Stormwater Grab Sampling of Truckee River Outfalls and Tributaries within the Truckee Meadows

Alan McKay
Alan Heyvaert
Brian Fitzgerald
Jeramie Memmott
Mary Miller

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Prepared by
Division of Hydrologic Sciences, Desert Research Institute, Reno, NV

Prepared for
Storwmater Permit Coordinating Committee, Cities of Reno and Sparks, and Washoe County

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ABSTRACT

Stormwater runoff within the Truckee Meadows is discharged by outfalls and tributaries to the Truckee River. The cities of Reno, Sparks and Washoe County jointly regulate the discharge of municipal storm water runoff within the Truckee Meadows through the Truckee River Storm Water Management Program (SWMP). Outfall and tributary discharges and associated contaminant loads to the Truckee River are managed by the SWMP. Specifically, the SWMP has been charged with addressing the terms of the National Pollutant Discharge Elimination System (NPDES) discharge permit, issued by the Nevada Division of Environmental Protection (NDEP). The historical record of study on these inputs has been irregular, given changes in funding levels, and there is pressing need to compile results from previous efforts in hopes of developing a comprehensive record of available water quality data on inputs to the Truckee River.

This pilot project was designed to assess the status of storm water discharges to the Truckee River through a systematic grab sampling program. Twelve tributary monitoring stations and ten outfall monitoring stations were investigated for a variety of water quality parameters. Results are compiled in this report, in addition to a compilation of historical sampling along many of the same sites. These findings are an important first step towards satisfying NPDES requirements, and building a long-term storm water monitoring program.

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ACRONYMS

BMP	Best management practices
CC	Chalk Creek
CWW	Clean Water Way
DO	Dissolved Oxygen
DRI	Desert Research Institute
EC	Specific conductivity
E. coli	Escherichia coli
NDEP	Nevada Division of Environmental Protection
NO_3-N	Nitrate
NTD	North Truckee Drain
NTD@Orr	North Truckee Drain at Orr
NTD@Kleppe	North Truckee Drain at Kleppe
OR	Orr Ditch
PO_4-P	Orthophosphate
RR	Rhodes Road
SAP	Stormwater Analysis Plan
SBC	Steamboat Creek
SOW	Scope of Work
SWMP	Storm Water Monitoring Plan
SWPCC	Stormwater Permit Coordinating Committee
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMWRF	Truckee Meadows Water Reclamation Facility
TN	Total Nitrogen
TP	Total Phosphorus
TRIG	Truckee River Information Gateway (truckeeriverinfo.org)
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency

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INTRODUCTION

Storm water runoff within the Truckee Meadows is discharged by outfalls and tributaries to the Truckee River. These inputs are managed by the cities of Reno and Sparks (Cities) and Washoe County (County), who together form the Truckee Meadows Stormwater Permit Coordinating Committee (SWPCC). The Cities and County jointly manage discharge of municipal storm water runoff within the Truckee Meadows. Storm water sampling activities help assess the impacts of storm water discharge on water quality as required by the Nevada Division of Environmental Protection (NDEP) under the auspices of the Clean Water Act and the U.S. Environmental Protection Agency (USEPA), by way of the National Pollution Discharge Elimination System (NPDES). NDEP issues a discharge permit to the three governmental entities: Reno, Sparks, and Washoe County (co-permittees). The Permit allows the municipalities to discharge storm water runoff, and also requires them to develop, administer, implement and enforce a Storm Water Monitoring Plan (SWMP). Section V.A of the Permit outlines the requirements for storm water monitoring. No specific sampling locations or collection frequencies are specified in the Permit. Section V.A.1 requires the permitees to submit a Stormwater Analysis Plan (SAP) to NDEP each year, on or before October 1. "Monitoring" is defined as the regular observation, recording of events and activities and is not exclusively sample collection for water quality determinations. Numerous monitoring activities carried out by the co-permittees are described in the SWMP document.

Recently, Stantec Incorporated developed a Storm Water Monitoring and Sample Analysis Plan (SAP, December, 2012) that defines current practices in storm water management in the Truckee Meadows and proposes new sampling efforts to better quantify inputs to selected tributaries to the Truckee River. The SAP defines the activities and goals necessary for a successful storm water sampling program. At the request of the SWPCC, the Desert Research Institute (DRI) developed a scope of work (SOW) that follows the outline of that SAP document. This pilot project was designed with four overarching goals (from DRI's SOW):

1) Implement three different Truckee River Inlet grab sampling regimes to better quantify input of constituents;

2) Each of the three sampling efforts will occur twice (two tributary dry events; two tributary wet events; and two storm outfall wet events);

3) Interpret the results of nutrient and solids analyses and report the data collected and initial operating methods developed in this pilot study. The results should contribute to the design of a regular Truckee River tributary and storm water outfall sampling scheme and provide needed information to managers and scientists; and

4) Assess historical data in the context of the current analyses.

Previous to this pilot project, there were only two sampling activities of inputs being performed: a scheduled quarterly tributary monitoring, and unscheduled storm event sampling of a single, yearly-changing tributary. The former, scheduled monitoring was also referred to as

"dry weather sampling", in that it occurs not in response to specific weather events, but during periods in which little, to any precipitation has occurred. Conversely, the latter, storm-based sampling was known as "wet weather" sampling in that it takes place specifically during, and in response to, precipitation events. There is a need to continue the long-term storm water sampling record, and to expand that record to give more comprehensive and decision-relevant view of inputs to the Truckee River.

Relationship between Pilot Program and Previous Monitoring Projects

As noted above, and described in the 2012 SAP document, there are two different sampling activities presently being performed by the SWPCC: 1) scheduled quarterly tributary monitoring; and 2) unscheduled storm event sampling of a single tributary. Tributary grab sampling has been ongoing quarterly for 12 fixed sites on six tributaries of the Truckee River. The six tributaries are: Steamboat Creek, Whites Creek, Thomas Creek, Alum Creek, Chalk Creek, and the North Truckee Drain. In general, monitoring locations are located upstream and downstream of urban development for each tributary. Chalk Creek contains a single sampling site in the middle reach (perennial discharge region). Samples are not collected in the upper reaches of Chalk Creek due to intermittent, ephemeral stream discharge. Prior to 2010, monitoring included the same tributaries and sites with the exception of Alum Creek, Chalk Creek and Steamboat Creek at the Narrows. The goal of these efforts has been to establish a preliminary spatial understanding of potential sources and characteristics of nonpoint-source pollution entering waterways from urbanized areas, by bracketing development between sample locations. These sites were selected on the basis of existing data, the need for additional data, representativeness of the entire watershed, and proximity to existing stream discharge gage equipment.

Each year, one of the six tributaries is selected for storm event sampling. The selected tributary is sampled for one full year during storm events, with a minimum of two sampling events representing one wet season storm and one dry season storm, if possible. The tributary selected for storm water sampling events is identified each year in the Annual Report. These storm event samples have been collected using automatic samplers.

For this project, tributary and storm event monitoring consists of both field and laboratory measurements. In the field, dissolved oxygen (DO), pH, specific conductance, water temperature and discharge (when possible), were measured and recorded. Grab (tributary) or composite (storm event) water samples were collected and analyzed for total dissolved solids (TDS), total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) (individual analyses of nitrate, nitrite and total Kjeldahl nitrogen (TKN), reported as total nitrogen) at the DRI Water Analysis Laboratory in Reno. Figure 1 is a location map for all tributaries and outfalls sampled for this pilot project. Table 1 provides locational data and site ID's for each sampling station.

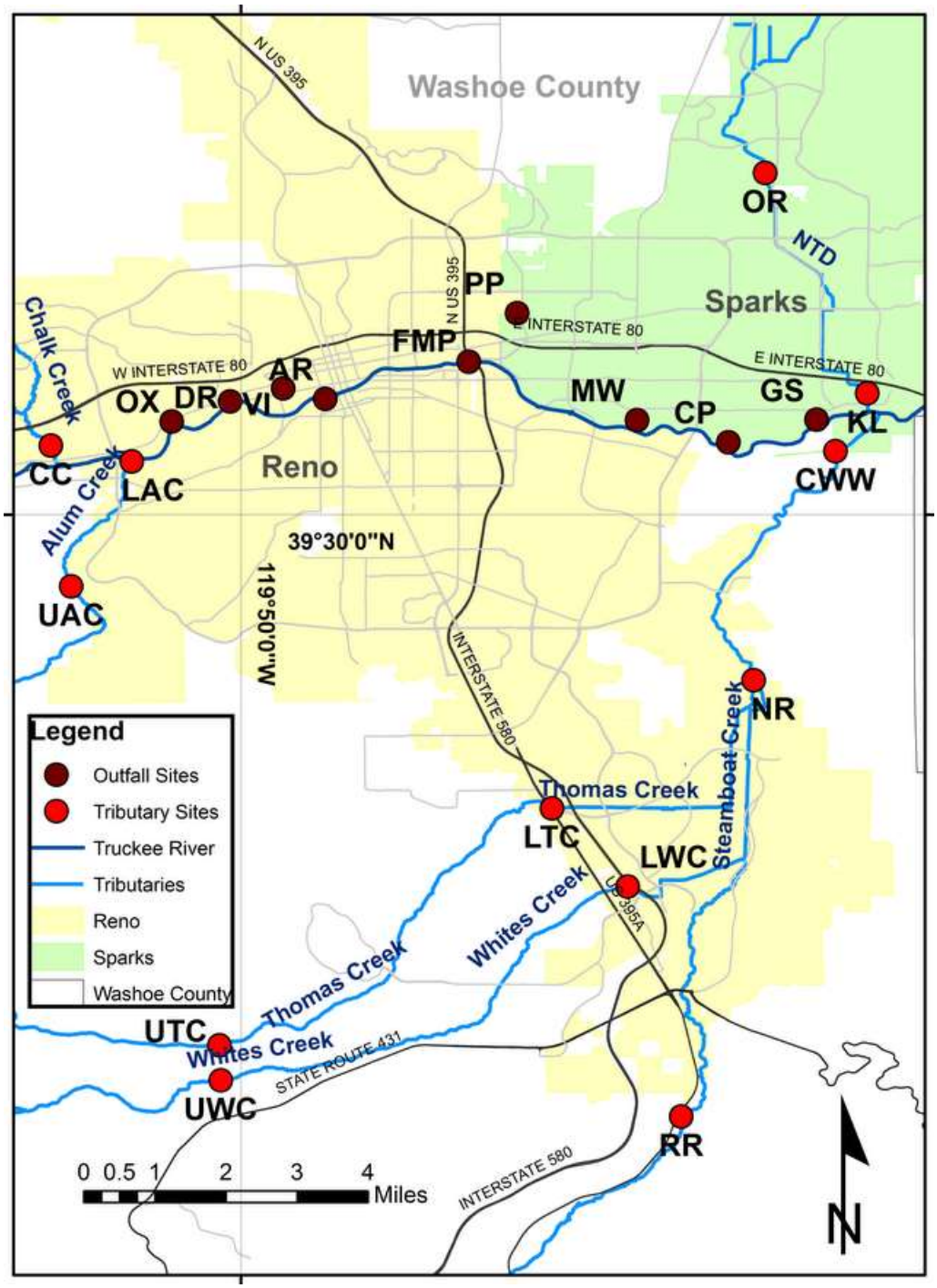

Figure 1. Sampling location map for the 2013 pilot study.

Table 1. Site ID's and Locational Data to Accompany Figure 1.

Sampling Site	ID	Latitude (degrees)	Longitude (degrees)
Oxbow	OX	39.518994	-119.847431
Dickerson Rd	DR	39.523108	-119.835522
Vine	Vine	39.525742	-119.824744
Arlington Island	AR	39.523594	-119.816156
Fisherman's Park	FMP	39.531181	-119.786922
Teglia	PP	39.541092	-119.777078
Mary Wahl	MW	39.519264	-119.752661
Cottonwood Park	CP	39.514747	-119.73405
Greg St	GS	39.519356	-119.71615
Chalk	CC	39.514096	-119.872013
Upper Alum	UAC	39.485393	-119.867887
Lower Alum	LAC	39.510858	-119.855553
Upper Thomas	UTC	39.391857	-119.837705
Upper Whites	UWC	39.384699	-119.837421
Lower Thomas	LTC	39.440159	-119.770018
Lower Whites	LWC	39.424185	-119.754588
Steamboat @ Rhodes	RR	39.377302	-119.743696
Steamboat @ Narrows	NR	39.466247	-119.728937
Steamboat @ Clean Water Way	CWW	39.512942	-119.712271
NTD @ Orr	OR	39.569699	-119.726608
NTD @ Kleppe	KL	39.524749	-119.705808

In addition to these storm water programs, both the Truckee Meadows Water Reclamation Facility (TMWRF) and DRI have conducted extensive monitoring programs on the Truckee River and selected tributaries. TMWRF's monitoring efforts have consisted of: 1) monthly grab samples at nine sites; 2) quarterly sampling of benthic macroinvertebrates at four sites; and, 3) continuous (hourly) monitoring, using water quality sondes, at two sites (DRI, 2011). The TMWRF program was largely driven by NPDES discharge permit requirements and is available on TRIG (www.truckeeriverinfo.org). Since the late 1960's, DRI's program has consisted of baseline water quality monitoring in the Truckee River basin (DRI, 2011). Up until the late 1980's, the program consisted of over 30 sites on the main-stem and tributaries. In 2010 the collection program consisted of sample collection at six sites in California and three in Nevada. The primary objective of DRI's existing monitoring program was to provide ambient water quality data to several stakeholders in the Truckee River Basin (DRI, 2010). A compilation of historical water quality data is shown in Table 2.

Specific Objectives

At present, there is a need to incorporate the historical record of stormwater sampling into the design of future sampling. Likewise, the goal of improved water quality inputs to the Truckee River needs to be correlated to the past sampling record. Sampling for this pilot project seeks to bridge current monitoring activities with a more comprehensive SWMP. Our objectives for this grab-sampling pilot project were (from the DRI SOW):

- Dry weather sampling of 10-12 tributaries, twice. There is a need for background measurements of tributary inputs. The "dry" season in northern Nevada can consist of up to 10 months of the year, depending on the weather and the size of a particular watershed.
- Wet weather sampling of 10-12 tributaries, twice. Primarily a spring runoff issue, peak discharge can deliver significantly more contaminants to the Truckee River. The same locations will be sampled in "wet" weather as in "dry" weather. The information gathered will be useful for estimating yearly storm water inputs.
- Wet weather sampling of 12 storm drain outfalls, twice. Similar sampling to the wet weather tributary sampling, this will occur on an opportunistic basis. Two precipitation events will be extensively sampled for elevated discharge regimes.
- Laboratory analysis of grab samples. Samples were analyzed by the Water Laboratory at the Desert Research Institute. Constituents to be analyzed are described in detail below, including nutrients and solids.
- Data Analysis and Interpretation. The interpretation of laboratory analyses and evaluation of sampling methods will be essential to developing a long-term working SWMP. This task was to evaluate the methods and results of this pilot project and historical data.

Table 2. Compilation of Historical Data.

Tributaries					
Site Name	**1982-1983**	**1993-2011**	**2005-2008**	**2003-2012**	**2013 Pilot Study**
Chalk Creek			2007-2010, real-time WQS data	quarterly grab sampling	wet & dry event grab sampling
Upper Alum				quarterly grab sampling	wet & dry event grab sampling
Lower Alum				quarterly grab sampling	wet & dry event grab sampling
NTD @Kleppe		TRIG		quarterly grab sampling	wet & dry event grab sampling
NTD @ Orr				quarterly grab sampling	wet & dry event grab sampling
Upper Whites				quarterly grab sampling	wet & dry event grab sampling
Lower Whites			2005-2008, grab sampling	quarterly grab sampling	wet & dry event grab sampling
Upper Thomas	WQ & metals analyses			quarterly grab sampling	wet & dry event grab sampling
Lower Thomas	WQ & metals analyses		2005-2008, grab sampling	quarterly grab sampling	wet & dry event grab sampling
Rhodes	WQ & metals analyses			quarterly grab sampling	wet & dry event grab sampling
Narrows	WQ & metals analyses			quarterly grab sampling	wet & dry event grab sampling
Clean Water	WQ & metals analyses	TRIG		quarterly grab sampling	wet & dry event grab sampling
Outfalls					
Site Name	**1982-1983**	**1993-2011**	**2005-2008**	**2011-2012**	**2013 Pilot Study**
Lower Alum	n/a	n/a	n/a	n/a	wet & dry event grab sampling
Oxbow	n/a	n/a	n/a	n/a	wet event grab sampling
Vine	n/a	n/a	n/a	n/a	wet event grab sampling
Arlington	n/a	n/a	n/a	n/a	wet event grab sampling
Fisherman's	n/a	n/a	n/a	n/a	wet event grab sampling
Mary Wahl	n/a	n/a	n/a	n/a	wet event grab sampling
Cottonwood	n/a	n/a	n/a	n/a	wet event grab sampling
Greg	n/a	n/a	n/a	n/a	wet event grab sampling
Teglia	n/a	n/a	n/a	n/a	wet event grab sampling
Dickerson	n/a	n/a	n/a	n/a	wet event grab sampling

APPROACH, METHODOLOGY, AND GEOGRAPHIC LOCATION

This monitoring effort was similar to the tributary monitoring effort described in the 2012 SAP document. The SWPCC recommended continuing the existing tributary monitoring effort by collecting upstream and downstream samples on five major tributaries plus Chalk Creek, but modifying the sampling frequency and analytical parameters, while adding storm event grab sampling. The Tributary Monitoring program has two components:

- Semi-annual tributary sample collection (scheduled, dry weather)
- Storm event grab sample collection (wet weather)

Sampling of tributaries and storm water outfalls were conducted using grab sampling techniques. Each sampling station was visited for sample collection, as precipitation and resultant creek runoff dictated. Both components involved grab sample collection at the same 12 sampling locations, but at different times. The semi-annual background tributary sample collection was scheduled, while the rain event grab sample collection was event dependent.

The magnitude of baseflow regime inputs can be substantial, on a relative loading scale, if the spring runoff season is small in a particular water year. Sampling during the low-flow period of late summer and early fall should be a goal of "dry" weather sampling. Often, increased discharge due to storm events in the spring, i.e., "wet" weather, may result in elevated suspended solids (it should be noted, however, that dilutional effects may have the opposite impact.) It is important to quantify the level of nutrient and suspended solids concentration in these peak discharge regimes. Best management practices (BMP) are designed to mitigate the maximum load delivery of these nutrients and sediment to the river. The effectiveness of specific BMPs has not yet been rigorously tested in the Truckee Meadows.

Sample analytes were: nitrate, nitrite, total P, ortho-P, total N, total suspended solids (TSS), total dissolved solids (TDS), E. coli (Table 3), and field water quality measurements (Tables 4 & 6). Where possible and safe, stream discharge rates at the time of sample collection were measured or recorded. Several of the tributaries have stream discharge gages in the vicinity. Chalk Creek has a weir at its sampling location. The sampling sites without level-gaging installations required manual discharge rate measurements using a portable velocity meter (Marsh McBirney-Hach Company, Loveland, CO). Tributary sampling locations and discharge obtainment methods are summarized in Table 5. During short-lived high discharge runoff events it can be difficult to assess as many as 24 stations at or near peak discharge. Priority was given to those stations without a gage.

Table 3. Analytical Methods for Samples collected for the Truckee Meadows Regional Water Quality Management Program. Methods Summary for Accredited Testing. See references for source.

Analyte	Method	Description	MDL	Reporting Limit
Ortho-Phosphate*	SM 4500-P F	Colorimeric, Automated, Ascorbic Acid	0.60 µg/l	2 µg/l
Total Phosphorus	SM 4500-P F USGS I-4600-85	Persulfate Digestion, Colorimeric, Automated, Ascorbic Acid	0.63 µg/l	2 µg/l
Nitrite*	SM 4500-NO3 F	Colorimeric, Automated	0.50 µg/l	2 µg/l
Nitrate*	SM 4500-NO3 F	Colorimetric, Automated, Cadmium Reduction	0.84 µg/l	2 µg/l
Total Kjeldahl Nitrogen	EPA 351.2	Block Digestion, Automated Phenate	11.3 µg/l	20 µg/l
Total Suspended Solids	EPA 160.2	Gravimetric	NA	0.1 mg/l
Total Dissolved Solids	SM 2540 C	Gravimetric	NA	1 mg/l
Turbidity	SM 2130B	Nephelometric	NA	ntu

*Samples filtered, 0.45 µ

Table 4. Overview of Tributary Sampling. From Stantec 2012 SAP Document.

Task, Item or Activity	Description
Sampling Site	Steamboat Creek @ Rhodes Road Steamboat Creek @ the Narrows Steamboat Creek @ Clean Water Way Whites Creek @ Timberline Dr. Whites Creek @ Old Virginia Hwy Thomas Creek @ Timberline Dr. Thomas Creek @ S. Meadows Pkwy North Truckee Drain @ Orr North Truckee Drain @ Kleppe Ln. Chalk Creek @ Chalk Bluff Alum Creek @ Steamboat Ditch Alum Creek @ Truckee River
Sample Type	Grab
Sampling Frequency	2/year, scheduled (non-rain event) and 2/year, unscheduled (rain events)
Standard Analytical Parameters	TDS, TSS, TP, OP, TN and Field WQ (Temp, EC, pH, DO, Turbidity)
Additional Site Specific Parameters	Steamboat Creek @ Rhodes Road – E. coli Whites Creek @ Timberline Dr. – E. coli Whites Creek @ Old Virginia Hwy – E. coli Alum Creek @ Steamboat Ditch – E. coli Alum Creek @ Truckee River – E. coli Chalk Creek @ Chalk Bluff – NO3
Discharge Measurement	Yes (where possible)

Table 5. Tributary Sampling. From Stantec 2012 SAP Document.

Tributary	Sampling Location	Upstream/ Downstream	Gage?	Discharge Measurement	Owner	Future
Steamboat Creek	@ Rhodes	Upstream	Yes	USGS (Real Time)	TRFP	
	@ Narrows	Midstream	Yes	USGS (Real Time)	USGS	
	@ Clean Water Way	Downstream	Yes	USGS (Read Onsite)	WCDWR/ TMWA	
Whites Creek	@ Timberline	Upstream	Yes	Real Time	Washoe County	
	@ Old Virginia	Downstream	No	Manual		
Thomas Creek	@ Timberline	Upstream	No	Manual		TRFP future Gage install?
	@ S. Meadows	Downstream	No	Manual	Washoe County	
N. Truckee Drain	@ Orr	Upstream	Yes	USGS (Real Time)	TRFP	
	@Kleppe	Downstream	Yes	USGS (Read Onsite)	Sparks	Abandon or relocate in the next few years
Chalk Creek	@ Chalk Bluff	Downstream	No	Weir	Reno	
Alum Creek	@ Steamboat Ditch	Upstream	No	Manual		
	@ Truckee River	Downstream	Yes	Weir or Manual	UNR	

Table 6. Outfall Sampling. From Stantec 2012 SAP Document.

Task, Item or Activity	Description
Outfall Name	Alum Creek at Chrissie Caughlin Park Oxbow Nature Park Dickerson Road Vine and Second Arlington (South) Fisherman's Park II Paradise Pond/Galletti Way Mary Wahl Ditch Cottonwood Park (west) Greg Street (East)
Sample Type	Grab (during rain events)
Sampling Frequency	Target 2/year
Standard Analytical Parameters	TDS, TSS, TP, OP, TN, NO3, E. coli Field WQ (Temp, EC, pH, DO, Turbidity)
Discharge Measurement	Where possible and safe, otherwise visual estimates only

Quality Assurance/Quality Control

Field blanks and duplicate discrete grab samples are an accepted method for assuring the quality of field sampling methods and analytical techniques. For this pilot study, two field blanks and three field duplicate samples were analyzed to ensure accuracy and precision. The results of the field blank analyses are found in Table 7. The results of the field duplicate analyses are found in Table 8 and Table 9. Standard deviations calculated on field duplicates yielded good results. Field blanks resulted in laboratory measurements below detection level for most analytes.

Table 7. Field blank measurements taken during sample collection times at the Rhodes Road tributary monitoring site on Steamboat Creek.

Site Name	Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	NO_2-N (mg/L)	TKN (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)
Field Blank	FB	5/2/13	<.002	<.002	<.02	<.02	<.002	<.002	n/a	<1
Field Blank	FB	6/21/13	0.002	<.002	<.05	<.05	<.002	0.002	n/a	n/a

Table 8. Field duplicate measurement taken during sample collection times at the Rhodes Road tributary monitoring site on Steamboat Creek.

Site Name	Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	NO_2-N (mg/L)	TKN (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)
Rhodes	RR	5/2/13 10:25	0.034	0.003	0.34	0.38	0.095	0.135	2.8	158
Rhodes	RR	5/2/13 10:25	n/a	n/a	0.35	n/a	n/a	0.134	n/a	n/a
std dev			n/a	n/a	0.0071	n/a	n/a	0.0007	n/a	n/a

Table 9. Field duplicate measurements taken during sample collection times at the NTD@Kleppe Road tributary monitoring site on North Truckee Drain.

Site Name	Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	NO_2-N (mg/L)	TKN (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)
Kleppe	KL	5/2/13 13:30	0.288	0.038	0.81	1.14	0.211	0.258	5.8	645
Kleppe	KL	5/2/13 13:30	0.290	0.039	0.73	1.06	0.211	0.262	4.8	650
Kleppe	KL	5/2/13 13:30	n/a	n/a	0.75	n/a	n/a	0.257	n/a	n/a
std dev			0.0014	0.0007	0.0416	0.0544	0.0000	0.0026	0.7071	3.5355

Truckee River Discharges

The water volume discharge for the Truckee River is an important consideration for contaminant loading inputs in the vicinity of the Truckee Meadows. The average discharge for the months January 1 to October 1 for the 20-year period 1990-2010 is shown in Figure 2 (USGS 10348000). The continuous real-time data for the sampling period of this pilot project (2013) is shown by the blue line.

If the discharge of most outfalls within the Truckee Meadows is relatively small, compared to the total discharge of the river proper, then the loading of contaminants from outfalls may not be important. If the discharge of outfalls and tributaries is high, as in a summer rain storm, then the contaminant loading may be an important consideration to the overall water quality of the Truckee River. For example, the summer storms of late June, July, and August 2013 are clearly noted in Figure 2. These summer events may result in significant loading of sediment and nutrients from outfalls and tributaries. The discharge of the river during these events approximates the highest discharges during spring run-off. In the following sections, examination of each specific tributary and outfall is considered in this context.

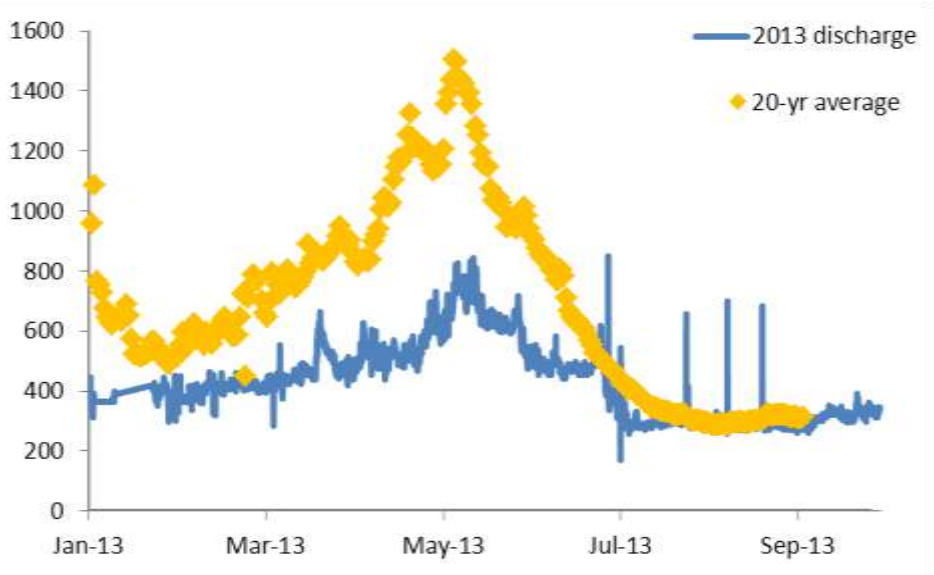

Figure 2. Discharge measurements at the Reno gaging station for the Truckee River during the Water Year 2013 sampling period.

TRIBUTARY ASSESSMENTS, SITE SPECIFIC

The discharge rate of a particular watershed is needed to better assess its contribution of contaminants to the Truckee River. In order to extrapolate information from the grab samples of this pilot project into a larger assessment of water quality, the snapshot was integrated into the historical record for some of the tributaries. The long-term record can begin to quantify the extent to which each watershed influences the Truckee River.

Steamboat Creek

Steamboat Creek is one of the main tributaries out of the Truckee Meadows to the Truckee River. It is instrumented for continuous discharge measurements by the USGS at three gaging stations distributed longitudinally prior to its confluence with the Truckee River. The Rhodes gaging station is located in the upper watershed near Pleasant Valley. The Narrows gaging station is located about midway downstream on Steamboat Creek at its crossing with Short Lane. The Clean Water Way gaging station is located just upstream of the Truckee Meadows Water Reclamation Facility, near the Steamboat Creek crossing with Clean Water Way, close to its confluence with the Truckee River. Grab samples were collected at each of these three gaging stations during four selected runoff events in Water Year 2013 (Figure 3). Similar grab sampling programs had been conducted at these sites previously in Water Years 2011 and 2012.

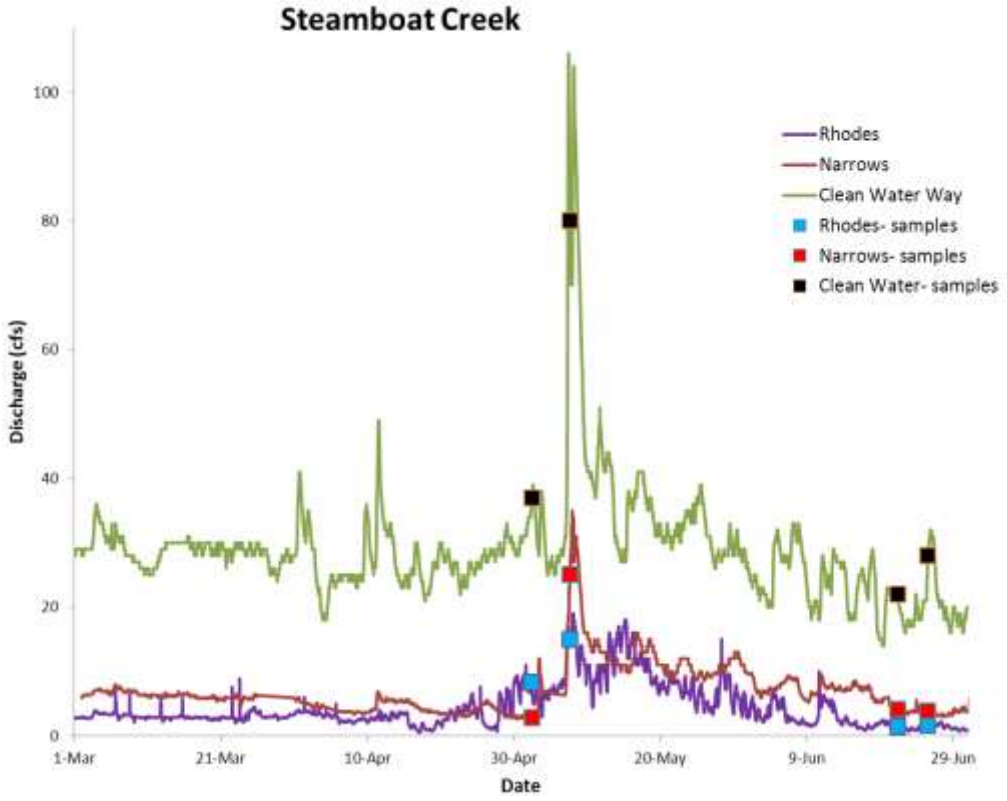

Figure 3. Flow measurements at gaging stations on Steamboat Creek during the Water Year 2013 sampling period. Also shown are times when grab samples were collected for analysis. The precipitation events of May 7th and June 25th had total accumulations of 0.61 inches and 0.07 inches, respectively (Table 10). Peak discharge rates for the May event were 19 cfs at Rhodes Road, 35 cfs at the Narrows station, and 106 cfs at Clean Water Way (Figure 3). During the smaller June precipitation event (June 25th) there were only slight increases in the discharge at each gaging station, with a peak discharge of 2.0 cfs at Rhodes Road, 4.7 cfs at the Narrows station, and 32 cfs at Clean Water Way. The grab sampling on May 2nd and June 21st were conducted to provide data for dry weather, low-flow conditions. The sampling times are given in local time.

Table 10. Project sampling dates and precipitation characteristics for Steamboat Creek sites. Precipitation data from meteorological station KNVRENO45 in South Reno.

Project Sampling Date	Precipitation Start Date Time	Event Duration (hr)	Event Total Precipitation (inches)	Peak Intensity (inch/hr)	Event Type
5/2/2013	No precipitation	--	--	--	Dry weather discharge
5/7/2013	5/6/2013 17:30	29	0.61	0.1	Rain
6/21/2013	No precipitation	--	--	--	Dry weather discharge
6/25/2013	6/25/2013 08:00	2.5	0.07	0.03	Rain

Field measurements were taken at each Steamboat Creek monitoring station for discharge, water temperature, specific conductivity (SC), dissolved oxygen (DO), and pH. Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli).

Rhodes Tributary Site **(**Steamboat Creek**)**

This station was located at the north end of Pleasant Valley at Rhodes Road crossing of Steamboat Creek, which collects water from the Washoe Valley and its tributaries. The sampling site was at the USGS gage, located just upstream from the point of return water discharges from Steamboat Ditch. Field measurements taken during WY 2013 at Rhodes Road (RR) are within the range of values observed in previous years (Appendix A-1). Turbidity was not measured on May 2, 2013 because of a faulty meter. Lab analytic results from samples collected in WY 2013 are also within the range of results from previous years for TN, orthophosphate, TP and TDS (Appendix A-2). Samples were not analyzed for nitrate, TSS, turbidity or E. coli in previous years. The WY 2011 to 2013 data series are shown for TN, TP, TDS and discharge in Figure 4. This site is upstream of the apparent source(s) of contamination of Steamboat Creek. It would be advantageous to continue sampling this site with opportunistic grab sampling, especially considering the USGS gaging station already in place. In Table 31, we recommend that the grab sampling regime continue.

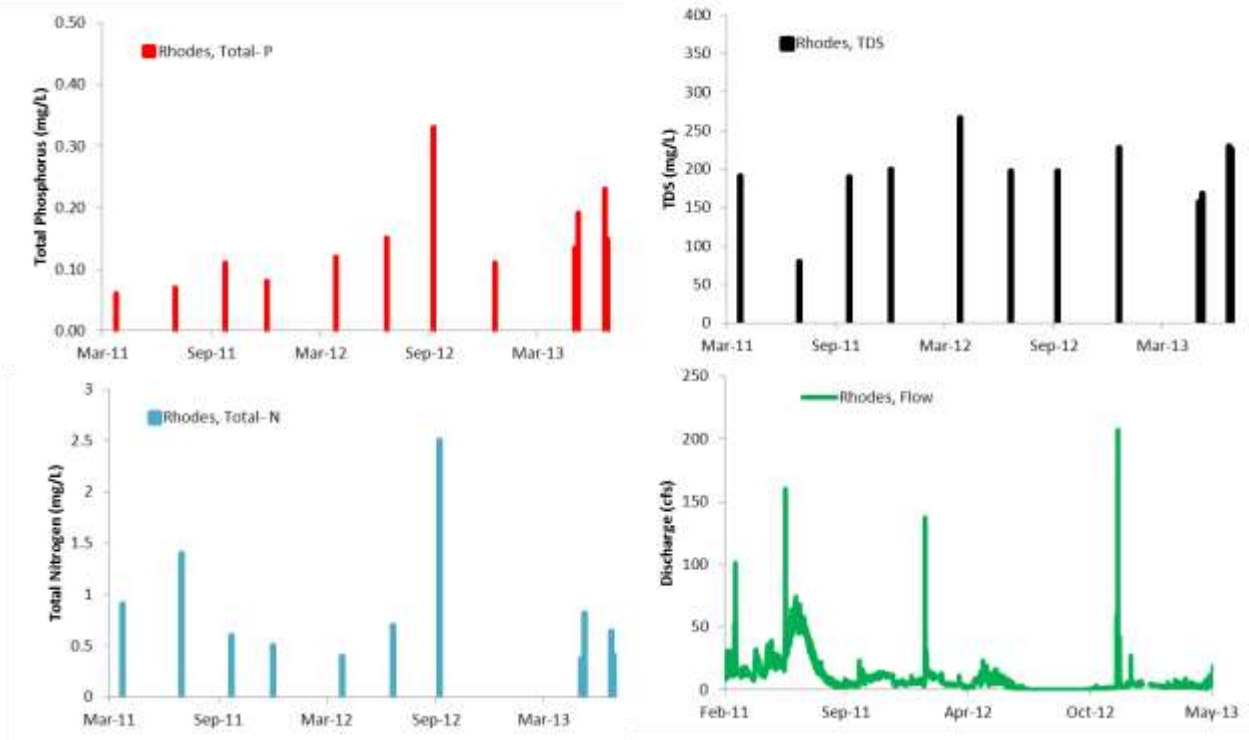

Figure 4. Total phosphorus, total nitrogen, total dissolved solids, and discharge for water years 2011 to 2013 at the Rhodes site on Steamboat Creek.

Narrows Tributary Site **(**Steamboat Creek)

Both Whites Creek and Thomas Creek are substantial tributaries that enter Steamboat Creek between the Rhodes Road and the Narrows gaging stations. Field measurements for the Narrows (NR) site were generally within the range of values observed in previous years (Appendix A-3). Specific conductance and concentrations of total dissolved solids were relatively high compared to other sites. Turbidity was not measured on May 2nd because of a faulty meter. Lab analytic results for TN, TP and TDS samples from WY 2013 ranged somewhat higher than observed in previous years (Appendix A-4). In previous years samples were not analyzed for nitrate, TSS, or turbidity. For WY 2013 the project design did not include E. coli sampling at the Narrows station. WY 2011 to 2013 data for TN, TP, TDS and discharge are shown in Figure 5. The poor TDS results at this site indicate that the apparent source(s) of contamination of Steamboat Creek is upstream. It would be advantageous to continue sampling this site with opportunistic grab sampling, especially considering the USGS gaging station already in place. In Table 31, we recommend that the grab sampling regime continue and that a real-time electrical conductivity sensor be installed.

