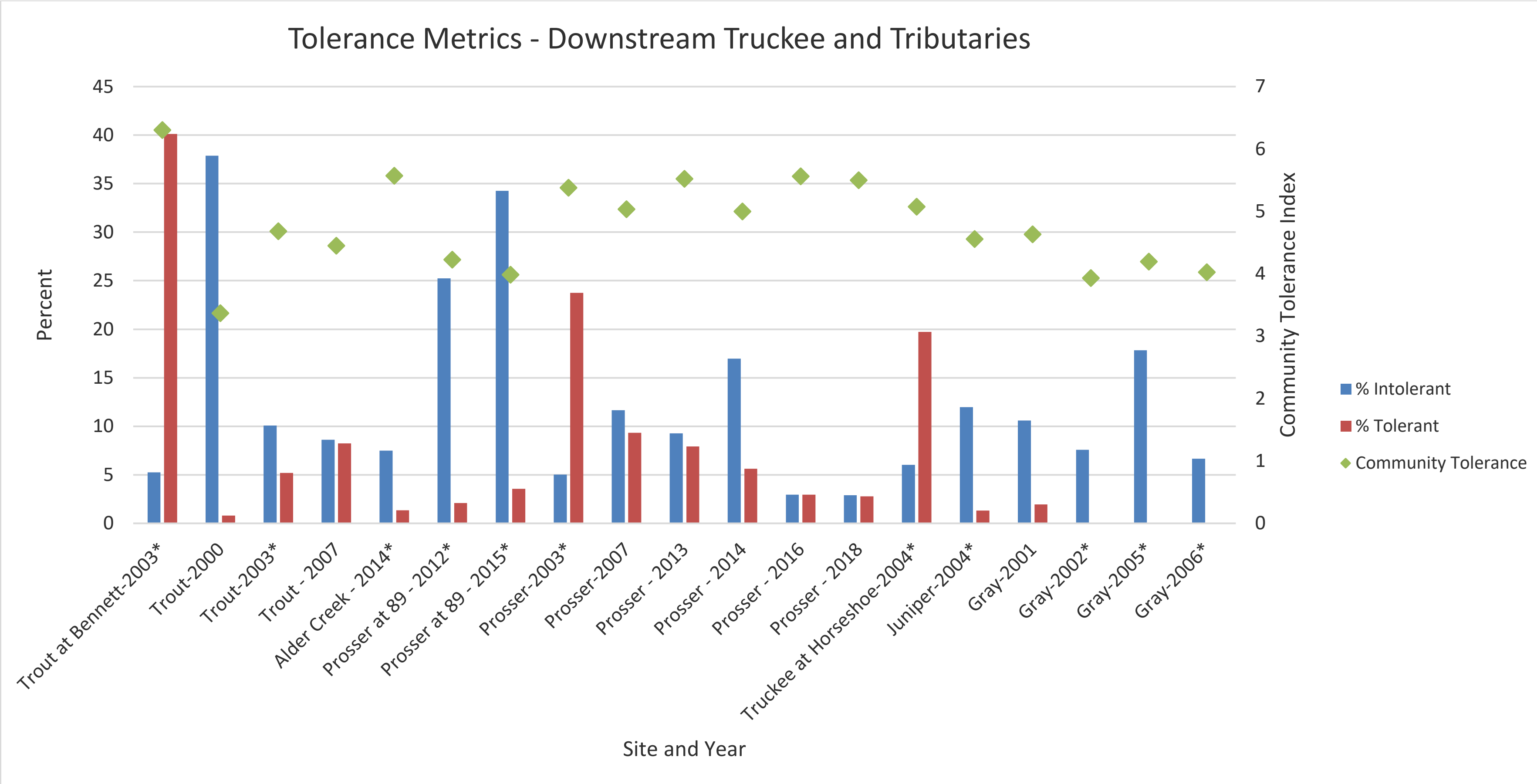


Figure 23b. Tolerance metrics, Truckee River tributaries and Truckee River sites downstream of Town of Truckee.

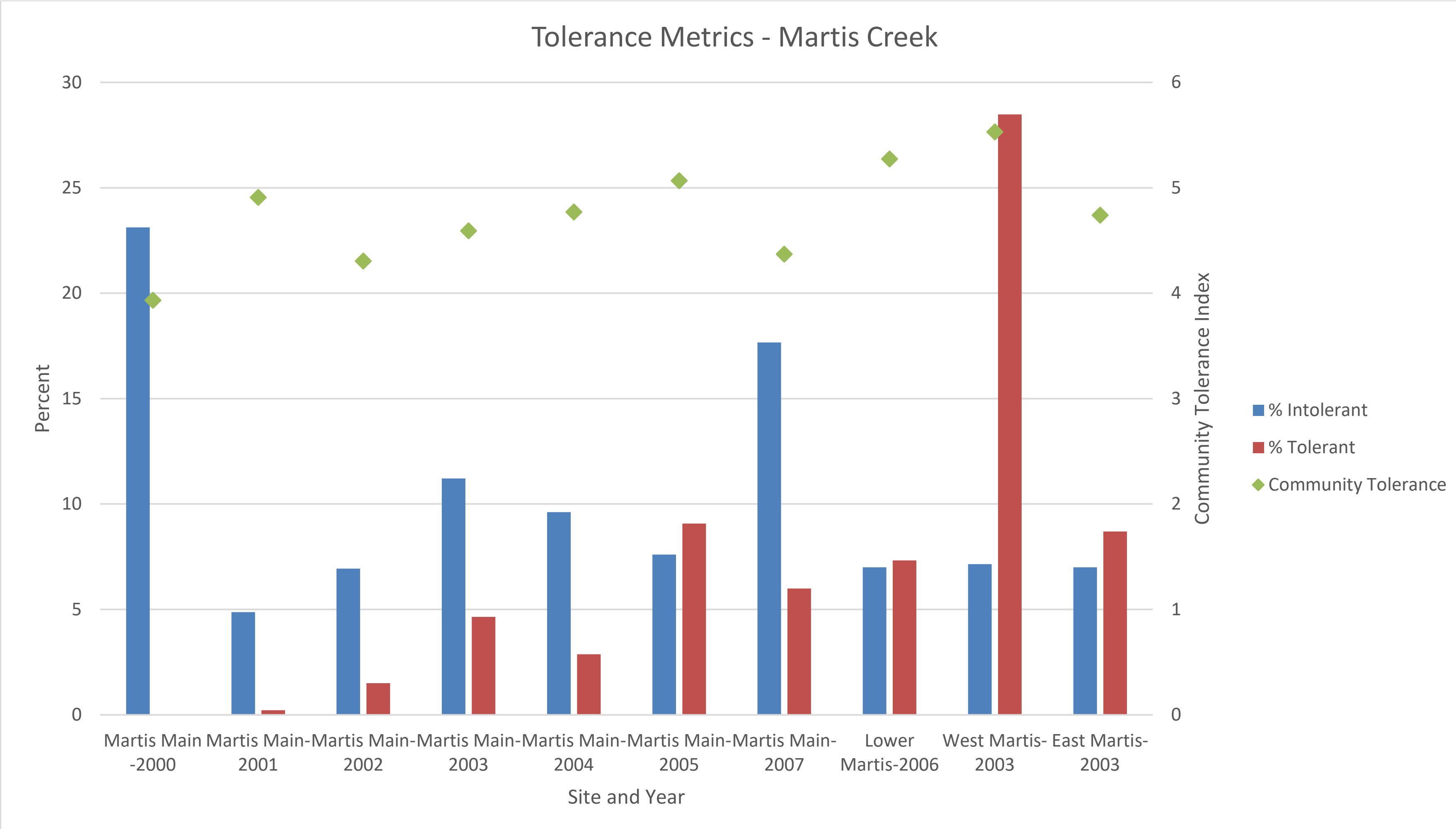


Figure 23c. Tolerance metrics for branches of Martis Creek.