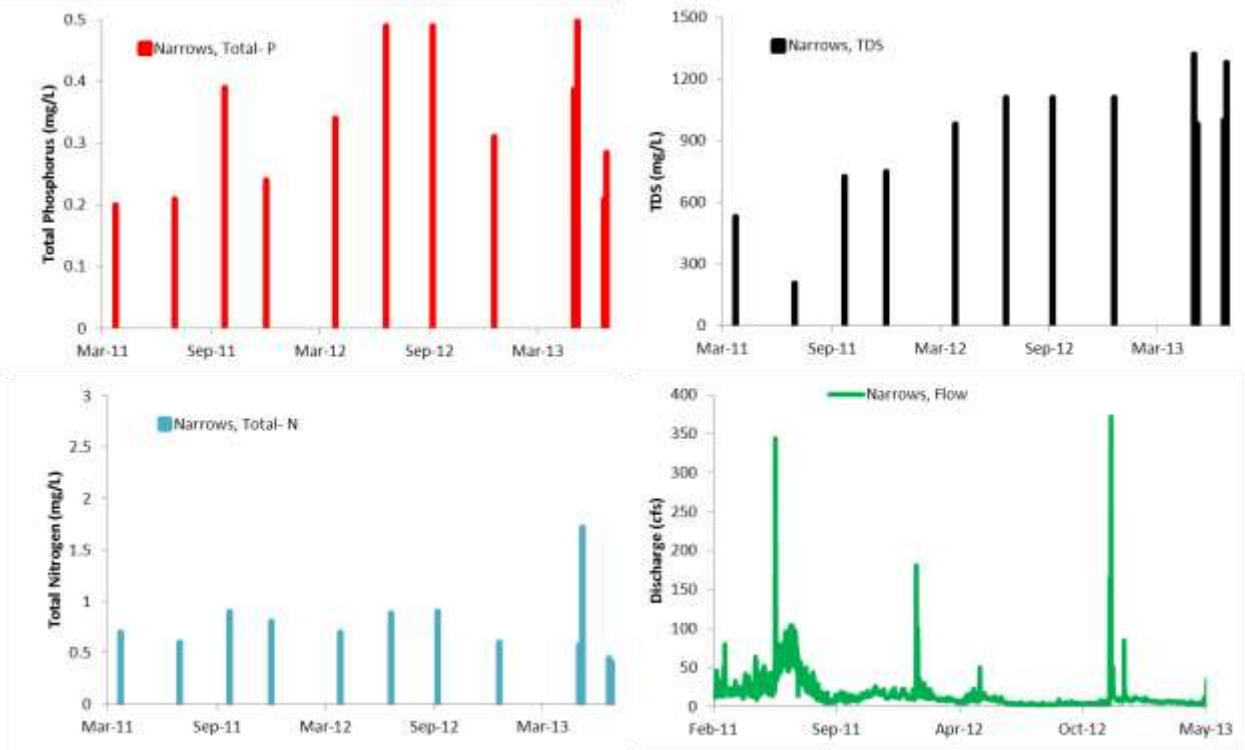

Figure 5. Total phosphorus, total nitrogen, total dissolved solids, and discharge for water years 2011 to 2013 from the Narrows site on Steamboat Creek.

Clean Water Way Tributary Site (Steamboat Creek)

Dry Creek and South Evans Creek discharge to Steamboat Creek between the Narrows gaging station and Clean Water Way. Field measurements for the Clean Water Way (CWW) site are within the range of values observed in previous years (Appendix A-5). Measurements of DO and pH were not available from previous years. Turbidity was not measured on May 2nd because of a faulty meter. Lab analytic results from samples collected in WY 2013 are also within the range of results from previous years for TN, orthophosphate, TP and TDS (Appendix A-6), although concentrations of nitrate are an order of magnitude greater than found at any other south Reno tributary monitoring site during WY 2013. In previous years samples were not analyzed for nitrate, TSS, or turbidity. For WY 2013 the project design did not include E. coli sampling at the Narrows station. WY 2011 to 2013 data for TN, TP, TDS and discharge are shown in Figure 6. Data have been collected at the outlet of Steamboat Creek quarterly since 1985. Longer term data for dissolved nutrients showed an apparent trend of increasing orthophosphate and nitrate concentrations, although concentrations were somewhat lower for nitrate in WY 2013 (Figure 7). This site is the outlet for Steamboat Creek. The recommended course of action is to add a fully automated sampling station, complete with water quality sensors and telemetry, in order to better monitor this important contaminant loading location (Table 31).

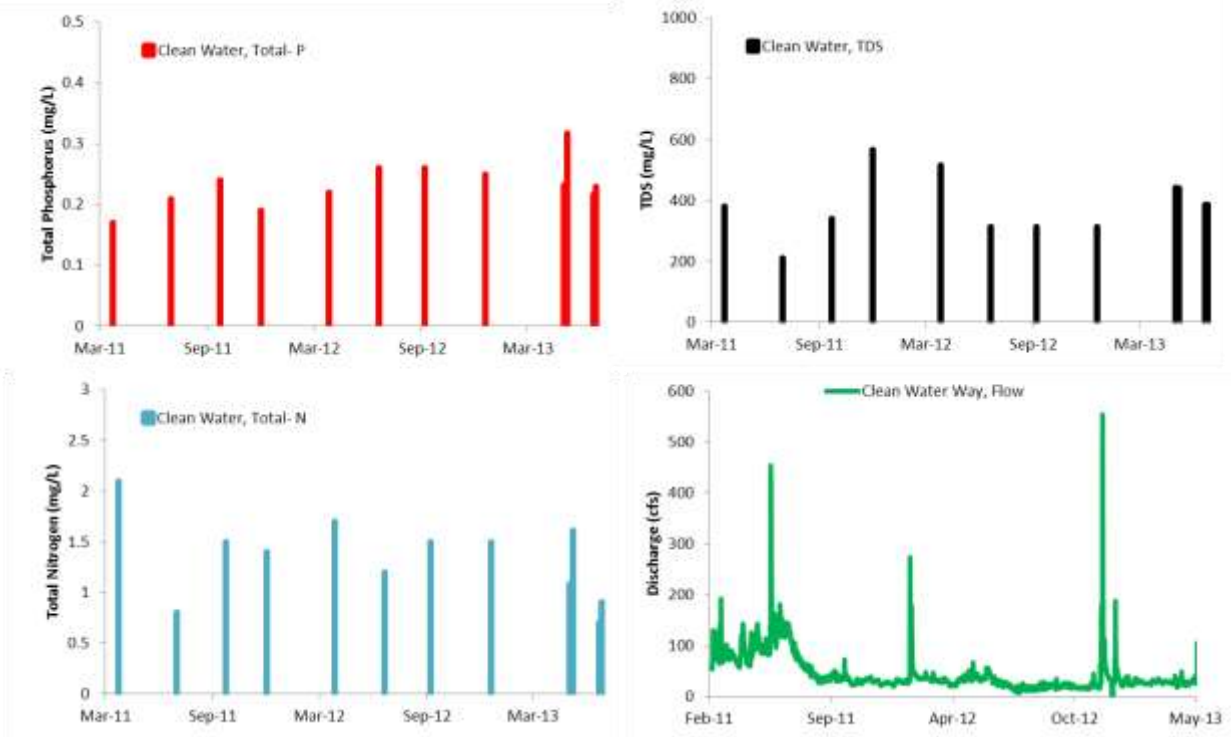

Figure 6. Water Year 2011 to 2013 data from the Clean Water Way site on Steamboat Creek for total phosphorus, total nitrogen, total dissolved solids, and discharge.

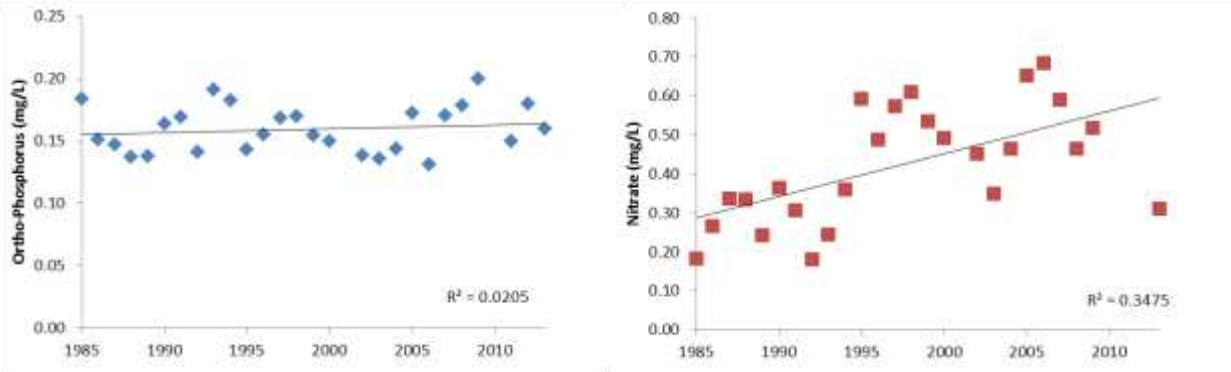

Figure 7. Orthophosphate and nitrate concentrations at Clean Water Way on Steamboat Creek. Previous to 2010, the exact location of sample collection was not provided.

Whites Creek and Thomas Creek

Whites and Thomas Creeks drain to the middle section of Steamboat Creek, and are situated above 9000 feet and fed by snowmelt. Both creeks discharge from west to east from headwaters in high alpine bowls cut into the mountains in the Toiyabe National Forest. These watersheds drain the east slope of the Carson Range. The upper grab sampling stations, "Upper Whites" and "Upper Thomas", are located where the creeks cross Timberline Rd. The middle reaches, below the stations, are relatively undisturbed; however in some places, loss of riparian vegetation, encroachment by development, channel alignment, irrigation diversions and ranching operations affect stream function and water quality. Once reaching the lowlands, the creeks move through broad flood control channels in housing developments and commercial property. Both creeks feed into Steamboat Creek. Last Chance and Steamboat Ditch discharges may contribute to some of the degradation of water quality that occur between the upper and lower stations of these creeks. The "Lower Whites" station has approximately half the discharge as the upper station, as there is a discharge splitter just below Thomas Creek Road.

The upper stations at both Thomas and Whites Creeks were minimally impacted by macronutrients, TDS, and TSS. Concentrations of water quality parameters during both background and precipitation events were relatively low (Figures 8, 9, 10 and 11), suggesting that discharge from precipitation events may have a dilutionaly impact on background concentrations. The upper Thomas and Whites creek watersheds were relatively undisturbed and free of residential development upstream of the collection sites, so there was little in the way of run-off from disturbed sites. The lower station at both Thomas and Whites Creeks contained higher concentrations of macronutrients and salts (Appendix A-7 through A-14). White's and Thomas Creeks are hydrologically similar; the upper stations represent background conditions, and the lower stations may have some elevated contaminants based on residential and industrial inputs. The recommended course of action would be to take grab samples, opportunistically, during events for both creeks, upper and lower. Quarterly grab sampling would be useful in continuing the historical record. Adding continuous stage measurements would enhance the real-time data record and any loading calculations (Table 31).

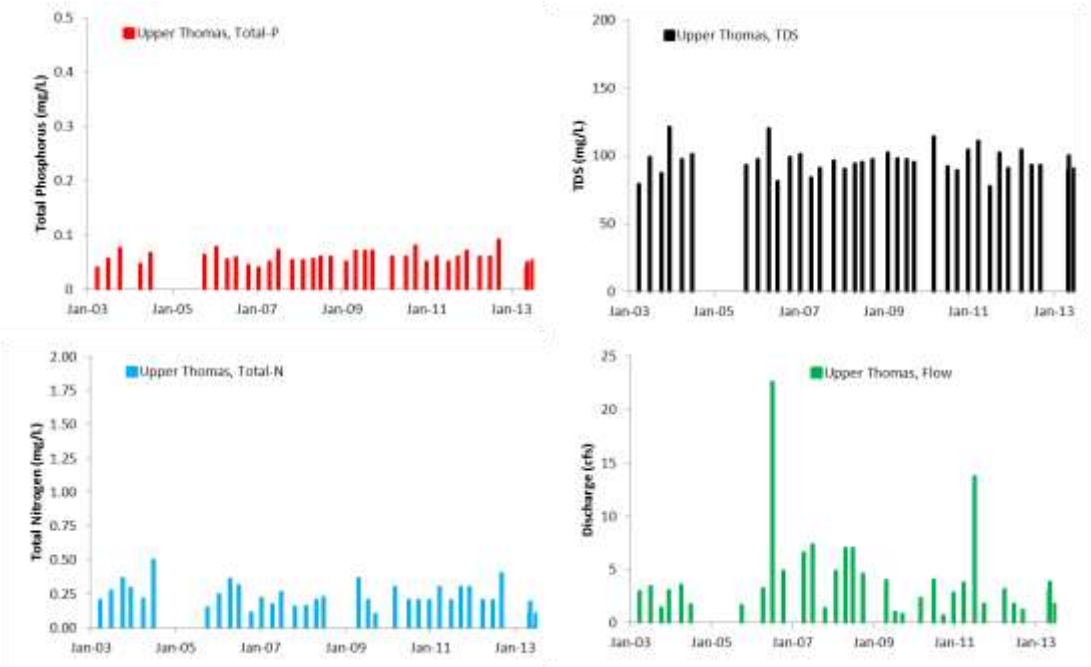

Figure 8. Total Phosphorus (upper left), Total Nitrogen (lower left), are depicted for the historical record for Thomas Creek, upper station. Total dissolved solids (upper right) and discharge (lower right) are depicted for the historical record for upper Thomas Creek station.

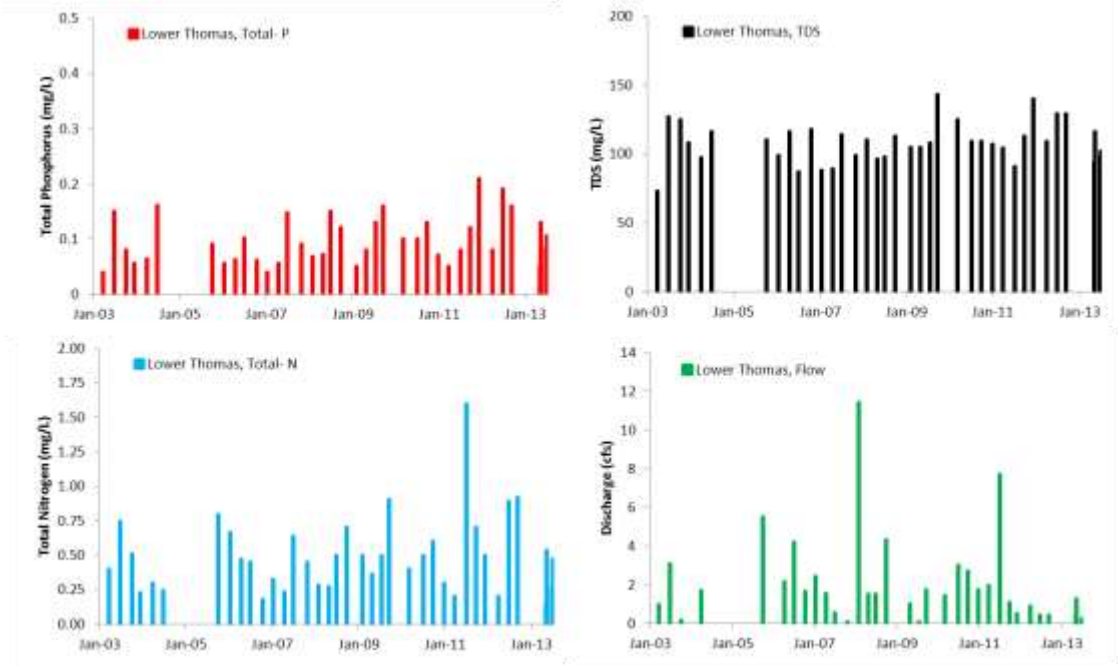

Figure 9. Total Phosphorus (upper left), Total Nitrogen (lower left), are depicted for the historical record for Thomas Creek, lower station. Total dissolved solids (upper right) and discharge (lower right) are depicted for the historical record for lower Thomas Creek station.

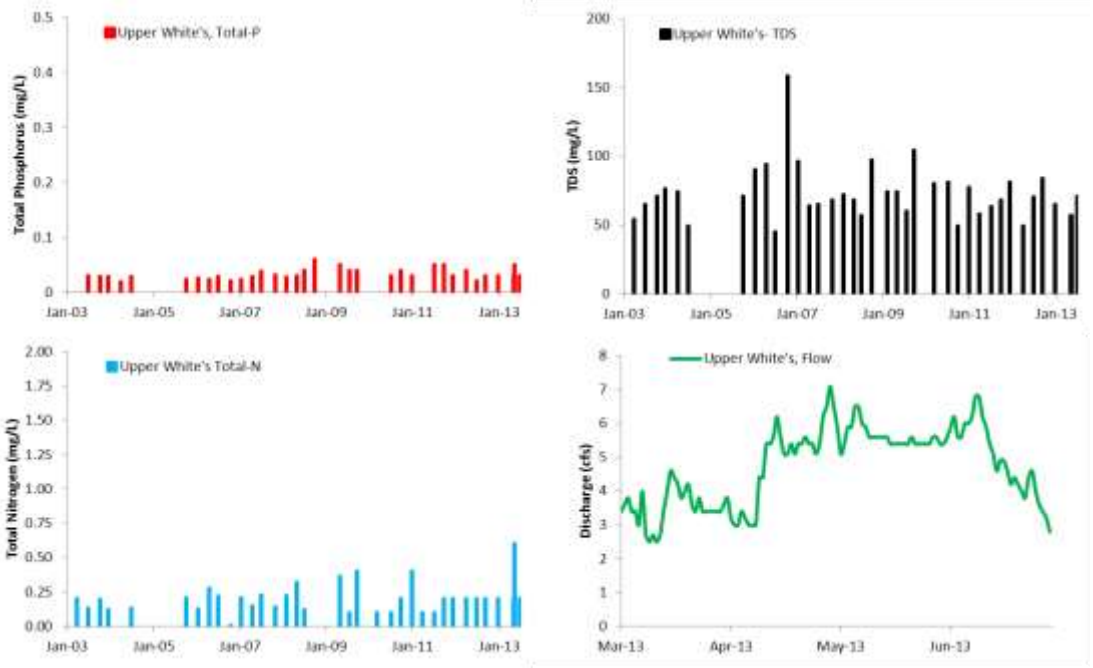

Figure 10. Total Phosphorus (upper left), Total Nitrogen (lower left), are depicted for the historical record for White's Creek, upper station. Total dissolved solids (upper right) and discharge (lower right) are depicted for the historical record for lower White's Creek station.

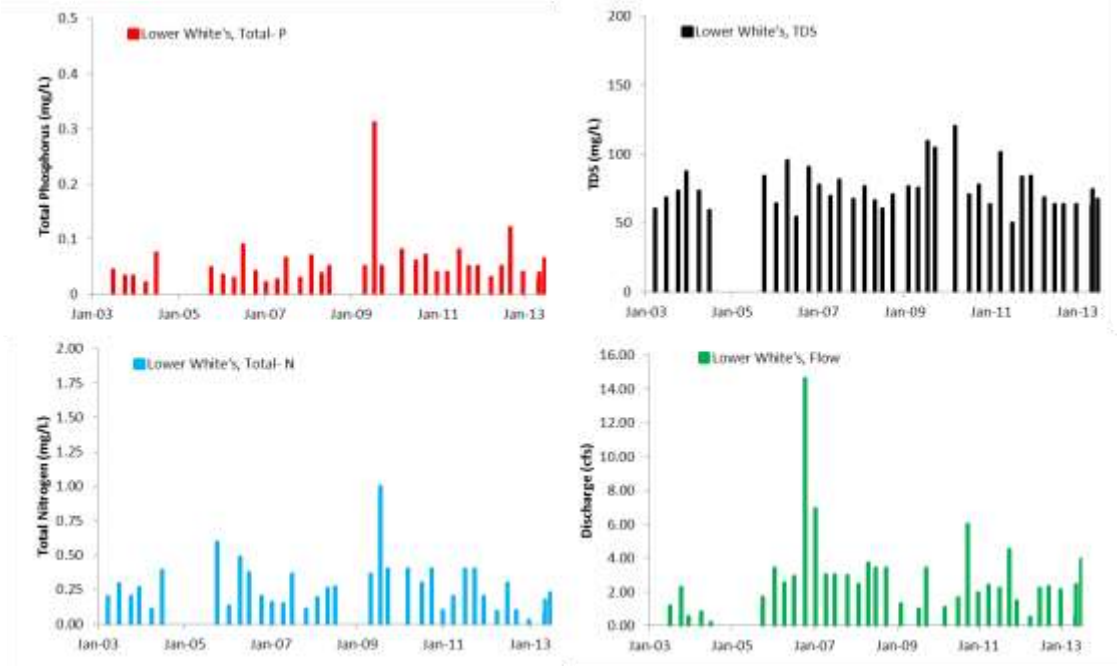

Figure 11. Total Phosphorus (upper left), Total Nitrogen (lower left), are depicted for the historical record for White's Creek, lower station. Total dissolved solids (upper right) and discharge (lower right) are depicted for the historical record for lower White's Creek station.

Chalk Creek Tributary Site

Chalk Creek is a tributary of the Truckee River in northwest Reno. Historically, it has been an ephemeral stream, but in recent years has become perennial as a result of increased irrigation and runoff from residential development in its headwaters. New residential neighborhoods, parks, and golf courses have been constructed in the last 40 years. This development has increased the watering schedule and may have extended the residence time of runoff in the shallow groundwater. Daily averages of air temperature, TDS, water temperature, and discharge were collected continuously from March 2007 to December 2010 at the Chalk Bluff water treatment facility. Since, it has been grab sampled on a quarterly basis for discharge, conductivity, TDS, TSS, and nutrients. This pilot project examined field water quality parameters, and lab analyses for macronutrients and sediment. While the sampling methods varied over each of these investigations, there exists a pattern of relatively poor water quality. Chalk Creek (CC) site has elevated levels of macronutrients and TDS on a consistent basis (Figure 12). During the valley-wide storm of May 7, 2013, TDS, total phosphorus, total nitrogen, and orthophosphorus were substantially higher (Appendix A-15).

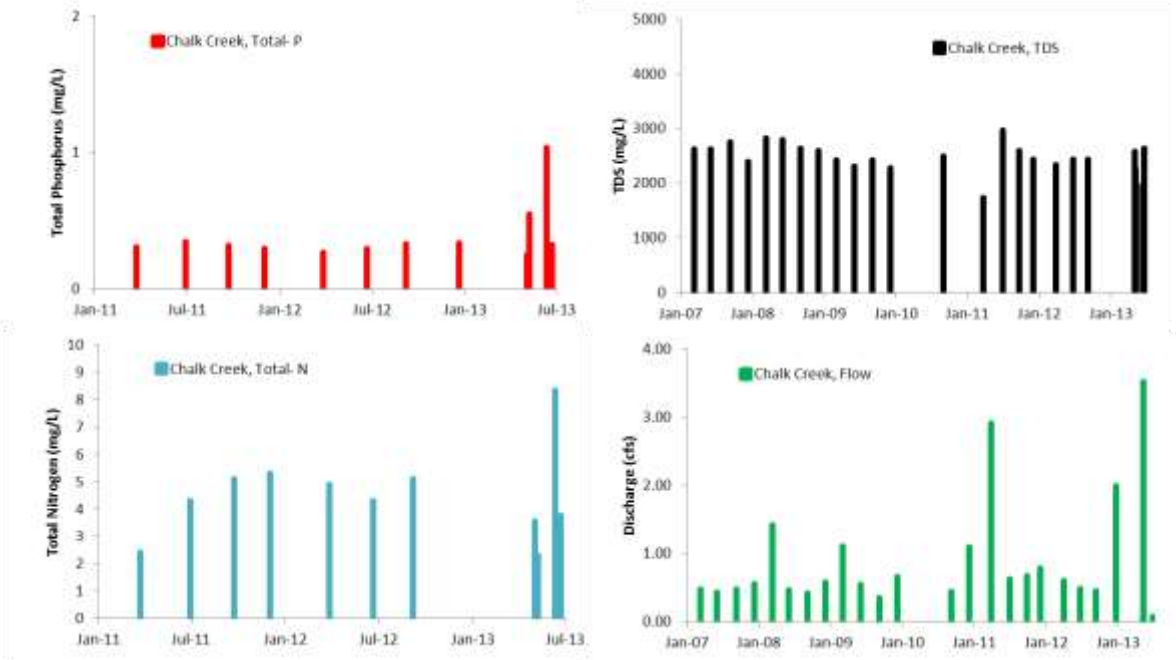

Figure 12. Total phosphorus (upper left), total nitrogen (lower left), total dissolved solids (upper right), and discharge (lower right) for the historical record (water years 2011 to 2013) and the current grab sampling project at Chalk Creek.

Field measurements were taken at Chalk Creek (CC) monitoring station for discharge, water temperature, specific conductivity (SC), dissolved oxygen (DO), and pH. Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli). Turbidity was not measured on May 2nd because of a faulty meter.

Field measurements for the Chalk Creek site were particularly high for specific conductance and total dissolved solids, and will be discussed in the recommendations section (Appendix A-16). Turbidity was not measured on May 2nd because of a faulty meter. E. coli samples were not collected for analysis at the Chalk Creek station, by project design.

Chalk Creek water quality has been relatively poor for the entirety of the period of record (Water Years 2007-2013). The Watershed Assessment report of 2011 called this watershed a "Medium" restoration priority, and indicated that "lawn care chemicals from the upper reaches may be a source of nutrients." (Stantec, 2011) This watershed needs more rigorous monitoring, as discharge is not continuously monitored at present. Therefore, the loading input of the contaminants of concern to the Truckee River was indeterminate. This creek may be significant inasmuch as the contribution of high concentrations of macronutrients and TDS were suggested by the data record, but the total loading was not known. This site, as the drainage for the Somersett neighborhood of Reno, has historically high TDS. The recommended course of action for the stormwater monitoring program is to add a fully automated sampling station, complete with water quality sensors and telemetry, in order to better monitor this important contaminant loading location (Table 31).

Alum Creek Tributary Sites

Alum Creek discharges from south to north out of the Carson Range, through the Caughlin Ranch area of southwest Reno to its confluence with the Truckee River. The upper Alum Creek station near Caughlin Ranch did not have surface discharge during any of our field visits in the spring and summer of 2013. During the quarterly grab sampling in 2011-2012, this station had flowing water on 3 out of 8 occasions (Appendix A-17). When sampled, the water quality of the Upper Alum Creek station was found to be in relatively good condition, with total phosphorus averaging 0.06 mg/L, total nitrogen averaging 0.5 mg/L, and TDS averaging 471 mg/L (Appendix A-18). The upper station at Alum Creek should be considered for removal from the sampling plan, as will be discussed in the recommendations section. After flowing through the residential areas, being diverted for irrigation, and moving through fertilized grassy areas to the lower station, water quality was deteriorated. Graphs of water quality parameters were not produced for the Upper Alum Creek station because it was dry upon each field visit during this pilot project. The Lower Alum Creek station has relatively fair to good water quality for most of the year, as seen during background sampling during this pilot study and in the quarterly sampling of 2011-2012 (Figure 14). During high-intensity rain events, this station can see elevated concentrations of macronutrients, TDS and TSS, as was observed during such an event on June 28, 2013 (Figure 13, Appendix A-18). This creek, as the drainage for the Caughlin Ranch neighborhood of Reno, has historically high TDS. The recommended course of action would be to take grab samples, opportunistically, for the upper and lower stations. Quarterly grab sampling would be useful in continuing the historical record. Adding continuous stage measurements for the lower station would enhance the real-time data record and any loading calculations (Table 31).



Figure 13. Lower Alum Creek during precipitation event on June 28, 2013.

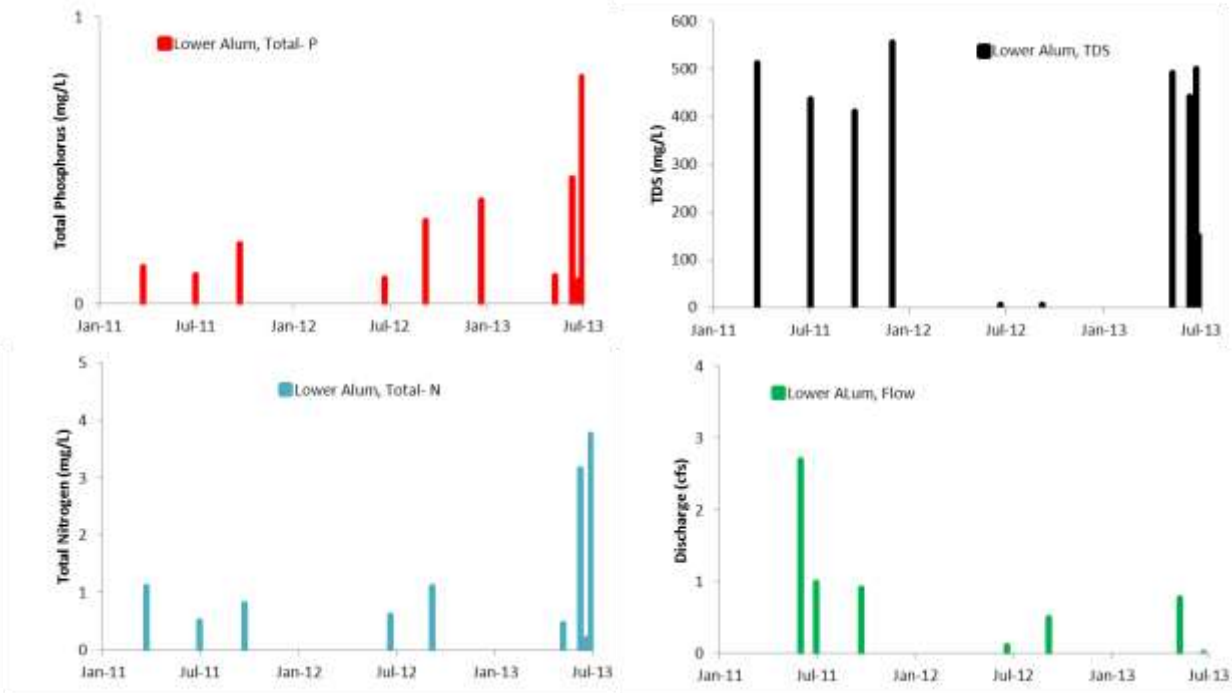

Figure 14. Total phosphorus and total nitrogen (left); and total dissolved solids and discharge (right) are depicted for the historical record (water year 2011 to 2013) at the tributary monitoring site for Lower Alum Creek.

North Truckee Drain Tributary Sites

The North Truckee Drain (NTD) discharges from north to south, out of the Spanish Springs area of Sparks. Orr Ditch delivers irrigation water from the Truckee River to the northern areas of Sparks. The NTD is comprised of return waters from the ditch, springs, and domestic runoff. Below Orr Ditch, the NTD discharges along Sparks Boulevard and can be highly channelized by concrete channels and incision by flood waters. Water quality contaminants could enter the water from groundwater through this section of the drain. The lower reaches are comprised of an industrial area south of Interstate 80, and low water velocities may tend to matriculate contaminants to the Truckee River. Discharge for the North Truckee Drain can be much lower at the NTD @ Orr site than that of NTD @ Kleppe (Figure 15). For water year 2013, flows were sustained above average for both stations.

Precipitation events of May 7th 2013 and June 25th 2013 had total accumulations of 0.61 inches and 0.07 inches, respectively (Table 11). The grab sampling on May 2nd and June21st were conducted to provide data for dry weather, low-flow conditions.

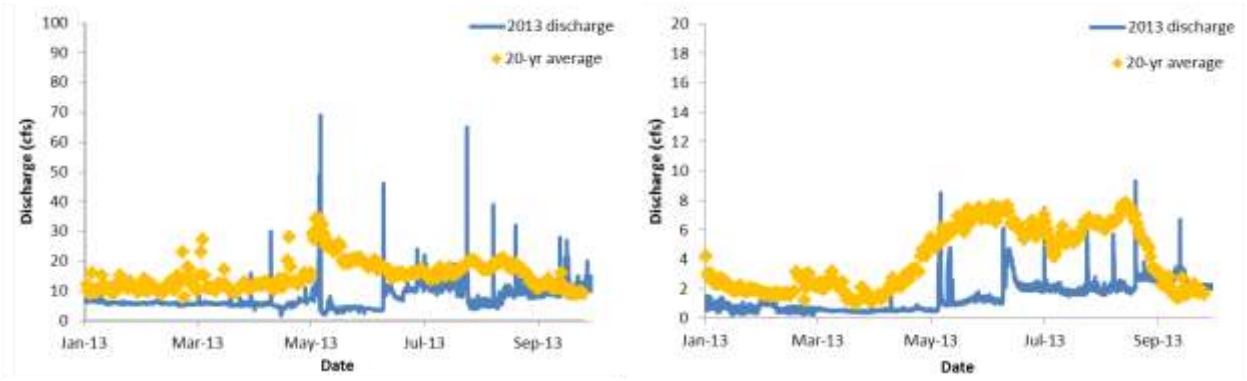

Figure 15. Discharge measurements from gaging stations on the North Truckee Drain during the Water Year 2013 sampling period.

Table 11. Sampling dates and precipitation characteristics for North Truckee Drain sites. Precipitation data from meteorological station (KNVRENO 8) midtown Reno.

Sampling Date	Precipitation Start Date Time (PST)	Event Duration (hr)	Event Total Precipitation (inches)	Peak Intensity (inch/hr)	Event Type
5/2/2013	No precipitation	--	--	--	Dry weather discharge
5/7/2013	5/6/2013 17:30	29	0.61	0.1	Rain
6/21/2013	No precipitation	--	--	--	Dry weather discharge
6/25/2013	6/25/2013 08:00	2.5	0.07	0.03	Rain

Field measurements were taken at each NTD monitoring station for discharge, water temperature, specific conductivity (SC), dissolved oxygen (DO), and pH. Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli).

Orr (North Truckee Drain) Tributary Site

This station is located at the outlet of Spanish Springs drainage, which collects water from the valleys of north Sparks. This sampling site is co-located with a USGS gage. Field measurements for Orr (OR) were elevated for specific conductance, indicating a potential high TDS load from upstream (Appendix A-19). Turbidity was not measured on May 2nd because of a faulty meter (Appendix A-20). The NTD @ Orr station has relatively poor water quality for the period of record, especially for macronutrients and TDS during both background and storm sampling during this pilot study and in the quarterly sampling of 2011-2012 (Figure 16). The

elevated TDS results at this site indicate that the apparent source(s) of contamination of the North Truckee Drain is upstream. It would be advantageous to continue sampling this site with opportunistic grab sampling, especially considering the USGS gaging station already in place. In Table 31, we recommend that the grab sampling regime continue.

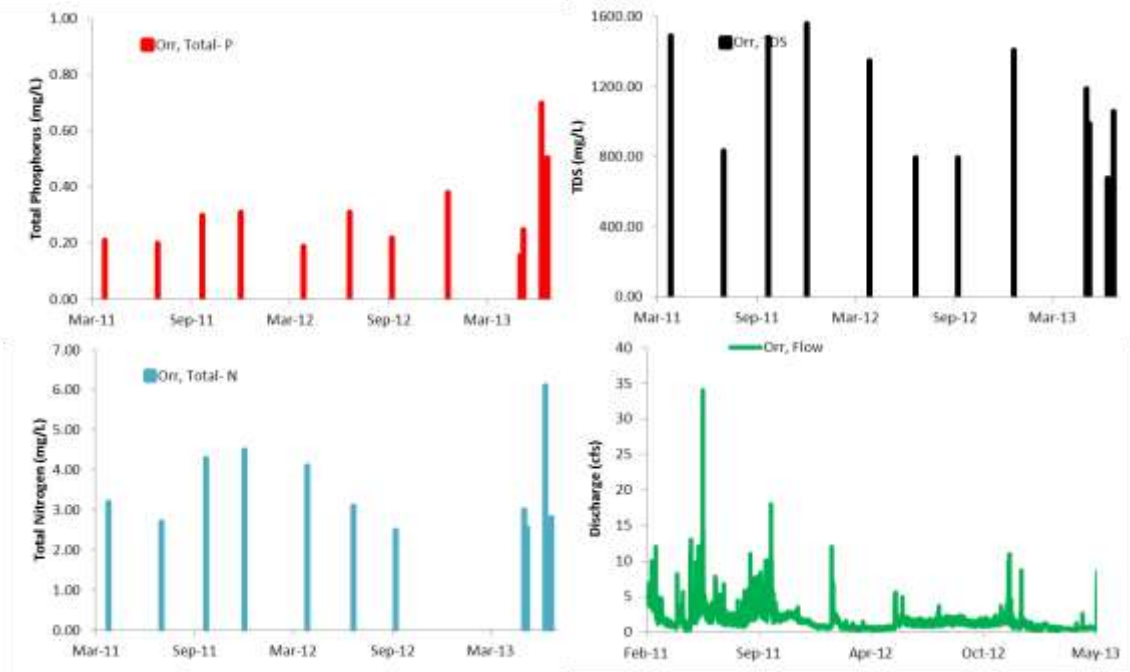

Figure 16. Total phosphorus (upper left), total nitrogen (lower left), total dissolved solids (upper right), and discharge (lower right) for the historical record (water years 2011 and 2012) and the current grab sampling project at the tributary monitoring site on the North Truckee Drain at Orr Ditch.

Kleppe Lane (North Truckee Drain) Tributary Site

The station at Kleppe Lane is co-located with a USGS gage. This site was particularly high for specific conductance and total dissolved solids, and was given high priority status as will be discussed in the recommendations section (Appendix A-21 and A-22). Turbidity was not measured on May 2nd because of a faulty meter. E. coli samples were not collected for analysis at the Kleppe Lane station, by project design. The NTD @ Kleppe station showed poor water quality, especially for total nitrogen, as seen for all flow regimes during this pilot study and in the quarterly sampling of 2011-2012 (Figure 17). In a historical context, the yearly averages show decreasing trends for nitrate and increasing trends for ortho-phosphorous (Figure 18). This site is the outlet for the North Truckee Drain. The recommended course of action for the stormwater monitoring program is to add a fully automated sampling station, complete with water quality sensors and telemetry, in order to better monitor this important contaminant loading location (Table 31).

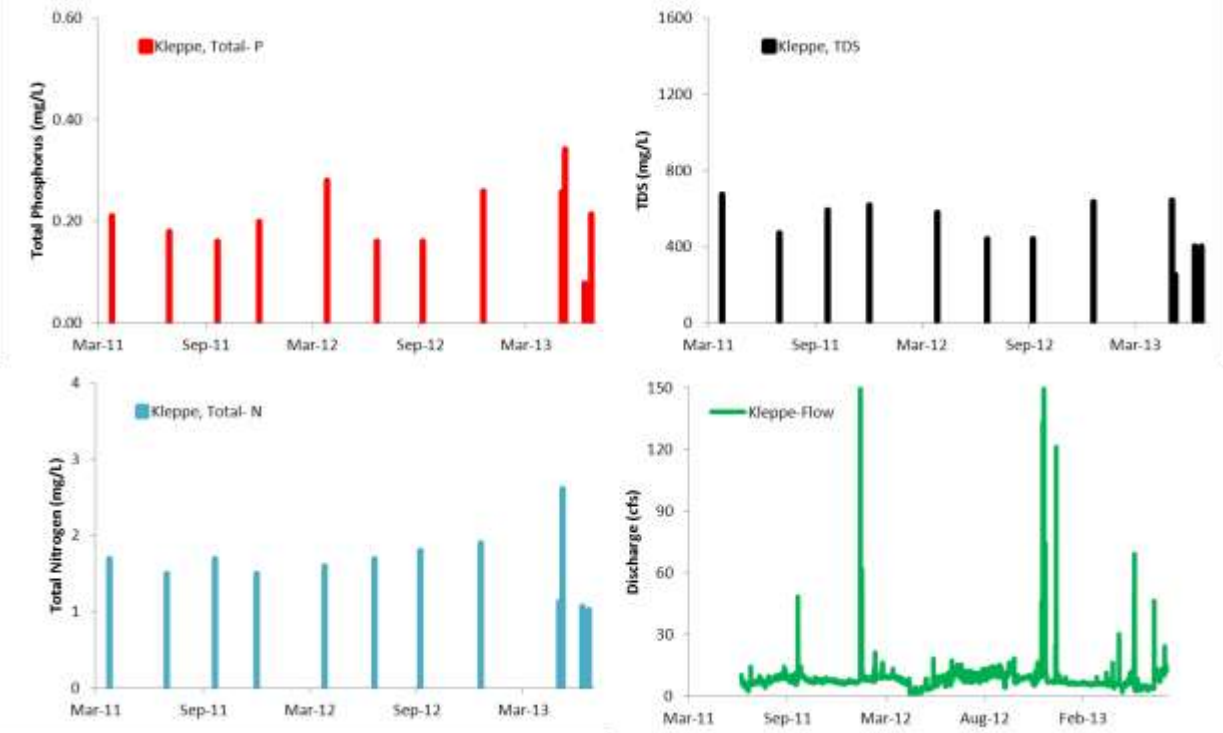

Figure 17. Total phosphorus (upper left), total nitrogen (lower left), total dissolved solids (upper right), and discharge (lower right) for the historical record (water years 2011 and 2012) and the current grab sampling project at the tributary monitoring site on the North Truckee Drain at Kleppe.

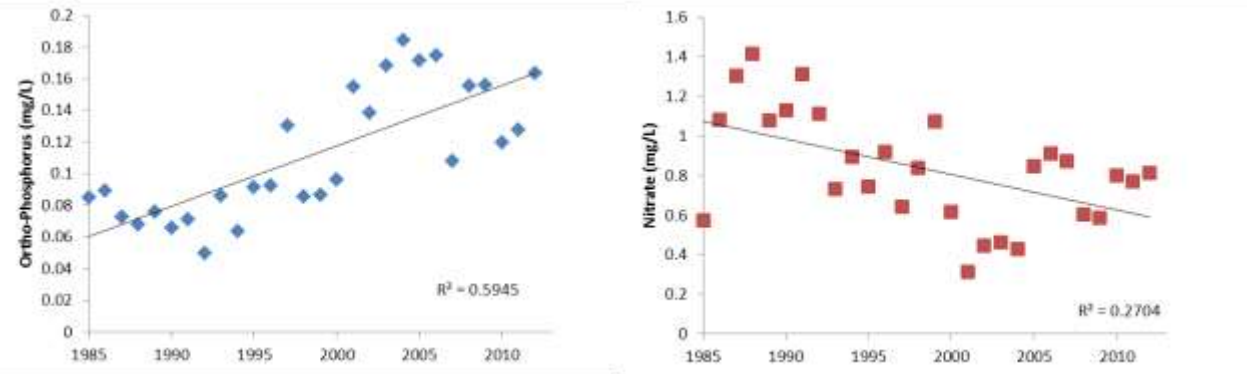

Figure 18. Average yearly orthophosphorus and nitrate concentrations for the historical period (1985 to 2013) for NTD at Kleppe Lane. This is the longest period of record for matching constituents.

OUTFALL ASSESSMENTS, SITE SPECIFIC

This section of the report will detail the results of field measurements, field observations, and analytical results from grab samples collected from storm water outfalls during the pilot project. One of the findings of the investigation of outfalls during this pilot project was that some have greater discharge than expected and some have lower discharge than expected. The outfalls at Vine, Teglia, and Dickerson were found to have low discharge or to be compromised in some fashion. At the Vine St. location, discharge was less than 5 gpm during all visits, except the relatively intense storm of June 28th. Upon investigation, this manhole was decommissioned in the ReTRAC storm drainage realignment and another manhole in the active Vine St. system has been selected. The Teglia station was located at the overflow for Paradise Pond. This station had flowing water on only one occasion—the highly localized storm over Sparks and Spanish Springs of June 10th. The Dickerson Rd station was found to be too low in elevation upon the first field visit, and was backed up with standing Truckee River water. Moving forward, this station was disregarded as unsuitable for the remainder of the pilot study, while an attempt was made to find a suitable replacement further upstream of the station. The next storm discharge basin to the west provides a good alternative with similar land use, and an accessible manhole on Dickerson Rd. before Oxboy Bend Park. This was identified and selected for sampling to begin January 2014.

Greg St and Cottonwood Park were often found to contain shallow standing water only upon field visits during storms. These catchments are seemingly small, relative to some of the other outfalls considered in this study. Yet, when highly localized storms such as June 10th occurred, the discharge was substantial and of relatively poor water quality. For example, the total nitrogen concentration at Greg St and Cottonwood Park locations were 17.1 mg/L and 29.0 mg/L, respectively; total phosphorus concentrations were 1.10 mg/L and 2.73 mg/L, respectively. These catchments, while having relatively poor water quality, are water volume-dependent discharges to the Truckee River (i.e. the loading delivery of contaminants is generally well-correlated to water volume). These sites should continue to be investigated in future studies as opportunistic grab sampling locations. The precipitation events (Table 12) for outfall runoff events were obtained from the nearest rain gage with continuous historical data the Reno-Tahoe International Airport.

Table 12. Sampling dates and precipitation characteristics for outfall runoff events sites. Precipitation data from meteorological station KRNO at the Reno Airport.

Sampling Date	Precipitation Start Date Time (PST)	Event Duration (hr)	Event Total Precipitation (inches)	Peak Intensity (inch/hr)	Event Type
3/31/2013	3/31/13 6:30 AM	4	0.16	0.05	Rain
5/7/2013	5/6/13 5:30 PM	29	0.61	0.1	Rain
6/9/2013	6/9/13 3:30 PM	1.5	Trace	Trace	Rain
6/10/2013	6/10/13 1:00 PM	7	0.11	0.05	Rain
6/25/2013	6/25/13 8:00 AM	2.5	0.07	0.03	Rain
6/28/2013	6/1/13 5:30 PM	1.5	0.01	0.01	Rain

Arlington Island Outfall Site

The culvert drain at the intersection of South Arlington Ave and Island Ave was observed generating substantial discharge during this pilot study. Grab samples were collected at the culvert outfall during four selected runoff events in Water Year 2013 (Figure 19).

The four sampled events for this site were of varying length and intensity. The events of March 31st and May 7th had precipitation totals of 0.16 inches and 0.61 inches, respectively (Table 12). The precipitation totals were taken miles away from this outfall catchment, and do not reflect the substantial, localized event of June 28th. This event, in fact, was extremely intense, resulting in ponding on the roads of downtown Reno.



Figure 19. The culvert at Arlington Island Outfall site during the storm of June 9th.

The catchment for the Arlington Island outfall site is relatively small and was prone to discharge abruptly with a relatively short duration after precipitation events. This site provided a situation wherein sampling would optimally be carried out through automated methods, as the

time for mobilization of a grab sampling effort may cause the discharge to be missed completely. Nonetheless, grab samples were successfully collected during this pilot study, though time for mobilizing some equipment was not available and some measurements could not be collected. Field measurements were taken at Arlington Island site for discharge (Q), water temperature (Temp), specific conductivity (EC), dissolved oxygen (DO), and pH. Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli). Field and analytic results are summarized by site in the following pages (Table 13, Table 14, and Figure 20). This site has been identified as a fully automated sampling station in the recommendations, based on the proximity to the city offices. We recommend water quality sensors and telemetry if the sampling effort is mobilized from a remote location (Table 31).

Table 13. Field measurements collected during sample collection times at the Arlington outfall monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
AR	3/31/2013 11:40	0.14	10.43	0.201	82.3	7.48
AR	5/7/2013 9:40	0.21	11.37	0.14	90.5	9.6
AR	6/9/2013 16:05	0.41	n/a	n/a	n/a	n/a
AR	6/9/2013 16:09	0.41	n/a	n/a	n/a	n/a
AR	6/28/2013 18:21	0.53	n/a	n/a	n/a	n/a

Table 14. Analytical results from grab samples collected at the Arlington outfall monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
AR	3/31/2013 11:40	1.28	6.617	1.20	1.41	19.5	180	19.1	>24196
AR	5/7/2013 9:40	0.393	2.67	0.460	0.729	25.0	102	20.7	>2419.6
AR	6/9/2013 16:05	1.72	28.9	2.02	3.91	1030	414	310	n/a
AR	6/9/2013 16:09	1.24	37.8	1.91	4.57	1620	396	490	n/a
AR	6/28/2013 18:21	0.022	5.477	0.433	1.02	238	116	56.5	n/a

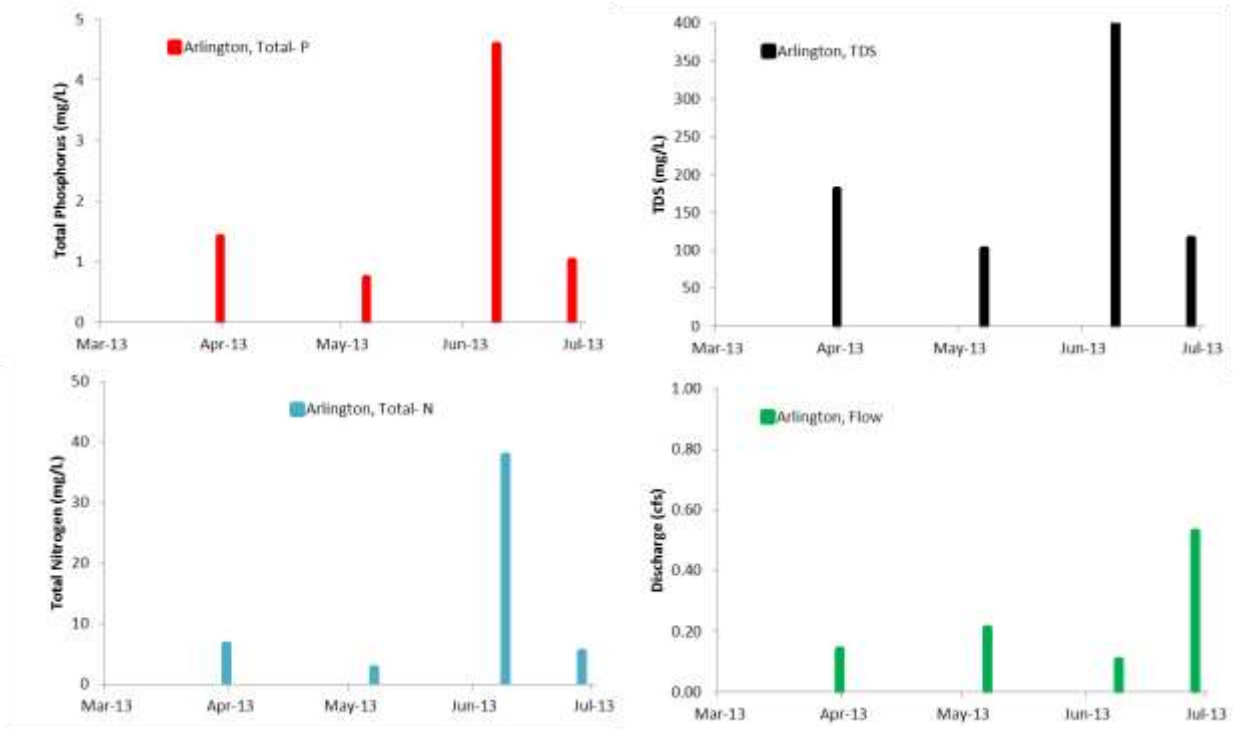

Figure 20. Total phosphorus, total nitrogen, total dissolved solids, and discharge for grab samples in water year 2013 from the outfall site at Arlington Island.

Mary Wahl Outfall Site

The culvert ditch at the intersection of Marietta Way and Coney Island Dr can collect substantial storm runoff. Grab samples were collected at the culvert outfall during three selected runoff events in Water Year 2013 (Figure 21).

The three sampled events for this station were of varying length and intensity. The events of March 31st, May 7th, and June 9th had precipitation totals of 0.16 inches, 0.61 inches, and trace, respectively. Field measurements were taken at Mary Wahl Ditch station for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 15). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 16). This site is a low slope drain for industrial Sparks, NV. The recommended course of action for the stormwater monitoring program is to add a fully automated sampling station, complete with water quality sensors and telemetry (Table 31). The site is relatively easy to access and has less vandalism potential than some other outfalls.

Table 15. Field measurements collected during sample collection times at the outfall monitoring site at Mary Wahl.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
MW	3/31/2013 13:25	0.40	11.06	0.212	6.42	7.18
MW	5/7/2013 10:50	2.80	10.13	0.106	9.33	7.21
MW	6/9/2013 17:56	0.70	17.42	0.228	3.13	7.14

Table 16. Macronutrient concentrations, turbidity and E. coli of grab samples collected from the outfall monitoring site at Mary Wahl.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
MW	3/31/2013 13:25	0.83	3.753	0.343	0.501	30.0	148	31.8	3654
MW	5/7/2013 10:50	0.184	0.76	0.063	0.125	14.8	64	12.5	>2419.6
MW	6/9/2013 17:56	1.3	2.3	0.090	0.179	6.0	152	2.6	7733

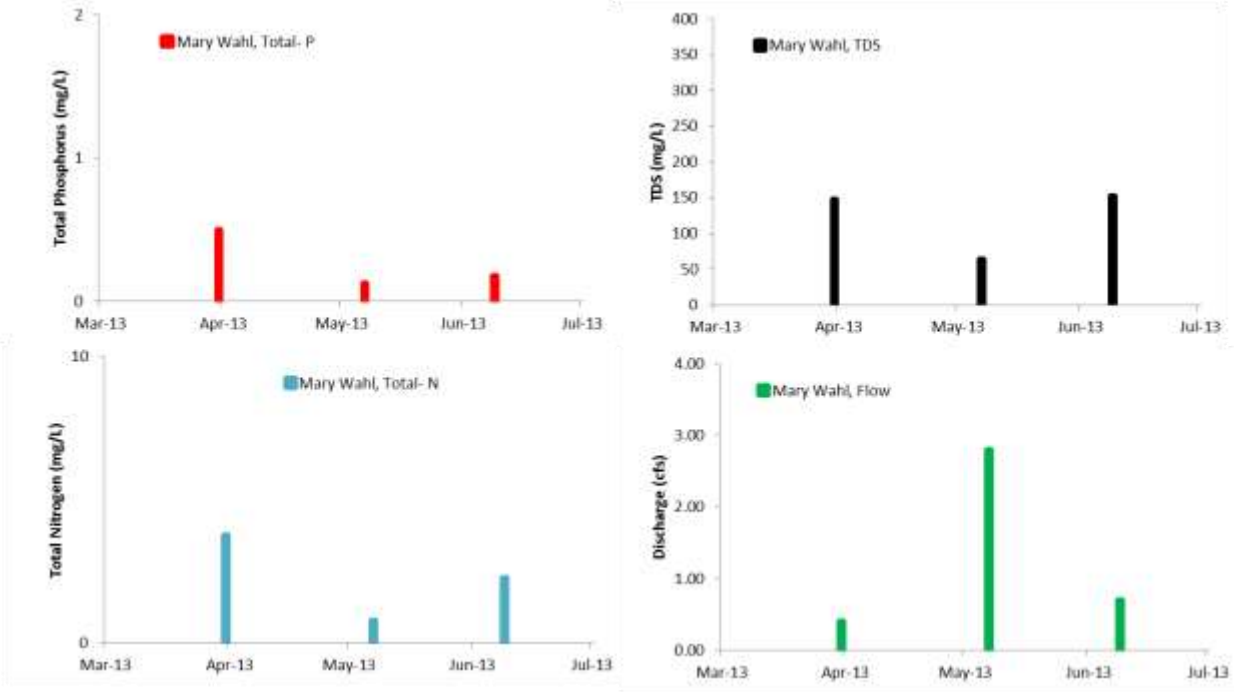

Figure 21. Total phosphorus, total nitrogen, total dissolved solids, and discharge for grab samples collected from the outfall monitoring site at Mary Wahl Ditch.

Fisherman's Park Outfall Site

The culvert drain at the intersection of N. Kietzke Lane and Galetti Way can collect substantial storm runoff. Grab samples were collected at the culvert outfall during three selected runoff events in Water Year 2013 (Figure 22).

The three sampled events for this station were of varying length and intensity. The events of March 31st, May 7th, and June 9th had precipitation totals of 0.16 inches, 0.61 inches, and trace, respectively (Table 12). The precipitation measurements were taken miles away from the outfall catchment, and hence may not be indicative of the precipitation reaching the catchment due to the localized nature of the sampled events. These events resulted in substantial discharges from the outfall for each of the sampled events, although discharge was not measured for the June 9th event.

Field measurements were taken at Fisherman's Park site for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 17). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 18). This site has significant source(s) of contamination and discharge. Yet, it would be prudent to continue sampling this site with opportunistic grab sampling. In Table 31, we recommend that only a grab sampling regime continue, because of vandalism and safety concerns.

Table 17. Field measurements collected during sample collection times at the Fisherman's Park outfall monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
FMP	3/31/2013 12:48	1.90	10.55	0.244	7.93	7.81
FMP	5/7/2013 10:30	3.50	11.09	0.199	9.35	7.44
FMP	6/9/2013 17:30	n/a	n/a	n/a	n/a	n/a

Table 18. Analytic results from grab samples collected at the Fisherman's Park outfall monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
FMP	3/31/2013 12:48	1.12	4.386	0.393	0.517	22.0	284	35.2	663
FMP	5/7/2013 10:30	0.561	2.52	0.223	0.401	34.7	125	43.2	>2419.6
FMP	6/9/2013 17:30	0.713	8.0	0.537	1.23	179	220	79.6	n/a

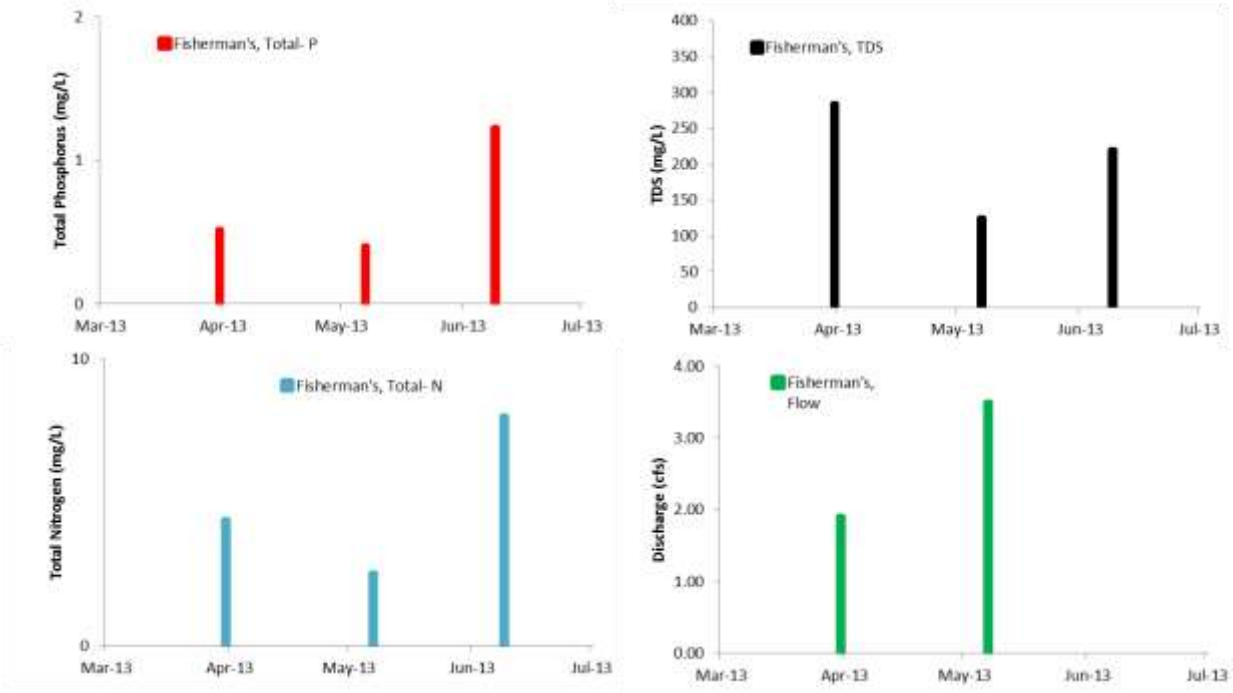

Figure 22. Total phosphorus, total nitrogen, total dissolved solids, and discharge for the grab samples collected at the outfall site at Fisherman's Park.

Greg St Outfall Site

The culvert drain underneath the driveway for American Ready Mix concrete company appeared to have substantial discharge nearly coincident with precipitation but with short duration. After numerous field visits during precipitation events when no discharge was observed, a focused sampling effort enabled sampling of substantial discharge on June 10th shortly after 5pm. This, also, was a site where stage measurements would have benefited the study by allowing the estimation of the delay between precipitation and discharge at the outfall site.

Grab samples were collected at the culvert outfall during only two selected runoff events in Water Year 2013. The two sampled events for this station were of varying length and intensity. The events of May 7th and June 10th had precipitation totals of 0.61 inches and 0.11 inches, respectively (Table 12). These precipitation measurements were taken at the Reno Tahoe International Airport, which is approximately 3 miles away from the outfall catchment. There were two samples taken for the event of June 10th, one for a 24-inch culvert that drains from the north and one for a smaller 12-inch culvert that drained from the west. The sample at 5:20 pm was from the north with greater discharge that was approximated to be above 2 cfs and found to have higher TDS than TSS. From the west draining culvert, discharge was less and TSS concentrations were greater than those for TDS.

Field measurements were taken at the Greg St station for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 19). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 20). This site has significant source(s) of contamination but modest discharge. It would be prudent to continue sampling this site with opportunistic grab sampling. In Table 31, we recommend that only a grab sampling regime continue, because of access, vandalism, and safety concerns, in addition to the moderate level of contaminant loading.

Table 19. Field measurements collected during sample collection times at the outfall monitoring site at Greg St.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
GS	5/7/2013 11:30	0.02	12.25	0.44	9.56	7.21
GS	6/10/2013 17:20	2.10	17.32	0.308	7.27	6.56
GS	6/10/2013 17:25	1.00	n/a	n/a	n/a	n/a

Table 20. Macronutrient concentrations, turbidity and E. coli from grab samples collected at the outfall monitoring site at Greg St.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
GS	5/7/2013 11:30	1.17	6.342	0.109	0.483	22.7	291	17.7	290.9
GS	6/10/2013 17:20	3.23	17.14	0.398	1.10	146	381	140	1078
GS	6/10/2013 17:25	n/a	n/a	n/a	n/a	382	185	170	n/a

Cottonwood Park Outfall Site

The culvert drain for this station was underneath Spice Island Drive in Sparks, near Cottonwood Park. Grab samples were collected at the culvert outfall during two selected runoff events in Water Year 2013. The two sampled events for this station were of varying length and intensity. The events of May 7th and June 10th had precipitation totals of 0.61 inches and 0.11 inches, respectively (Table 12). The precipitation measurements were taken approximately 3 miles away from the outfall catchment.

Field measurements were taken at Cottonwood Park station for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 21). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate

(PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 22). This site has significant source(s) of contamination but modest discharge. It would be prudent to continue sampling this site with opportunistic grab sampling. In Table 31, we recommend that only a grab sampling regime continue, because of access, vandalism, and safety concerns, in addition to the moderate level of contaminant loading.

Table 21. Field measurements collected during sample collection times at the Cottonwood Park outfall monitoring site.

Sampling Site (ID)	Sampling Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
Cottonwood Park	5/7/2013 11:10	0.02	13	0.136	9.61	6.94
Cottonwood Park	6/10/2013 16:53	1.00	18.98	0.412	6.84	6.68

Table 22. Analytic results from grab samples collected at the Cottonwood Park outfall monitoring site.

Sampling Site (ID)	Sampling Date Time	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Cottonwood Park	5/7/2013 11:10	0.594	3.35	0.068	0.502	21.3	88	30.5	691
Cottonwood Park	6/10/2013 16:53	3.03	29.0	1.23	2.73	598	602	262	7458

Oxbow Outfall Site

The culvert drain within the Oxbow Bend Park on Dickerson Rd drains a portion of northwest Reno. Grab samples were collected in a culvert drop-induring three runoff events in Water Year 2013 (Figure 23). The events of May 7th, June 25th, and June 28th had precipitation totals of 0.61 inches, 0.07 inches, and 0.01 inches, respectively (Table 12). For logistical reasons, the samples were likely collected during a falling hydrograph regime. Yet, the sustained discharge over the course of events at this drop-in suggest that the catchment was relatively large. The catchment may collect water from a residential and commercial area that tended to have relatively clean water (Tables 23 and 24). The low discharge measured at this station represents some point on the falling hydrograph, but was likely indicative of some substantial discharges earlier in the storm.

Field measurements were taken at Oxbow Bend for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 23). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 24). It would be advantageous to continue sampling this site with opportunistic grab sampling. In Table 31, we recommend that the grab sampling regime continue and that a real-time electrical conductivity sensor be installed because it would be safe and easy to access.

Table 23. Field measurements collected during sample collection times at the outfall monitoring site at Oxbow Bend.

Sampling Site (ID)	Sampling Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
OX	5/7/2013 12:55	0.10	12.06	0.135	11.47	8
OX	6/25/2013 17:33	0.25	15.97	0.333	7.44	7.37
OX	6/28/2013 19:15	0.15	20.38	0.209	7.01	7.07

Table 24. Macronutrient concentrations, turbidity and E. coli from grab samples collected at the outfall monitoring site at Oxbow Bend.

Sampling Site (ID)	Sampling Date Time	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
OX	5/7/2013 12:55	0.237	0.58	0.032	0.056	2.1	83	2.8	533.5
OX	6/25/2013 17:33	1.12	1.314	0.167	0.187	1.4	198	1	n/a
OX	6/28/2013 19:15	1.19	2.652	0.232	0.343	20.4	162	7.3	n/a

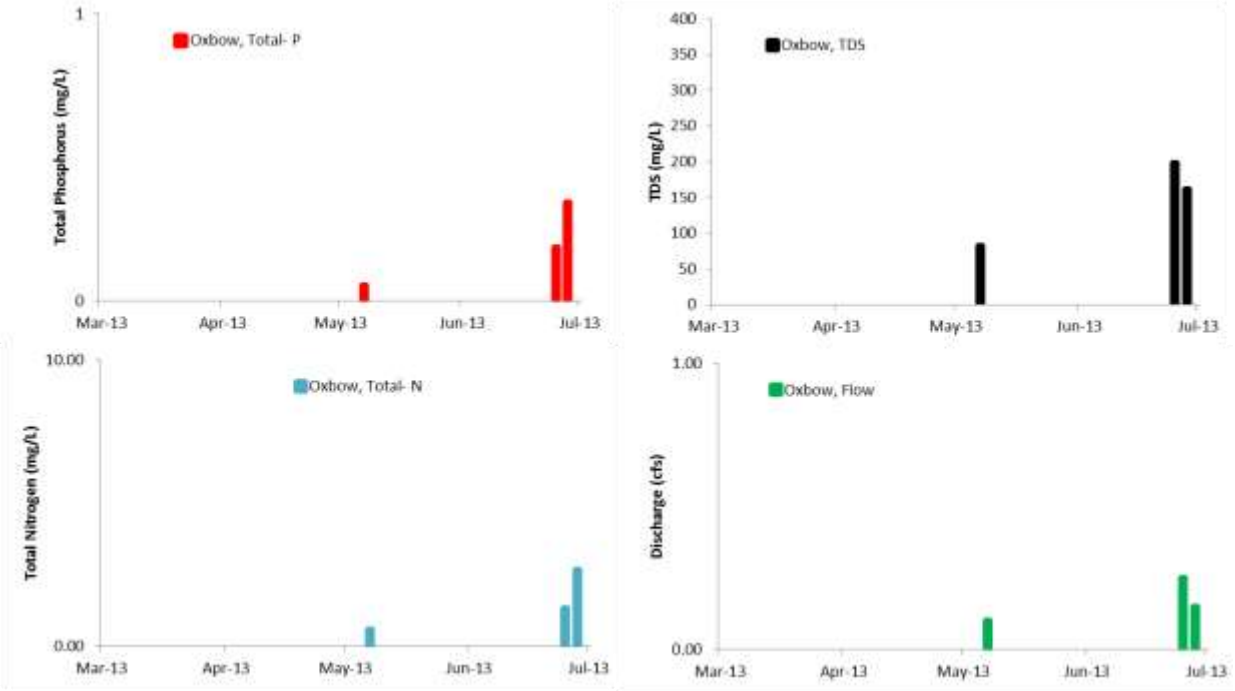

Figure 23. Total phosphorus, total nitrogen, total dissolved solids, and discharge for the grab samples collected at the manhole leading to the outfall at Oxbow Bend.

Vine St Outfall Site

The culvert drop-in underneath Vine Street, near 2nd St, represented a smaller catchment area than anticipated as a result of changes to the storm drain system made during the ReTRAC project. An effort has been made to identify a new sampling location that captures the storm runoff from the Old Northwest neighborhood in Reno, which was the original intent of this site. Grab samples were collected at the culvert during two storm events in Water Year 2013. The events May 7th and June 28th had precipitation totals of 0.61 inches and 0.01 inches, respectively (Table 25). The event of May 7th resulted in minimal discharges, 0.05 cfs. Conversely, the precipitation measured at the airport was unaffected by the highly localized and intense storm of June 28th, which inundated the drop-in, producing 3.5 cfs discharge. Of particular note was the decrease in discharge over the course of 42 minutes, which suggested relatively small catchment which discharged shortly after precipitation events for a relatively short duration. There was no sonde available for the event of June 28th.

Field measurements were taken at Vine St station for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 25). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 26). In Table 31, we recommend that the station be moved to a culvert that represents the discharge from the catchment of south Reno, east of Keystone Ave.

Table 25. Field measurements collected during sample collection times at the outfall monitoring site at Vine St.

Sampling Site (ID)	Sampling Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
Vine	5/7/2013 9:25	0.05	12.96	0.164	9.02	7.81
Vine	6/28/2013 18:08	3.50	n/a	n/a	n/a	n/a
Vine	6/28/2013 18:50	0.50	n/a	n/a	n/a	n/a

Table 26. Macronutrient concentrations, turbidity and E. coli from grab samples collected at the outfall monitoring site at Vine St.

Sampling Site (ID)	Sampling Date Time	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Vine	5/7/2013 9:25	0.795	3.72	0.174	0.370	32.5	112	45.1	>2419.6
Vine	6/28/2013 18:08	0.456	4.404	0.262	0.713	220	51	73	n/a
Vine	6/28/2013 18:50	0.046	11.156	1.13	1.91	59.5	211	32.3	n/a

Dickerson Rd Outfall Site

This station was removed from the sampling scheme after consultation with SWPCC staff. Water from the Truckee River was mixing with storm water at the collection site due to the close proximity of the river and the lack of elevation gain to the site; i.e., river water is backing up into the outfall, precluding the acquisition of a representative sample from the upstream catchment. A feasible alternative for the Dickerson Rd sampling site was not identified before the end of the pilot study. In Table 31, we recommend that the station be moved to an upstream culvert.

Teglia Outfall Site

The Teglia station was located at the culvert drain overflow for Paradise Pond. This station was rarely found to be wet during precipitation events. Grab samples were collected at the culvert outfall during only one runoff event in Water Year 2013. While the station was inspected during most events in Sparks, Paradise Pond did not overflow in to the culvert except on June 10th. The event of June 10th had a daily precipitation total of 0.11 inches, though precipitation measurements were taken miles away from the outfall catchment. This event resulted in low discharge in to the culvert, but a sample was collected.

Field measurements were taken at Teglia station for discharge, water temperature, specific conductivity (EC), dissolved oxygen (DO), and pH (Table 27). Grab samples were collected for laboratory analysis of nitrate (NO3-N), total nitrogen, orthophosphate (PO4-P), total suspended solids (TSS), total dissolved solids (TDS), turbidity, and Escherichia coli (E. coli, Table 28). This site was neither a significant source(s) of contamination nor discharge. Yet, it would be prudent to continue sampling this site with opportunistic grab sampling. In Table 31, we recommend that only a grab sampling regime continue.

Table 27. Field measurements collected during sample collection times at the outfall monitoring site at Teglia.

Sampling Site (ID)	Sampling Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
TG	6/10/2013 16:00	0.05	23.36	1.204	9.76	8.95

Table 28. E. coli from grab samples collected at the outfall monitoring site at Teglia outfall monitoring site.

Sampling Site (ID)	Sampling Date Time	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
TG	6/10/2013 16:00	0.002	1.20	0.091	0.221	9.4	768	7.2	330

CONTAMINANT LOADINGS IN OUTFALLS AND TRIBUTARIES

Water quality loads, specifically those for macronutrients and sediment, are difficult to accurately quantify. In general, the accuracy and precision of load estimation will increase with the frequency of sampling. Methods for estimating loads have been established that are based on the concentration of grab samples and discharge (EPA-841-B-03-004). When using grab sampling to quantify loads, the concentration of water quality parameters is known for one specific time and place when the grab sample was collected. In the ratio method referenced above, the concentrations in the grab samples are correlated to the discharge that was measured continuously to arrive at an estimate of load. Though this method of quantification produces only a rough estimate of load and has limited utility, the information may be used for comparing a number of outfalls or tributaries to determine how to focus future sampling efforts. Estimates of which tributaries or outfalls might be producing the most substantial loads could be assessed using this method to prioritize the sites for more rigorous investigations.

The grab sample or "snapshot" approach leaves many gaps in our knowledge and there are many more rigorous approaches that will likely produce more accurate results though may be outside the scope of budget and necessity for the system being evaluated. Without knowing certain key factors about the storm event runoff, we cannot make determinations about the most problematic stormwater outfalls: 1) where on the hydrograph was the grab sample collected, and 2) what were the concentrations of contaminants before and after the sample. Grab sampling at short and regular intervals from one station during an event would have allowed for increased knowledge of the overall contaminant loading to the river, but at great time investment and analytical cost. In order to calculate macronutrient and sediment loads more accurately during an entire event, some surrogate parameter would need to be monitored in real-time, e.g.—specific conductance for TDS, or turbidity for TSS. Interpretation of the lab analyses should be tenuously considered without the greater context of site-specific precipitation rates and discharge rates. Though it is possible to approximate the instantaneous loading at the ungagged outfall stations, there remain questions about the changing concentrations of contaminants over time, especially for flashy catchments such as the sampled outfalls. Discharge of large water volumes during a precipitation event can be a driver of decreased water quality through mobilization of detrimental constituents. The unknown residence time of standing water, either within the channel or through culverts, can be important to contaminant concentrations. The ratio of nitrite to nitrate concentrations reported suggests that, while nitrate is considered to be more environmentally detrimental, it was highest in concentration during low-discharge scenarios. Convention dictates that higher discharge should produce higher degradation of water quality inputs. The load versus concentration question usually is dependent on water discharge levels, but this is not always the case (Susfalk *et al*., 2007).

Because the discharge for many of the outfall sites and some of the tributary sites was not measured continuously during the current study, load estimation over time cannot be made with the information available. The characteristics and concentrations in the grab samples and the

discharge collected during the sampling events (i.e. instantaneous load) could be used in developing the correlation of concentration to discharge, and may be used in load estimation in future studies were discharge is collected continuously. For tributary sites where the discharge was collected continuously, a Ratio (EPA-841-B-03-004) or similar method may be used to obtain a rough estimate of load over time.

The instantaneous loadings were calculated (where data is available) for the nine outfall and eleven tributary sites of this study, then averaged to give greater weight to the results (Table 29). The units selected were the number of colonies delivered per second for E. coli, and the grams delivered per second for macronutrients and sediments. As these are instantaneous calculations, loading units were chosen to be of comparable scale to the sample timing, giving contextual perspective for their applicability. For the tributary sites, instantaneous loadings were calculated for each historical grab sample, and then seasonally averaged (Table 30). These seasonal averages allow for enhanced perspective of temporal and spatial changes in delivery loads from each tributary site. The higher discharges of spring contain greater loadings of contaminants than the lower flows of fall, for example, for most stations.

Table 29. Instantaneous loading calculations from grab samples collected at the nine outfall stations for the year 2013. The values were averaged over the total number of grab samples from each station.

Sampling Site (ID)	Sample Count	NO3-N (g/min)	TN (g/min)	PO4-P (g/min)	TP (g/min)	TSS (g/min)	TDS (g/min)	E. coli (#10^5/sec)
Arlington	5	0.20	3.89	0.31	0.61	141	66	5.56
GregSt	3	5.78	30.68	0.71	1.97	390	561	3.21
Mary Wahl	3	1.00	2.95	0.21	0.38	33	195	12.88
Fisherman's	3	3.48	14.56	1.30	2.03	139	830	13.77
Cottonwood Park	2	2.58	24.72	1.05	2.33	508	513	10.58
Vine	3	0.94	11.99	0.84	1.96	454	164	0.34
Oxbow	3	0.27	0.44	0.05	0.06	2	46	0.15
Lower Alum	4	0.03	0.30	0.03	0.06	42	326	0.43
Teglia	1	<0.01	0.10	0.01	0.02	1	65	0.05

Table 30. Instantaneous loading calculations from grab samples collected at the eleven tributary stations for the years 2003 to 2013. The values were averaged over the total number of seasonal grab samples from each station.