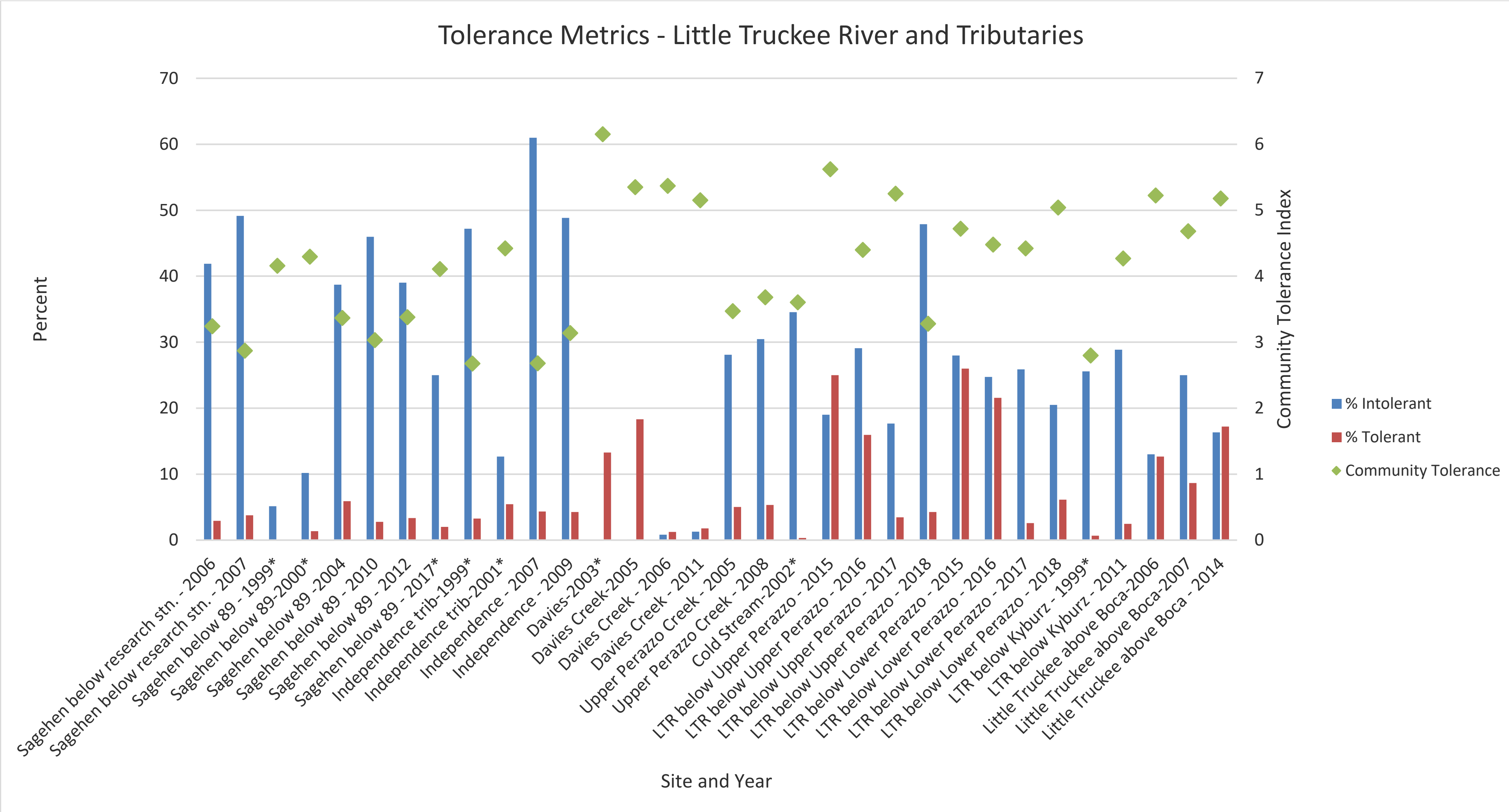


Figure 23d. Tolerance metrics, sites tributary to or located on the Little Truckee River.

Locally, most of our streams would be considered headwater streams. The main stem of the Truckee River would even be considered a headwater stream according to how streams are classified, but has many of the characteristics of a mid-reach stream. In the tributary streams, we should see communities that have large percentage of shredders, with smaller numbers of collectors, filterers, scrapers, and predators.

Figures 24a-c show the percentages of functional feeding groups seen in samples analyzed to a higher taxonomic level (by professional laboratories) and Figure 24d shows the same data for samples analyzed to family level (by volunteers).

Generally speaking, the percentage of shredders in area steams is fairly low. Low numbers of shredders often indicate that there is a reduced availability of terrestrial vegetation as a food source.

The percent of scrapers should be low in our headwater streams, which is mostly the case. Martis Creek consistently has a fair percentage of scrapers, as does Cold Creek. Cold Creek scores high on the IBI and the tolerance metrics for Martis Creek are relatively good for these same samples. Therefore, the high percentage of scrapers does not seem to indicate overall impairment in these creeks, just a difference in the food web.

Many of the streams are dominated by collectors, which could potentially indicate excess sediment.

It is interesting to note that the feeding guilds can vary substantially between years at sites for which we have multiple years of data. Collection dates do not vary much between years for each site, so the shift is not likely to be an artifact of the time of year, but probably reflects annual variation in conditions.

Goal: To screen for water quality problems typically associated with common land use practices in the Truckee River watershed – Is there evidence of impacts to water quality at urban sites as compared to non-urban sites?

One land use change that is occurring in the Truckee River watershed is increased urbanization. The urban areas are fairly concentrated in a handful of sub-basins: Bear Creek, Squaw Creek, Donner Creek, Trout Creek, and Union Valley Creek (Figure 25). Urbanization is predicted to affect some ambient parameters more than others. In particular we expect to see:

- Increased temperature in more urbanized areas because of lack of streamside vegetation;
- Increased electrical conductivity in more urbanized area because of influences of roads and urban run-off;
- Increased turbidity in more urbanized areas because of increased erosion

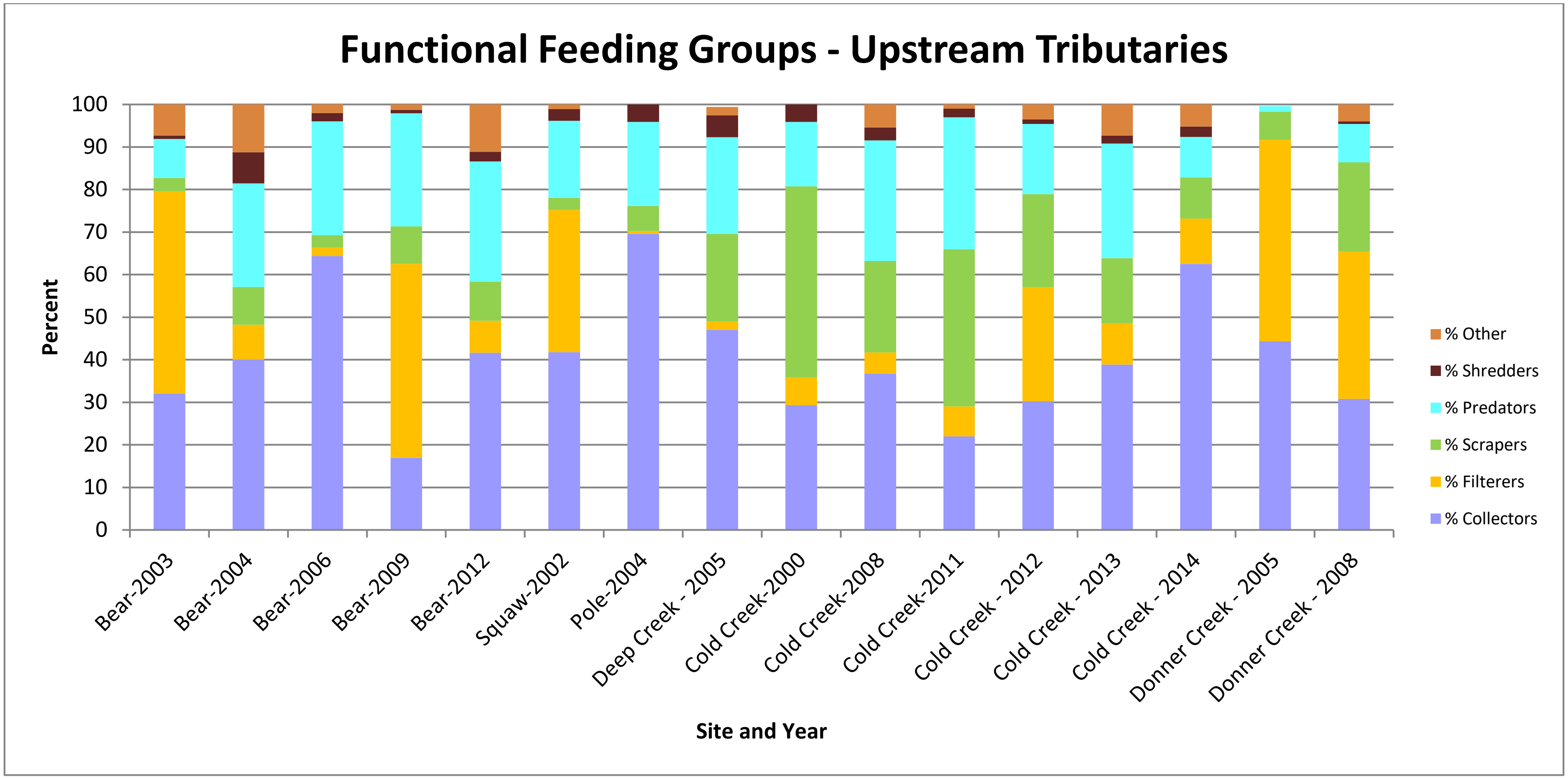


Figure 24a. Functional feeding groups, upstream tributaries.

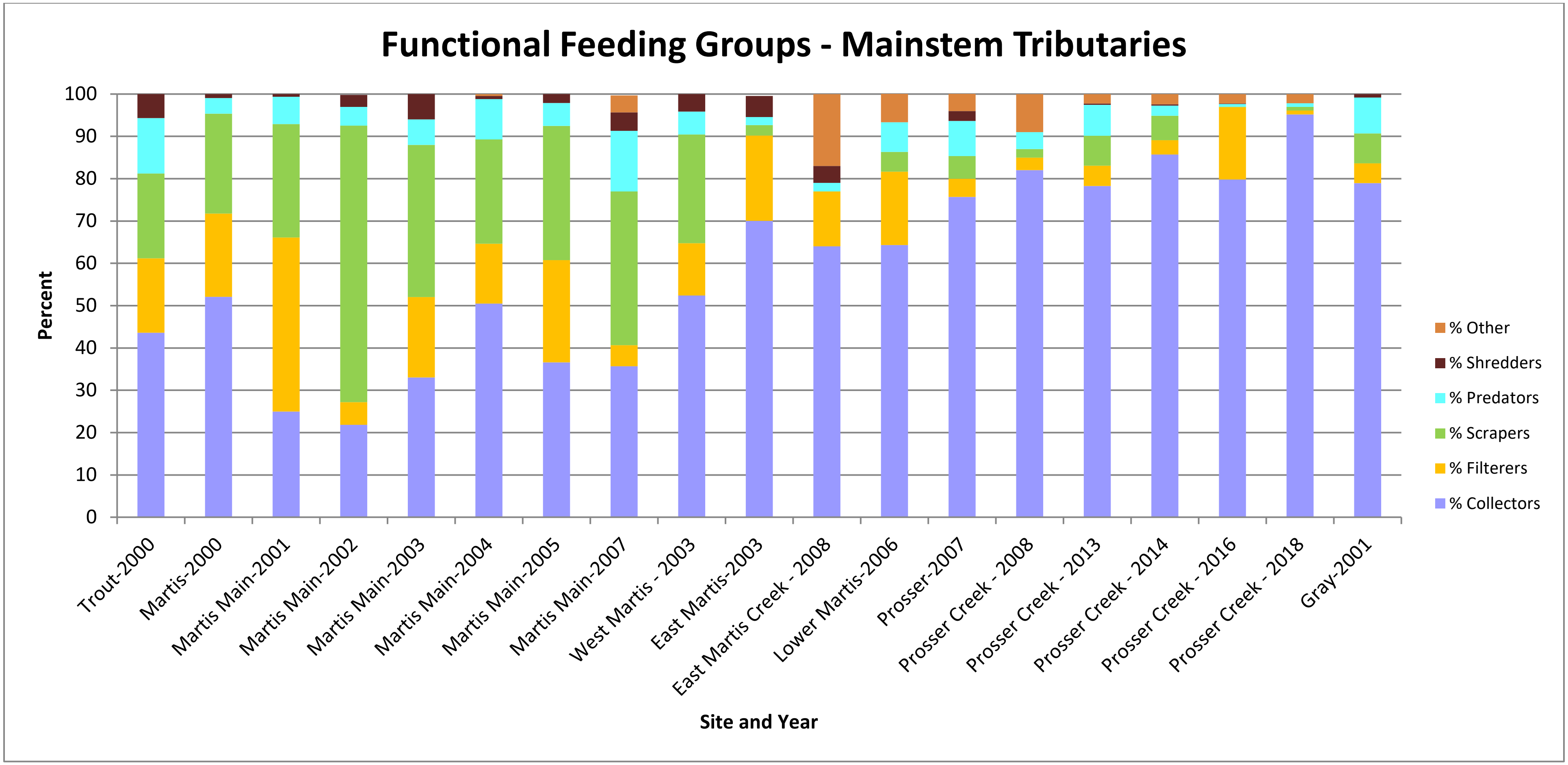


Figure 24b. Functional feeding groups, mainstem tributaries.

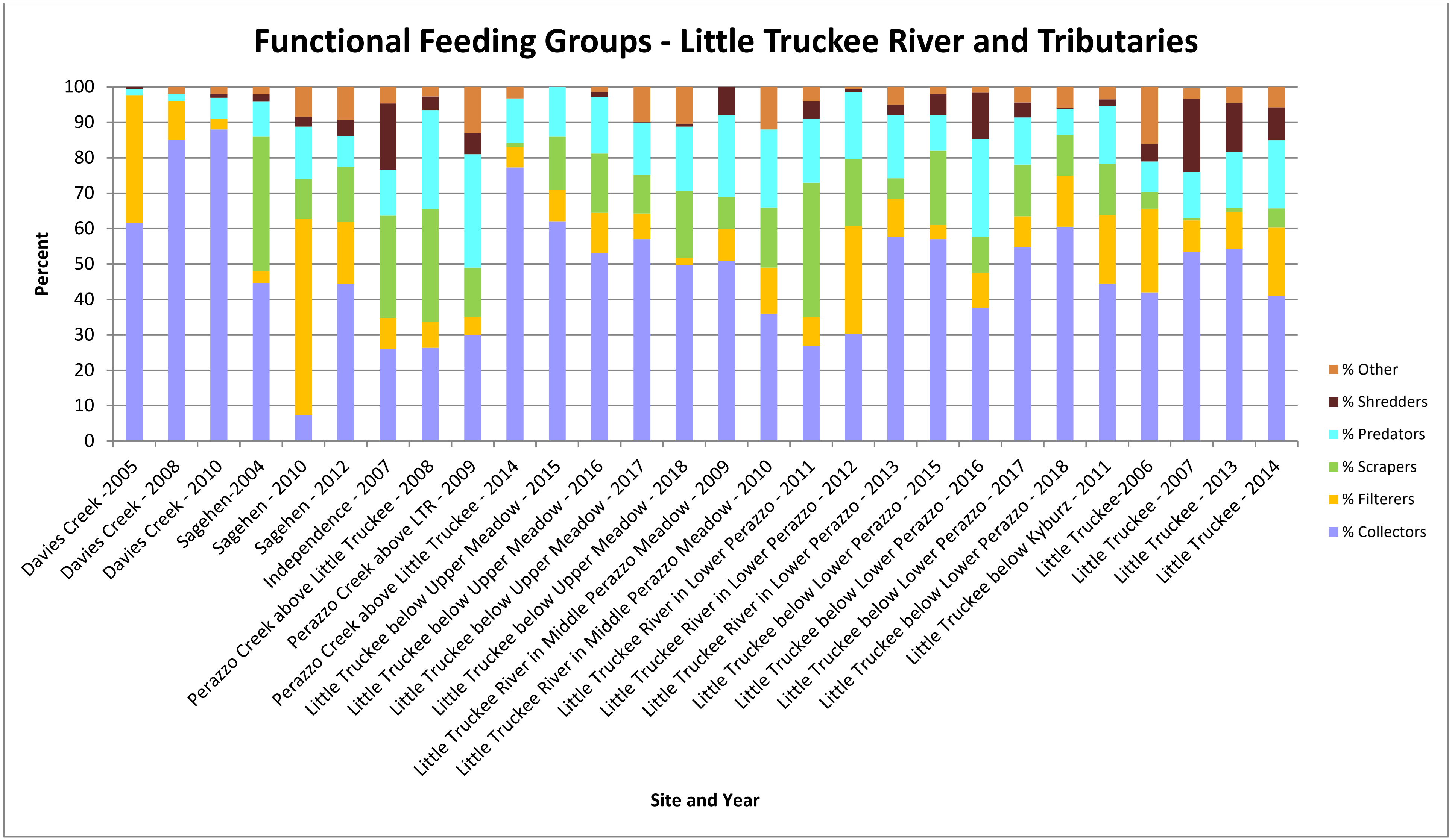


Figure 24c. Functional feeding groups, Little Truckee River tributaries.