Sampling Site (ID)	Season	Sample Count	Discharge	NO3-N (g/min)	TN (g/min)	PO4-P (g/min)	TP (g/min)	TSS (g/min)	TDS (g/min)	E. coli (#10^5/sec)
RR	winter	9	6.5	5.19	12.42	0.75	1.17	36	2612	--
RR	spring	16	13.6	3.05	18.67	1.59	2.30	183	2885	18.12
RR	summer	7	1.5	0.13	1.88	0.60	0.38	6	632	--
RR	fall	7	5.8	0.59	9.06	0.48	1.10	176	1957	--
NR	winter	2	12.5	--	14.81	3.72	4.93	--	13466	--
NR	spring	6	20.2	0.69	28.45	7.97	10.30	1318	16675	--
NR	summer	2	8.7	--	13.30	4.84	6.05	--	11852	--
NR	fall	2	9.7	--	11.88	3.49	4.37	--	14529	--
CWW	winter	9	40.3	29.75	157.88	9.83	15.74	3164	31779	--
CWW	spring	16	33.8	14.35	67.24	13.30	14.72	2044	22054	--
CWW	summer	7	36.6	14.49	88.17	11.18	16.51	1832	24894	--
CWW	fall	7	34.6	171.92	153.84	7.21	13.42	1928	25608	--
KL	winter	9	15.7	8.44	49.42	6.31	7.13	785	17586	--
KL	spring	16	9.2	4.96	20.97	1.69	3.60	249	6892	--
KL	summer	7	12.6	2.37	28.44	1.62	3.63	443	9847	--
KL	fall	7	25.3	20.56	83.91	2.45	29.23	679	27123	--
OR	winter	9	1.3	1.91	9.06	0.41	0.78	396	3049	--
OR	spring	17	3.3	2.59	11.00	0.48	1.84	149	2764	--
OR	summer	7	2.4	1.20	9.40	0.33	0.69	77	3215	--
OR	fall	7	7.2	5.83	51.93	0.46	3.23	564	14333	--
UTC	winter	9	2.9	0.48	1.24	0.23	0.30	14	567	--
UTC	spring	16	5.7	0.75	2.42	0.27	0.55	68	865	--
UTC	summer	6	1.8	1.29	0.61	0.11	0.20	16	288	--
UTC	fall	7	2.5	0.05	0.84	0.11	0.21	16	438	--
LTC	winter	10	2.4	0.18	1.39	0.07	0.28	31	475	--
LTC	spring	16	1.8	0.13	2.45	0.19	0.32	45	329	--
LTC	summer	7	2.3	0.75	2.86	0.08	0.45	76	443	--
LTC	fall	6	0.8	0.02	0.41	0.14	0.12	3	164	--
UWC	winter	9	3.6	0.34	1.08	0.14	0.14	13	480	--
UWC	spring	16	6.0	0.41	1.98	0.27	0.34	180	592	3.04
UWC	summer	9	2.7	0.08	0.94	0.11	0.14	22	330	--
UWC	fall	7	3.0	0.05	0.65	0.29	0.17	31	480	--
LWC	winter	9	1.8	0.55	0.65	0.09	0.17	64	281	--
LWC	spring	16	3.8	3.47	1.95	0.15	0.39	201	419	21.78
LWC	summer	7	2.1	1.59	2.10	0.10	0.49	102	306	--
LWC	fall	7	2.0	3.03	0.56	0.02	0.13	55	271	--
CC	winter	5	1.3	--	8.49	0.79	0.91	--	4916	--
CC	spring	9	0.8	1.79	4.54	0.61	0.80	188	3191	<0.01
CC	summer	6	0.5	--	4.94	0.29	0.31	--	2066	--
CC	fall	6	0.9	--	7.11	0.74	0.78	--	2667	--
LAC	winter	0	--	--	--	--	--	--	--	--
LAC	spring	4	0.9	0.03	0.39	0.05	0.08	42	347	0.43
LAC	summer	2	0.7	--	1.07	0.17	0.28	70	317	--
LAC	fall	0	--	--	--	--	--	--	--	--

The primary value of these calculations can be found in qualitative, and comparative analyses. The smaller catchment culverts of Fisherman's Park, Cottonwood Park, Vine St, and Greg St tend to have higher loadings of macronutrients and sediment than the others. Arlington, Oxbow, and Lower Alum tend to flow more often and heavily and therefore may flush contaminants over a longer period of time, which would not be captured by the grab sampling method employed in this study. Fisherman's Park appears to be the only outfall that is relatively high in both flow and concentration of contaminants on a regular basis. For the tributaries, the watershed terminuses of the North Truckee Drain and Steamboat Creek, or the stations NTD @ Kleppe and Steamboat @ Clean Water Way, respectively, were much higher in deliveries of most nutrients and suspended and dissolved solids to the Truckee River. This result was expected for the outlets of the two largest watersheds in this study.

Grab sampling, as conducted in this pilot project, was not the optimal scheme for determining the quality of water deliveries to the Truckee River. Higher frequency sampling will be needed to support accurate load estimation. Loading calculations would be more robust with more frequent grab sampling or a more comprehensive, automated sampling system that included real-time monitoring sensors. More detail about the need for real-time monitoring is provided in the recommendations section, CC.BB.

COMPARATIVE DATA ANALYSIS – OUTFALL SITES

Comparative distributions of data from field measurements and analytic results at the nine outfall sites sampled during 2013 are shown in Figures 24 through 35. Although discharge was not measured with every sampling at each site, due to considerations of access and safety, the data are represented in each plot when available but excluded if the corresponding analyte was not reported for that sampling date (Appendix A). Thus, the number of discharge measurements represented in these distributions varies by analyte and is sometimes less than the number of analytic data points (if discharge was not measured). Field measurements and analytic results from most sites consist of at least two to three or more data points collected during 2013, although the Teglia site was only sampled on one occasion (6/10/13). None of the field measurements (temperature, specific conductance, dissolved oxygen, pH) showed any significant relationship ($p<0.1$) to discharge in regression analysis, nor did any of the analytic results (nitrate, total nitrogen, orthophosphate, total phosphorus, total suspended solids, total dissolved solids, turbidity, E. coli).

Water temperature varied from about 10 to 20°C at most outfall sites during the sampling program, although the single measurement taken at Teglia during low discharge showed a somewhat higher temperature (23°C) than observed other sites. These temperatures are within expected ranges for drainages in the area during spring and summer.

Specific electrical conductance was also relatively consistent across sites, from about 0.1 to 0.7 mS/cm up to 1.2 mS/cm measured at Teglia. These values are consistent with clean runoff at the low range to typical road surface runoff at the higher range.

At most outfall sites the dissolved oxygen varied within a tight range from about 6 to 10 mg/L, which is healthy for aerobic aquatic systems, although one higher concentration was observed at Oxbow (11.5 mg/L) and a low concentration occurred at Mary Wahl (3.1 mg/L) on 6/9/13.

The pH ranged from 6.5 to 8.0, which is close to neutral and typical for the area, although one relative alkaline sample was collected at Teglia (8.95) and another at Arlington (9.6) on 5/7/13. There was no relationship between measurements of discharge and pH.

Nitrate concentrations were also quite low, ranging from the 0.002 mg/L to 1.72 mg/L, although two higher concentration samples (~3 mg/L) were collected at Cottonwood Park and at Greg Street on 6/10/13 during a runoff event (1-2 cfs) that may have intercepted or washed a localize source of nitrate from the surrounding landscape.

Total nitrogen concentrations show a typical lognormal distribution, with the bulk of samples between 0.2 to 5.0 mg/L and two high concentration samples (~29 mg/L) collected at Arlington Island and Cottonwood Park. One sample collected at Arlington Island on 6/9/13 measured 38 mg/L of TN. Total nitrogen mainly reflects the contribution of biological material, often organic material washed from the landscape. These high concentration TN samples generally corresponded to high nitrate concentrations collected at the same sites during the same runoff event (6/9/13 to 6/10/13).

Taken in aggregate the orthophosphate concentrations from outfall sites show a lognormal distribution, as commonly observed in nutrient analyses of stormwater samples. The bulk of the samples are low concentrations from 0.03 to 0.5 mg/L. Higher concentrations samples were collected at Arlington Island on three occasions (1.2–2.0 mg/L) and at both Cottonwood Park and at Vine on one occasion each (1.1–1.2 mg/L).

Total phosphorus concentrations were highly correlated with orthophosphate concentrations (Figure 36), also showing a lognormal distribution overall. High concentration samples generally corresponded to the same samples that demonstrated high concentrations of nitrogen.

Concentrations of total suspended solids, total dissolved solids and turbidity all followed lognormal distributions. Not surprisingly, the highest concentrations of TSS (1030–1620 mg/L) corresponded to the highest concentrations of turbidity (310–490 NTU). These were collected at the Arlington site on 6/9/13, when high concentrations of nitrogen and phosphorus were also observed at that site. A regression of the full set of outfall samples shows a good fit between TSS and turbidity (Figure 37), as well as a reasonable fit between TDS and SC (Figure 38). There was no corresponding evidence of any relationship between TSS and TDS concentrations.

The highest concentrations of E. coli (>7000 colonies/100 mL) were measured in samples taken at Mary Wahl and at Cottonwood Park during the 6/9/13 to 6/10/13 runoff event, followed by another relatively high concentration (>3500 colonies/100 mL) sample collected at Mary Wahl on 3/31/13. Otherwise E. coli samples ranged from a low of 291 colonies/100 mL to ~2500 colonies/100 mL.

Instantaneous loads can be calculated from sample results where discharge data is also available. Since these are only one point in time discharge and concentration measurements, however (and as noted in the previous section) it can be misleading to represent estimates of load from these data. Nonetheless, calculations show the following as being unusually high instantaneous loading rates compared to the rest:

- Greg Street (6/10/13) for nitrate;
- Greg Street (6/10/13) and Cottonwood Park (6/10/13) for TN;
- Cottonwood Park (6/10/13) and Vine (6/28/13) for orthophosphate;
- Cottonwood Park (6/10/13), Vine (6/28/13) and Greg Street (6/10/13) for TP;
- Vine (6/28/13) and Cottonwood Park (6/10/13) for TSS;
- Greg Street (6/10/13), Cottonwood Park (6/10/13) and Fisherman's (3/31/2013) for TDS;
- Fisherman's (5/7/13), Cottonwood Park (6/10/13), Mary Wahl (5/7/13) and Mary Wahl (6/9/13) for E. coli.

In terms of concentrations only, the following sites showed relatively high values compared to the rest:

- Greg Street (6/10/13) and Cottonwood Park (6/10/13) for nitrate;
- Arlington (6/9/13), Cottonwood Park (6/10/13) and Arlington (6/9/13) for TN;
- Arlington (6/9/13), Cottonwood Park (6/10/13), Arlington (3/31/13) and Vine (6/28/13) for orthophosphate;
- Arlington (6/9/13) and Cottonwood Park for TP;
- Arlington (6/9/13) for TSS;
- Teglia (6/10/13) was highest value for TDS;
- Arlington (6/9/13) and Cottonwood Park (6/10/13) for NTU;
- Mary Wahl (6/9/13) and Cottonwood Park (6/10/13) for E. coli.

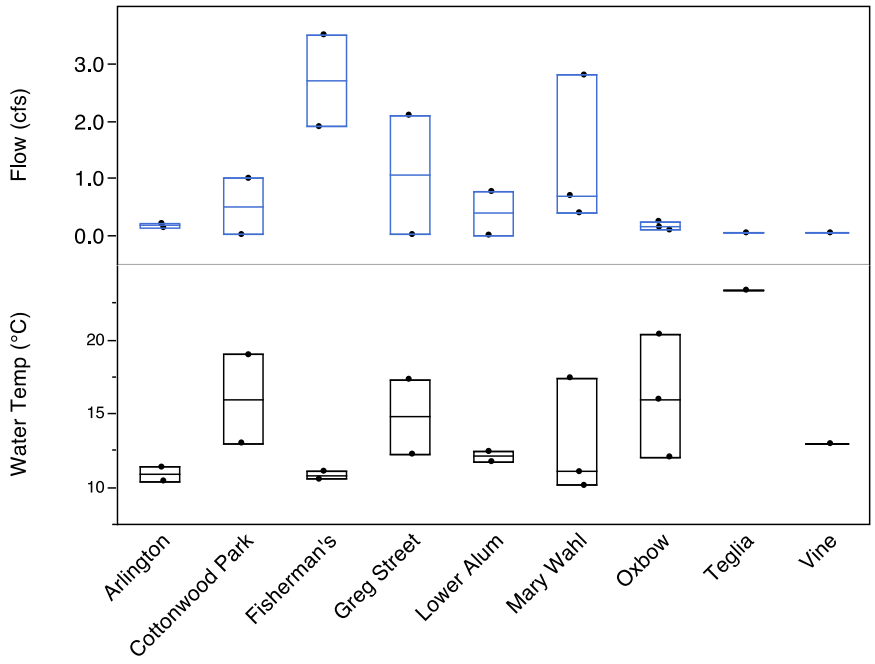

Figure 24. Water temperatures measurements at outfall monitoring sites during 2013. Discharges are not shown for dates when temperature measurements are not available.

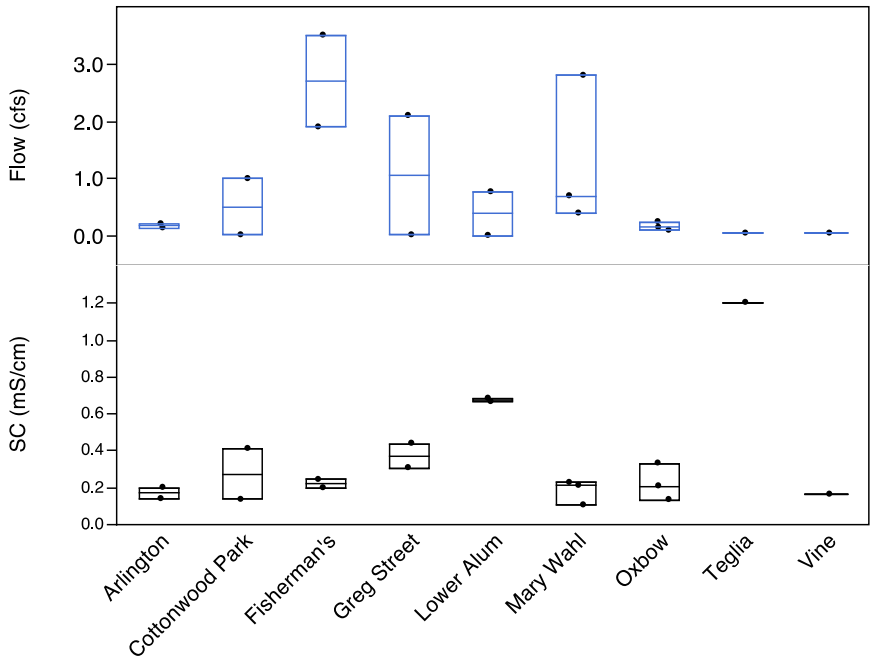

Figure 25. Specific conductivity measurements at outfall monitoring sites during 2013. Discharges are not shown for dates when conductivity data are not available.

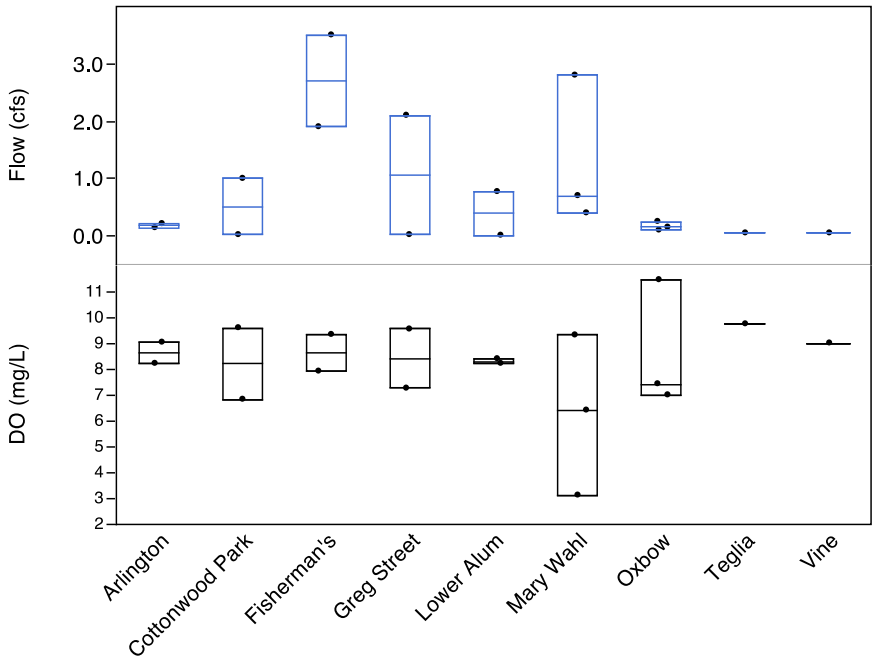

Figure 26. Dissolved oxygen measurements at outfall monitoring sites during 2013. Discharges are not shown for dates when DO data are not available.

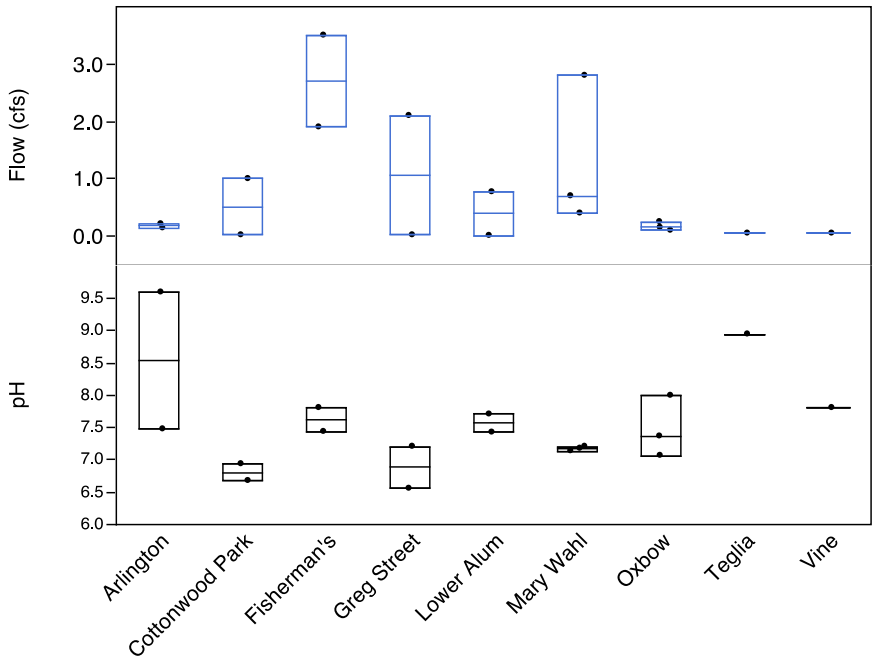

Figure 27. Water pH measurements at outfall monitoring sites during 2013. Discharges are not shown for dates when pH data are not available.

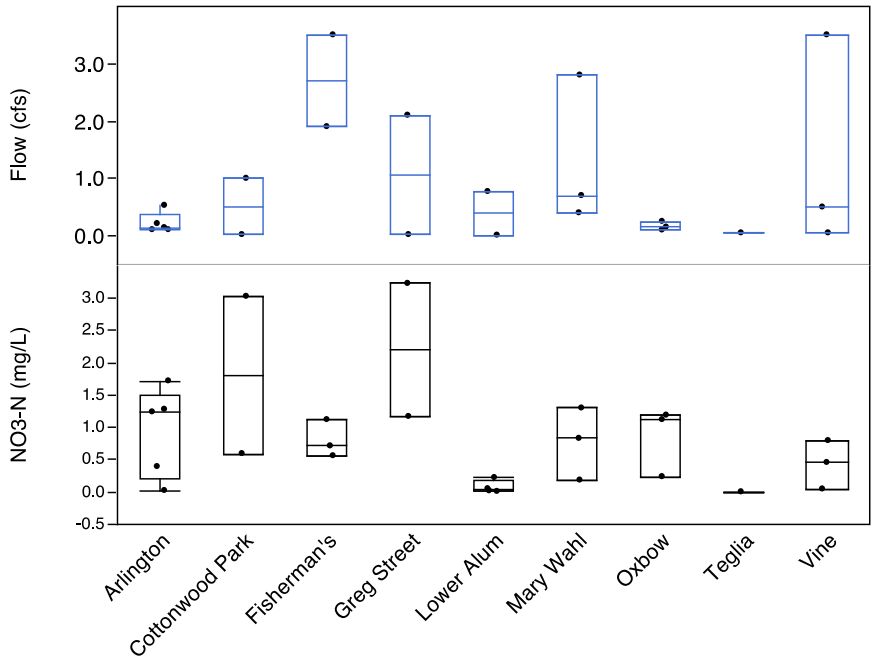

Figure 28. Nitrate concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when nitrate data are not available.

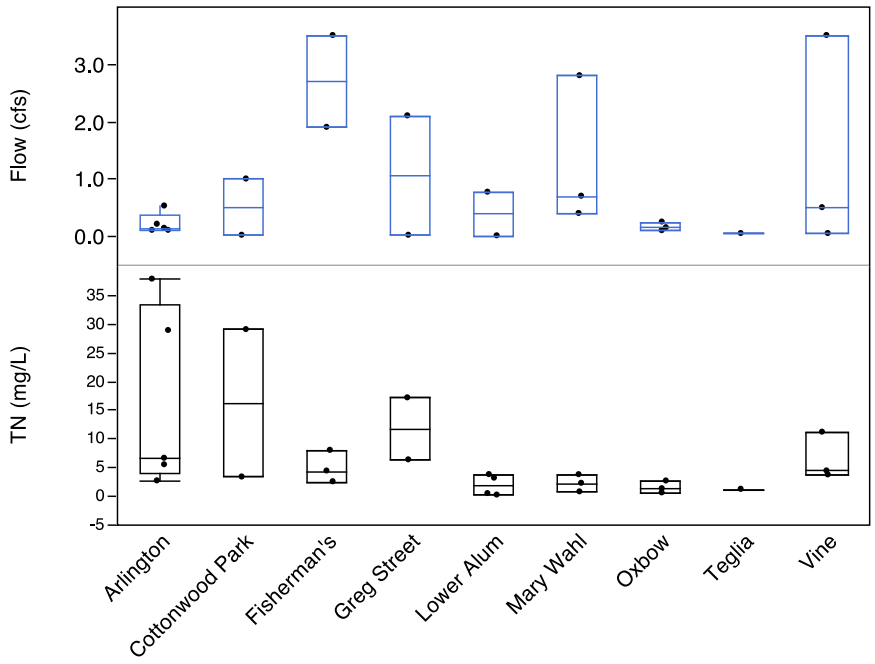

Figure 29. Total nitrogen concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when TN data are not available.

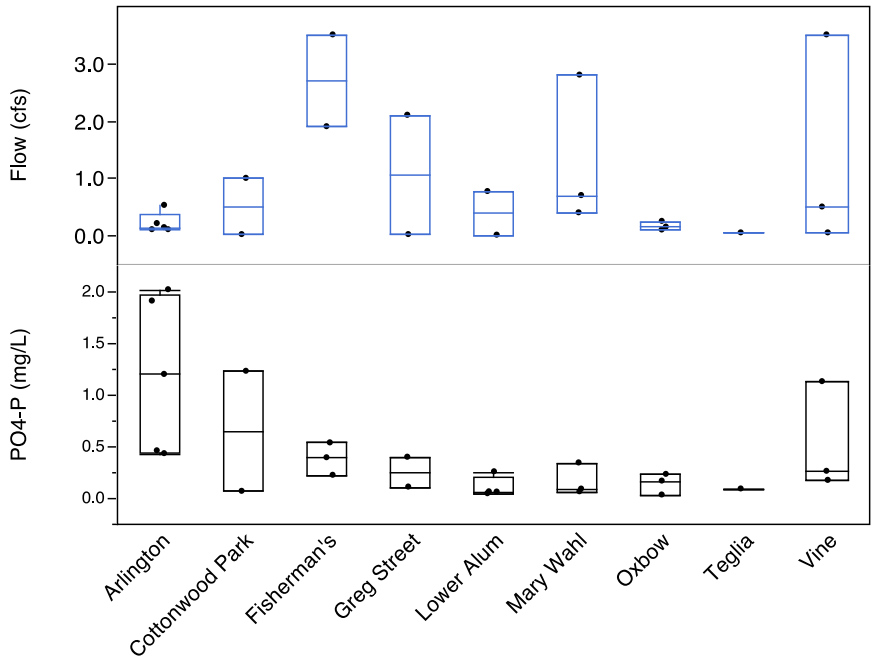

Figure 30. Orthophosphate concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when orthophosphate data are not available.

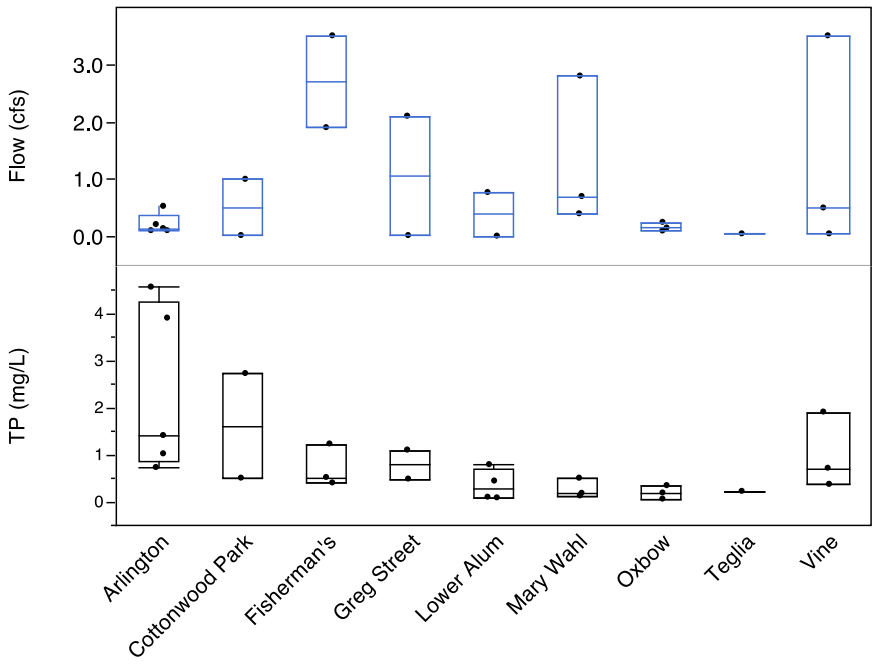

Figure 31. Total phosphorus concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when TP data are not available.

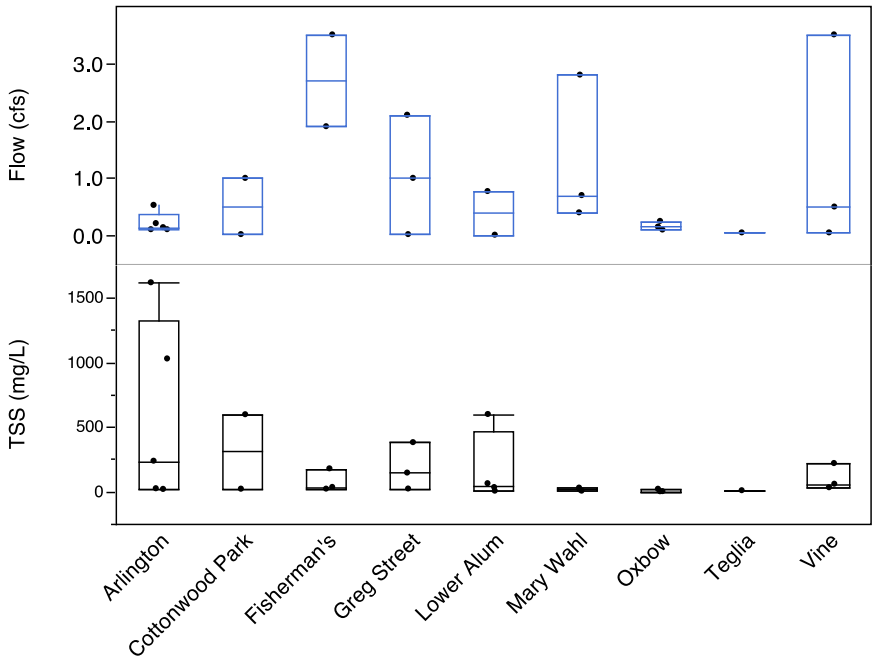

Figure 32. Total suspended solids concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when TSS data are not available.

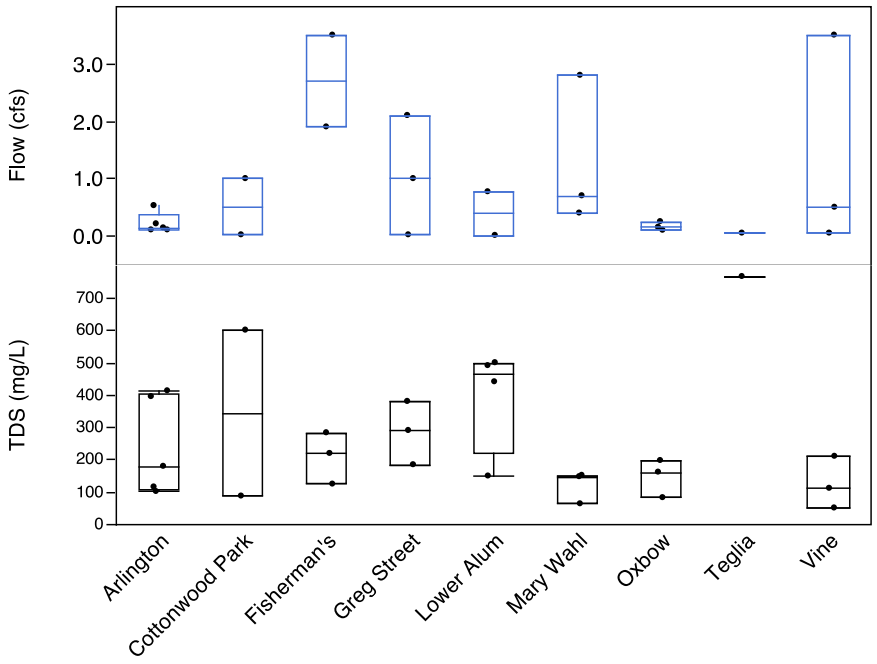

Figure 33. Total dissolved solids concentrations from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when TDS data are not available.

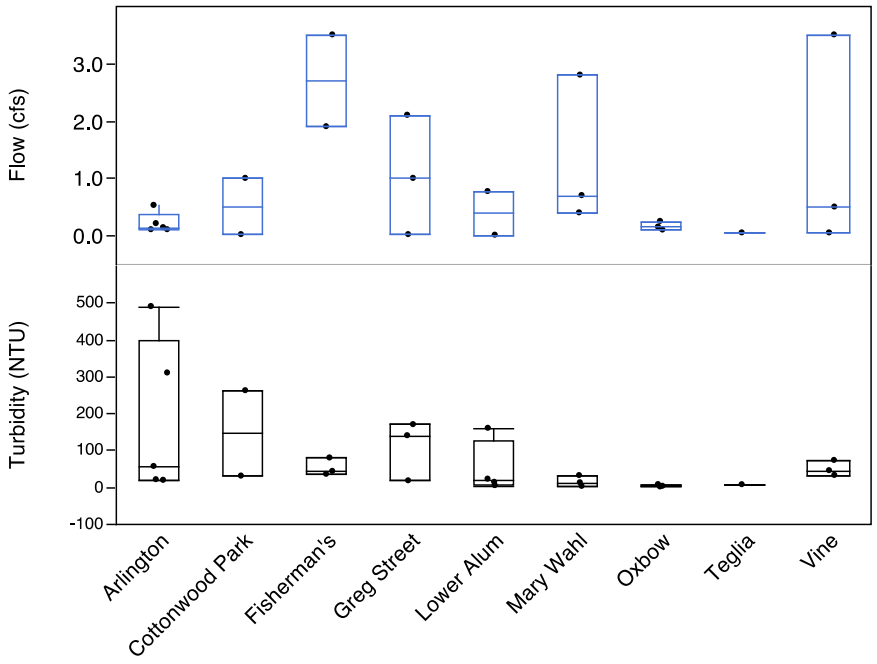

Figure 34. Turbidity measurements from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when turbidity data are not available.

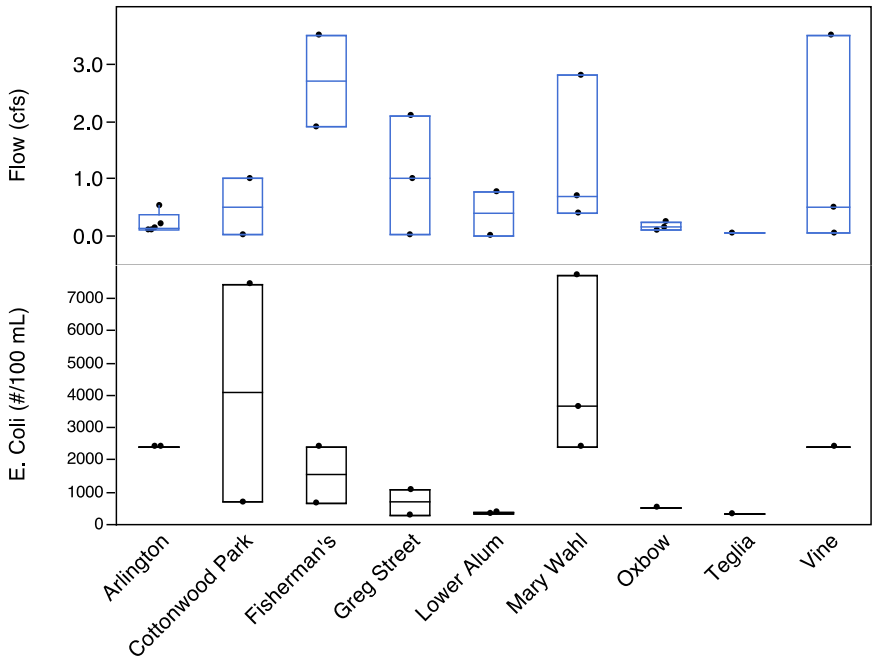

Figure 35. Escherichia coli data from samples taken at outfall monitoring sites during 2013. Discharges are not shown for dates when E. coli data are not available.

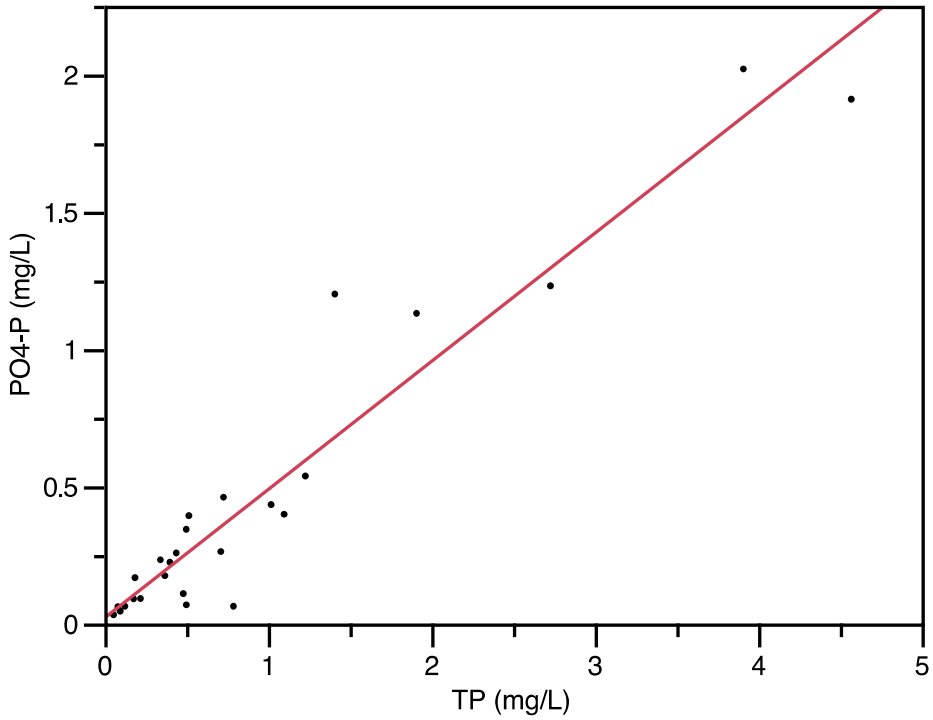

Figure 36. Bivariate plot of orthophosphate concentrations against total phosphorus from all samples taken at outfall monitoring sites during 2013. Orthophosphate-P concentrations are approximately half the corresponding TP concentrations (adjusted R2 = 0.91 with $p<0.0001$).

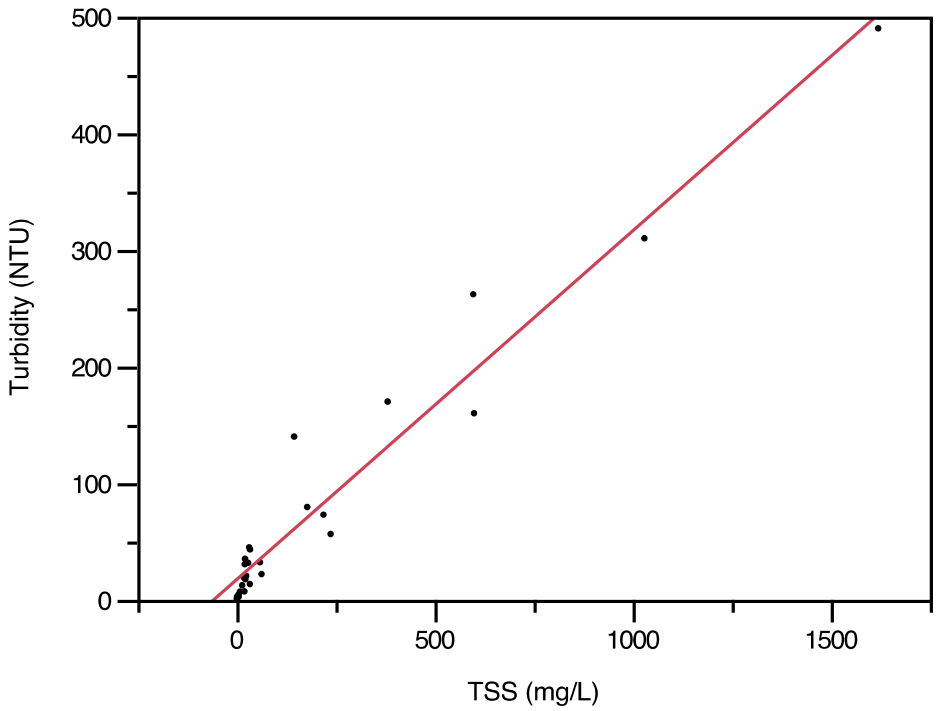

Figure 37. Bivariate plot of turbidity concentrations against total suspended solids from all samples taken at outfall monitoring sites during 2013. Turbidity values are about one-third the corresponding TSS concentrations (adjusted R2 = 0.95 with $p<0.0001$).