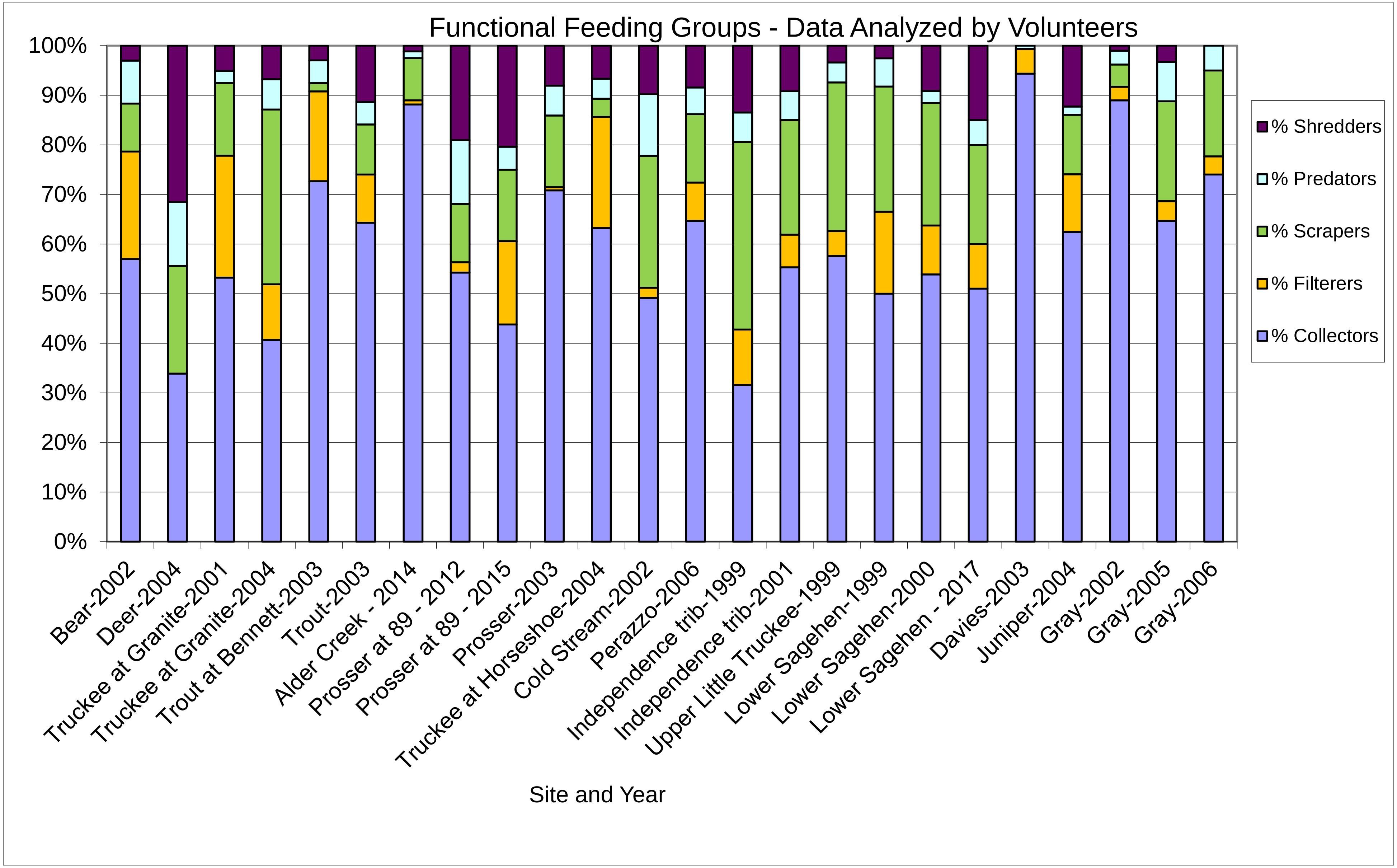


Figure 24d. Functional feeding groups, data analyzed by volunteers.

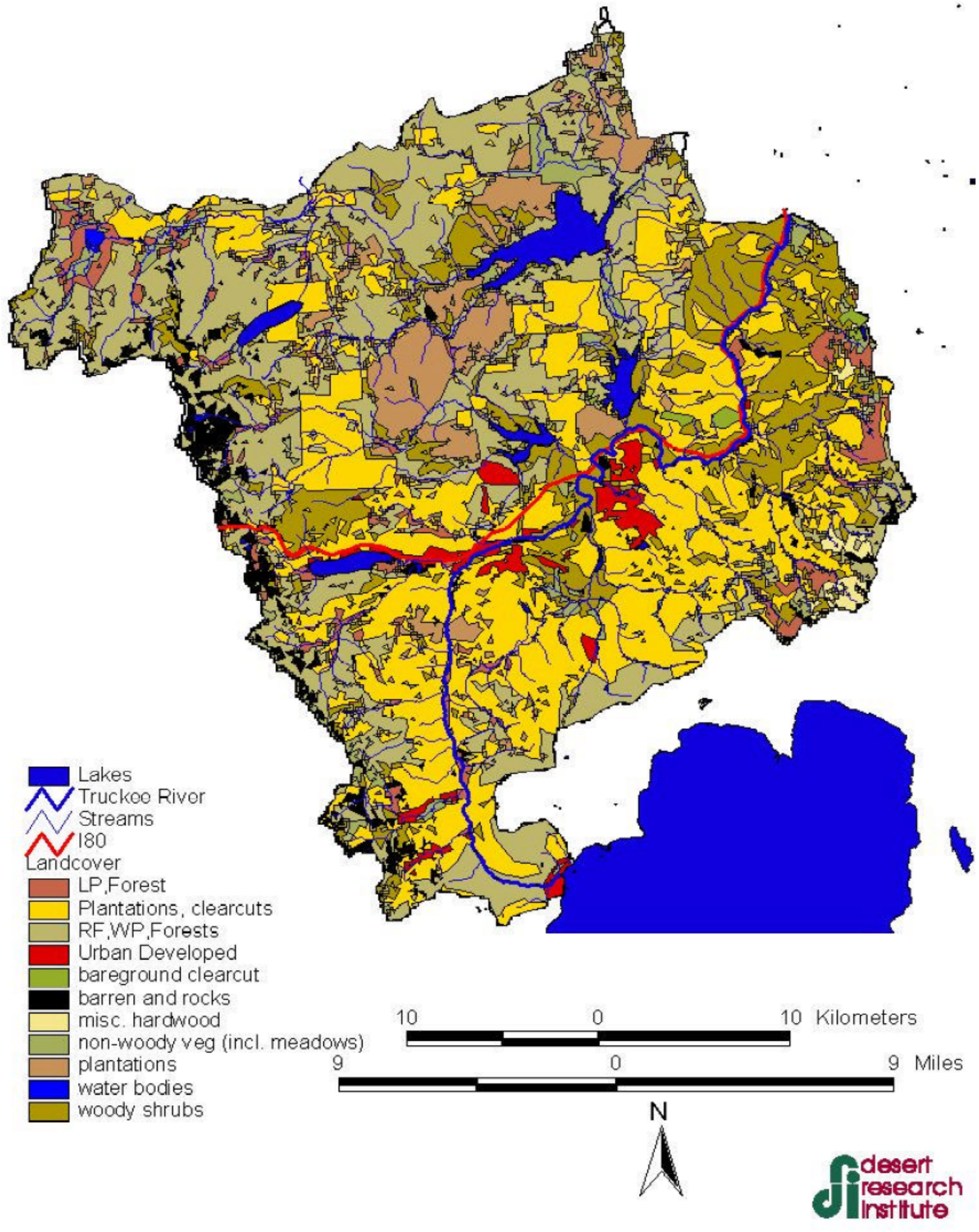


Figure 5. Land cover data layer.

Figure 25. Land cover in the Middle Truckee River watershed. Figure generated by Desert Research Institute, taken from McGraw, et al., 2001.

Temperature, turbidity, and conductivity are all fairly sensitive to flow, so the data have been broken out into high flow and low flow sampling events. Because of the history of our monitoring program, there are more high flow data available than low flow data and low flow data are only available for a subset of monitoring locations.

Figures 26a and b show average water temperature compared between urban and non-urban sites, separated by flow conditions.

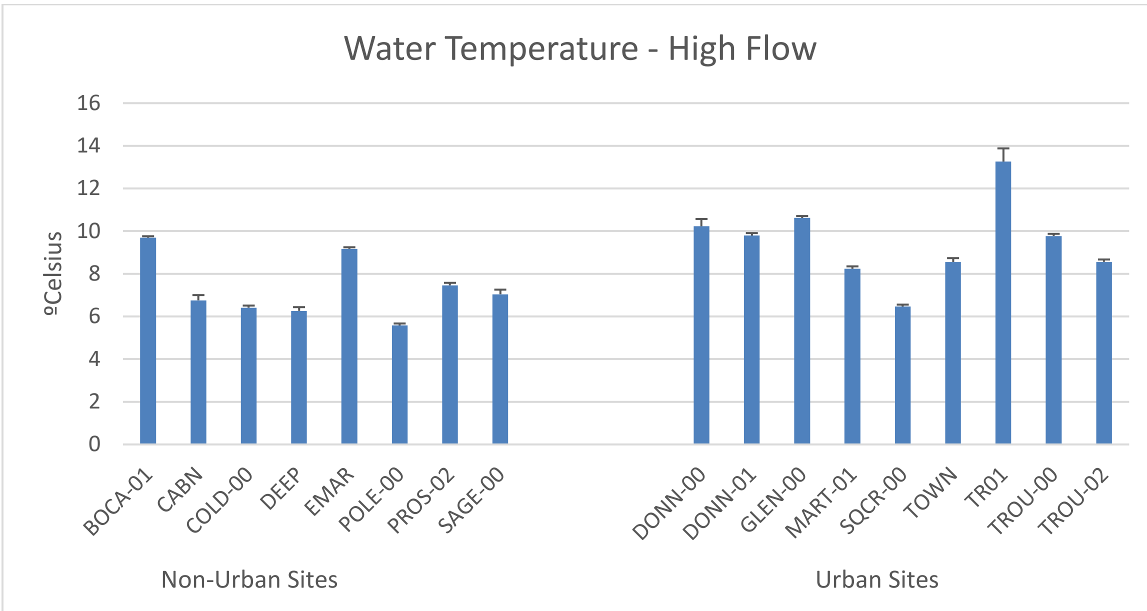


Figure 26a. Average water temperature at urban and non-urban sites, measured during high flow.