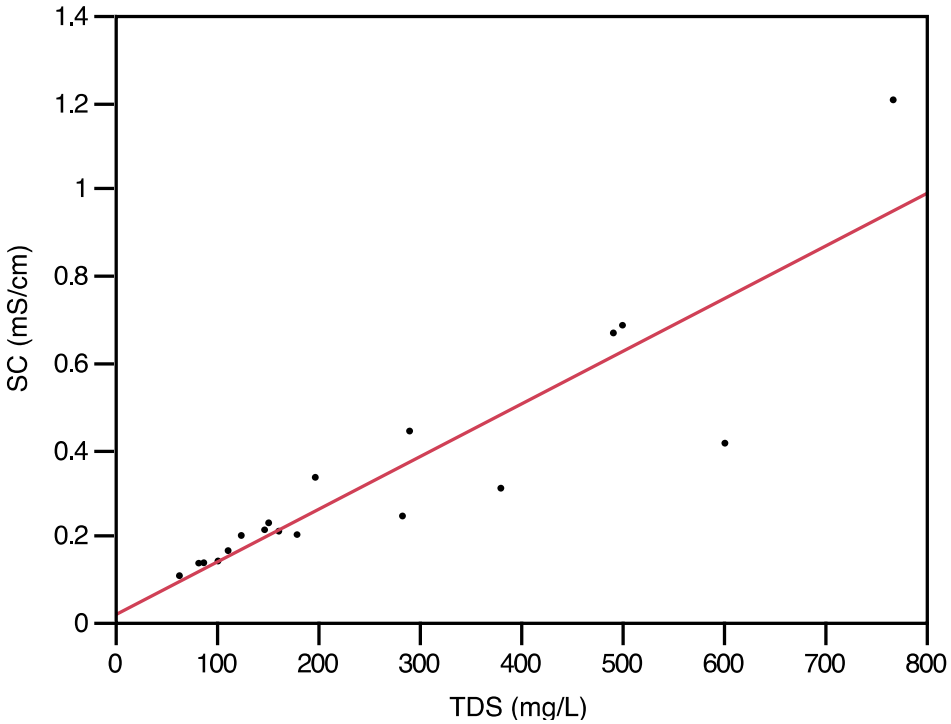

Figure 38. Bivariate plot of specific concentrations against total dissolved solids from all samples taken at outfall monitoring sites during 2013. Adjusted R2 = 0.80 with p<0.0001).

COMPARATIVE DATA ANALYSIS – TRIBUTARY SITES

Comparative distributions of data from field measurements and analytic results at the eleven tributary sites sampled from 2003 to 2013 are shown in Figures 39 through 50. All data prior to 2013 were downloaded from the Truckee River Information Gateway (TRIG) website (http://truckeeriverinfo.org). Field characteristics and samples analyses were not reported in all cases (Appendix B). Nonetheless, each set of field measurements and analytic results are represented by nearly 300 cases or more over the record of monitoring (2003 to 2013), except for nitrate (n=238), orthophosphate (n=132), total suspended solids (n=268), turbidity (n=35) and E. coli (n=15). Values reported as less than method detection limits (MDL) were substituted with entries set at one half the MDL for subsequent data analysis. Distributions of the aggregate data are approximately lognormal for all field characteristics and sample analytes, with the exception of water temperature, dissolved oxygen and pH, which show normal distributions.

Discharges varied from zero (dry channel) to about 100 cfs, with the highest range of discharges observed on Steamboat Creek at Clean Water Way, followed the Narrows site and then Rhodes Road. NTD@Kleppe showed the highest range of discharges outside of Steamboat Creek. None of the other field measurements (temperature, specific conductance, dissolved oxygen, pH) showed any significant relationship ($p<0.1$) to discharge in regression analysis, nor did any of the analytic results (nitrate, total nitrogen, orthophosphate, total phosphorus, total suspended solids, total dissolved solids, turbidity, E. coli).

Water temperature varied from about 0 to 25°C at most tributary sites over the record of monitoring, with Upper Whites Creek and Upper Thomas Creek showing the lowest ranges, while measurements at NTD@Orr, Narrows and Clean Water Way sites showed the highest ranges. Overall, these temperatures are within the expected ranges for tributaries in this area.

Specific conductance generally ranged up to about 3 mS/cm with a few excursions to higher values (which may be data errors). Chalk Creek demonstrated notably higher conductivity than at other sites, followed by NTD@Orr and Narrows.

Dissolved oxygen concentrations were usually between about 5 to 15 mg/L, representing aerobic conditions, although NTD@Orr showed a much broader range than other sites, followed by Clean Water Way.

The pH generally ranged from about 7.0 to 9.0, which is neutral to slightly alkaline. The most alkaline conditions were observed at the NTD@Orr site, followed by Clean Water Way.

Nitrate concentrations were highest in Chalk Creek, ranging from ~1 mg/L to over 3 mg/L. Concentrations at other sites more generally ranged from 0.1 mg/L to 0.8 mg/L, although NTD@Orr ranged somewhat higher than other sites. Alum Creek, Thomas Creek and Whites Creek were all in the low range for nitrate, although higher concentrations were evident at Lower Whites Creek compared to Upper Whites Creek.

Total nitrogen concentrations show greater variability among sites than nitrate. As with nitrate, however, both Chalk Creek and NTD@Orr show much higher ranges than the other sites. Lower Alum Creek also shows greater variability. Excluding those three sites, the range of TN concentrations generally ranged from about 0.1 to 3 mg/L. NTD@Orr site ranged from about 1 to 6 mg/L while Chalk Creek ranged from about 0.1 to 8 mg/L TN. There is some correlation between TN concentrations and nitrate, as well as with TDS and TP.

Median orthophosphate concentration overall was 0.1 mg/L, but concentrations ranged much higher at the Narrows site on Steamboat Creek and at Chalk Creek (>0.3 mg/L). Upper and Lower Whites Creek showed the lowest concentrations (<0.5 mg/L) followed by Upper Thomas Creek. Note, however, that orthophosphate was measured intermittently, so the record of results from sample analysis is much lower (n ~130) compared to other analytes (n ~300).

Median total phosphorus concentration was only 0.12 mg/L overall. Higher ranges in TP concentrations were observed at the Narrows, NTD@Orr and Lower Alum Creek sites. There is a moderate correlation between TP concentration and orthophosphate (regression yields adjusted $R2=0.56$ with $p<0.0001$), as well as some correlation with TN and TDS.

Concentrations of total suspended solids, total dissolved solids and turbidity all followed lognormal distributions. High concentrations of TSS (>50 mg/L) generally correspond to high concentrations of turbidity (>30 NTU). Note, however, that there were much fewer turbidity sample measurements (n=35) compared to the TSS measurements (n=267). The regression of TSS against turbidity for tributary sites shows a good fit (Figure 51), as well as between TDS and SC. Interestingly, a subset of Chalk Creek samples collected since September 2009 show a distinct offset from the regression line for all other samples (see Figure 52).

There is not much data on E. coli from tributary samples (n=15). However, Lower Whites Creek shows much higher concentrations (>2000 colonies/100 mL) than the other tributary sites.

Summarizing observations from tributary measurements and analytic results:

- Chalk Creek, NTD@Orr and Narrows showed highest range of specific conductance;
- NTD@Orr and Clean Water Way had wider ranges of dissolved oxygen concentrations and higher pH compared to other sites;
- Chalk Creek and NTD@Orr had the highest nitrate and TN concentrations;
- Narrows, Chalk Creek and NTD@Orr sites had the highest orthophosphate concentrations, although data was sparse;
- Narrows, NTD@Orr and Lower Alum Creek had high TP concentrations compared to other sites;
- Chalk Creek samples had high concentrations for TSS and TDS;
- Not many samples have been collected for E. coli analysis, but Lower Whites Creek showed the highest concentrations among tributary sites.

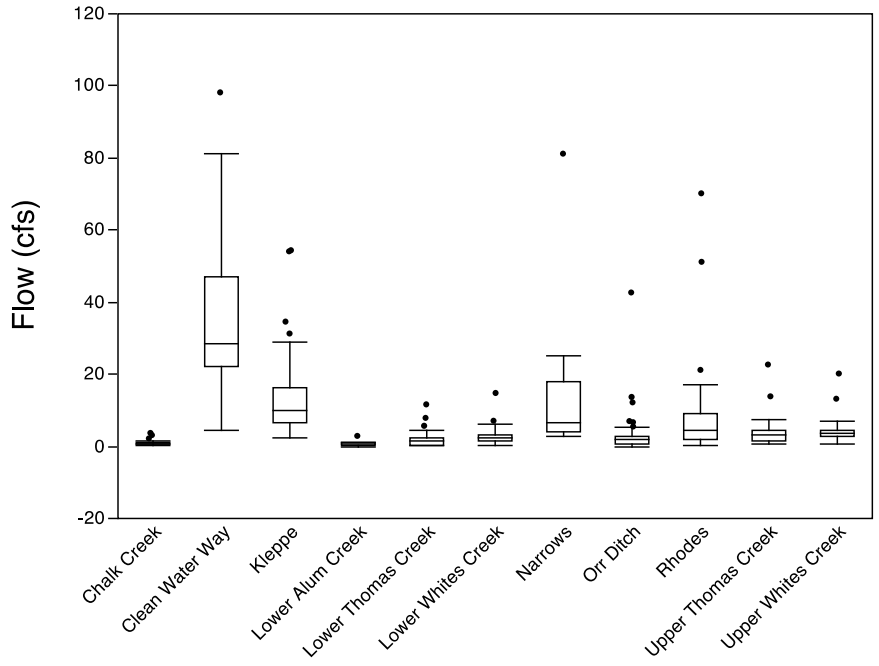

Figure 39. Distributions of discharge measurements at tributary monitoring sites from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

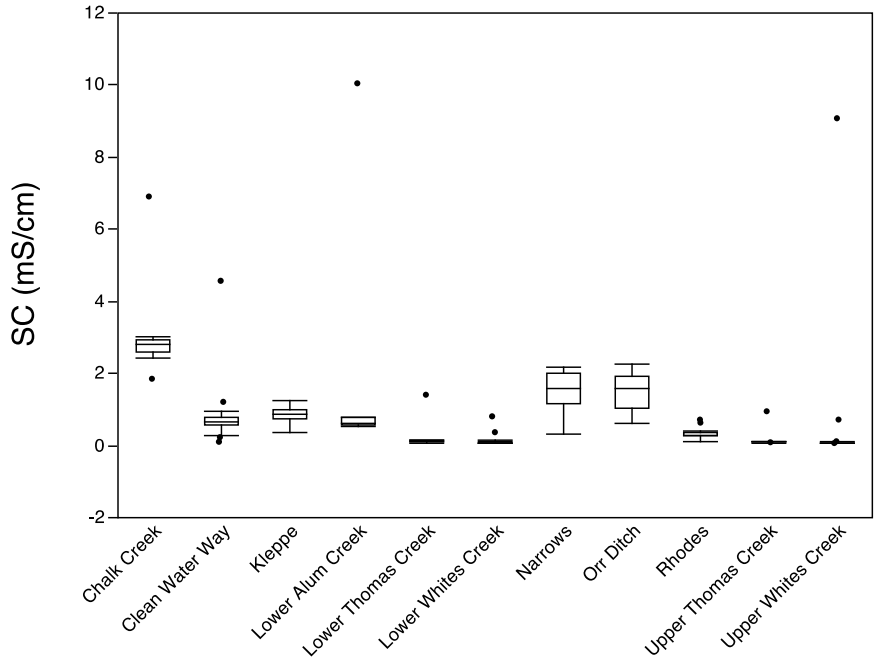

Figure 40. Distributions of specific conductance measured at tributary monitoring sites from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

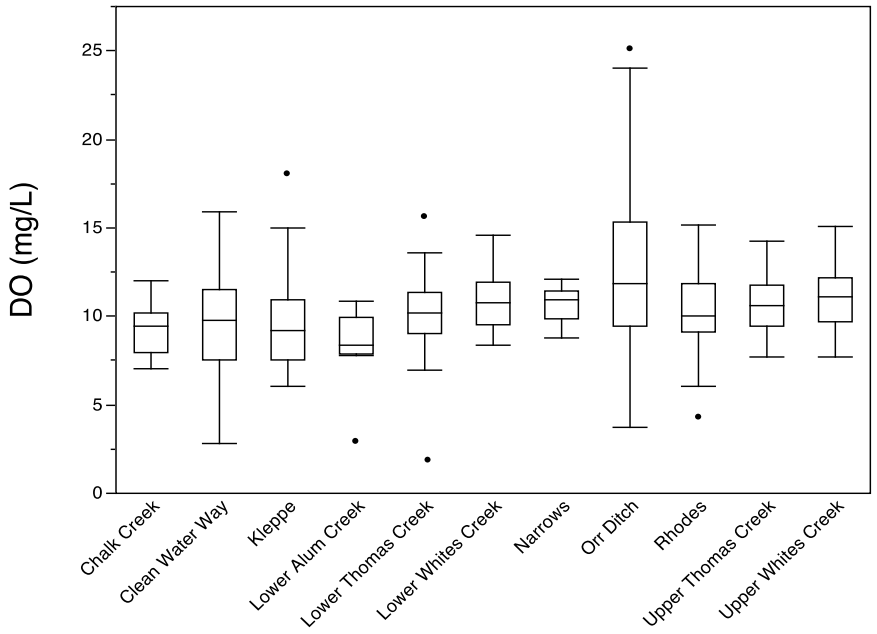

Figure 41. Distributions of dissolved oxygen measured at tributary monitoring sites from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

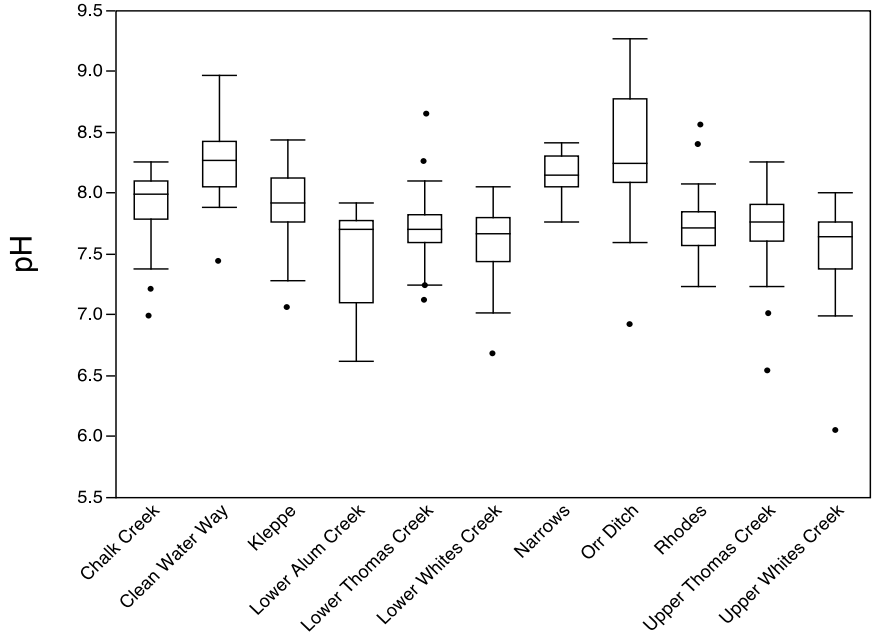

Figure 42. Distributions of pH measured at tributary monitoring sites from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

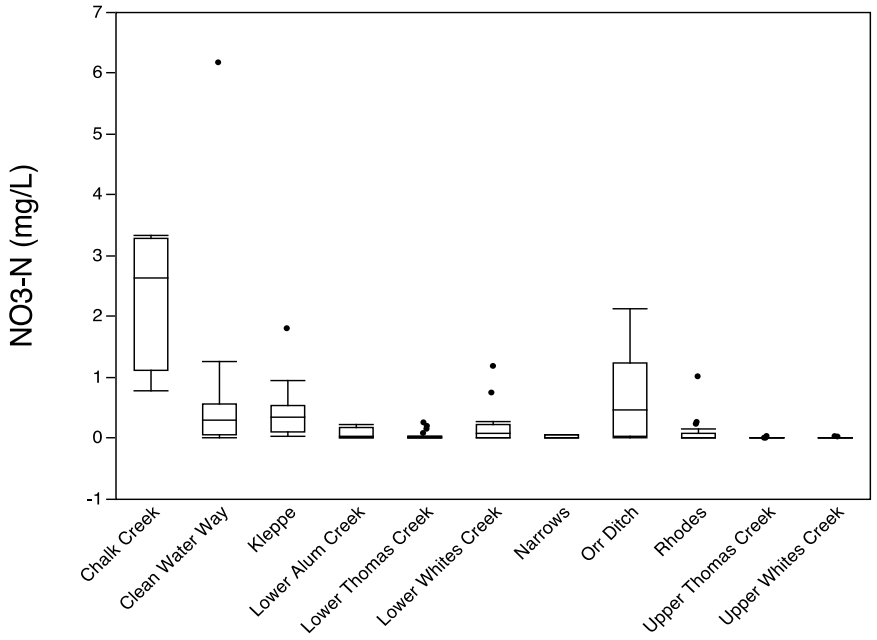

Figure 43. Distributions of nitrate measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

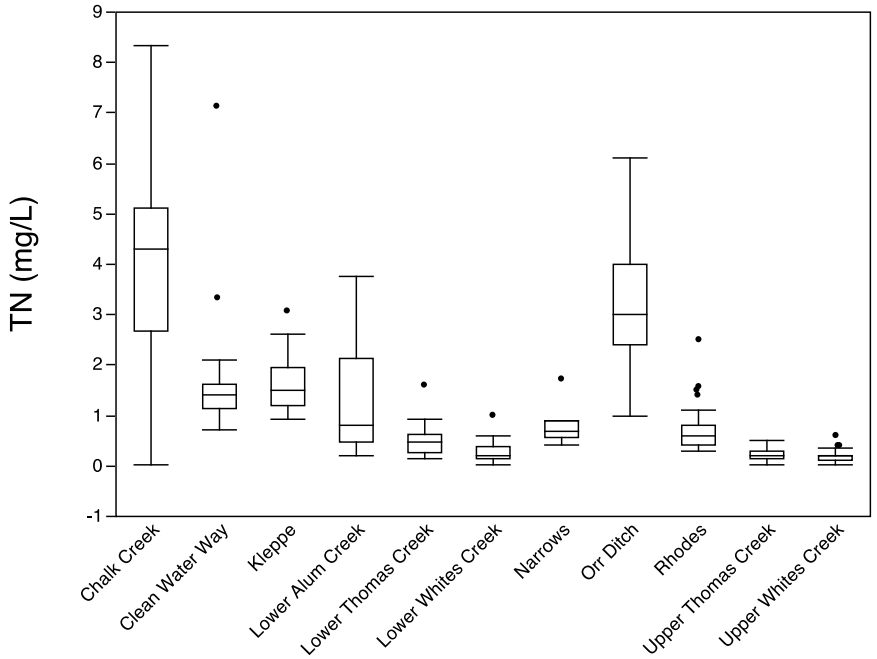

Figure 44. Distributions of total nitrogen measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

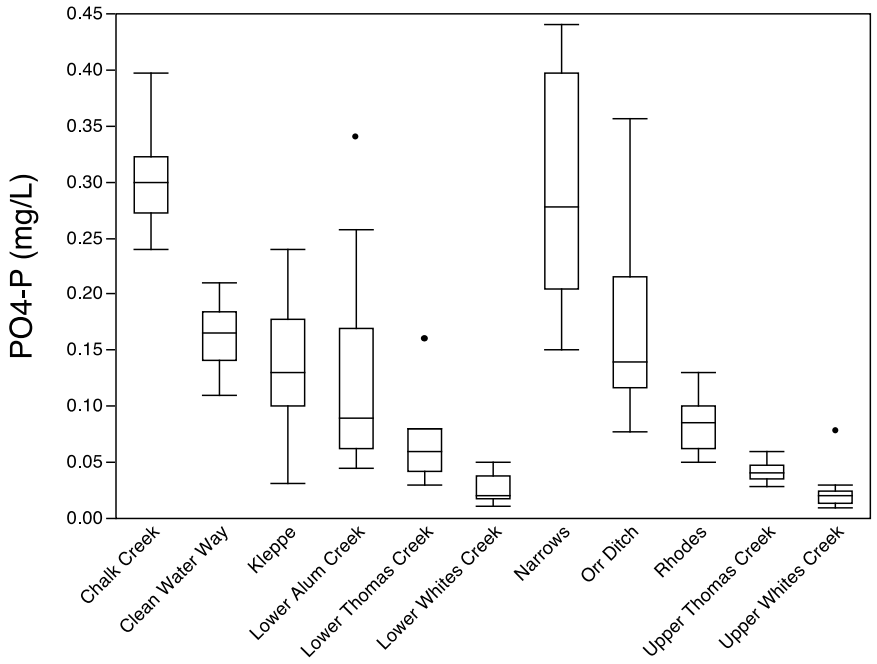

Figure 45. Distributions of orthophosphate measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

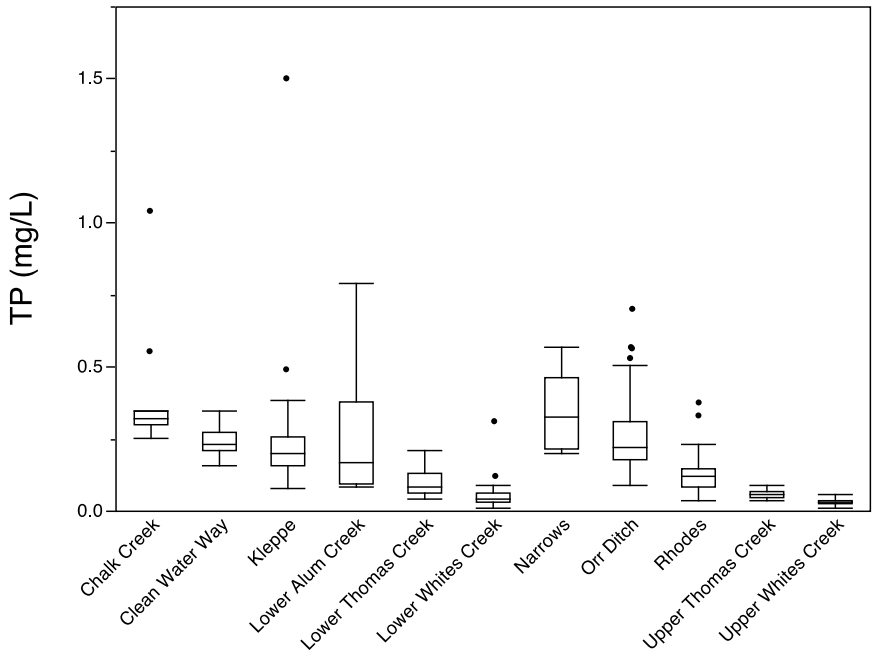

Figure 46. Distributions of total phosphorus measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

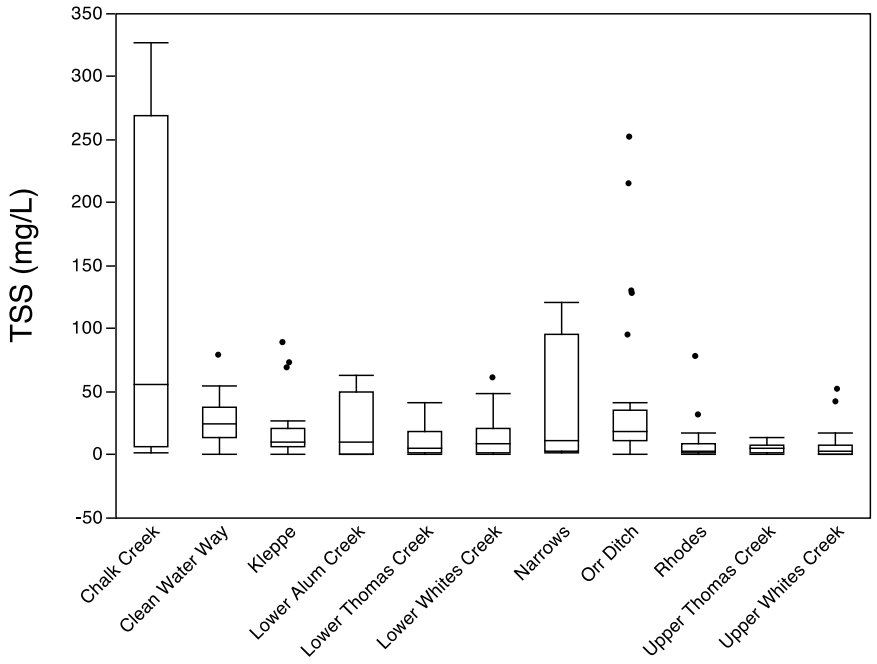

Figure 47. Distributions of total suspended solids measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

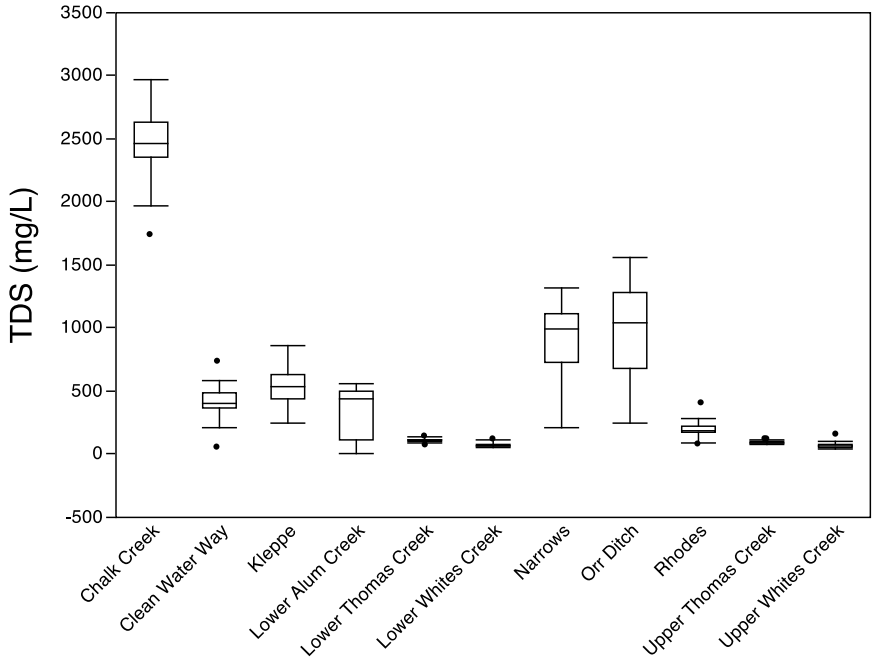

Figure 48. Distributions of total dissolved solids measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

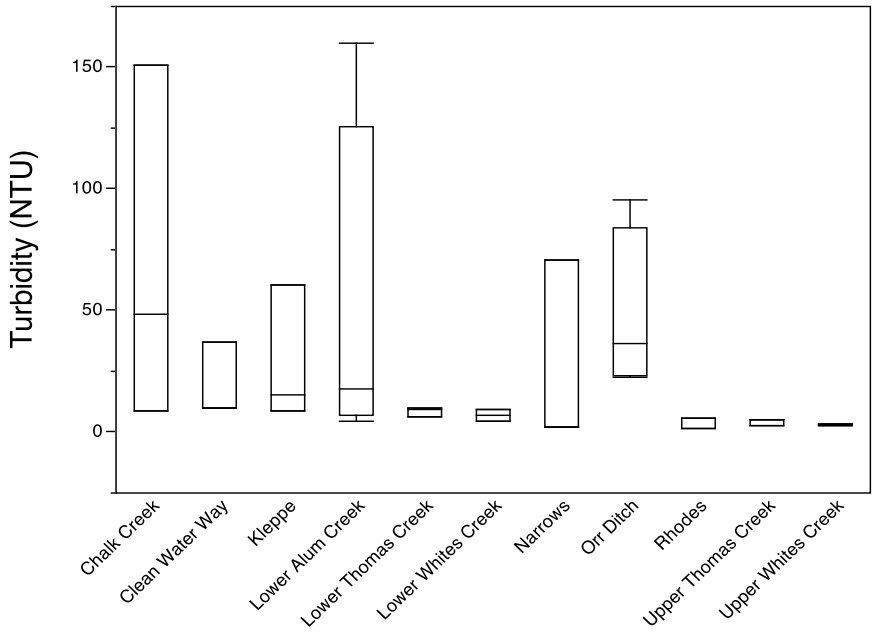

Figure 49. Distributions of turbidity measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

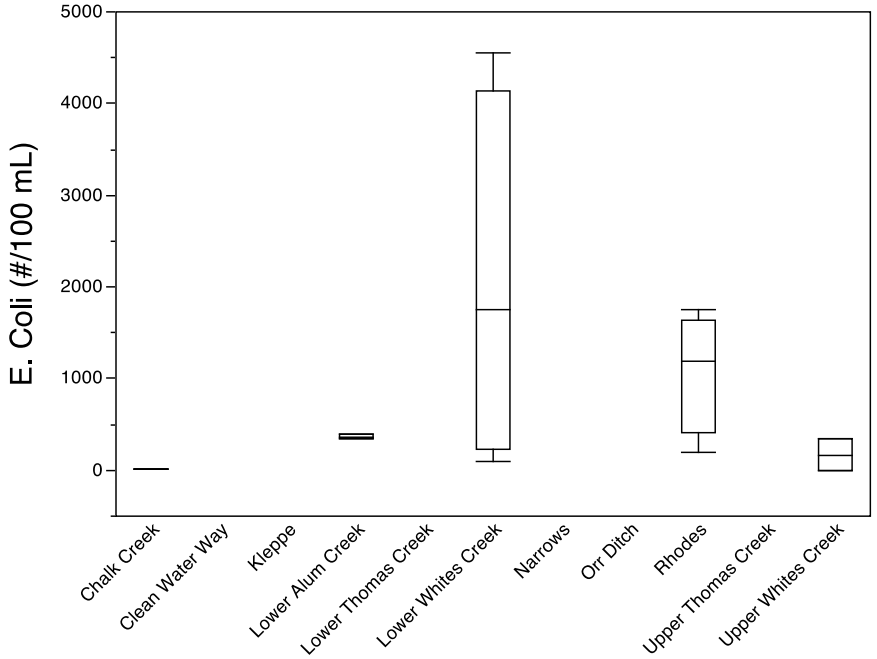

Figure 50. Distributions of Escherichia coli measured in tributary monitoring site samples from 2003 to 2013. Kleppe = North Truckee Drain at Kleppe and Orr Ditch = North Truckee Drain at Orr.

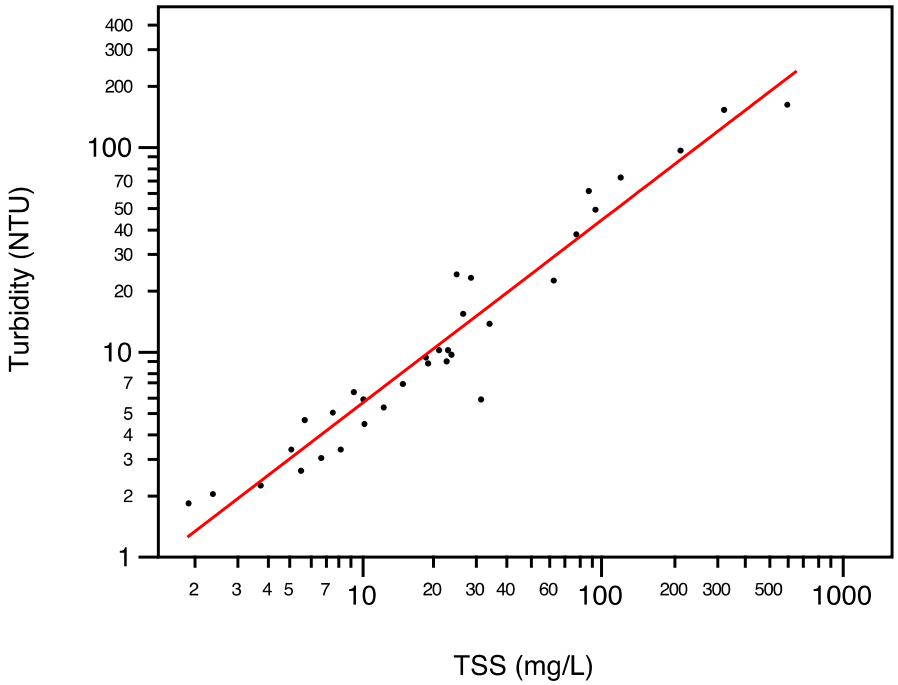

Figure 51. Bivariate plot of turbidity concentrations against total suspended solids from all samples taken at tributary monitoring sites 2003 to 2013. Regression yields an adjusted R2 = 0.94 with p<0.0001.

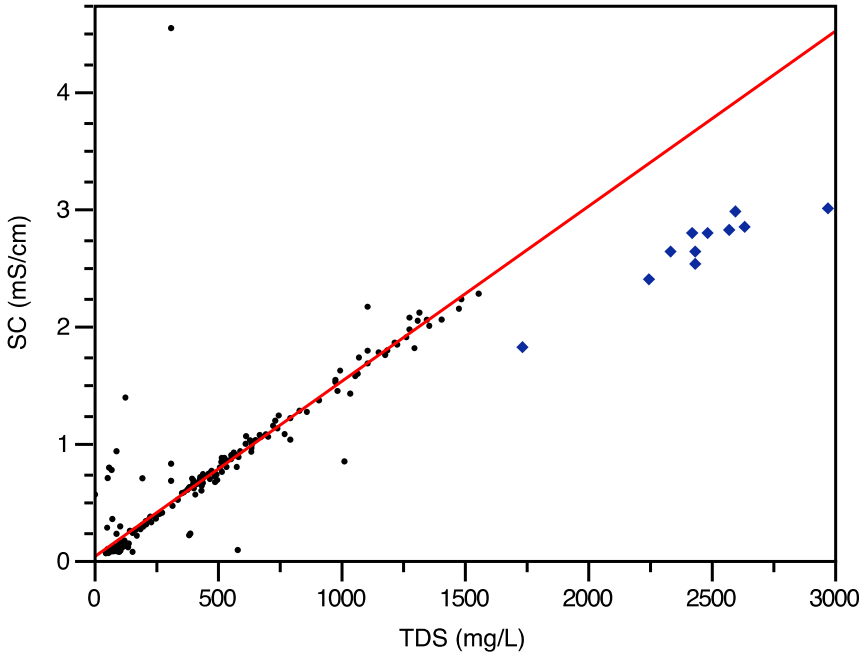

Figure 52. Bivariate plot of specific concentrations against total dissolved solids from all samples taken at tributary monitoring sites 2003 to 2013. Excluding Chalk Creek samples shown as blue dots, the regression yields an adjusted R2 = 0.78 with p<0.0001.

SUMMARY AND CONCLUSIONS

A total of 12 tributaries and 9 storm outfalls were sampled over a 3 month period as part of a pilot project designed to inform decisions regarding future storm water sampling in the Truckee Meadows. Sampling consisted of a combination of grab samples during baseline (i.e., dry) conditions as well as event-based (i.e., wet) conditions. Laboratory analyses included OP, TP, NO_3, NO_2, TKN, TSS, TDS, turbidity and E. coli. Field measurements included DO, temperature, pH, turbidity, and where feasible, discharge.

Outfall Sites: Comparative distributions of data from field measurements and analytic results at the nine outfall sites sampled during 2013 showed only moderate variation between sites. Water temperature varied from about 10 to 20°C at most outfall sites during the sampling program. These temperatures are within expected ranges for drainages in the area during spring and summer. Specific electrical conductance was relatively consistent across sites, from about 0.1 to 0.7 mS/cm up to 1.2 mS/cm measured at Teglia. These values are consistent with clean runoff at the low range to typical road surface runoff at the higher range.

At most outfall sites DO varied within a relatively tight range from about 6 to 10 mg/L, which is healthy for aerobic aquatic systems, although one higher concentration was observed at Oxbow (11.5 mg/L) and a low concentration occurred at Mary Wahl (3.1 mg/L) on 6/9/13. pH ranged from 6.5 to 8.0, which is close to neutral and typical for the area, although one relatively alkaline sample was collected at Teglia (8.95) and another at Arlington (9.6) on 5/7/13. There was no statistical relationship between measurements of discharge and pH.

Nitrate (NO_3) concentrations were quite low, ranging from the 0.002 mg/L to 1.72 mg/L, although two higher concentration samples (~3 mg/L) were collected at Cottonwood Park and at Greg Street on 6/10/13 during a runoff event (1-2 cfs) that may have intercepted or washed a localize source of nitrate from the surrounding landscape. Total nitrogen concentrations showed a typical lognormal distribution, with the bulk of samples between 0.2 to 5.0 mg/L and two high concentration samples (~29 mg/L) collected at Arlington Island and Cottonwood Park. One sample collected at Arlington Island on 6/9/13 measured 38 mg/L of TN. Total nitrogen mainly reflects the contribution of biological material, often organic material washed from the landscape. These high concentration TN samples generally corresponded to high nitrate concentrations collected at the same sites during the same runoff event (6/9/13–6/10/13).

Taken in aggregate the orthophosphate concentrations from outfall sites show a lognormal distribution, as commonly observed in nutrient analyses of stormwater samples. The bulk of the samples are low concentrations from 0.03 to 0.5 mg/L. Higher concentrations samples were collected at Arlington Island on three occasions (1.2–2.0 mg/L) and at both Cottonwood Park and at Vine on one occasion each (1.1–1.2 mg/L). Total phosphorus concentrations were highly correlated with orthophosphate concentrations (Figure 36), also showing a lognormal distribution overall. High concentration samples generally corresponded to the same samples that demonstrated high concentrations of nitrogen.

Concentrations of total suspended solids, total dissolved solids and turbidity all followed lognormal distributions. Not surprisingly, the highest concentrations of TSS (1030 to 1620 mg/L) corresponded to the highest concentrations of turbidity (310 to 490 NTU). These were collected at the Arlington site on 6/9/13, when high concentrations of nitrogen and phosphorus were also observed at that site. A regression of the full set of outfall samples shows a good fit between TSS and turbidity (Figure 37), as well as a reasonable fit between TDS and SC (Figure 38). There was no corresponding evidence of any relationship between TSS and TDS concentrations.

Tributaries: Comparative analyses of data from field measurements and analytic results at the eleven tributary sites indicate a moderate amount of variation both in time and space. For example, discharge varied from zero (dry channel) to about 100 cfs, with the highest range of discharges observed on Steamboat Creek at Clean Water Way, followed the Narrows site and then Rhodes Road. NTD@Kleppe showed the highest range of discharges outside of Steamboat Creek. Somewhat significantly, none of the other field measurements (temperature, specific conductance, dissolved oxygen, pH) or analytic results showed any significant relationship ($p<0.1$) to discharge in regression analysis.

Dissolved oxygen concentrations were usually between about 5 to 15 mg/L, representing aerobic conditions, although NTD@Orr showed a much broader range than other sites, followed by Clean Water Way. The pH generally ranged from about 7.0 to 9.0, which is neutral to slightly alkaline. The most alkaline conditions were observed at the NTD@Orr site, followed by Clean Water Way.

Nitrate concentrations were highest in Chalk Creek, ranging from ~1 mg/L to over 3 mg/L. Concentrations at other sites more generally ranged from 0.1 mg/L to 0.8 mg/L, although NTD@Orr ranged somewhat higher than other sites. Alum Creek, Thomas Creek and Whites Creek were all in the low range for nitrate, although higher concentrations were evident at Lower Whites Creek compared to Upper Whites Creek. Total nitrogen concentrations show greater variability among sites than nitrate. As with nitrate, however, both Chalk Creek and NTD@Orr show much higher ranges than the other sites. Lower Alum Creek also shows greater variability. Excluding those three sites, the range of TN concentrations generally ranged from about 0.1 to 3 mg/L. NTD@Orr site ranged from about 1 to 6 mg/L while Chalk Creek ranged from about 0.1 to 8 mg/L TN. There is some correlation between TN concentrations and nitrate, as well as with TDS and TP.