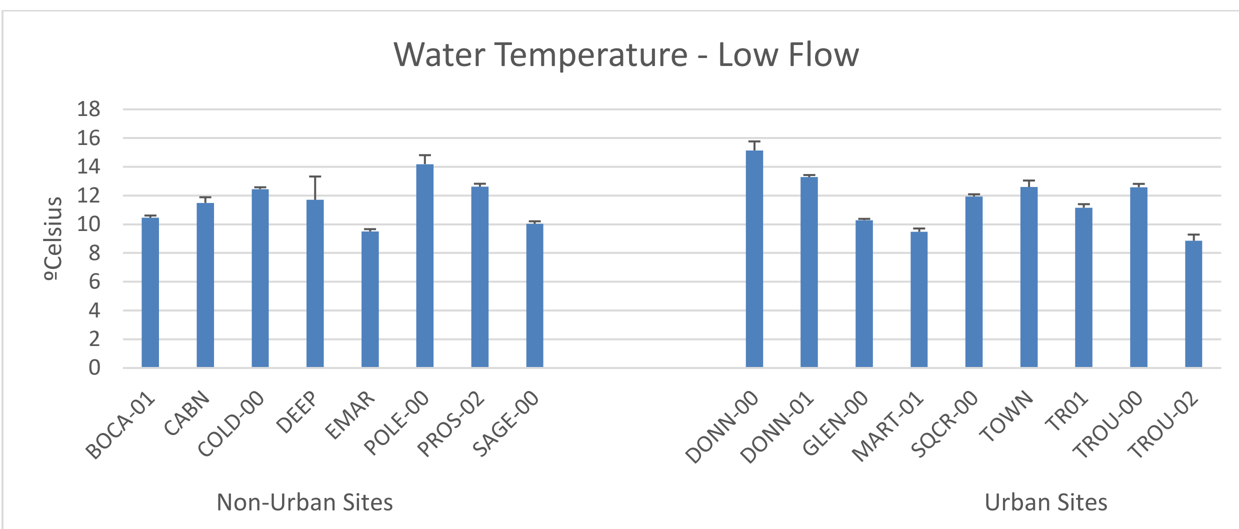


Figure 26b. Average water temperature at urban and non-urban sites, measured during low flow.

Table 8. Average water temperature by site type (non-urban and urban) and flow (high or low). We predicted that water temperature should be higher in urban areas than non-urban.

	Average Water Temperature	
Site Type	High Flow	Low Flow
Non-Urban	7.3	11.6
Urban	9.5	11.7

Water temperature is higher at the urban monitoring locations than at the non-urban locations in high flow conditions. In low flow, the average is the same. The inclusion of several drought years in the data set could factor into overall higher temperatures across all sites especially at low flows. However we still expected that urban sites would have higher temperatures during low flows as well.

Figures 27a and b show electrical conductivity for urban and non-urban sites, separated by flow conditions.

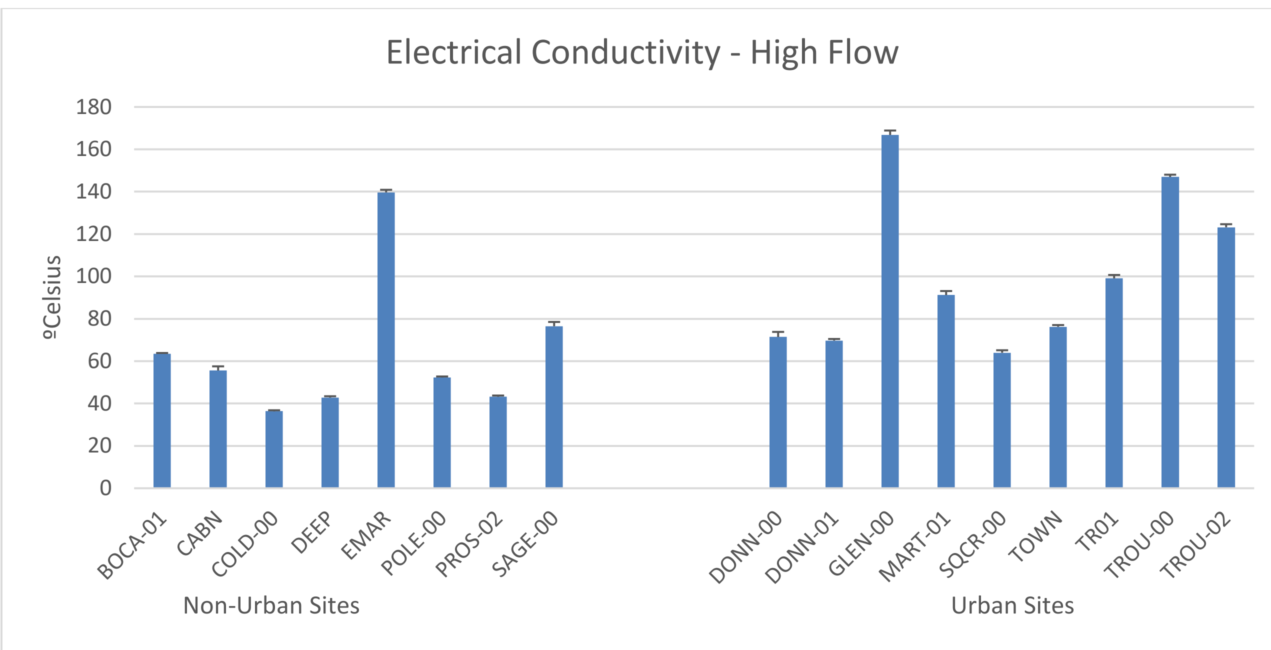


Figure 27a. Average electrical conductivity at urban and non-urban sites, measured during high flow.

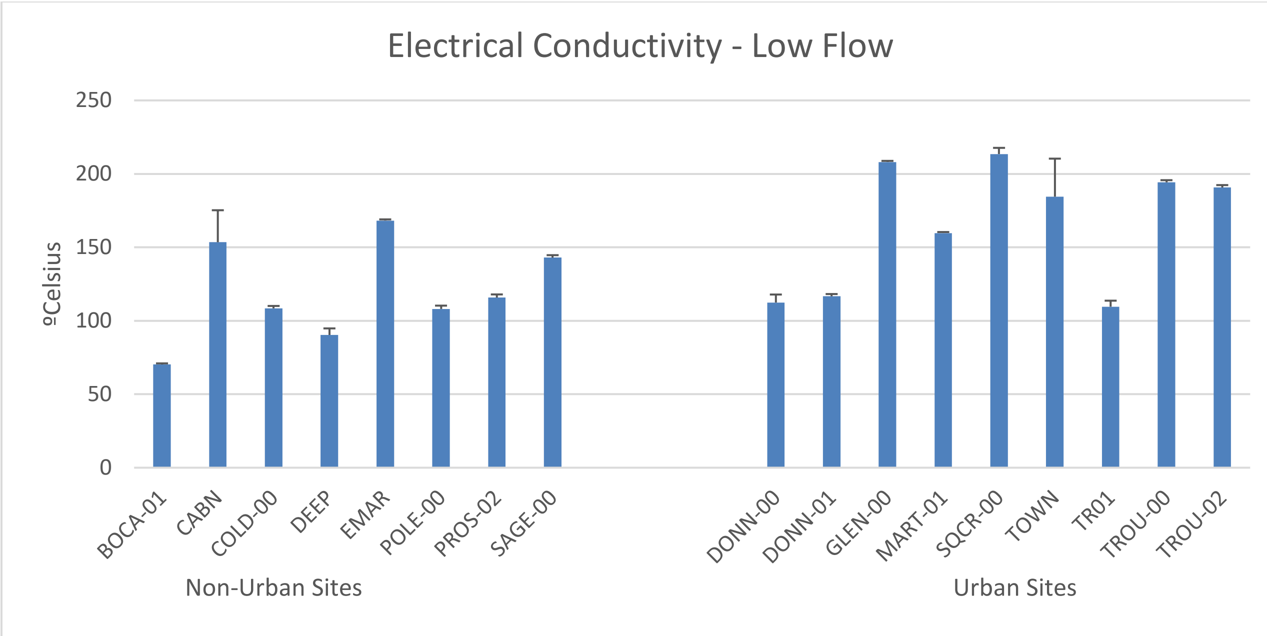


Figure 27b. Average electrical conductivity at urban and non-urban sites, measured during low flow.

Table 9. Average electrical conductivity by site type (non-urban or urban) and flow (high or low flow). Conductivity is higher, on average, at urban sites at both high and low flows.

	Average Conductivity	
Site Type	High Flow	Low Flow
Non-Urban	63.7 μS/cm	119.7 μS/cm
Urban	100.9 μS/cm	165.5 μS/cm

The trend is in the predicted direction – urban sites exhibit higher conductivity in both low and high flow conditions (Table 9). However, there is a lot of overlap and variation between individual sites (Figures 27a, 27b). Many other factors are likely to be influencing conductivity readings besides relative urbanization in the watershed. For example, proximity of the sampling location to a road that is regularly sanded could have a much greater influence, even though the site may be categorized as "non-urban".

Figures 28a and 28b show turbidity separated by urban and non-urban sites, for both high and low flow monitoring events.

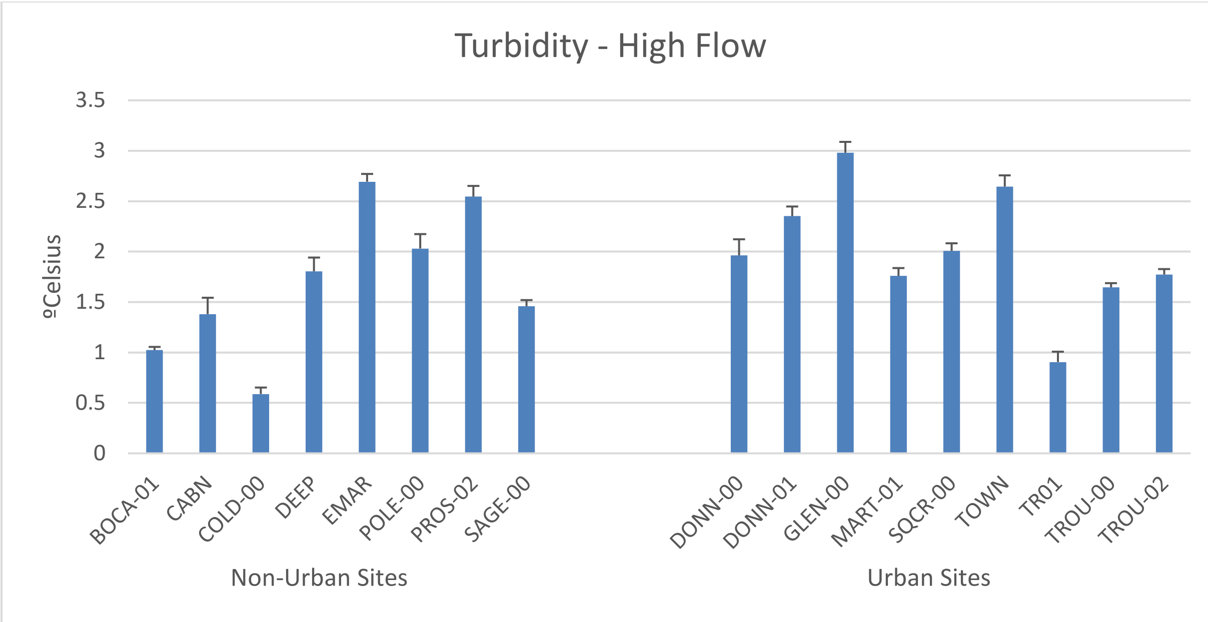


Figure 28a. Average turbidity at urban and non-urban sites, measured during high flow.

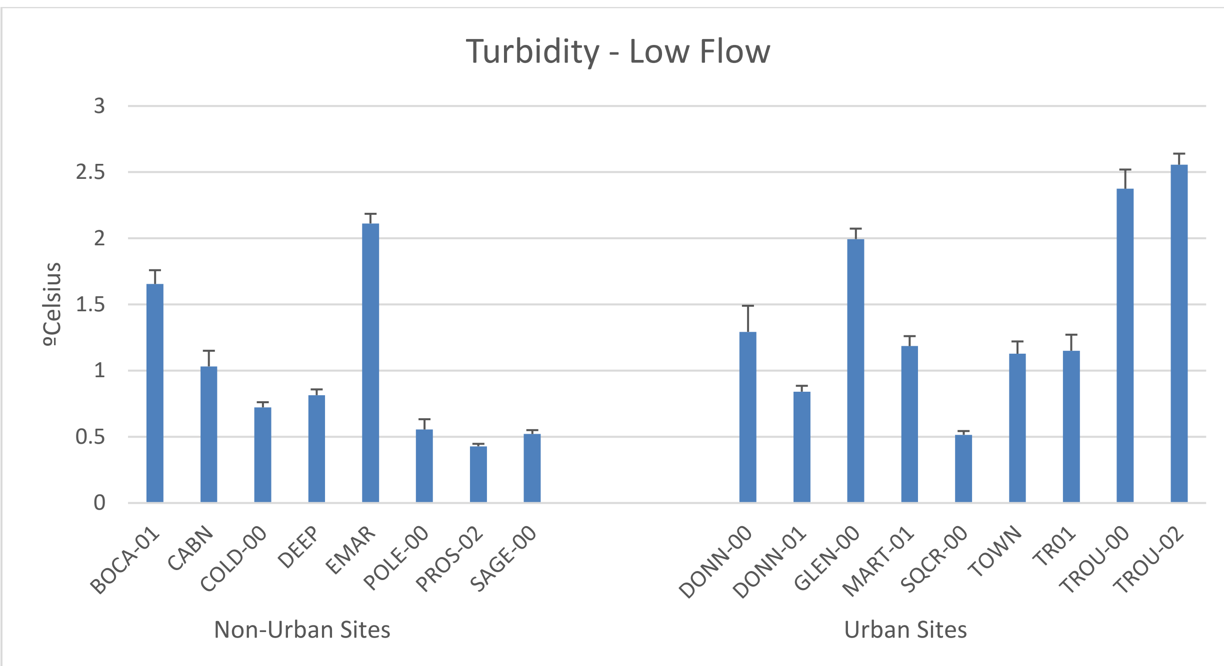


Figure 28b. Average turbidity at urban and non-urban sites, measured during low flow.

Table 10. Average turbidity by site type (non-urban or urban) and flow (high or low flow).

	Average Turbidity	
Site Type	High Flow	Low Flow
Non-Urban	1.69 NTU	0.98 NTU
Urban	2.00 NTU	1.45 NTU

Turbidity is highly variable among our sites (Figures 15a, 15b). However, there is a slight difference between urban and non-urban sites, with urban sites having higher turbidity than non-urban sites.

Goal: To collect data related to the Truckee River Operating Agreement (TROA) – How has TROA changed water quality at sites below dams?

The Truckee River Operating Agreement (TROA) is a plan for river management, which was finally adopted in December of 2015 after approximately 20 years of negotiations and legal challenges. TROA affects dam operations in the Middle Truckee River watershed and one of the goals of TROA is to improve aquatic habitat in the river. However, at present, there is no monitoring program designed to assess current conditions in the Truckee River and tributaries below dams.

To help provide at least some baseline and implementation data, TRWC periodically collects benthic macroinvertebrate data from sites below dams that are affected by TROA. The dams included in TROA are: Lake Tahoe, Donner Lake, Prosser, Independence Lake, Boca, and Stampede. Martis Lake operations are not presently included in TROA.

We are still in the early years of TROA implementation as 2016 was the first year of TROA operations. The first two years of TROA implementation were atypical since 2016 was the final year of a historic drought, which severely limited reservoir operations. 2017 was a historically wet year, which also leads to limitations in reservoir operations. On the other hand 2018 was relatively "normal". Given these conditions, it is premature to make any conclusions about the influences of TROA operations on water quality, however we can make some pre- and post- TROA comparisons. We do know that TROA altered flow patterns in our watershed.

TROA resulted in a change in the way both Stampede Reservoir and Prosser Reservoir were operated, affecting flow in the Little Truckee River and Prosser Creek respectively. Nutrient levels were high in these streams during 2016, particularly in the Little Truckee River. Temperature and dissolved oxygen levels were comparable to previous years, however – two parameters that are strongly influenced by low flows. In 2017, flows were still uneven early in the year at Prosser Creek (Figure 29) despite overall higher flows in the Truckee River watershed. Flows in 2018 were a little more typical during the summer months.

We predicted that biological indicators would be most affected by TROA operations, as benthic macroinvertebrates are sensitive to changes in flow. Other potential impacts such as temporary turbidity spikes associated with releases would be harder to detect with our quarterly monitoring program.