Median orthophosphate concentration overall was 0.1 mg/L, but concentrations ranged much higher at the Narrows site on Steamboat Creek and at Chalk Creek (>0.3 mg/L). Upper and Lower Whites Creek showed the lowest concentrations (<0.5 mg/L) followed by Upper Thomas Creek. Note, however, that orthophosphate was measured intermittently, so the record of results from sample analysis is much lower (n ~130) compared to other analytes (n ~300). Median total phosphorus concentration was only 0.12 mg/L overall. Higher ranges in TP concentrations were observed at the Narrows, NTD@Orr and Lower Alum Creek sites. There is a moderate

correlation between TP concentration and orthophosphate (regression yields adjusted R2=0.56 with p<0.0001), as well as some correlation with TN and TDS.

Concentrations of total suspended solids, total dissolved solids and turbidity all followed lognormal distributions. As expected, high concentrations of TSS (>50 mg/L) generally correspond to high concentrations of turbidity (>30 NTU). Note, however, that there were much fewer turbidity sample measurements (n=35) compared to the TSS measurements (n=267).

Loadings: From a water quality perspective, contaminant loads, as opposed to concentrations, are often a more important indicator of ecosystem health. Regrettably, the nature and design of this pilot program did not allow for rigorous computation of contaminant loads due to the "snapshot" nature of the sampling; i.e., samples were collected at one moment in time, as were estimates of discharge (the other critical element to computing loads). That said, calculation of instantaneous loads does provide some insight into the nature of these systems. Generally speaking, for those tributaries where upgradient and down-gradient samples were collected, the down-gradient samples exhibited relatively higher contaminant loadings. This was most pronounced for North Truckee Drain and Steamboat Creek.

RECOMMENDATIONS

A high quality stormwater sampling program would need to include a range of temporal and spatial investigation. One method to broaden our understanding of loading deliveries would be to install real-time monitoring stations at some outfalls. Real-time monitoring stations are capable of collecting data on multiple water-quality parameters at any prescribed interval. Common water-quality sensors include those that might record turbidity, specific conductance, water temperature, and stage. These sensors can be programmed, through a data-logger, to collect water quality information on a regular basis. For flashy systems like stormwater outfalls, a data recording interval of every 2 to 10 minutes would be suggested.

The NPDES MS4 Permit regulates the discharge of stormwater to the Truckee River. Best management practices (BMP) are an important part of meeting the permit requirements. If the BMPs are to achieve maximum efficiency of reducing contaminant loads to the Truckee River, their function must be assessed. A SWMP should not only determine where, when and which BMP to install, but also assess their function by monitoring above and below, and before and after installation.

This project was to focus on seven specific watersheds within the Truckee Meadows, and was designed to capture precipitation events and dry background conditions of both outfalls and tributaries. It is also hoped that this pilot project provides an in-depth, snapshot interpretation of the highest-concentration contaminants in a representation of catchment outfalls. As described above in the section titled Contaminant Loadings, the calculation of a contaminant loading is substandard without a continuous discharge-measuring device. Results from this project suggest recommendations that would enhance the quality of data collected for the SWMP. Any new BMP should have monitoring in place before construction/installation. Only this "before"

measurement can give the baseline perspective necessary to gauge BMP effectiveness in improving runoff water quality and/or Truckee River water quality.

The results of this study could and should be considered as a first step towards a more comprehensive stormwater monitoring scheme. Total maximum daily loads (TMDL) are in place in the Truckee Meadows for nutrients and sediment. TMDLs have been established on the Truckee River for three constituents, total nitrogen (TN), total phosphorus (TP), and total dissolved solids (TDS). The control point is at Lockwood under the assumption that if the TMDLs are being met at this location (downstream from the Truckee Meadows Water Reclamation Facility [TMWRF]) they are being met on the rest of the impaired river reach (NDEP, 1994). Each of the tributaries under consideration for this pilot grab-sampling project was considered "low priority" impairment status in the 2009 document.

If the greater goal of storm water monitoring is to assess the entirety of water quality delivery to the Truckee River from within the Truckee Meadows, then more temporally rigorous real-time data should be established at some outfalls. Also, the benefits of adding water quality sensors at established gaging stations, like those of the USGS, would greatly enhance the future quantification of contaminant delivery.

Some generalized recommendations that would greatly enhance the quality of stormwater data collection would be to:

1) Consider installing autosamplers at the highest-discharge outfall and tributary sites with generally higher concentrations of constituents (Arlington Island, Chalk Creek, North Truckee Drain at Orr, SBC at Clean Water Way) to give assurance that all types of runoff regimes are captured in real-time by sampling.
2) Add water level stage sensors to autosampler stations (Arlington, Chalk Creek, North Truckee Drain at Orr, and Clean Water Way) as well as at a few other sites (Upper Whites Creek, Lower Whites Creek, Lower Thomas Creek) for better discharge estimates.
3) Add water-quality sensors to selected stations, especially outfalls, optimally turbidity and conductivity at Chalk Creek, North Truckee Drain at Orr, Narrows, and Clean Water Way.
4) Remote telemetry would be useful at Clean Water Way and Chalk Creek.
5) Obtain localized, watershed-scale precipitation rates with rain gauges installed at each of the recommended autosampler sites.
6) Grab sampling is difficult to execute efficiently in watersheds with flashy hydrologic response. Reduce the use of grab sampling as a primary collection method, and substitute sensors or autosamplers where feasible. Continue use of grab sampling as an exploratory or data augmentation method.

7) The Nevada State Health Laboratory is disinclined to accept E. coli samples on Fridays and are closed Saturdays and Sundays. This means on only four days of the week can samples be analyzed within their holding times. E. coli should be submitted when storm sampling occur on Monday through Thursday.

Some specific recommendations that would greatly enhance the quality of stormwater data collection would be to:

1) Remove from sampling scheme the smaller watershed outfalls and find alternative sites with similar land use to: Dickerson Rd., Vine St.

2) Remove from sampling scheme Upper Alum station, which discharges only under snowmelt and extreme precipitation events.

3) Co-locate water-quality sensors at USGS gaged stations at NTD at Orr, Steamboat Creek at Clean Water Way, and Steamboat Creek at Narrows. NTD at Kleppe and Steamboat Creek at Rhodes Rd would be optional yet improve our knowledge of inputs at lower cost.

4) Investigate the Steamboat Ditch return discharges just below USGS Station at Rhodes Rd., "Steamboat Creek at Steamboat". This could be a part of the next round of sampling as an added grab sampling station.

5) Investigate Steamboat Creek above the Narrows site with occasional longitudinal grab sampling to evaluate inputs leading to increasing concentrations in some constituents observed at Narrows.

To summarize the results of this pilot study, a table was developed that comprises the recommendations, priority levels, and future options for each station (Table 31 and 32). Some stations regularly have minimal to no discharge, and would therefore be considered less important for loading and TMDL concerns. Some stations have vandalism concerns and may garner a "drop" rating as a result. For "Priority", we considered the discharge for wet and dry events, as well as comparative historical and current data to give one of three values to each station as "low", "medium, or "high" priority. These stations would be monitored more extensively than in the past to improve site assessment. Several options for monitoring are included in the "Options" columns. These options are based on the availability and cost of equipment, and the need for checking some of the outfalls remotely in order to facilitate field visits and bottle collection.

Table 31. Tributary site options for longer term monitoring strategy.

Tributary Site	Sampling Priority	Stage or Discharge	Water Quality Sonde	Sampling	Telemetry
Chalk Creek	high	Continuous stage	Turbidity and EC	Autosampler	Telemetry
Upper Alum	low	Event measurements		Grab	
Lower Alum	medium	Continuous stage		Grab	
NTD @ Orr	medium	USGS discharge		Grab	
NTD @ Kleppe	high	USGS discharge	Turbidity and EC	Autosampler	
Upper Whites	low	Event measurements		Grab	
Lower Whites	medium	Continuous stage		Grab	
Upper Thomas	low	Event measurements		Grab	
Lower Thomas	medium	Continuous stage		Grab	
SBC @ Rhodes	low	USGS discharge		Grab	
SBC @ Narrows	high	USGS discharge	EC	Grab	
SBC @ Clean Water Way	high	USGS discharge	Turbidity and EC	Autosampler	Telemetry

Chalk Creek site is very flashy and hard to anticipate, so telemetry and autosampler would be useful.

NTD@Kleppe is important urban contributor to Truckee River.

SBC @ Clean Water Way could use more focus as it is last point on SBC before wasterwater treatment plant and discharge to Truckee River.

Although upper sites are listed as low sampling priority, one or more may need to be elevated to serve as reference to undisturbed conditions.

Table 32. Outfall site options for longer term monitoring strategy.

Outfall Site	Sampling Priority	Stage or Discharge	Water Quality Sonde	Sampling	Telemetry
Oxbow	medium	Continuous stage	EC	Grab	
Vine	relocate				
Arlington	high	Continuous stage	Turbidity and EC	Autosampler	
Fisherman's	high	Event measurements		Grab	
Mary Wahl	high	Continuous stage	Turbidity and EC	Autosampler	Telemetry
Cottonwood	low	Event measurements		Grab	
Greg	low	Event measurements		Grab	
Teglia	low	Event measurements		Grab	
Dickerson	relocate			Grab	

Vine site is offline since conveyance routes changed.

Arlington Island is an important site, close to City offices so easy to manage autosampler if installed.

Dickerson site is backwatered by the Truckee River, so needs to be relocated up gradient in conveyance or to new outfall.

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APPENDIX A: TRIBUTARY FIELD AND LAB DATA FROM THE 2013 PILOT STUDY

Appendix A-1. Field measurements taken during sample collection times at the Rhodes Road tributary monitoring site on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
RR	3/20/2003	6.00	--	--	--	--
RR	6/25/2003	7.50	--	--	--	--
RR	10/2/2003	0.62	12.93	0.302	10.34	7.93
RR	12/9/2003	1.30	2.85	0.404	6.06	7.96
RR	3/29/2004	5.10	--	--	--	--
RR	6/23/2004	2.43	21.22	0.257	9.2	7.87
RR	9/28/2005	1.90	11.36	0.372	9.32	7.78
RR	1/10/2006	15.00	7.50	0.323	10.76	7.72
RR	4/10/2006	14.70	8.1	0.249	12.27	8.4
RR	6/29/2006	70.00	--	--	--	--
RR	10/11/2006	9.32	8.45	0.223	11.6	7.24
RR	1/9/2007	5.11	3.49	0.287	14.34	7.74
RR	4/11/2007	4.91	8.18	0.282	9.99	7.69
RR	6/26/2007	2.17	15.2	0.282	8.35	8.56
RR	10/22/2007	3.60	6.52	0.248	10.39	7.8
RR	1/28/2008	3.63	2.48	0.401	12.81	7.89
RR	4/23/2008	4.15	7.83	0.278	9.76	7.48
RR	6/24/2008	4.15	14.03	0.269	9.09	7.77
RR	9/23/2008	0.00	n/a	n/a	n/a	n/a
RR	2/2/2009	0.00	3.66	0.304	12.52	7.69
RR	4/21/2009	9.00	13.95	0.285	11.33	7.76
RR	7/15/2009	2.00	19.38	0.272	15.16	7.85
RR	9/15/2009	0.10	14.13	0.614	9.22	8.08
RR	3/1/2010	7.70	8.23	0.37	15.11	8.03
RR	6/28/2010	21.00	17.74	0.131	8.38	7.6
RR	9/21/2010	1.30	15.33	0.208	9.36	7.32
RR	12/22/2010	17.0	4.93	0.340	15.10	7.44
RR	3/23/2011	14	4.41	0.285	10.80	7.60
RR	6/30/2011	51	12.44	0.117	10.62	7.57
RR	9/22/2011	3.9	16.29	0.262	8.94	7.77
RR	12/1/2011	5.6	1.50	0.283	12.09	7.58
RR	3/26/2012	1.8	7.26	0.393	9.32	7.41
RR	6/20/2012	0.98	16.59	0.302	8.8	7.49
RR	9/6/2012	0	18.1	0.699	4.29	7.26
RR	12/19/2012	2.9	1.81	0.354	--	7.65
RR	5/2/2013	8.30	8.92	0.232	10.22	7.66
RR	5/7/2013	15.00	13.1	0.256	9.72	7.72
RR	6/21/2013	1.40	14.53	0.37	7.56	7.58
RR	6/25/2013	1.70	16.37	0.352	9.62	7.78

Appendix A-2. Analytic results from grab samples collected at the Rhodes Road tributary monitoring site on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
RR	3/20/2003	< 0.5	0.50	--	0.08	<5	190	--	--
RR	6/25/2003	0.012	0.55	--	0.127	3	184	--	--
RR	10/2/2003	0.02	0.34	--	0.375	3	201	--	--
RR	12/9/2003	0.036	0.79	--	0.183	10	278	--	--
RR	3/29/2004	0.028	0.48	--	0.132	9	209	--	--
RR	6/23/2004	0.024	0.514	--	0.132	3	170	--	--
RR	9/28/2005	0.074	1.104	--	0.132	3	251	--	--
RR	1/10/2006	1.01	1.570	--	0.121	1	234	--	--
RR	4/10/2006	0.228	0.718	--	0.039	1	147	--	--
RR	6/29/2006	0.058	0.578	--	0.089	10	107	--	--
RR	10/11/2006	0.124	0.434	--	0.08	0	93	--	--
RR	1/9/2007	0.261	0.641	--	0.064	6	108	--	--
RR	4/11/2007	0.161	0.551	--	0.117	5	184	--	--
RR	6/26/2007	0.09	0.520	--	0.122	6	189	--	--
RR	10/22/2007	--	0.720	--	0.142	78	170	--	--
RR	1/28/2008	<0.02	0.63	--	0.09	<2	262	--	--
RR	4/23/2008	<0.02	0.560	--	0.1	2	185	--	--
RR	6/24/2008	0.02	0.960	--	0.19	18	189	--	--
RR	9/23/2008	n/a		--	n/a	n/a	n/a	--	--
RR	2/2/2009	<.1	0.400	--	0.07	<2	213	--	--
RR	4/21/2009	<.10	0.780	--	0.18	9	201	--	--
RR	7/15/2009	0	0.300	--	0.14	0	187	--	--
RR	9/15/2009	0	1.100	--	0.2	5	406	--	--
RR	3/1/2010	0.02	0.800	--	0.11	2	250	--	--
RR	6/28/2010	<.10	0.300	--	0.08	16	106	--	--
RR	9/21/2010	<0.02	0.30	--	0.11	3	175	--	--
RR	12/22/2010	<0.02	1.5	--	0.12	7	225	--	--
RR	3/23/2011	--	0.91	0.05	0.06	--	191	--	--
RR	6/30/2011	--	1.4	0.05	0.07	--	80	--	--
RR	9/22/2011	--	0.6	0.09	0.11	--	190	--	--
RR	12/1/2011	--	0.5	0.06	0.08	--	200	--	--
RR	3/26/2012	--	0.4	0.10	0.12	--	267	--	--
RR	6/20/2012	--	0.7	0.13	0.15	--	198	--	--
RR	9/6/2012	--	2.5	0.1	0.3	--	198	--	--
RR	12/19/2012	--	0.4	0.08	0.11	--	--	--	--
RR	5/2/2013	0.034	0.38	0.095	0.135	2.8	158	n/a	193.5
RR	5/7/2013	0.071	0.82	0.126	0.191	10.2	169	5.8	1299.7
RR	6/21/2013	0.040	0.64	0.067	0.230	31.6	230	5.8	1078
RR	6/25/2013	0.031	0.41	0.100	0.148	1.9	226	1.8	1760

Appendix A-3. Field measurements taken during sample collection times at the Narrows tributary monitoring site on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
NR	3/23/2011	19.0	9.37	0.874	11.68	8.33
NR	6/30/2011	81.0	21.16	0.324	10.96	8.42
NR	9/22/2011	14.0	21.11	1.148	9.82	8.26
NR	12/1/2011	12.0	1.75	1.236	12.07	8.04
NR	3/26/2012	5.9	9.48	1.540	10.94	8.13
NR	6/20/2012	4.4	24.18	1.790	11.12	8.14
NR	9/6/2012	3.4	18.95	2.166	8.8	8.17
NR	12/19/2012	7.3	1.70	1.681	--	7.76
NR	5/2/2013 12:20	2.8	16.56	2.116	10.39	8.09
NR	5/7/2013 16:20	25.0	17.00	1.521	10.73	8.35
NR	6/21/2013 11:21	4.1	18.27	1.620	9.69	8.05
NR	6/25/2013 13:40	3.8	21.33	2.073	11.39	8.15

Appendix A-4. Macronutrient concentrations, turbidity and E. coli of grab samples collected at the Narrows tributary monitoring site on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
NR	3/23/2011	--	0.70	0.15	0.20	--	530	--	--
NR	6/30/2011	--	0.60	0.16	0.21	--	208	--	--
NR	9/22/2011	--	0.90	0.30	0.39	--	727	--	--
NR	12/1/2011	--	0.80	0.19	0.24	--	750	--	--
NR	3/26/2012	--	0.70	0.26	0.34	--	980	--	--
NR	6/20/2012	--	0.88	0.44	0.49	--	1110	--	--
NR	9/6/2012	--	0.90	0.40	0.50	--	1420	--	--
NR	12/19/2012	--	0.60	0.25	0.31	--	1040	--	--
NR	5/2/2013 12:20	0.014	0.57	0.387	0.388	19.2	1320	n/a	--
NR	5/7/2013 16:20	0.061	1.72	0.401	0.568	121	980	70.5	--
NR	6/21/2013 11:21	0.008	0.45	0.250	0.209	2.4	999	2.0	--
NR	6/25/2013 13:40	0.005	0.41	0.296	0.285	3.8	1280	2.2	--

Appendix A-5. Field measurements taken during sample collection times at the tributary monitoring site at Clean Water Way on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
CWW	3/20/2003	28.62	--	--	--	--
CWW	6/25/2003	55.25	--	--	--	--
CWW	10/2/2003	33.50	16.41	0.562	12.95	8.56
CWW	12/9/2003	17.40	0.19	0.085	5.19	8.06
CWW	3/29/2004	33.53	--	--	--	--
CWW	6/23/2004	28.04	21.02	0.572	7.46	8.3
CWW	9/28/2005	55.25	18.96	0.579	11.29	8.35
CWW	1/10/2006	--	--	--	--	--
CWW	4/10/2006	--	10.98	0.708	5.72	8.03
CWW	6/29/2006	--	--	--	--	--
CWW	10/11/2006	47.14	11.27	0.211	10.38	8.22
CWW	1/9/2007	32.80	2.41	0.276	13.32	8.18
CWW	4/11/2007	4.40	13.13	0.69	8.46	8.16
CWW	6/26/2007	10.38	19.77	0.225	10.44	8.97
CWW	10/22/2007	19.50	12.66	0.85	2.78	8.54
CWW	1/28/2008	55.25	4.98	0.938	9.64	8.06
CWW	4/23/2008	28.62	15.78	1.192	9.48	8.49
CWW	6/24/2008	28.62	19.28	0.645	6.95	8.29
CWW	9/23/2008	17.88	17.12	0.647	15.87	8.84
CWW	2/2/2009	0.00	8.09	0.795	11.51	8.32
CWW	4/21/2009	28.00	23.3	0.762	11.72	8.42
CWW	7/15/2009	44.00	21.48	0.744	7.49	8.32
CWW	9/15/2009	23.30	16.73	0.717	7.65	8.08
CWW	3/1/2010	71.85	7.95	0.659	11.55	7.89
CWW	6/28/2010	5.32	23.01	0.463	6.64	7.96
CWW	9/21/2010	44.00	15.56	0.636	9.67	7.9
CWW	12/22/2010	73.90	3.39	0.657	10.40	7.44
CWW	3/23/2011	81	8.80	0.600	10.70	8.26
CWW	6/30/2011	98	20.53	0.333	9.79	8.02
CWW	9/22/2011	46	22.32	0.515	9.07	8.21
CWW	12/1/2011	24	5.21	0.918	15.81	8.42
CWW	3/26/2012	19	7.47	0.838	11.04	8.37
CWW	6/20/2012	20	21.4	4.55	9.69	8.43
CWW	9/7/2012	26	17.62	0.677	5.42	7.93
CWW	12/19/2012	27	3.96	0.823	--	8.14
CWW	5/2/2013	37.00	18.4	0.715	11.21	8.42
CWW	5/7/2013	80.00	13.7	0.692	9.02	8.03
CWW	6/21/2013	22.00	20.11	0.615	12.41	8.62
CWW	6/25/2013	28.00	20.56	0.632	12.49	8.5

Appendix A-6. Macronutrient concentrations, turbidity and E. coli for grab samples collected at the tributary monitoring site at Clean Water Way on Steamboat Creek.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
CWW	3/20/2003	0.56	1.26	--	0.16	46	400	--	--
CWW	6/25/2003	0.273	1.34	--	0.214	13	362	--	--
CWW	10/2/2003	0.292	1.11	--	0.177	14	408	--	--
CWW	12/9/2003	0.591	1.44	--	0.234	29	584	--	--
CWW	3/29/2004	0.423	1.05	--	0.196	32	379	--	--
CWW	6/23/2004	0.171	0.911	--	0.248	12	358	--	--
CWW	9/28/2005	0.641	1.151	--	0.237	37	366	--	--
CWW	1/10/2006	--	--	--		5	558	--	--
CWW	4/10/2006	0.713	0.826	--	0.182	22	432	--	--
CWW	6/29/2006	0.329	1.229	--	0.232	21	245	--	--
CWW	10/11/2006	6.17	7.130	--	0.206	46	387	--	--
CWW	1/9/2007	0.754	1.714	--	0.174	22	55	--	--
CWW	4/11/2007	0.602	1.632	--	0.261	0	431	--	--
CWW	6/26/2007	0.429	1.329	--	0.282	18	392	--	--
CWW	10/22/2007	--	1.450	--	0.222	<2	539	--	--
CWW	1/28/2008	0.46	3.33	--	0.245	55	589	--	--
CWW	4/23/2008	0.03	1.640	--	0.282	46	736	--	--
CWW	6/24/2008	0.04	1.170	--	0.35	25	403	--	--
CWW	9/23/2008	<.1	1.600	--	0.22	35	406	--	--
CWW	2/2/2009	<.1	1.400	--	0.23	22	580	--	--
CWW	4/21/2009	<.10	1.260	--	0.28	31	478	--	--
CWW	7/15/2009	0.06	1.200	--	0.3	9	491	--	--
CWW	9/15/2009	0.14	1.900	--	0.33	28	490	--	--
CWW	3/1/2010	0.1	1.900	--	0.23	44	443	--	--
CWW	6/28/2010	0.03	0.920	--	0.3	9	320	--	--
CWW	9/21/2010	<0.02	1.50	--	0.28	38	414	--	--
CWW	12/22/2010	1.27	1.8	--	0.27	34	417	--	--
CWW	3/23/2011	--	2.1	0.11	0.17	--	380	--	--
CWW	6/30/2011	--	0.8	0.16	0.21	--	212	--	--
CWW	9/22/2011	--	1.5	0.19	0.24	--	341	--	--
CWW	12/1/2011	--	1.40	0.14	0.19	--	568	--	--
CWW	3/26/2012	--	1.7	0.14	0.22	--	517	--	--
CWW	6/20/2012	--	1.2	0.21	0.26	--	314	--	--
CWW	9/7/2012	--	1.5	0.17	0.3	--	314	--	--
CWW	12/19/2012	--	1.5	0.19	0.25	--	314	--	--
CWW	5/2/2013	0.348	1.09	0.168	0.232	43.8	444	n/a	--
CWW	5/7/2013	0.419	1.61	0.163	0.317	79.0	440	37.2	--
CWW	6/21/2013	0.159	0.71	0.143	0.216	20.8	386	10.2	--
CWW	6/25/2013	0.297	0.91	0.168	0.229	23.0	388	10.1	--

Appendix A-7. Field measurements taken during sample collection times at the tributary monitoring site at Upper White's Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
UWC	3/20/2003	3.50	--	--	--	--
UWC	6/25/2003	3.80	--	--	--	--
UWC	10/2/2003	2.00	7.28	0.073	12.25	7.94
UWC	12/9/2003	2.80	--	--	--	--
UWC	3/29/2004	2.90	--	--	--	--
UWC	6/23/2004	5.20	13.08	0.06	9.24	7.66
UWC	9/28/2005	3.70	5.86	0.069	10.58	7.77
UWC	1/10/2006	4.00	2.18	0.094	11.93	7.66
UWC	4/10/2006	6.50	--	--	--	--
UWC	6/29/2006	13.00	--	--	--	--
UWC	10/11/2006	5.00	3.74	0.069	11.82	6.99
UWC	1/9/2007	4.50	0.60	0.076	13.85	7.57
UWC	4/11/2007	4.40	1.71	0.076	11.97	7.78
UWC	6/26/2007	3.80	8.1	0.08	9.12	6.05
UWC	10/22/2007	2.00	1.13	0.075	12.24	7.76
UWC	1/28/2008	2.90	0.59	0.097	12.92	8
UWC	4/23/2008	4.00	2.45	0.08	10.87	7.23
UWC	6/24/2008	3.20	7.81	0.056	10.58	7.72
UWC	9/23/2008	2.10	4.62	0.073	7.73	12.05
UWC	2/2/2009	--	0.24	0.076	11.83	7.38
UWC	4/21/2009	4.50	7.21	0.072	11.91	7.65
UWC	7/15/2009	3.00	11.95	0.059	11.51	7.76
UWC	9/15/2009	1.05	8.83	0.069	10.08	7.79
UWC	9/15/2009	2.50	--	--	--	--
UWC	3/1/2010	3.10	2.24	0.078	13.06	7.91
UWC	6/28/2010	7.00	14.81	0.049	8.65	7.62
UWC	9/21/2010	1.93	7.41	0.074	10.11	7.41
UWC	9/21/2010	3.60	--	--	--	--
UWC	12/22/2010	2.37	0.06	0.078	15.10	7.00
UWC	12/22/2010	3.9	--	--	--	--
UWC	3/23/2011	4.0	0.420	0.085	11.32	7.15
UWC	6/30/2011	20	7.160	0.055	12.15	7.70
UWC	9/21/2011	5.6	9.570	0.073	9.53	7.49
UWC	12/1/2011	--	-0.070	0.075	12.61	7.46
UWC	3/26/2012	--	1.530	0.080	10.94	7.73
UWC	6/20/2012	0.71	10.550	0.700	9.61	7.53
UWC	9/6/2012	0.73	16.180	0.094	9.06	7.73
UWC	12/19/2012	3.2	7.730	9.060	--	7.64
UWC	5/2/2013	n/a	1.37	0.077	12.33	7.8
UWC	5/7/2013	4.31	5.62	0.071	10.44	7.4
UWC	6/21/2013	4.60	4.68	0.069	10.33	7.26
UWC	6/25/2013	4.90	8.65	0.066	9.6	7.33

Appendix A-8. Analytic results from grab samples collected at the Upper White's Creek tributary monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
UWC	3/20/2003	<0.5	0.20	--	<.02	<5	54	--	--
UWC	6/25/2003	<.005	0.13	--	0.03	15	65	--	--
UWC	10/2/2003	0.015	0.20	--	0.029	2	71	--	--
UWC	12/9/2003	0.0	0.12	--	0.029	<1	76	--	--
UWC	3/29/2004	0	0.00	--	0.019	<1	74	--	--
UWC	6/23/2004	<.005	0.13	--	0.028	8	49	--	--
UWC	9/28/2005	0.005	0.205	--	0.023	1	71	--	--
UWC	1/10/2006	0.0	0.126	--	0.026	4	90	--	--
UWC	4/10/2006	0.005	0.275	--	0.023	1	94	--	--
UWC	6/29/2006	0.009	0.219	--	0.028	42	45	--	--
UWC	10/11/2006	0.005	0.005	--	0.02	5	158	--	--
UWC	1/9/2007	0.007	0.207	--	0.023	<2	96	--	--
UWC	4/11/2007	0.005	0.145	--	0.029	0	64	--	--
UWC	6/26/2007	0.008	0.228	--	0.038	2	65	--	--
UWC	10/22/2007	--	0.140	--	0.031	3	68	--	--
UWC	1/28/2008	<0.02	0.22	--	0.027	3	72	--	--
UWC	4/23/2008	<0.02	0.320	--	0.03	<2	68	--	--
UWC	6/24/2008	0.02	0.120	--	0.04	6	57	--	--
UWC	9/23/2008	<.1	<.3	--	0.06	5	97	--	--
UWC	2/2/2009	<.1	<.3	--	<.04	<2	74	--	--
UWC	4/21/2009	<.10	0.360	--	0.05	8	74	--	--
UWC	7/15/2009	0	0.100	--	0.04	0	60	--	--
UWC	9/15/2009	0	0.400	--	0.04	8	104	--	--
UWC	9/15/2009	0	0.100	--	--	3	80	--	--
UWC	3/1/2010	<0.02	0.100	--	0.03	< 2	81	--	--
UWC	6/28/2010	<0.02	0.200	--	0.04	52	49	--	--
UWC	9/21/2010	<0.02	0.40	--	0.03	18	77	--	--
UWC	9/21/2010	<0.02	0.10	--	--	<1.7	58	--	--
UWC	12/22/2010	<0.02	0.1	--	0.05	4	63	--	--
UWC	12/22/2010	<0.02	0.2	0.078	0.05	16	68	--	--
UWC	3/23/2011	--	0.200	0.020	0.030	--	81.000	--	--
UWC	6/30/2011	--	0.200	0.030	0.040	--	49.000	--	--
UWC	9/21/2011	--	0.200	0.020	0.020	--	70.000	--	--
UWC	12/1/2011	--	0.200	0.020	0.030	--	84.000	--	--
UWC	3/26/2012	--	0.200	0.020	0.030	--	65.000	--	--
UWC	6/20/2012	--	0.200	0.020	0.030	--	57.000	--	--
UWC	9/6/2012	--	0.600	0.030	0.050	--	57.000	--	--
UWC	12/19/2012	--	0.200	0.010	0.030	--		--	--
UWC	5/2/2013	0.028	0.08	0.014	0.024	4.8	71	n/a	1
UWC	5/7/2013	0.003	0.103	0.013	0.025	5.1	69	3.3	7.4
UWC	6/21/2013	0.002	0.025	0.015	0.029	5.6	57	2.6	341
UWC	6/25/2013	0.002	0.025	0.012	0.028	8.2	60	3.3	330

Appendix A-9. Field measurements taken during sample collection times at the Lower White's Creek tributary monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (µSmS/cm)	DO (mg/L)	pH
LWC	3/20/2003	1.14	--	--	--	--
LWC	6/25/2003	2.25	--	--	--	--
LWC	10/2/2003	0.55	13.87	0.77	10.8	7.94
LWC	12/9/2003	0.80	--	--	--	--
LWC	3/29/2004	0.20	--	--	--	--
LWC	6/23/2004	1.70	15.28	0.06	9.13	7.56
LWC	9/28/2005	3.40	12.68	0.116	9.6	7.87
LWC	1/10/2006	2.50	2.46	0.098	12.37	7.72
LWC	4/10/2006	2.90	--	--	--	--
LWC	6/29/2006	14.60	--	--	--	--
LWC	10/11/2006	6.90	7.98	0.113	11.2	7.08
LWC	1/9/2007	3.00	0.03	0.076	14.6	7.57
LWC	4/11/2007	3.00	5.21	0.075	11.62	7.77
LWC	6/26/2007	2.97	14.9	0.112	8.74	6.68
LWC	10/22/2007	2.42	3.59	0.077	12.12	7.67
LWC	1/28/2008	3.70	5.42	0.35	9.58	8
LWC	4/23/2008	3.40	6.64	0.08	10.24	7.35
LWC	6/24/2008	3.40	13.28	0.071	9.56	7.8
LWC	9/23/2008	1.30	9.53	0.083	11.92	7.79
LWC	2/2/2009	0.00	0.01	0.077	13.03	7.47
LWC	4/21/2009	1.00	9.54	0.07	11.68	7.62
LWC	7/15/2009	3.40	17.98	0.128	8.98	7.81
LWC	9/15/2009	1.05	13.45	0.1	9.47	8.05
LWC	3/1/2010	1.64	5.24	0.13	13.42	8
LWC	6/28/2010	5.99	15.01	0.062	8.96	7.71
LWC	9/21/2010	1.93	13.16	0.113	9.83	7.34
LWC	12/22/2010	2.37	0.46	0.082	12.80	7.02
LWC	3/23/2011	2.190	0.460	0.082	11.58	8.05
LWC	6/30/2011	4.500	9.970	0.058	11.98	7.60
LWC	9/21/2011	1.470	13.590	0.092	10.03	7.75
LWC	12/1/2011	0.500	-0.060	0.083	12.65	7.24
LWC	3/26/2012	2.220	5.490	0.079	10.93	7.68
LWC	6/20/2012	2.290	13.130	0.790	9.4	7.7
LWC	9/6/2012	2.110	11.000	0.077	8.36	7.85
LWC	12/19/2012	0.490	-0.050	0.090	--	7.35
LWC	5/2/2013	2.430	7.14	0.071	10.9	7.4
LWC	5/7/2013	3.170	9.22	0.074	10.77	7.54
LWC	6/21/2013	3.930	10.61	0.089	9.04	7.59
LWC	6/25/2013	3.712	14.13	0.078	9.88	7.64

Appendix A-10. Macronutrient concentrations, turbidity and E. coli of grab samples collected at the tributary monitoring site at Lower White's Creek.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
LWC	3/20/2003	--	0.20	--	<.02	<5	60	--	--
LWC	6/25/2003	--	0.29	--	0.044	14	68	--	--
LWC	10/2/2003	0.04	0.20	--	0.033	2	73	--	--
LWC	12/9/2003	0.24	0.27	--	0.033	<1	87	--	--
LWC	3/29/2004	0.00	0.11	--	0.02	<1	73	--	--
LWC	6/23/2004	0.05	0.39	--	0.074	25	59	--	--
LWC	9/28/2005	0.275	0.595	--	0.047	9	84	--	--
LWC	1/10/2006	0.162	0.132	--	0.034	1	64	--	--
LWC	4/10/2006	0.078	0.485	--	0.028	3	95	--	--
LWC	6/29/2006	1.180	0.375	--	0.089	61	54	--	--
LWC	10/11/2006	0.744	0.2	--	0.041	10	90	--	--
LWC	1/9/2007	0.081	0.155	--	0.02	<2	77	--	--
LWC	4/11/2007	0.081	0.145	--	0.026	43	69	--	--
LWC	6/26/2007	0.192	0.362	--	0.065	9	81	--	--
LWC	10/22/2007	--	0.110	--	0.029	21	67	--	--
LWC	1/28/2008	--	0.19	--	0.069	27	76	--	--
LWC	4/23/2008	--	0.260	--	0.037	14	66	--	--
LWC	6/24/2008	--	0.270	--	0.05	14	60	--	--
LWC	9/23/2008	--	<.3	--	<.04	<2	70	--	--
LWC	2/2/2009	--	<.3	--	<.04	2	76	--	--
LWC	4/21/2009	--	0.360	--	0.05	4	75	--	--
LWC	7/15/2009	--	1.000	--	0.31	49	109	--	--
LWC	9/15/2009	--	0.400	--	0.05	8	104	--	--
LWC	3/1/2010	--	0.400	--	0.08	6	120	--	--
LWC	6/28/2010	--	0.300	--	0.06	38	70	--	--
LWC	9/21/2010	--	0.40	--	0.07	18	77	--	--
LWC	12/22/2010	--	0.1	--	0.04	4	63	--	--
LWC	3/23/2011	--	0.200	0.030	0.040	--	101.000	--	--
LWC	6/30/2011	--	0.400	0.050	0.080	--	50.000	--	--
LWC	9/21/2011	--	0.400	0.020	0.050	--	83.000	--	--
LWC	12/1/2011	--	0.200	0.030	0.050	--	84.000	--	--
LWC	3/26/2012	--	0.090	0.020	0.030	--	68.000	--	--
LWC	6/20/2012	--	0.300	0.040	0.050	--	63.000	--	--
LWC	9/6/2012	--	0.100	0.040	0.120	--	63.000	--	--
LWC	12/19/2012	--	0.030	0.020	0.040	--	63.000	--	--
LWC	5/2/2013	0.004	0.07	0.011	0.026	7.000	62.000	--	93.3
LWC	5/7/2013	0.002	0.17	0.017	0.038	10.300	74.000	4.4	613.1
LWC	6/21/2013	0.003	0.23	0.021	0.063	23.800	67.000	9.6	4554
LWC	6/25/2013	0.003	0.16	0.017	0.046	14.900	65.000	6.9	2882

Appendix A-11. Field measurements taken during sample collection times at the tributary monitoring site at Upper Thomas Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
UTC	3/20/2003	2.90	--	--	--	--
UTC	6/25/2003	3.36	--	--	--	--
UTC	10/2/2003	1.40	9.04	0.1	11.53	7.96
UTC	12/9/2003	3.00	--	--	--	--
UTC	3/29/2004	3.5	--	--	--	--
UTC	6/23/2004	1.7	15.17	0.096	8.61	7.83
UTC	9/28/2005	1.60	7.38	0.092	10.34	7.77
UTC	1/10/2006	n/a	2.14	0.102	12.35	7.79
UTC	4/10/2006	3.20	--	--	--	--
UTC	6/29/2006	22.5	--	--	--	--
UTC	10/11/2006	4.84	4.78	0.096	11.71	7.01
UTC	1/9/2007	--	0.38	0.097	14.23	7.76
UTC	4/11/2007	6.57	2.84	0.092	11.8	7.91
UTC	6/26/2007	7.29	9.7	0.114	9.16	6.54
UTC	10/22/2007	1.35	2.33	0.095	11.84	7.93
UTC	1/28/2008	4.85	0.02	0.093	12.82	7.81
UTC	4/23/2008	6.95	3.79	0.089	10.45	7.59
UTC	6/24/2008	6.95	10.71	0.087	9.56	7.95
UTC	9/23/2008	4.52	6.24	0.095	11.4	7.89
UTC	2/2/2009	0.00	0.24	0.098	12.28	7.68
UTC	4/21/2009	3.90	9.63	0.086	11.31	7.87
UTC	7/15/2009	1.00	14.59	0.089	9	7.99
UTC	9/15/2009	0.80	10.92	0.093	9.57	7.97
UTC	3/1/2010	2.30	3.02	0.105	13.67	7.92
UTC	6/28/2010	3.98	15.14	0.079	8.58	7.82
UTC	9/21/2010	0.67	9.53	0.095	9.71	7.41
UTC	12/22/2010	2.8	1.82	0.108	11.53	7.38
UTC	3/23/2011	3.8	0.67	0.110	11.30	8.26
UTC	6/30/2011	13.7	8.12	0.070	11.39	7.83
UTC	9/21/2011	1.76	11.09	0.089	9.42	7.64
UTC	12/1/2011	--	-0.02	0.109	11.9	7.24
UTC	3/26/2012	3.09	-0.05	0.091	10.03	7.92
UTC	6/20/2012	1.76	11.93	0.93	8.64	7.67
UTC	9/6/2012	1.22	12.67	0.093	7.7	7.28
UTC	12/19/2012	1.59	-0.05	0.106	--	7.73
UTC	5/2/2013	3.06	3.3	0.093	10.72	7.73
UTC	5/7/2013	3.79	6.89	0.092	10.5	7.61
UTC	6/21/2013	1.50	6.65	0.096	9.42	7.6
UTC	6/25/2013	1.72	9.88	0.093	9.39	7.64