Pre-and Post-TROA Bioassessment Data. One commonly used metric of community composition is the "EPT Index". This metric is simply the percent of the sample composed of insects in the order Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Organisms in these orders tend to be less tolerant of poor water quality than other taxa. Additionally, this metric can be compared using both professionally and volunteer identified data. Community tolerance is also a good metric for looking at the overall biotic condition of the stream. IBI scores are another way to examine bioassessment data to compare pre- and post-TROA conditions.

We have pre- and post-TROA bioassessment data from Prosser Creek. Figure 30 shows the EPT Index and community tolerance values for samples collected prior to TROA implementation and two samples collected after TROA went into effect. Community tolerance is fairly consistent between the two time periods, but the percent of the sample composed of mayflies, stoneflies, and caddisflies is much lower post-TROA.

Figure 31 shows the IBI scores for two samples collected prior to TROA implementation, and two collected after. The IBI scores post-TROA are extremely low, indicating significant impairment.

As discussed above, there are several confounding factors for the initial years of TROA implementation. However, these results indicate a reduction in the biological condition of the stream.

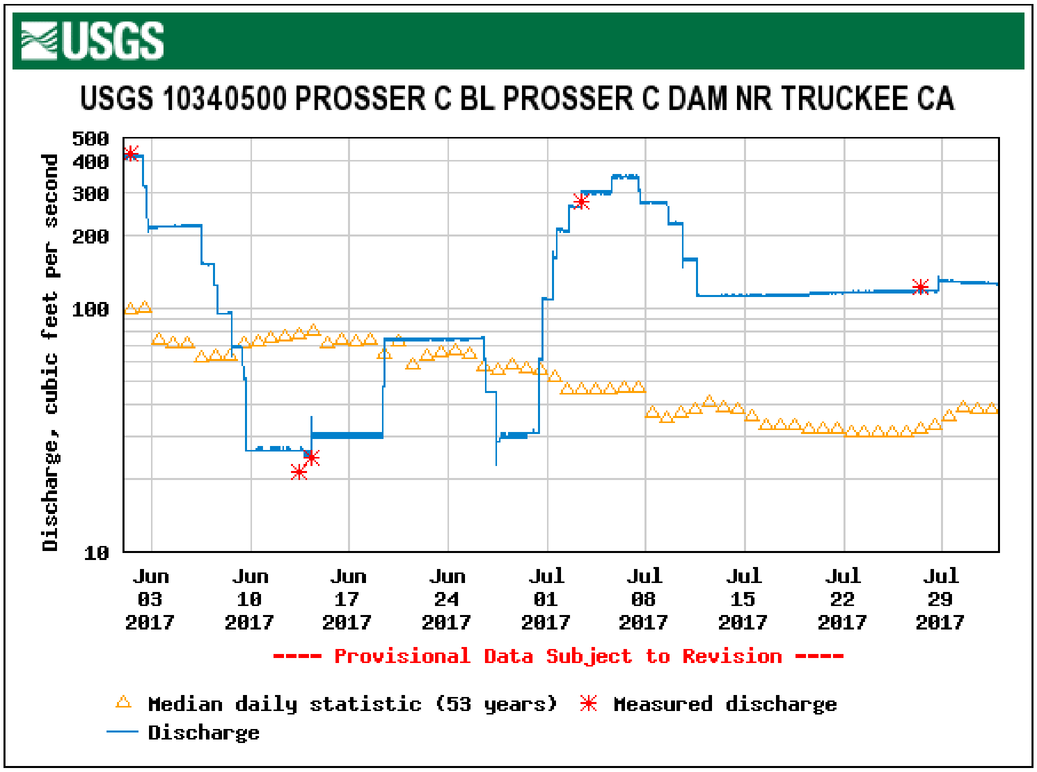


Figure 29. Flow rates in Prosser Creek below the dam, June – July, 2017.

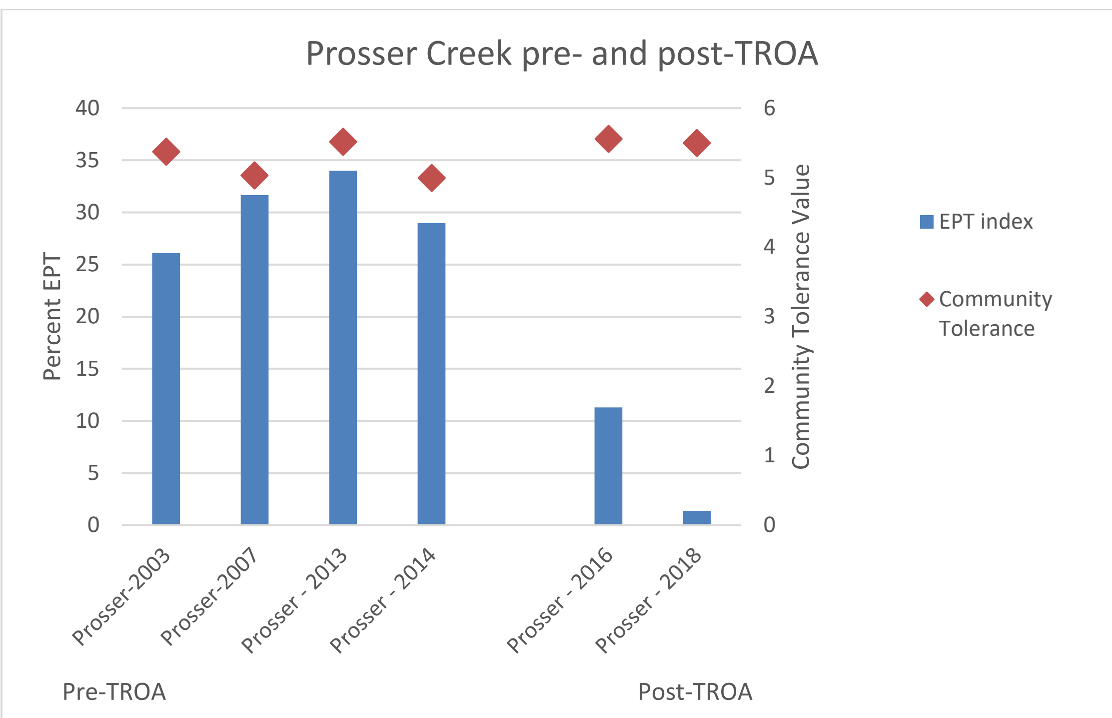


Figure 30. Community composition and tolerance data for Prosser Creek below the dam, pre- and post-TROA.

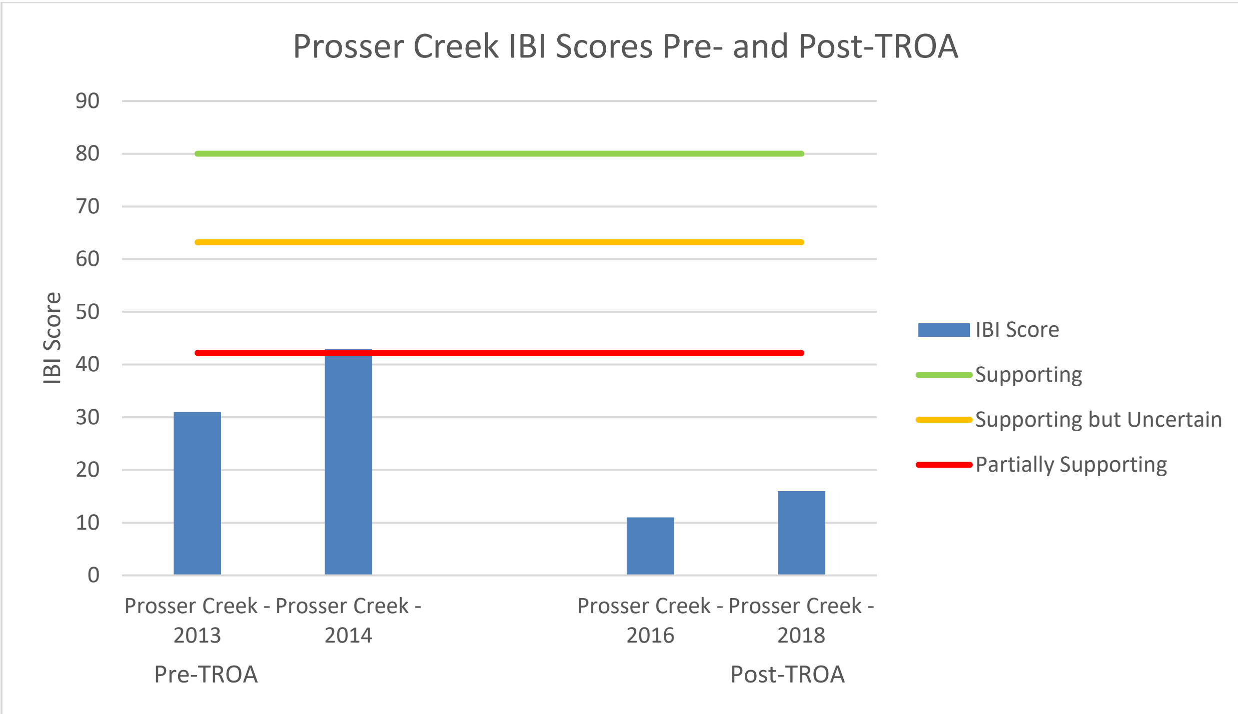


Figure 31. IBI scores for Prosser Creek below the dam, pre- and post-TROA.

Goal: To support the Truckee River sediment TMDL monitoring program – Is there evidence of water quality impairment due to excess sediment?

Our historic data provide a baseline for tracking implementation of the Truckee River Sediment TMDL. The TMDL was adopted in 2008 (Amorfini and Holden, 2008). The best data to use for detecting impairment due to excess sediment is the bioassessment data. Benthic macroinvertebrates integrate impacts from sediment over time, so the stream community paints a more accurate picture than point measurements for on-going impairment.

Although turbidity is a surrogate for suspended sediment concentration, and is more directly relatable to the TMDL standards, turbidity is extremely variable – even over short time periods. Therefore, quarterly single measurements are not an accurate depiction of turbidity over time.

TRWC completed additional (non-volunteer based) monitoring between 2010 and 2014 to support tracking of the TMDL, including establishment of continuous turbidity monitoring stations on two key tributaries (Cold Creek and Trout Creek) and further bioassessment studies, completed by contractors (Balance Hydrologics, 2013, 2014, and 2015; Herbst, 2011; Herbst et al., 2013).

This TMDL-focused monitoring demonstrated that although suspended sediment concentration was meeting standards defined in the Truckee River TMDL, we observed clear biological impacts from excess deposited sediment. Preliminary surveys indicated that deposited sediment may be widespread in certain habitat types along the river. TRWC has had discussions with LRWQCB staff to explore the options of adding a deposited sediment standard to the TMDL.

Reports produced for the TMDL monitoring project are available at: www.truckeeriverwc.org/about/documents.

Goal: To empower citizens to be responsible stewards and decision-makers – What is the level of public engagement in our Adopt a Stream program?

Approximately 120 volunteers participated in at least one monitoring activity in 2018. Twenty-five locations were monitored for ambient or biological data. Education is stressed at monitoring trainings and events and the level of awareness among participants has increased.

Conclusions

Our monitoring program indicates that water quality in the Truckee River watershed often does not meet established objectives, specifically:

- Dissolved oxygen: 29 of 34 sites monitored for dissolved oxygen have recorded concentrations less than 7.0 mg/l which is considered impaired
- Nitrogen and phosphorus: Numeric objectives have been established for five of our monitoring locations. Four of those five locations regularly exceed the standards for forms of nitrogen or phosphorus.

Additionally, biological monitoring indicates that many streams do not fully support beneficial uses – over half of our samples collected exhibit impairment as determined by the Eastern Sierra IBI.

The following streams exhibit degraded water quality across multiple parameters:

- Martis Creek above Martis Lake (MART-00);
- Union Valley Creek at Truckee River (GLEN-00);
- Trout Creek at mouth (TROU-00);
- Squaw Creek at mouth (SQCR-00);
- Donner Creek below dam (DONN-03); and
- Prosser Creek below dam (PROS-01).

Several sites continue to express fairly good water quality such as Sagehen Creek at Highway 89 (SAGE-00), Pole Creek (POLE-00), and Cold Creek (COLD-00). Protecting high value streams provides refugia for invertebrates and life stages of fish that are sensitive to pollution. The only means we have of assessing whether water quality is preserved at these sites in our watershed is the TRWC monitoring program. No other entities are regularly monitoring these streams.

There is a slight signal of elevated temperature, electrical conductivity, and turbidity at monitoring locations in urbanized areas as compared to non-urbanized areas.

Our program is providing important baseline data to track TROA implementation. We saw substantial changes in reservoir operations during the first year of TROA (2016) and we will continue to collect water quality data at sites most affected by TROA. We continue to provide the data to the State of California to improve their efforts to protect water quality under TROA.

Volunteer engagement continued to be strong in 2018 and we continued to support expanded volunteer nutrient monitoring.

Next Steps

Nutrient monitoring appears to be the biggest gap in our watershed. Besides our limited monitoring program, periodic monitoring occurs through the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). Our data indicate that regular monitoring seems to be important, and that recording all forms of nitrogen is particularly important. SWAMP data follows a similar pattern to ours – nitrate levels are relatively low, but TKN was relatively high in approximately a third of the SWAMP samples collected since 2000 (www.ceden.org). Phosphorus levels recorded by SWAMP were somewhat high as well – although they have collected limited samples from locations with established numeric phosphorus (or nitrogen) standards.

Every three years, the Lahontan Regional Water Quality Control Board completes a "Triennial Review" that identifies high priority planning projects to be addressed over the next three years. The most recent review occurred in 2018. TRWC met with LRWQCB staff to ensure that the "Truckee River Embedded/Deposited Objective" project remained as a high priority on the project list. Specifically working with TRWC to develop a strategy for additional data collection and analysis was called out as a next step to be accomplished in 2019.

The implementation of the Truckee River Operating Agreement in 2016 brought new concerns to our watershed regarding water quality, but TROA also provides significant opportunity for improvements. TRWC will increase our efforts around monitoring water quality in relationship to flows affected by TROA.

In general, trying to better understand the sources of water quality impairment would be an important next step for our program. Based on our knowledge of the watershed, we can infer why certain sites exhibit water quality impairment. However, we have not tested any specific hypotheses to determine causes of impairment, which would then allow us to devise solutions to correct the problems. Detailed source analyses are complex, but in areas of continued water quality problems, we may need to consider taking on this challenge.

References

2nd Nature, 2008. Truckee River Water Quality Monitoring Plan. Prepared for Placer County and the Town of Truckee. http://www.placer.ca.gov/Departments/Works/StrmWtr/StmWtrMonitoring.aspx

Amorfini, B. and A. Holden. 2008. Staff Report, Total Maximum Daily Load for Sediment, Middle Truckee River Watershed, Placer, Nevada and Sierra Counties. May, 2008. California Regional Water Quality Control Board, Lahontan Region.

Balance Hydrologics, Inc. 2012. Middle Truckee River Total Maximum Daily Load (TMDL) Suspended Sediment Monitoring Report, Water Year 2012. Nevada County, CA. https://www.truckeeriverwc.org/about/documents

Balance Hydrologics, Inc. 2013. Middle Truckee River Total Maximum Daily Load (TMDL) Suspended Sediment Monitoring Report, Water Year 2013. Nevada County, CA. https://www.truckeeriverwc.org/about/documents

Balance Hydrologics, Inc. 2014. Middle Truckee River Total Maximum Daily Load (TMDL) Suspended Sediment Monitoring Report, Water Year 2014. Nevada County, CA. https://www.truckeeriverwc.org/about/documents

CDM Smith, 2017. Town of Truckee/County of Placer Final Joint Monitoring Report for: Implementation of the Truckee River Water Quality Monitoring Plan, Water Year 2016. Prepared for Placer County and Town of Truckee.

Harrington, J. and M. Born. 1999. Measuring the Health of California Streams and Rivers. 2nd Edition. Sustainable land Stewardship International institute.

Herbst, D. 2011. Use of Benthic Invertebrate Biological Indicators in Evaluating Sediment Deposition Impairment on the Middle Truckee River, California. Sierra Nevada Aquatic Research Laboratory, University of California. https://www.truckeeriverwc.org/about/documents

Herbst, D. and E. Silldorff, 2009. Development of a Benthic Macroinvertebrate Index of Biological Integrity (IBI) for Stream Assessments in the Eastern Sierra Nevada of California. California State Water Resources Control Board Surface Water Ambient Monitoring Program.

Herbst, D., B. Medhurst, and I. Bell, 2013. Benthic Macroinvertebrate Responses to Sediment Deposition as Criteria for Evaluating and Monitoring the Extent of Habitat Degradation on the Middle Truckee River, California. Sierra Nevada Aquatic Research Laboratory, University of California. https://www.truckeeriverwc.org/about/documents

Lahontan Regional Water Quality Control Board, 2015. Water Quality Control Plan for the Lahontan Region (Basin Plan). http://www.waterboards.ca.gov/lahontan/water_issues/programs/basin_plan/references.shtml

McGraw, D., A. McKay, G. Duan, T. Bullard, T. Minor, and J. Kuchnicki, 2001. Water quality assessment and modeling of the California portion of the Truckee River basin, Publication No. 41170, prepared for: Town of Truckee and Lahontan Regional Water Quality Control Board, Desert Research Institute, University of Nevada, 167 p.

Northwest Hydraulic Consultants, 2006. Gray Creek Watershed Assessment and Restoration Plan. Prepared for Truckee River Watershed Council.

Ode, P.R.. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

Richards, A. B., and D. C. Rogers, 2011. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels. http://www.safit.org/Docs/STE_1_March_2011_7MB.pdf