Appendix A-12. Macronutrient concentrations, turbidity and E. coli of grab samples collected at the tributary monitoring site at Upper Thomas Creek.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
UTC	3/20/2003	< 0.5	0.20	--	0.04	<5	79	--	--
UTC	6/25/2003	<.005	0.27	--	0.055	8	99	--	--
UTC	10/2/2003	0.012	0.36	--	0.076	8	87	--	--
UTC	12/9/2003	0.0	0.29	--	--	2	121	--	--
UTC	3/29/2004	0	0.21	--	0.046	3	97	--	--
UTC	6/23/2004	<.005	0.5	--	0.066	12	101	--	--
UTC	9/28/2005	0.005	0.145	--	0.062	3	93	--	--
UTC	1/10/2006	0.0	0.242	--	0.077	4	97	--	--
UTC	4/10/2006	0.006	0.356	--	0.054	1	120	--	--
UTC	6/29/2006	0.008	0.308	--	0.058	11	81	--	--
UTC	10/11/2006	0.008	0.108	--	0.043	2	99	--	--
UTC	1/9/2007	0.007	0.217	--	0.04	<2	101	--	--
UTC	4/11/2007	0.007	0.167	--	0.05	0	84	--	--
UTC	6/26/2007	0.008	0.258	--	0.072	6	91	--	--
UTC	10/22/2007	--	0.150	--	0.053	14	96	--	--
UTC	1/28/2008	<0.02	0.16	--	0.053	<2	90	--	--
UTC	4/23/2008	<0.02	0.200	--	0.055	2	94	--	--
UTC	6/24/2008	<0.02	0.220	--	0.06	6	95	--	--
UTC	9/23/2008	<.1	<.3	--	0.06	5	97	--	--
UTC	2/2/2009	<.1	<.3	--	0.05	<2	102	--	--
UTC	4/21/2009	<.10	0.360	--	0.07	6	98	--	--
UTC	7/15/2009	0	0.200	--	0.07	5	97	--	--
UTC	9/15/2009	0	0.100	--	0.07	5	95	--	--
UTC	3/1/2010	0.03	0.300	--	0.06	5	114	--	--
UTC	6/28/2010	<.10	0.200	--	0.06	8	92	--	--
UTC	9/21/2010	<0.02	0.20	--	0.08	8	89	--	--
UTC	12/22/2010	<0.02	0.2	--	0.05	<1.7	104	--	--
UTC	3/23/2011	--	0.3	0.04	0.06	--	111	--	--
UTC	6/30/2011	--	0.2	0.04	0.05	--	77	--	--
UTC	9/21/2011	--	0.3	0.04	0.06	--	102	--	--
UTC	12/1/2011	--	0.3	0.06	0.07	--	91	--	--
UTC	3/26/2012	--	0.1	0.04	0.05	--	103	--	--
UTC	6/20/2012	--	0.2	0.05	0.06	--	93	--	--
UTC	9/6/2012	--	0.4	0.05	0.09	--	93	--	--
UTC	12/19/2012	--	0.2	0.04	0.06	--	104	--	--
UTC	5/2/2013	0.003	0.103	0.029	0.039	2.8	89	**n/a**	**--**
UTC	5/7/2013	<.002	0.19	0.03	0.049	7.6	100	5.0	**--**
UTC	6/21/2013	<.002	0.025	0.038	0.052	6.8	90	3.0	**--**
UTC	6/25/2013	0.002	0.102	0.034	0.053	12.4	90	5.3	**--**

Appendix A-13. Field measurements taken during sample collection times at the tributary monitoring site at Lower Thomas Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
LTC	3/20/2003	0.96	--	--	--	--
LTC	6/25/2003	3.10	--	--	--	--
LTC	10/2/2003	0.15	16.23	0.166	11.56	8.65
LTC	12/9/2003	--	--	--	--	--
LTC	3/29/2004	1.70	--	--	--	--
LTC	6/23/2004	0.00	18.47	0.147	9.12	8.1
LTC	9/28/2005	5.50	13.91	0.148	8.89	7.77
LTC	1/10/2006	--	3.76	0.116	11.71	7.86
LTC	4/10/2006	2.18	--	--	--	--
LTC	6/29/2006	4.20	--	--	--	--
LTC	10/11/2006	1.68	8.72	0.11	10.43	7.36
LTC	1/9/2007	2.44	0.11	0.097	15.62	7.6
LTC	4/11/2007	1.56	6.66	0.096	11.16	7.82
LTC	6/26/2007	0.56	16.37	0.0152	8.61	7.12
LTC	10/22/2007	0.10	6.99	0.115	10.28	7.67
LTC	1/28/2008	11.44	0.20	0.127	13.41	7.88
LTC	4/23/2008	1.50	7.68	0.103	9.97	7.62
LTC	6/24/2008	1.50	16.59	0.121	8.52	7.82
LTC	9/23/2008	4.30	12.18	0.147	10.26	7.83
LTC	2/2/2009	0.00	0.33	0.1	12.99	7.61
LTC	4/21/2009	1.00	11.16	0.09	11.17	7.7
LTC	7/15/2009	0.10	22.25	0.112	1.86	7.71
LTC	9/15/2009	1.75	14.57	0.141	8.98	7.78
LTC	3/1/2010	1.45	4.45	0.121	13.61	8
LTC	6/28/2010	3.00	21.1	0.1	6.95	7.54
LTC	9/21/2010	2.70	14.49	0.145	9.11	7.29
LTC	12/22/2010	1.7	1.30	0.122	11.30	7.25
LTC	3/23/2011	2.0	3.53	0.112	11.30	8.26
LTC	6/30/2011	7.7	13.00	0.079	11.39	7.83
LTC	9/21/2011	1.07	13.64	0.117	9.42	7.64
LTC	12/1/2011	0.5	-0.02	0.109	11.9	7.24
LTC	3/26/2012	0.91	7.24	0.099	10.03	7.92
LTC	6/20/2012	0.43	16.25	1.39	8.64	7.67
LTC	9/6/2012	0.44	19.58	0.148	7.7	7.28
LTC	3/26/2012	0.38	1.53	0.08	--	7.73
LTC	5/2/2013	0.420066	8.96	0.098	10.19	7.62
LTC	5/7/2013	1.274621	12.32	0.113	11	7.65
LTC	6/21/2013	0.23766	13.26		9.26	7.59
LTC	6/25/2013	0.032016	17.8	0.125	9.08	7.71

Appendix A-14. Macronutrient concentrations, turbidity and E. coli grab samples collected at the tributary monitoring site at Lower Thomas Creek.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
LTC	3/20/2003	< 0.5	0.40	--	0.04	<5	73	--	--
LTC	6/25/2003	0.037	0.75	--	0.15	25	127	--	--
LTC	10/2/2003	0.148	0.51	--	0.08	2	125	--	--
LTC	12/9/2003	0.01	0.23	--	0.055	3	108	--	--
LTC	3/29/2004	0	0.30	--	0.063	19	97	--	--
LTC	6/23/2004	0.036	0.246	--	0.161	6	116	--	--
LTC	9/28/2005	0.196	0.796	--	0.09	5	110	--	--
LTC	1/10/2006	0.253	0.663	--	0.056	1	99	--	--
LTC	4/10/2006	0.008	0.468	--	0.062	2	116	--	--
LTC	6/29/2006	0.02	0.450	--	0.102	18	87	--	--
LTC	10/11/2006	0.008	0.178	--	0.061	3	118	--	--
LTC	1/9/2007	0.006	0.326	--	0.04	<2	88	--	--
LTC	4/11/2007	0.012	0.232	--	0.055	41	89	--	--
LTC	6/26/2007	0.078	0.638	--	0.147	5	114	--	--
LTC	10/22/2007	--	0.45	--	0.091	<2	99	--	--
LTC	1/28/2008	<0.02	0.28	--	0.067	3	110	--	--
LTC	4/23/2008	<0.02	0.27	--	0.072	<2	96	--	--
LTC	6/24/2008	0.03	0.5	--	0.15	16	98	--	--
LTC	9/23/2008	<.1	0.7	--	0.12	24	113	--	--
LTC	2/2/2009	<.1	0.5	--	0.05	<2	105	--	--
LTC	4/21/2009	<.10	0.36	--	0.08	2	105	--	--
LTC	7/15/2009	0	0.5	--	0.13	5	108	--	--
LTC	9/15/2009	0	0.9	--	0.16	22	143	--	--
LTC	3/1/2010	0.03	0.4	--	0.1	2	125	--	--
LTC	6/28/2010	0.03	0.5	--	0.1	22	109	--	--
LTC	9/21/2010	<0.02	0.6	--	0.13	20	109	--	--
LTC	12/22/2010	<0.02	0.3	--	0.07	<1.7	107	--	--
LTC	3/23/2011	--	0.2	0.04	0.05	--	104	--	--
LTC	6/30/2011	--	1.6	0.06	0.08	--	91	--	--
LTC	9/21/2011	--	0.7	0.06	0.12	--	113	--	--
LTC	12/1/2011	--	0.5	0.16	0.21	--	140	--	--
LTC	3/26/2012	--	0.2	0.03	0.05	--	109	--	--
LTC	6/20/2012	--	0.89	0.16	0.19	--	129	--	--
LTC	9/6/2012	--	0.92	0.08	0.16	--	129	--	--
LTC	3/26/2012	--	0.2	0.05	0.08	--	109	--	--
LTC	5/2/2013	0.008	0.148	0.036	0.051	3.6	94	n/a	--
LTC	5/7/2013	0.043	0.535	0.08	0.13	18.6	116	9.3	--
LTC	6/21/2013	0.010	0.262	0.048	0.083	9.3	99	6.3	--
LTC	6/25/2013	0.031	0.473	0.06	0.106	21.1	102	10.1	--

Appendix A-15. Field measurements taken during sample collection times at the tributary monitoring site at Chalk Creek.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
CC	3/7/2007	0.48	9.56	--	--	8.10
CC	6/1/2007	0.43	15.36	--	--	8.08
CC	9/7/2007	0.49	13.63	--	--	7.91
CC	12/7/2007	0.56	4.61	--	--	--
CC	3/8/2008	1.42	8.54	--	--	--
CC	6/1/2008	0.47	14.94	--	--	--
CC	9/1/2008	0.42	13.31	--	--	--
CC	12/1/2008	0.58	4.54	--	--	8.08
CC	3/1/2009	1.11	7.08	--	--	8.26
CC	6/1/2009	0.55	14.75	--	7.97	8.18
CC	9/1/2009	0.36	13.75	--	8.82	7.83
CC	12/1/2009	0.66	2.89	--	10.75	7.67
CC	9/1/2010	0.44	13.29	2.803	7.51	8.14
CC	12/1/2010	1.10	6.75	2.674	10.16	8.11
CC	3/23/2011	2.92	7.52	1.833	10.26	6.99
CC	6/28/2011	0.63	18.23	3.006	9.42	7.21
CC	9/21/2011	0.68	12.01	2.992	9.50	7.38
CC	12/1/2011	0.79	4.97	2.796	7.26	7.99
CC	3/26/2012	0.61	6.93	2.652	12.02	8.15
CC	6/20/2012	0.49	6.93	2.652	10.06	7.99
CC	9/6/2012	0.46	14.72	2.536	7.07	7.88
CC	12/19/2012	2.00	7.85	6.890	--	8.02
CC	5/2/2013 7:50	0.04	6.74	2.816	10.22	7.78
CC	5/7/2013 8:20	3.52	9.29	2.409	8.88	7.79
CC	6/10/2013 18:25	n/a	n/a	n/a	n/a	n/a
CC	6/21/2013 7:55	0.08	10.76	2.858	8.04	7.84

Appendix A-16. Macronutrients, turbidity and E. coli for grab samples collected at the tributary monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
CC	3/7/2007	--	--	--	--	--	2624	--	--
CC	6/1/2007	--	--	--	--	--	2628	--	--
CC	9/7/2007	--	--	--	--	--	2753	--	--
CC	12/7/2007	--	--	--	--	--	2399	--	--
CC	3/8/2008	--	--	--	--	--	2819	--	--
CC	6/1/2008	--	--	--	--	--	2802	--	--
CC	9/1/2008	--	--	--	--	--	2631	--	--
CC	12/1/2008	--	--	--	--	--	2598	--	--
CC	3/1/2009	--	--	--	--	--	2418	--	--
CC	6/1/2009	--	--	--	--	--	2311	--	--
CC	9/1/2009	--	--	--	--	--	2426	--	--
CC	12/1/2009	--	--	--	--	--	2283	--	--
CC	9/1/2010	--	--	--	--	--	2488	--	--
CC	12/1/2010	--	--	--	--	--	n/a	--	--
CC	3/23/2011	--	2.4	0.27	0.31	--	1740	--	--
CC	6/28/2011	--	4.3	0.34	0.35	--	2970	--	--
CC	9/21/2011	--	5.1	0.31	0.32	--	2600	--	--
CC	12/1/2011	--	5.3	0.3	0.3	--	2430	--	--
CC	3/26/2012	--	4.9	0.24	0.27	--	2340	--	--
CC	6/20/2012	--	4.3	0.3	0.3	--	2440	--	--
CC	9/6/2012	--	5.1	0.28	0.33	--	2440	--	--
CC	12/19/2012	--	0	0.32	0.34	--	n/a	--	--
CC	5/2/2013 7:50	3.14	3.549	0.244	0.251	1.8	2580	n/a	8.5
CC	5/7/2013 8:20	0.784	2.30	0.397	0.553	94.0	2250	48.3	--
CC	6/10/2013 18:25	2.13	8.3	0.323	1.04	327	1970	151	--
CC	6/21/2013 7:55	3.34	3.8	0.279	0.328	19.0	2640	8.7	--

Appendix A-17. Field measurements taken during sample collection times at the Lower Alum Creek tributary monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
LAC	3/23/2011	--	2.42	0.792	10.89	7.42
LAC	5/31/2011	2.7	17.9	0.55	--	--
LAC	6/30/2011	0.99	14.28	0.593	10.15	7.7
LAC	9/21/2011	0.9	14.48	0.559	8.31	7.92
LAC	12/1/2011	0	0	0	2.92	6.79
LAC	3/26/2012	0	0	0	--	--
LAC	6/20/2012	0.1	14.73	675	9.42	7.76
LAC	9/6/2012	0.49	16.76	0.56	7.76	7.79
LAC	12/19/2012	0	7.75	10.03	--	6.62
LAC	5/7/2013	0.77	11.74	0.666	8.41	7.43
LAC	6/9/2013	n/a	n/a	n/a	n/a	n/a
LAC	6/21/2013	0.01	12.43	0.684	8.23	7.71
LAC	6/28/2013	n/a	n/a	n/a	n/a	n/a

Appendix A-18. Analytic results from grab samples collected at Lower Alum Creek tributary monitoring site.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
LAC	3/23/2011	--	1.1	0.1	0.13	54	512	--	--
LAC	5/31/2011	--	--	--	--	--	--	--	--
LAC	6/30/2011	--	0.5	0.08	0.1	DNM	437	--	--
LAC	9/21/2011	--	0.8	0.14	0.21	46	412	--	--
LAC	12/1/2011	--	--	--	--	10	556	--	--
LAC	3/26/2012	--	--	--	--	0	--	--	--
LAC	6/20/2012	--	0.6	0.07	0.09	0	6	--	--
LAC	9/6/2012	--	1.1	0.14	0.29	0	6	--	--
LAC	12/19/2012	--	--	0.34	0.36	0	--	--	--
LAC	5/7/2013	0.050	0.46	0.045	0.097	63.6	492	22.1	387.3
LAC	6/9/2013	0.223	3.15	0.257	0.44	34.3	442	13.6	--
LAC	6/21/2013	0.008	0.20	0.061	0.083	5.8	501	4.6	341
LAC	6/28/2013	0.018	3.763	0.063	0.79	600	150	160	--

Appendix A-19. Field measurements taken during sample collection times at North Truckee Drain at Orr Ditch.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
OR	3/21/2003	0.50	--	--	--	--
OR	6/25/2003	12.00	--	--	--	--
OR	10/2/2003	2.90	13.93	0.676	13.78	8.34
OR	12/9/2003	0.75	2.54	1.054	5.69	8.13
OR	3/29/2004	--	--	--	--	--
OR	6/23/2004	13.50	20.42	0.624	9.9	8.18
OR	9/28/2005	6.80	13.64	0.665	10.99	8.25
OR	1/10/2006	1.50	3.06	0.843	11.88	7.6
OR	4/10/2006	0.02	10.45	2.047	19.84	8.91
OR	6/29/2006	6.50	--	--	--	--
OR	10/11/2006	1.60	9.55	1.366	11.78	8.04
OR	1/9/2007	0.90	5.27	1.732	9.56	7.6
OR	4/11/2007	0.80	10.93	1.905	18.48	8.93
OR	6/26/2007	5.30	14.8	0.754	10.94	6.92
OR	10/22/2007	0.66	14.49	1.754	15.13	8.66
OR	1/28/2008	2.40	1.56	1.776	11.86	8.27
OR	4/23/2008	0.14	17.17	2.003	23.99	9.27
OR	6/24/2008	0.14	15.67	1.076	11.33	8.29
OR	9/23/2008	2.00	13.4	1.593	10.98	8.13
OR	2/2/2009	0.00	8.87	1.812	19.25	8.87
OR	4/21/2009	0.10	16.7	1.972	23.74	8.9
OR	7/15/2009	1.80	21.77	0.635	9.1	8.07
OR	9/15/2009	1.70	16.54	1.423	9.03	8.12
OR	3/1/2010	--	--	--	--	--
OR	6/28/2010	5.20	22.83	0.692	11.9	8.48
OR	9/21/2010	2.50	16.29	1.843	13.53	8.36
OR	12/22/2010	42.5	4.83	1.859	10.99	7.85
OR	3/24/2011	2.7	7.66	2.23	25.10	9.00
OR	6/30/2011	2.1	25.25	1.28	13.03	8.78
OR	9/21/2011	1.1	13.53	2.15	5.88	8.04
OR	12/1/2011	1.2	6.24	2.278	15.8	8.56
OR	3/26/2012	0.78	5.03	2.054	8.53	8.18
OR	6/20/2012	1.2	27.03	1.213	14.54	8.99
OR	9/6/2012	1.2	22.9	1.029	6.89	7.85
OR	12/19/2012	0.93	2.02	2.056	--	8.17
OR	5/2/13 13:55	1.72	20.71	1.793	16.89	8.78
OR	5/7/13 12:25	1.87	13.12	1.446	12.09	8.25
OR	6/10/13 13:25	2.20	21.6	0.696	6.9	8.09
OR	6/10/13 15:33	2.13	20.07	1.052	3.76	8.1
OR	6/21/13 12:20	1.77	20.32	1.573	9.64	8.2

Appendix A-20. Analytic results from grab samples collected at the tributary monitoring site on North Truckee Drain at Orr Ditch.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
OR	3/21/2003	1.2	37701.92	--	0.28	37	860	--	--
OR	6/25/2003	0.071	37797.00	--	0.311	9	241	--	--
OR	10/2/2003	0.466	1.30	--	0.133	30	435	--	--
OR	12/9/2003	1.37	2.54	--	0.567	23	707	--	--
OR	3/29/2004	1.84	2.64	--	0.124	32	1389	--	--
OR	6/23/2004	0.104	1.434	--	0.421	15	389	--	--
OR	9/28/2005	0.39	1.020	--	0.087	11	425	--	--
OR	1/10/2006	1.1	2.490	--	0.529	130	1016	--	--
OR	4/10/2006	1.88	3.470	--	0.173	35	1313	--	--
OR	6/29/2006	0.47	1.450	--	0.187	5	316	--	--
OR	10/11/2006	1.51	2.2	--	0.115	15	913	--	--
OR	1/9/2007	2.13	3.680	--	0.215	128	1075	--	--
OR	4/11/2007	1.73	3.980	--	0.206	0	1267	--	--
OR	6/26/2007	0.87	1.800	--	0.154	8	520	--	--
OR	10/22/2007		4.710	--	0.16	3	1181	--	--
OR	1/28/2008	0.14	3.24	--	0.38	252	1155	--	--
OR	4/23/2008	0.12	5.060	--	0.179	19	1360	--	--
OR	6/24/2008	0.04	2.820	--	0.18	17	698	--	--
OR	9/23/2008	<.1	3.400	--	0.13	15	1070	--	--
OR	2/2/2009	<.1	4.500	--	0.23	42	1300	--	--
OR	4/21/2009	<.10	5.900	--	0.19	14	1280	--	--
OR	7/15/2009	0	1.800	--	0.27	8	438	--	--
OR	9/15/2009	0.02	2.800	--	0.27	11	1040	--	--
OR	3/1/2010	--	--	--	--	--	--	--	--
OR	6/28/2010	0.02	2.200	--	0.3	7	471	--	--
OR	9/21/2010	0.02	3.70	--	0.18	36	1230	--	--
OR	12/22/2010	0.21	3.9	--	0.27	36	1220	--	--
OR	3/24/2011	--	3.20	0.14	0.21	--	1490.00	--	--
OR	6/30/2011	--	2.70	0.14	0.20	--	834.00	--	--
OR	9/21/2011	--	4.3	0.20	0.30	--	1480.00	--	--
OR	12/1/2011	--	4.5	0.21	0.31	--	1560	--	--
OR	3/26/2012	--	4.1	0.13	0.19	--	1350	--	--
OR	6/20/2012	--	3.1	0.22	0.31	--	797	--	--
OR	9/6/2012	--	2.5	0.14	0.22	--	797	--	--
OR	12/19/2012	--		0.31	0.38	--	1410	--	--
OR	5/2/13 13:55	2.00	3.008	0.077	0.156	13.2	1190	n/a	--
OR	5/7/13 12:25	0.926	2.559	0.103	0.248	28.7	988	22.8	--
OR	6/10/13 13:25	1.07	6.097	0.091	0.70	215	399	95.5	--
OR	6/10/13 15:33	0.810	5.223	0.133	0.563	95.0	678	49.1	--
OR	6/21/13 12:20	1.20	2.82	0.356	0.504	25.0	1060	23.7	--

Appendix A-21. Field measurements taken during sample collection times at the tributary monitoring site on the North Truckee Drain at Kleppe Lane.

Sampling Site (ID)	Sampling Date Time (PST)	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH
KL	3/21/2003	14.70	--	--	--	--
KL	6/25/2003	15.00	--	--	--	--
KL	10/2/2003	--	15.87	0.717	9.59	7.92
KL	12/9/2003	6.80	10.82	0.796	6.08	7.62
KL	3/29/2004	4.60	--	--	--	--
KL	6/23/2004	31.10	20.15	0.58	6.67	7.87
KL	9/28/2005	12.7	13.06	0.649	9.11	7.82
KL	1/10/2006	--	6.32	0.873	11.46	7.8
KL	4/10/2006	9.60	11.17	1.014	12.84	8.24
KL	6/29/2006	16.80	--	--	--	--
KL	10/11/2006	22.6	13.85	0.925	8.8	7.54
KL	1/9/2007	7.50	6.23	1.077	11.07	7.6
KL	4/11/2007	2.88	12.84	1.125	11.71	8.18
KL	6/26/2007	10.50	17.9	0.846	6.74	7.06
KL	10/22/2007	53.9	12.96	1.026	11.01	8.33
KL	1/28/2008	28.90	5.08	0.989	9.8	7.77
KL	4/23/2008	2.20	12.93	0.863	7.64	7.54
KL	6/24/2008	2.20	19.41	0.896	6.37	8.22
KL	9/23/2008	2.78	15.18	0.856	8	7.85
KL	2/2/2009		7.99	0.958	10.64	7.81
KL	4/21/2009	6.00	12.74	0.88	9.2	7.78
KL	7/15/2009	17.20	20.7	0.739	7.03	7.98
KL	9/15/2009	10.00	15.18	0.731	8.07	7.95
KL	3/1/2010	11.30	8.03	1.267	15.01	8.13
KL	6/28/2010	4.03	19.37	0.737	7.08	7.71
KL	9/21/2010	25.95	16.67	0.626	8.9	7.92
KL	12/22/2010	54.2	6.52	0.993	9.80	7.43
KL	3/24/11	34.4	8.07	1.069	18.04	8.11
KL	6/30/11	7.3	21.82	0.747	10.94	8.44
KL	9/21/11	7.8	17.09	0.931	7.27	7.99
KL	12/1/11	7.8	7.2	1.059	10.15	8.05
KL	3/26/12	8.8	8.21	0.895	9.68	8.08
KL	6/20/12	11	20.69	0.698	9.42	8.3
KL	9/6/12	12	21.35	0.734	6.93	7.96
KL	12/19/12	6.5	7.03	1.024	--	7.94
KL	5/2/13 13:30	7.4	17.4	1.011	11.54	8.4
KL	5/7/13 12:00	8.4	11.88	0.353	7.84	7.77
KL	6/10/13 14:13	2.4	20.3	0.681	7.28	8.27
KL	6/21/13 12:00	10	18.12	0.655	8.34	8.06

Appendix A-22. Analytic results from grab samples collected at the tributary monitoring site on the North Truckee Drain at Kleppe Lane.

Sampling Site (ID)	Sampling Date Time (PST)	NO_3-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100mL)
KL	3/21/2003	0.54	1.34	--	0.49	<5	520	--	--
KL	6/25/2003	0.173	1.20	--	0.188	10	357	--	--
KL	10/2/2003	0.443	1.53	--	0.109	73	488	--	--
KL	12/9/2003	0.561	1.11	--	0.297	10	538	--	--
KL	3/29/2004	0.475	0.93	--	0.242	7	536	--	--
KL	6/23/2004	0.12	1.03	--	0.328	8	358	--	--
KL	9/28/2005	0.389	1.039	--	0.188	18	417	--	--
KL	1/10/2006	1.8	3.070	--	0.384	2	519	--	--
KL	4/10/2006	0.641	1.491	--	0.166	7	629	--	--
KL	6/29/2006	0.366	1.266	--	0.233	10	397	--	--
KL	10/11/2006	0.766	1.716	--	0.157	27	639	--	--
KL	1/9/2007	0.887	2.147	--	0.19	21	774	--	--
KL	4/11/2007	0.955	1.945	--	0.143	0	745	--	--
KL	6/26/2007	0.484	1.164	--	0.149	4	523	--	--
KL	10/22/2007		2.080	--	1.5	<2	656	--	--
KL	1/28/2008	0.22	2.21	--	0.239	69	641	--	--
KL	4/23/2008	0.14	1.040	--	0.38	9	557	--	--
KL	6/24/2008	0.08	1.270	--	0.18	17	558	--	--
KL	9/23/2008	0.12	1.200	--	0.16	10	551	--	--
KL	2/2/2009	0.34	2.000	--	0.25	7	640	--	--
KL	4/21/2009	0.12	1.330	--	0.2	3	587	--	--
KL	7/15/2009	0.03	1.200	--	0.2	13	492	--	--
KL	9/15/2009	0.04	1.400	--	0.19	20	498	--	--
KL	3/1/2010	0.15	2.400	--	0.27	8	864	--	--
KL	6/28/2010	0.09	2.000	--	0.19	11	465	--	--
KL	9/21/2010	0.03	1.20	--	0.14	24	399	--	--
KL	12/22/2010	0.28	2.1	--	0.25	16	616	--	--
KL	3/24/11	--	1.7	0.17	0.21	--	673	--	--
KL	6/30/11	--	1.5	0.13	0.18	--	473	--	--
KL	9/21/11	--	1.7	0.09	0.16	--	594	--	--
KL	12/1/11	--	1.5	0.17	0.2	--	618	--	--
KL	3/26/12	--	1.6	0.18	0.28	--	580	--	--
KL	6/20/12	--	1.7	0.13	0.16	--	443	--	--
KL	9/6/12	--	1.8	0.1	0.16	--	443	--	--
KL	12/19/12	--	1.9	0.24	0.26	--	634	--	--
KL	5/2/13 13:30	0.288	1.136	0.211	0.258	5.8	645	n/a	--
KL	5/7/13 12:00	0.634	2.619	0.103	0.342	89	252	60.6	--
KL	6/10/13 14:13	0.366	1.073	0.031	0.078	22.7	404	8.9	--
KL	6/21/13 12:00	0.451	1.029	0.108	0.214	26.6	404	15.2	--

APPENDIX B: OUTFALL FIELD AND LAB DATA FROM THE 2013 PILOT STUDY.

Appendix B-1. Outfall site measurements and analytic results from sampling in 2013. SC=specific conductance, DO=dissolved oxygen, NO3-N=nitrate as nitrogen, TN=total nitrogen, PO4-P=orthophosphate as phosphorus, TP=total phosphorus, TSS=total suspended solids, TDS=total dissolved solids, E. coli=Escherichia coli as number of colonies per 100 mL. Entries marked "n/a" indicate results from site measurement, sample collection or analysis are not available.

Sampling Site	Sample Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Arlington	3/31/13 11:40	0.1412	10.43	0.201	82.3	7.48	1.28	6.617	1.2	1.41	19.5	180	19.1	>2419.6
Arlington	5/7/13 9:40	0.2118	11.37	0.14	90.5	9.6	0.393	2.67	0.46	0.729	25	102	20.7	>2419.6
Arlington	6/9/13 16:05	0.1059	n/a	n/a	n/a	n/a	1.72	28.873	2.02	3.91	1030	414	310	n/a
Arlington	6/9/13 16:09	0.1059	n/a	n/a	n/a	n/a	1.24	37.817	1.91	4.57	1620	396	490	n/a
Arlington	6/28/13 18:21	0.5295	n/a	n/a	n/a	n/a	0.022	5.477	0.433	1.02	238	116	56.5	n/a
Cottonwood Park	5/7/13 11:10	0.02	13	0.136	9.61	6.94	0.594	3.35	0.068	0.502	21.3	88	30.5	691
Cottonwood Park	6/10/13 16:53	1	18.98	0.412	6.84	6.68	3.03	29.032	1.23	2.73	598	602	262	7458
Fisherman's	3/31/13 12:48	1.9	10.55	0.244	7.93	7.81	1.12	4.386	0.393	0.517	22	284	35.2	663
Fisherman's	5/7/13 10:30	3.5	11.09	0.199	9.35	7.44	0.561	2.516	0.223	0.401	34.7	125	43.2	>2419.6
Fisherman's	6/9/13 17:30	n/a	n/a	n/a	n/a	n/a	0.713	7.991	0.537	1.23	179	220	79.6	n/a
Greg Street	5/7/13 11:30	0.02	12.25	0.44	9.56	7.21	1.17	6.342	0.109	0.483	22.7	291	17.7	290.9
Greg Street	6/10/13 17:20	2.1	17.32	0.308	7.27	6.56	3.23	17.139	0.398	1.1	146	381	140	1078
Greg Street	6/10/13 17:25	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	382	185	170	n/a
Lower Alum	5/7/13 8:45	0.77	11.74	0.666	8.41	7.43	0.05	0.462	0.045	0.097	63.6	492	22.1	387.3

Sampling Site	Sample Date Time	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Alum	6/9/13 16:28	n/a	n/a	n/a	n/a	n/a	0.223	3.152	0.257	0.44	34.3	442	13.6	n/a
Lower Alum	6/21/13 8:15	0.01	12.43	0.684	8.23	7.71	0.008	0.198	0.061	0.083	5.8	501	4.6	341
Lower Alum	6/28/13 18:33	n/a	n/a	n/a	n/a	n/a	0.018	3.763	0.063	0.79	600	150	160	n/a
Mary Wahl	3/31/13 13:25	0.4	11.06	0.212	6.42	7.18	0.83	3.753	0.343	0.501	30	148	31.8	3654
Mary Wahl	5/7/13 10:50	2.8	10.13	0.106	9.33	7.21	0.184	0.759	0.063	0.125	14.8	64	12.5	>2419.6
Mary Wahl	6/9/13 17:56	0.7	17.42	0.228	3.13	7.14	1.3	2.252	0.09	0.179	6	152	2.6	7733
Oxbow	5/7/13 12:55	0.1	12.06	0.135	11.47	8	0.237	0.577	0.032	0.056	2.1	83	2.8	533.5
Oxbow	6/25/13 17:33	0.25	15.97	0.333	7.44	7.37	1.12	1.314	0.167	0.187	1.4	198	1	n/a
Oxbow	6/28/13 19:15	0.15	20.38	0.209	7.01	7.07	1.19	2.652	0.232	0.343	20.4	162	7.3	n/a
Teglia	6/10/13 16:00	0.05	23.36	1.204	9.76	8.95	0.002	1.204	0.091	0.221	9.4	768	7.2	330
Vine	5/7/13 9:25	0.05	12.96	0.164	9.02	7.81	0.795	3.716	0.174	0.37	32.5	112	45.1	>2419.6
Vine	6/28/13 18:08	3.5	n/a	n/a	n/a	n/a	0.456	4.404	0.262	0.713	220	51	73	n/a
Vine	6/28/13 18:50	0.5	n/a	n/a	n/a	n/a	0.046	11.156	1.13	1.91	59.5	211	32.3	n/a

Appendix B-2. Tributary site measurements and analytic results from sampling 2003–2013. SC=specific conductance, DO=dissolved oxygen, NO3-N=nitrate as nitrogen, TN=total nitrogen, PO4-P=orthophosphate as phosphorus, TP=total phosphorus, TSS=total suspended solids, TDS=total dissolved solids, E. coli=Escherichia coli as number of colonies per 100 mL. Entries marked "n/a" indicate results from site measurement, sample collection or analysis are not available.

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Rhodes	9/23/08 0:00	0	n/a	n/a	n/a	n/a	n/a	n/a	--	n/a	n/a	n/a	--	--
Upper Whites Creek	3/20/03 0:00	3.5	--	--	--	--	<0.5	0.2	--	<0.02	<5	54	--	--
Upper Thomas Creek	3/20/03 0:00	2.9	--	--	--	--	<0.5	0.2	--	0.04	<5	79	--	--
Rhodes	3/20/03 0:00	6	--	--	--	--	<0.5	0.5	--	0.08	<5	190	--	--
Lower Whites Creek	3/20/03 0:00	1.14	--	--	--	--	--	0.2	--	<0.02	<5	60	--	--
Lower Thomas Creek	3/20/03 0:00	0.96	--	--	--	--	<0.5	0.4	--	0.04	<5	73	--	--
NTD@ Kleppe	3/21/03 0:00	14.7	--	--	--	--	0.54	1.34	--	0.49	<5	520	--	--
Upper Whites Creek	4/23/08 0:00	4	2.45	0.08	10.87	7.23	<0.02	0.32	--	0.03	<2	68	--	--
Upper Whites Creek	2/2/09 0:00	--	0.24	0.076	11.83	7.38	<0.1	<0.3	--	<0.04	<2	74	--	--
Upper Whites Creek	1/9/07 0:00	4.5	0.6	0.076	13.85	7.57	0.007	0.207	--	0.023	<2	96	--	--
Lower Whites Creek	1/9/07 0:00	3	0.03	0.076	14.6	7.57	0.08085213	0.155	--	0.02	<2	77	--	--
Lower Thomas Creek	1/9/07 0:00	2.44	0.11	0.097	15.62	7.6	0.006	0.326	--	0.04	<2	88	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Thomas Creek	2/2/09 0:00	0	0.33	0.1	12.99	7.61	<0.1	0.5	--	0.05	<2	105	--	--
Lower Thomas Creek	4/23/08 0:00	1.5	7.68	0.103	9.97	7.62	<0.02	0.27	--	0.072	<2	96	--	--
Lower Thomas Creek	10/22/07 0:00	0.1	6.99	0.115	10.28	7.67	--	0.45	--	0.091	<2	99	--	--
Upper Thomas Creek	2/2/09 0:00	0	0.24	0.098	12.28	7.68	<0.1	<0.3	--	0.05	<2	102	--	--
Rhodes	2/2/09 0:00	0	3.66	0.304	12.52	7.69	<0.1	0.4	--	0.07	<2	213	--	--
Upper Thomas Creek	1/9/07 0:00	--	0.38	0.097	14.23	7.76	0.007	0.217	--	0.04	<2	101	--	--
Lower Whites Creek	9/23/08 0:00	1.3	9.53	0.083	11.92	7.79	--	<0.3	--	<0.04	<2	70	--	--
Upper Thomas Creek	1/28/08 0:00	4.85	0.02	0.093	12.82	7.81	<0.02	0.16	--	0.053	<2	90	--	--
Rhodes	1/28/08 0:00	3.63	2.48	0.401	12.81	7.89	<0.02	0.63	--	0.09	<2	262	--	--
Upper Whites Creek	3/1/10 0:00	3.1	2.24	0.078	13.06	7.91	<0.02	0.1	--	0.03	<2	81	--	--
NTD@ Kleppe	10/22/07 0:00	53.9	12.96	1.026	11.01	8.33		2.08	--	1.5	<2	656	--	--
Clean Water Way	10/22/07 0:00	19.5	12.66	0.85	2.78	8.54	--	1.45	--	0.222	<2	539	--	--
Lower Thomas Creek	12/22/10 0:00	1.74	1.3	0.122	11.3	7.25	<0.02	0.3	--	0.07	<1.7	107	--	--
Upper Thomas Creek	12/22/10 0:00	2.78	1.82	0.108	11.53	7.38	<0.02	0.2	--	0.05	<1.7	104	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Whites Creek	9/21/10 0:00	3.6	--	--	--	--	<0.02	0.1	--	--	<1.7	58	--	--
Upper Whites Creek	12/9/03 0:00	2.8	--	--	--	--	0.01	0.12	--	0.029	<1	76	--	--
Lower Whites Creek	12/9/03 0:00	0.8	--	--	--	--	0.241478362	0.266	--	0.033	<1	87	--	--
Upper Whites Creek	3/29/04 0:00	2.9	--	--	--	--	0	0	--	0.019	<1	74	--	--
Lower Whites Creek	3/29/04 0:00	0.2	--	--	--	--	0	0.11	--	0.02	<1	73	--	--
Chalk Creek	3/23/11 0:00	2.918	7.52	1.833	10.26	6.99	--	2.4	0.27	0.31	--	1740	--	--
Upper Whites Creek	3/23/11 0:00	4	0.42	0.085	11.32	7.15	--	0.2	0.02	0.03	--	81	--	--
Chalk Creek	6/28/11 0:00	0.628	18.23	3.006	9.42	7.21	--	4.3	0.34	0.35	--	2970	--	--
Upper Thomas Creek	12/1/11 0:00	--	-0.02	0.109	11.9	7.24	--	0.3	0.06	0.07	--	91	--	--
Lower Whites Creek	12/1/11 0:00	0.5	-0.06	0.083	12.65	7.24	--	0.2	0.03	0.05	--	84	--	--
Lower Thomas Creek	12/1/11 0:00	0.5	-0.02	0.109	11.9	7.24	--	0.5	0.16	0.21	--	140	--	--
Rhodes	9/6/12 0:00	n/a	18.1	0.699	4.29	7.26	--	2.5	0.08	0.33	--	198	--	--
Upper Thomas Creek	9/6/12 0:00	1.22	12.67	0.093	7.7	7.28	--	0.4	0.05	0.09	--	93	--	--
Lower Thomas Creek	9/6/12 0:00	0.44	19.58	0.148	7.7	7.28	--	0.92	0.08	0.16	--	129	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Whites Creek	12/19/12 0:00	0.49	-0.05	0.09	--	7.35	--	0.03	0.02	0.04	--	63	--	--
Chalk Creek	9/21/11 0:00	0.676	12.01	2.992	9.5	7.38	--	5.1	0.31	0.32	--	2600	--	--
Rhodes	3/26/12 0:00	1.8	7.26	0.393	9.32	7.41	--	0.4	0.1	0.12	--	267	--	--
Upper Whites Creek	12/1/11 0:00	--	-0.07	0.075	12.61	7.46	--	0.2	0.02	0.03	--	84	--	--
Upper Whites Creek	9/21/11 0:00	5.6	9.57	0.073	9.53	7.49	--	0.2	0.02	0.02	--	70	--	--
Rhodes	6/20/12 0:00	0.98	16.59	0.302	8.8	7.49	--	0.7	0.13	0.15	--	198	--	--
Upper Whites Creek	6/20/12 0:00	0.71	10.55	0.7	9.61	7.53	--	0.2	0.02	0.03	--	57	--	--
Rhodes	6/30/11 0:00	51	12.44	0.117	10.62	7.57	--	1.4	0.05	0.07	--	80	--	--
Rhodes	12/1/11 0:00	5.6	1.5	0.283	12.09	7.58	--	0.5	0.06	0.08	--	200	--	--
Rhodes	3/23/11 0:00	14	4.41	0.285	10.8	7.6	--	0.91	0.05	0.06	--	191	--	--
Lower Whites Creek	6/30/11 0:00	4.5	9.97	0.058	11.98	7.6	--	0.4	0.05	0.08	--	50	--	--
Upper Thomas Creek	9/21/11 0:00	1.76	11.09	0.089	9.42	7.64	--	0.3	0.04	0.06	--	102	--	--
Lower Thomas Creek	9/21/11 0:00	1.07	13.64	0.117	9.42	7.64	--	0.7	0.06	0.12	--	113	--	--
Upper Whites Creek	12/19/12 0:00	3.2	7.73	9.06	--	7.64	--	0.2	0.01	0.03	--		--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Rhodes	12/19/12 0:00	2.9	1.81	0.354	--	7.65	--	0.4	0.08	0.11	--	--	--	--
Chalk Creek	12/1/09 0:00	0.663031377	2.888025266	--	10.75405456	7.665621926	--	--	--	--	--	2282.940827	--	--
Upper Thomas Creek	6/20/12 0:00	1.76	11.93	0.93	8.64	7.67	--	0.2	0.05	0.06	--	93	--	--
Lower Thomas Creek	6/20/12 0:00	0.43	16.25	1.39	8.64	7.67	--	0.89	0.16	0.19	--	129	--	--
Lower Whites Creek	3/26/12 0:00	2.22	5.49	0.079	10.93	7.68	--	0.09	0.02	0.03	--	68	--	--
Upper Whites Creek	6/30/11 0:00	20	7.16	0.055	12.15	7.7	--	0.2	0.03	0.04	--	49	--	--
Lower Alum Creek	6/30/11 0:00	0.99	14.28	0.593	10.15	7.7	--	0.5	0.08	0.1	--	437	--	--
Lower Whites Creek	6/20/12 0:00	2.29	13.13	0.79	9.4	7.7	--	0.3	0.04	0.05	--	63	--	--
Upper Whites Creek	3/26/12 0:00	--	1.53	0.08	10.94	7.73	--	0.2	0.02	0.03	--	65	--	--
Lower Thomas Creek	3/26/12 0:00	0.38	1.53	0.08	--	7.73	--	0.2	0.05	0.08	--	109	--	--
Upper Whites Creek	9/6/12 0:00	0.73	16.18	0.094	9.06	7.73	--	0.6	0.03	0.05	--	57	--	--
Upper Thomas Creek	12/19/12 0:00	1.59	-0.05	0.106	--	7.73	--	0.2	0.04	0.06	--	104	--	--
Lower Whites Creek	9/21/11 0:00	1.47	13.59	0.092	10.03	7.75	--	0.4	0.02	0.05	--	83	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Narrows	12/19/12 0:00	7.3	1.7	1.681	--	7.76	--	0.6	0.25	0.31	--	1110	--	--
Rhodes	9/22/11 0:00	3.9	16.29	0.262	8.94	7.77	--	0.6	0.09	0.11	--	190	--	--
Upper Thomas Creek	6/30/11 0:00	13.68	8.12	0.07	11.39	7.83	--	0.2	0.04	0.05	--	77	--	--
Lower Thomas Creek	6/30/11 0:00	7.69	13	0.079	11.39	7.83	--	1.6	0.06	0.08	--	91	--	--
Chalk Creek	9/1/09 0:00	0.3572 91847	13.745 10783	--	8.8170 107	7.83 3858 379	--	--	--	--	--	2426.41 9983	--	--
NTD@ Orr	9/6/12 0:00	1.2	22.9	1.029	6.89	7.85	--	2.5	0.14	0.22	--	797	--	--
Lower Whites Creek	9/6/12 0:00	2.11	11	0.077	8.36	7.85	--	0.1	0.04	0.12	--	63	--	--
Chalk Creek	9/6/12 0:00	0.4635	14.72	2.536	7.07	7.88	--	5.1	0.28	0.33	--	2440	--	--
Chalk Creek	9/7/07 0:00	0.4859 26285	13.631 28805	--	--	7.90 5227 575	--	--	--	--	--	2753.48 5361	--	--
Upper Thomas Creek	3/26/12 0:00	3.09	-0.05	0.091	10.03	7.92	--	0.1	0.04	0.05	--	103	--	--
Lower Thomas Creek	3/26/12 0:00	0.91	7.24	0.099	10.03	7.92	--	0.2	0.03	0.05	--	109	--	--
Clean Water Way	9/7/12 0:00	26	17.62	0.677	5.42	7.93	--	1.5	0.17	0.26	--	314	--	--
NTD@ Kleppe	12/19/12 0:00	6.5	7.03	1.024	--	7.94	--	1.9	0.24	0.26	--	634	--	--
NTD@ Kleppe	9/6/12 0:00	12	21.35	0.734	6.93	7.96	--	1.8	0.1	0.16	--	443	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
NTD@ Kleppe	9/21/11 0:00	7.8	17.09	0.931	7.27	7.99	--	1.7	0.09	0.16	--	594	--	--
Chalk Creek	12/1/11 0:00	0.79	4.97	2.796	7.26	7.99	--	5.3	0.3	0.3	--	2430	--	--
Chalk Creek	6/20/12 0:00	0.49	6.93	2.652	10.06	7.99	--	4.3	0.3	0.3	--	2440	--	--
Clean Water Way	6/30/11 0:00	98	20.53	0.333	9.79	8.02	--	0.8	0.16	0.21	--	212	--	--
Chalk Creek	12/19/12 0:00	2	7.85	6.89	--	8.02	--	0	0.32	0.34	--	n/a	--	--
NTD@ Orr	9/21/11 0:00	1.1	13.53	2.15	5.88	8.04	--	4.3	0.2	0.3	--	1480	--	--
Narrows	12/1/11 0:00	12	1.75	1.236	12.07	8.04	--	0.8	0.19	0.24	--	750	--	--
Lower Whites Creek	3/23/11 0:00	2.19	0.46	0.082	11.58	8.05	--	0.2	0.03	0.04	--	101	--	--
NTD@ Kleppe	12/1/11 0:00	7.8	7.2	1.059	10.15	8.05	--	1.5	0.17	0.2	--	618	--	--
NTD@ Kleppe	3/26/12 0:00	8.8	8.21	0.895	9.68	8.08	--	1.6	0.18	0.28	--	580	--	--
Chalk Creek	12/1/08 0:00	0.5792 15407	4.5397 42139	--	--	8.08 2963 738	--	--	--	--	--	2597.65 4643	--	--
Chalk Creek	6/1/07 0:00	0.4333 06878	15.364 24303	--	--	8.08 3486 99	--	--	--	--	--	2628.11 3117	--	--
Chalk Creek	3/7/07 0:00	0.4830 48827	9.5625 49418	--	--	8.10 1937 388	--	--	--	--	--	2623.55 516	--	--
Chalk Creek	12/1/10 0:00	1.1006 03063	6.7501 94444	2.673558 333	10.155 38889	8.10 8277 778	--	--	--	--	--	n/a	--	--
NTD@ Kleppe	3/24/11 0:00	34.4	8.07	1.069	18.04	8.11	--	1.7	0.17	0.21	--	673	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Narrows	3/26/12 0:00	5.9	9.48	1.54	10.94	8.13	--	0.7	0.26	0.34	--	980	--	--
Chalk Creek	9/1/10 0:00	0.441220428	13.29156503	2.802872431	7.505344279	8.136014931	--	--	--	--	--	2488.323117	--	--
Narrows	6/20/12 0:00	4.4	24.18	1.79	11.12	8.14	--	0.88	0.44	0.49	--	1110	--	--
Clean Water Way	12/19/12 0:00	27	3.96	0.823	--	8.14	--	1.5	0.19	0.25	--	314	--	--
Chalk Creek	3/26/12 0:00	0.61	6.93	2.652	12.02	8.15	--	4.9	0.24	0.27	--	2340	--	--
Narrows	9/6/12 0:00	3.4	18.95	2.166	8.8	8.17	--	0.9	0.44	0.49	--	1110	--	--
NTD@ Orr	12/19/12 0:00	0.93	2.02	2.056	--	8.17	--		0.31	0.38	--	1410	--	--
Chalk Creek	6/1/09 0:00	0.549704758	14.75477185	--	7.970572192	8.179530126	--	--	--	--	--	2310.687177	--	--
NTD@ Orr	3/26/12 0:00	0.78	5.03	2.054	8.53	8.18	--	4.1	0.13	0.19	--	1350	--	--
Clean Water Way	9/22/11 0:00	46	22.32	0.515	9.07	8.21	--	1.5	0.19	0.24	--	341	--	--
Upper Thomas Creek	3/23/11 0:00	3.76	0.67	0.11	11.3	8.26	--	0.3	0.04	0.06	--	111	--	--
Lower Thomas Creek	3/23/11 0:00	1.98	3.53	0.112	11.3	8.26	--	0.2	0.04	0.05	--	104	--	--
Clean Water Way	3/23/11 0:00	81	8.8	0.6	10.7	8.26	--	2.1	0.11	0.17	--	380	--	--
Narrows	9/22/11 0:00	14	21.11	1.148	9.82	8.26	--	0.9	0.3	0.39	--	727	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Chalk Creek	3/1/09 0:00	1.114863439	7.080692559	--	--	8.260227308	--	--	--	--	--	2417.706876	--	--
NTD@ Kleppe	6/20/12 0:00	11	20.69	0.698	9.42	8.3	--	1.7	0.13	0.16	--	443	--	--
Narrows	3/23/11 0:00	19	9.37	0.874	11.68	8.33	--	0.7	0.15	0.2	--	530	--	--
Clean Water Way	3/26/12 0:00	19	7.47	0.838	11.04	8.37	--	1.7	0.14	0.22	--	517	--	--
Narrows	6/30/11 0:00	81	21.16	0.324	10.96	8.42	--	0.6	0.16	0.21	--	208	--	--
Clean Water Way	12/1/11 0:00	24	5.21	0.918	15.81	8.42	--	1.4	0.14	0.19	--	568	--	--
Clean Water Way	6/20/12 0:00	20	21.4	4.55	9.69	8.43	--	1.2	0.21	0.26	--	314	--	--
NTD@ Kleppe	6/30/11 0:00	7.3	21.82	0.747	10.94	8.44	--	1.5	0.13	0.18	--	473	--	--
NTD@ Orr	12/1/11 0:00	1.2	6.24	2.278	15.8	8.56	--	4.5	0.21	0.31	--	1560	--	--
NTD@ Orr	6/30/11 0:00	2.1	25.25	1.276	13.03	8.78	--	2.7	0.14	0.2	--	834	--	--
NTD@ Orr	6/20/12 0:00	1.2	27.03	1.213	14.54	8.99	--	3.1	0.22	0.31	--	797	--	--
NTD@ Orr	3/24/11 0:00	2.7	7.66	2.23	25.1	9	--	3.2	0.14	0.21	--	1490	--	--
Chalk Creek	12/7/07 0:00	0.559450156	4.610406522	--	--	--	--	--	--	--	--	2399.37883	--	--
Chalk Creek	3/8/08 0:00	1.419318 61	8.539870726	--	--	--	--	--	--	--	--	2818.546924	--	--
Chalk Creek	6/1/08 0:00	0.472021834	14.93573369	--	--	--	--	--	--	--	--	2802.300172	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Chalk Creek	9/1/08 0:00	0.4195 19549	13.308 59093	--	--	--	--	--	--	--	--	2630.75 3916	--	--
NTD@ Orr	3/1/10 0:00	--	--	--	--	--	--	--	--	--	--	--	--	--
Lower Alum Creek	5/31/11 0:00	2.7	17.9	0.55	--	--	--	--	--	--	--	--	--	--
Lower Alum Creek	3/26/12 0:00	0	n/a	n/a	n/a	n/a	--	n/a	n/a	n/a	--	n/a	--	--
Lower Alum Creek	6/28/13 18:33	n/a	n/a	n/a	n/a	n/a	0.018	3.763	0.063	0.79		150	160	--
Chalk Creek	6/10/13 18:25	n/a	n/a	n/a	n/a	n/a	2.13	8.332	0.323	1.04	327	1970	151	--
NTD@ Orr	1/28/08 0:00	2.4	1.56	1.776	11.86	8.27	0.14	3.24	--	0.38	252	1155	--	--
NTD@ Orr	6/10/13 13:25	2.2	21.6	0.696	6.9	8.09	1.07	6.097	0.091	0.7	215	399	95.5	--
NTD@ Orr	1/10/06 0:00	1.5	3.06	0.843	11.88	7.6	1.1	2.49	--	0.529	130	1016	--	--
NTD@ Orr	1/9/07 0:00	0.9	5.27	1.732	9.56	7.6	2.13	3.68	--	0.215	128	1075	--	--
Narrows	5/7/13 16:20	25	17	1.521	10.73	8.35	0.061	1.72	0.401	0.568	121	980	70.5	--
NTD@ Orr	6/10/13 15:33	2.13	20.07	1.052	3.76	8.1	0.81	5.223	0.133	0.563	95	678	49.1	--
Chalk Creek	5/7/13 8:20	3.52	9.29	2.409	8.88	7.79	0.784	2.302	0.397	0.553	94	2250	48.3	--
NTD@ Kleppe	5/7/13 12:00	8.4	11.88	0.353	7.77	7.84	0.634	2.619	0.103	0.342	89	252	60.6	--
Clean Water Way	5/7/13 16:40	80	13.7	0.692	9.02	8.03	0.419	1.613	0.163	0.317	79	440	37.2	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Rhodes	10/22/07 0:00	3.6	6.52	0.248	10.39	7.8	--	0.72	--	0.142	78	170	--	--
NTD@ Kleppe	10/2/03 0:00	--	15.87	0.717	9.59	7.92	0.443	1.533	--	0.109	73	488	--	--
NTD@ Kleppe	1/28/08 0:00	28.9	5.08	0.989	9.8	7.77	0.22	2.21	--	0.239	69	641	--	--
Lower Alum Creek	5/7/13 8:45	0.77	11.74	0.666	8.41	7.43	0.05	0.462	0.045	0.097	63.6	492	22.1	387.3
Lower Whites Creek	6/29/06 0:00	14.6	--	--	--	--	1.18044 1098	0.375	--	0.089	61	54	--	--
Clean Water Way	1/28/08 0:00	55.25	4.98	0.938	9.64	8.06	0.46	3.33	--	0.245	55	589	--	--
Lower Alum Creek	3/23/11 0:00	--	2.42	0.792	10.89	7.42	--	1.1	0.1	0.13	54	512	--	--
Upper Whites Creek	6/28/10 0:00	7	14.81	0.049	8.65	7.62	<0.02	0.2	--	0.04	52	49	--	--
Lower Whites Creek	7/15/09 0:00	3.4	17.98	0.128	8.98	7.81	--	1	--	0.31	49	109	--	--
Lower Alum Creek	9/21/11 0:00	0.9	14.48	0.559	8.31	7.92	--	0.8	0.14	0.21	46	412	--	--
Clean Water Way	10/11/06 0:00	47.14	11.27	0.211	10.38	8.22	6.17	7.13	--	0.206	46	387	--	--
Clean Water Way	4/23/08 0:00	28.62	15.78	1.192	9.48	8.49	0.03	1.64	--	0.282	46	736	--	--
Clean Water Way	3/20/03 0:00	28.62	--	--	--	--	0.56	1.26	--	0.16	46	400	--	--
Clean Water Way	3/1/10 0:00	71.85	7.95	0.659	11.55	7.89	0.1	1.9	--	0.23	44	443	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Clean Water Way	5/2/13 12:50	37	18.4	0.715	11.21	8.42	0.348	1.087	0.168	0.232	43.8	444	n/a	--
Lower Whites Creek	4/11/07 0:00	3	5.21	0.075	11.62	7.77	0.08085213	0.145	--	0.026	43	69	--	--
NTD@ Orr	2/2/09 0:00	0	8.87	1.812	19.25	8.87	<0.1	4.5	--	0.23	42	1300	--	--
Upper Whites Creek	6/29/06 0:00	13	--	--	--	--	0.009	0.219	--	0.028	42	45	--	--
Lower Thomas Creek	4/11/07 0:00	1.56	6.66	0.096	11.16	7.82	0.012	0.232	--	0.055	41	89	--	--
Lower Whites Creek	6/28/10 0:00	5.99	15.01	0.062	8.96	7.71	--	0.3	--	0.06	38	70	--	--
Clean Water Way	9/21/10 0:00	44	15.56	0.636	9.67	7.9	<0.02	1.5	--	0.28	38	414	--	--
Clean Water Way	9/28/05 0:00	55.25	18.96	0.579	11.29	8.35	0.641	1.151	--	0.237	37	366	--	--
NTD@ Orr	3/21/03 22:00	0.5	--	--	--	--	1.2	3	--	0.28	37	860	--	--
NTD@ Orr	12/22/10 0:00	42.49	4.83	1.859	10.99	7.85	0.21	3.9	--	0.27	36	1220	--	--
NTD@ Orr	9/21/10 0:00	2.5	16.29	1.843	13.53	8.36	0.02	3.7	--	0.18	36	1230	--	--
Clean Water Way	9/23/08 0:00	17.88	17.12	0.647	15.87	8.84	<0.1	1.6	--	0.22	35	406	--	--
NTD@ Orr	4/10/06 0:00	0.02	10.45	2.047	19.84	8.91	1.88	3.47	--	0.173	35	1313	--	--
Lower Alum Creek	6/9/13 16:28	n/a	n/a	n/a	n/a	n/a	0.223	3.152	0.257	0.44	34.3	442	13.6	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Clean Water Way	12/22/10 0:00	73.9	3.39	0.657	10.4	7.44	1.27	1.8	--	0.27	34	417	--	--
NTD@ Orr	3/29/04 0:00	--	--	--	--	--	1.84	2.64	--	0.124	32	1389	--	--
Clean Water Way	3/29/04 0:00	33.53	--	--	--	--	0.423	1.053	--	0.196	32	379	--	--
Rhodes	6/21/13 10:10	1.4	14.53	0.37	7.56	7.58	0.04	0.643	0.067	0.23	31.6	230	5.8	1078
Clean Water Way	4/21/09 0:00	28	23.3	0.762	11.72	8.42	<0.1	1.26	--	0.28	31	478	--	--
NTD@ Orr	10/2/03 0:00	2.9	13.93	0.676	13.78	8.34	0.466	1.296	--	0.133	30	435	--	--
Clean Water Way	12/9/03 0:00	17.4	0.19	0.085	5.19	8.06	0.591	1.441	--	0.234	29	584	--	--
NTD@ Orr	5/7/13 12:25	1.87	13.12	1.446	12.09	8.25	0.926	2.559	0.103	0.248	28.7	988	22.8	--
Clean Water Way	9/15/09 0:00	23.3	16.73	0.717	7.65	8.08	0.14	1.9	--	0.33	28	490	--	--
NTD@ Kleppe	10/11/06 0:00	22.6	13.85	0.925	8.8	7.54	0.766	1.716	--	0.157	27	639	--	--
Lower Whites Creek	1/28/08 0:00	3.7	5.42	0.35	9.58	8	--	0.19	--	0.069	27	76	--	--
NTD@ Kleppe	6/21/13 12:00	10	18.12	0.655	8.06	8.34	0.451	1.029	0.108	0.214	26.6	404	15.2	--
Lower Whites Creek	6/23/04 0:00	1.7	15.28	0.06	9.13	7.56	0.045816207	0.39	--	0.074	25	59	--	--
NTD@ Orr	6/21/13 12:20	1.77	20.32	1.573	9.64	8.2	1.2	2.82	0.356	0.504	25	1060	23.7	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Clean Water Way	6/24/08 0:00	28.62	19.28	0.645	6.95	8.29	0.04	1.17	--	0.35	25	403	--	--
Lower Thomas Creek	6/25/03 0:00	3.1	--	--	--	--	0.037	0.747	--	0.15	25	127	--	--
Lower Thomas Creek	9/23/08 0:00	4.3	12.18	0.147	10.26	7.83	<0.1	0.7	--	0.12	24	113	--	--
NTD@ Kleppe	9/21/10 0:00	25.95	16.67	0.626	8.9	7.92	0.03	1.2	--	0.14	24	399	--	--
Lower Whites Creek	6/21/13 10:30	3.93	10.61	0.089	9.04	7.59	0.003	0.225	0.021	0.063	23.8	67	9.6	4554
NTD@ Orr	12/9/03 0:00	0.75	2.54	1.054	5.69	8.13	1.37	2.54	--	0.567	23	707	--	--
Clean Water Way	6/25/13 14:00	28	20.56	0.632	12.49	8.5	0.297	0.912	0.168	0.229	23	388	10.1	--
NTD@ Kleppe	6/10/13 14:13	2.4	20.3	0.681	8.27	7.28	0.366	1.073	0.031	0.078	22.7	404	8.9	--
Lower Thomas Creek	6/28/10 0:00	3	21.1	0.1	6.95	7.54	0.03	0.5	--	0.1	22	109	--	--
Lower Thomas Creek	9/15/09 0:00	1.75	14.57	0.141	8.98	7.78	0	0.9	--	0.16	22	143	--	--
Clean Water Way	4/10/06 0:00	--	10.98	0.708	5.72	8.03	0.713	0.826	--	0.182	22	432	--	--
Clean Water Way	1/9/07 0:00	32.8	2.41	0.276	13.32	8.18	0.754	1.714	--	0.174	22	55	--	--
Clean Water Way	2/2/09 0:00	0	8.09	0.795	11.51	8.32	<0.1	1.4	--	0.23	22	580	--	--
Lower Thomas Creek	6/25/13 13:10	0.0320 1625	17.8	0.125	9.08	7.71	0.031	0.473	0.06	0.106	21.1	102	10.1	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
NTD@ Kleppe	1/9/07 0:00	7.5	6.23	1.077	11.07	7.6	0.887	2.147	--	0.19	21	774	--	--
Lower Whites Creek	10/22/07 0:00	2.42	3.59	0.077	12.12	7.67	--	0.11	--	0.029	21	67	--	--
Clean Water Way	6/29/06 0:00	--	--	--	--	--	0.329	1.229	--	0.232	21	245	--	--
Clean Water Way	6/21/13 11:45	22	20.11	0.615	12.41	8.62	0.159	0.708	0.143	0.216	20.8	386	10.2	--
Lower Thomas Creek	9/21/10 0:00	2.7	14.49	0.145	9.11	7.29	<0.02	0.6	--	0.13	20	109	--	--
NTD@ Kleppe	9/15/09 0:00	10	15.18	0.731	8.07	7.95	0.04	1.4	--	0.19	20	498	--	--
Narrows	5/2/13 12:20	2.8	16.56	2.116	10.39	8.09	0.014	0.57	0.387	0.388	19.2	1320	n/a	--
Chalk Creek	6/21/13 7:55	0.08	10.76	2.858	8.04	7.84	3.34	3.76	0.279	0.328	19	2640	8.7	--
NTD@ Orr	4/23/08 0:00	0.14	17.17	2.003	23.99	9.27	0.12	5.06	--	0.179	19	1360	--	--
Lower Thomas Creek	3/29/04 0:00	1.7	--	--	--	--	0	0.3	--	0.063	19	97	--	--
Lower Thomas Creek	5/7/13 15:50	1.27462125	12.32	0.113	11	7.65	0.043	0.535	0.08	0.13	18.6	116	9.3	--
Lower Whites Creek	9/21/10 0:00	1.93	13.16	0.113	9.83	7.34	--	0.4	--	0.07	18	77	--	--
Upper Whites Creek	9/21/10 0:00	1.93	7.41	0.074	10.11	7.41	<0.02	0.4	--	0.03	18	77	--	--
Rhodes	6/24/08 0:00	4.15	14.03	0.269	9.09	7.77	0.02	0.96	--	0.19	18	189	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
NTD@ Kleppe	9/28/05 0:00	12.7	13.06	0.649	9.11	7.82	0.389	1.039	--	0.188	18	417	--	--
Clean Water Way	6/26/07 0:00	10.38	19.77	0.225	10.44	8.97	0.429	1.329	--	0.282	18	392	--	--
Lower Thomas Creek	6/29/06 0:00	4.2	--	--	--	--	0.02	0.45	--	0.102	18	87	--	--
NTD@ Kleppe	6/24/08 0:00	2.2	19.41	0.896	6.37	8.22	0.08	1.27	--	0.18	17	558	--	--
NTD@ Orr	6/24/08 0:00	0.14	15.67	1.076	11.33	8.29	0.04	2.82	--	0.18	17	698	--	--
NTD@ Kleppe	12/22/10 0:00	54.2	6.52	0.993	9.8	7.43	0.28	2.1	--	0.25	16	616	--	--
Rhodes	6/28/10 0:00	21	17.74	0.131	8.38	7.6	<0.1	0.3	--	0.08	16	106	--	--
Lower Thomas Creek	6/24/08 0:00	1.5	16.59	0.121	8.52	7.82	0.03	0.5	--	0.15	16	98	--	--
Upper Whites Creek	12/22/10 0:00	3.9	--	--	--	--	<0.02	0.2	0.078	0.05	16	68	--	--
NTD@ Orr	10/11/06 0:00	1.6	9.55	1.366	11.78	8.04	1.51	2.2	--	0.115	15	913	--	--
NTD@ Orr	9/23/08 0:00	2	13.4	1.593	10.98	8.13	<0.1	3.4	--	0.13	15	1070	--	--
NTD@ Orr	6/23/04 0:00	13.5	20.42	0.624	9.9	8.18	0.104	1.434	--	0.421	15	389	--	--
Upper Whites Creek	6/25/03 0:00	3.8	--	--	--	--	<0.005	0.13	--	0.03	15	65	--	--
Lower Whites Creek	6/25/13 12:50	3.71231625	14.13	0.078	9.88	7.64	0.003	0.163	0.017	0.046	14.9	65	6.9	2882
Lower Whites Creek	4/23/08 0:00	3.4	6.64	0.08	10.24	7.35	--	0.26	--	0.037	14	66	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Whites Creek	6/24/08 0:00	3.4	13.28	0.071	9.56	7.8	--	0.27	--	0.05	14	60	--	--
Upper Thomas Creek	10/22/07 0:00	1.35	2.33	0.095	11.84	7.93	--	0.15	--	0.053	14	96	--	--
Clean Water Way	10/2/03 0:00	33.5	16.41	0.562	12.95	8.56	0.292	1.112	--	0.177	14	408	--	--
NTD@ Orr	4/21/09 0:00	0.1	16.7	1.972	23.74	8.9	<0.1	5.9	--	0.19	14	1280	--	--
Lower Whites Creek	6/25/03 0:00	2.25	--	--	--	--	--	0.29	--	0.044	14	68	--	--
NTD@ Orr	5/2/13 13:55	1.72	20.71	1.793	16.89	8.78	2	3.008	0.077	0.156	13.2	1190	n/a	--
NTD@ Kleppe	7/15/09 0:00	17.2	20.7	0.739	7.03	7.98	0.03	1.2	--	0.2	13	492	--	--
Clean Water Way	6/25/03 0:00	55.25	--	--	--	--	0.273	1.343	--	0.214	13	362	--	--
Upper Thomas Creek	6/25/13 12:08	1.7177 1375	9.88	0.093	9.39	7.64	0.002	0.102	0.034	0.053	12.4	90	5.3	--
Upper Thomas Creek	6/23/04 0:00	1.7	15.17	0.096	8.61	7.83	<0.005	0.5	--	0.066	12	101	--	--
Clean Water Way	6/23/04 0:00	28.04	21.02	0.572	7.46	8.3	0.171	0.911	--	0.248	12	358	--	--
NTD@ Kleppe	6/28/10 0:00	4.03	19.37	0.737	7.08	7.71	0.09	2	--	0.19	11	465	--	--
NTD@ Orr	9/15/09 0:00	1.7	16.54	1.423	9.03	8.12	0.02	2.8	--	0.27	11	1040	--	--
NTD@ Orr	9/28/05 0:00	6.8	13.64	0.665	10.99	8.25	0.39	1.02	--	0.087	11	425	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Thomas Creek	6/29/06 0:00	22.5	--	--	--	--	0.008	0.308	--	0.058	11	81	--	--
Lower Whites Creek	5/7/13 15:30	3.17	9.22	0.074	10.77	7.54	0.002	0.172	0.017	0.038	10.3	74	4.4	613.1
Rhodes	5/7/13 15:10	15	13.1	0.256	9.72	7.72	0.071	0.818	0.126	0.191	10.2	169	5.8	1299.7
Lower Alum Creek	12/1/11 0:00	0	0	0	2.92	6.79	--	--	--	--	10	556	--	--
Lower Whites Creek	10/11/06 0:00	6.9	7.98	0.113	11.2	7.08	0.743839596	0.2	--	0.041	10	90	--	--
NTD@ Kleppe	12/9/03 0:00	6.8	10.82	0.796	6.08	7.62	0.561	1.111	--	0.297	10	538	--	--
NTD@ Kleppe	9/23/08 0:00	2.78	15.18	0.856	8	7.85	0.12	1.2	--	0.16	10	551	--	--
Rhodes	12/9/03 0:00	1.3	2.85	0.404	6.06	7.96	0.036	0.786	--	0.183	10	278	--	--
NTD@ Kleppe	6/25/03 0:00	15	--	--	--	--	0.173	1.203	--	0.188	10	357	--	--
Rhodes	6/29/06 0:00	70	--	--	--	--	0.058	0.578	--	0.089	10	107	--	--
NTD@ Kleppe	6/29/06 0:00	16.8	--	--	--	--	0.366	1.266	--	0.233	10	397	--	--
Lower Thomas Creek	6/21/13 10:55	0.23766	13.26		9.26	7.59	0.01	0.262	0.048	0.083	9.3	99	6.3	--
Lower Whites Creek	6/26/07 0:00	2.97	14.9	0.112	8.74	6.68	0.192104661	0.362	--	0.065	9	81	--	--
NTD@ Kleppe	4/23/08 0:00	2.2	12.93	0.863	7.64	7.54	0.14	1.04	--	0.38	9	557	--	--
Rhodes	4/21/09 0:00	9	13.95	0.285	11.33	7.76	<0.1	0.78	--	0.18	9	201	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Whites Creek	9/28/05 0:00	3.4	12.68	0.116	9.6	7.87	0.274897242	0.595	--	0.047	9	84	--	--
Clean Water Way	6/28/10 0:00	5.32	23.01	0.463	6.64	7.96	0.03	0.92	--	0.3	9	320	--	--
Clean Water Way	7/15/09 0:00	44	21.48	0.744	7.49	8.32	0.06	1.2	--	0.3	9	491	--	--
NTD@ Orr	6/25/03 0:00	12	--	--	--	--	0.071	1.001	--	0.311	9	241	--	--
Rhodes	3/29/04 0:00	5.1	--	--	--	--	0.028	0.478	--	0.132	9	209	--	--
Upper Whites Creek	6/25/13 11:34	4.9	8.65	0.066	9.6	7.33	0.002	0.025	0.012	0.028	8.2	60	3.3	330
NTD@ Orr	6/26/07 0:00	5.3	14.8	0.754	10.94	6.92	0.87	1.8	--	0.154	8	520	--	--
Upper Thomas Creek	9/21/10 0:00	0.67	9.53	0.095	9.71	7.41	<0.02	0.2	--	0.08	8	89	--	--
Upper Whites Creek	4/21/09 0:00	4.5	7.21	0.072	11.91	7.65	<0.1	0.36	--	0.05	8	74	--	--
Upper Whites Creek	6/23/04 0:00	5.2	13.08	0.06	9.24	7.66	<0.005	0.13	--	0.028	8	49	--	--
Upper Whites Creek	9/15/09 0:00	1.05	8.83	0.069	10.08	7.79	0	0.4	--	0.04	8	104	--	--
Upper Thomas Creek	6/28/10 0:00	3.98	15.14	0.079	8.58	7.82	<0.1	0.2	--	0.06	8	92	--	--
NTD@ Kleppe	6/23/04 0:00	31.1	20.15	0.58	6.67	7.87	0.12	1.03	--	0.328	8	358	--	--
Upper Thomas Creek	10/2/03 0:00	1.4	9.04	0.1	11.53	7.96	0.012	0.362	--	0.076	8	87	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Whites Creek	9/15/09 0:00	1.05	13.45	0.1	9.47	8.05	--	0.4	--	0.05	8	104	--	--
NTD@ Orr	7/15/09 0:00	1.8	21.77	0.635	9.1	8.07	0	1.8	--	0.27	8	438	--	--
NTD@ Kleppe	3/1/10 0:00	11.3	8.03	1.267	15.01	8.13	0.15	2.4	--	0.27	8	864	--	--
Upper Thomas Creek	6/25/03 0:00	3.36	--	--	--	--	<0.005	0.27	--	0.055	8	99	--	--
Upper Thomas Creek	5/7/13 14:45	3.78635625	6.89	0.092	10.5	7.61	<0.002	0.19	0.03	0.049	7.6	100	5	--
Lower Whites Creek	5/2/13 11:30	2.43	7.14	0.071	10.9	7.4	0.004	0.074	0.011	0.026	7	62	--	93.3
Rhodes	12/22/10 0:00	17	4.93	0.34	15.1	7.44	<0.02	1.5	--	0.12	7	225	--	--
NTD@ Kleppe	2/2/09 0:00		7.99	0.958	10.64	7.81	0.34	2	--	0.25	7	640	--	--
NTD@ Kleppe	4/10/06 0:00	9.6	11.17	1.014	12.84	8.24	0.641	1.491	--	0.166	7	629	--	--
NTD@ Orr	6/28/10 0:00	5.2	22.83	0.692	11.9	8.48	0.02	2.2	--	0.3	7	471	--	--
NTD@ Kleppe	3/29/04 0:00	4.6	--	--	--	--	0.475	0.925	--	0.242	7	536	--	--
Upper Thomas Creek	6/21/13 9:45	1.4955575	6.65	0.096	9.42	7.6	<0.002	0.025	0.038	0.052	6.8	90	3	--
Upper Thomas Creek	6/26/07 0:00	7.29	9.7	0.114	9.16	6.54	0.008	0.258	--	0.072	6	91	--	--
Upper Whites Creek	6/24/08 0:00	3.2	7.81	0.056	10.58	7.72	0.02	0.12	--	0.04	6	57	--	--
Rhodes	1/9/07 0:00	5.11	3.49	0.287	14.34	7.74	0.261	0.641	--	0.064	6	108	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Thomas Creek	4/21/09 0:00	3.9	9.63	0.086	11.31	7.87	<0.1	0.36	--	0.07	6	98	--	--
Upper Thomas Creek	6/24/08 0:00	6.95	10.71	0.087	9.56	7.95	<0.02	0.22	--	0.06	6	95	--	--
Lower Whites Creek	3/1/10 0:00	1.64	5.24	0.13	13.42	8	--	0.4	--	0.08	6	120	--	--
Lower Thomas Creek	6/23/04 0:00	0	18.47	0.147	9.12	8.1	0.036	0.246	--	0.161	6	116	--	--
Rhodes	6/26/07 0:00	2.17	15.2	0.282	8.35	8.56	0.09	0.52	--	0.122	6	189	--	--
Lower Alum Creek	6/21/13 8:15	0.01	12.43	0.684	8.23	7.71	0.008	0.198	0.061	0.083	5.8	501	4.6	341
NTD@ Kleppe	5/2/13 13:30	7.4	17.4	1.011	11.54	8.4	0.288	1.136	0.211	0.258	5.8	645	n/a	--
Upper Whites Creek	6/21/13 9:21	4.6	4.68	0.069	10.33	7.26	0.002	0.025	0.015	0.029	5.6	57	2.6	341
Upper Whites Creek	5/7/13 14:25	4.312065	5.62	0.071	10.44	7.4	0.003	0.103	0.013	0.025	5.1	69	3.3	7.4
Upper Whites Creek	10/11/06 0:00	5	3.74	0.069	11.82	6.99	0.005	0.005	--	0.02	5	158	--	--
Lower Thomas Creek	6/26/07 0:00	0.56	16.37	0.0152	8.61	7.12	0.078	0.638	--	0.147	5	114	--	--
Rhodes	4/11/07 0:00	4.91	8.18	0.282	9.99	7.69	0.161	0.551	--	0.117	5	184	--	--
Lower Thomas Creek	7/15/09 0:00	0.1	22.25	0.112	1.86	7.71	0	0.5	--	0.13	5	108	--	--
Lower Thomas Creek	9/28/05 0:00	5.5	13.91	0.148	8.89	7.77	0.196	0.796	--	0.09	5	110	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Thomas Creek	9/23/08 0:00	4.5175	6.24	0.095	11.4	7.89	<0.1	<0.3	--	0.06	5	97	--	--
Upper Thomas Creek	3/1/10 0:00	2.3	3.02	0.105	13.67	7.92	0.03	0.3	--	0.06	5	114	--	--
Upper Thomas Creek	9/15/09 0:00	0.8	10.92	0.093	9.57	7.97	0	0.1	--	0.07	5	95	--	--
Upper Thomas Creek	7/15/09 0:00	1	14.59	0.089	9	7.99	0	0.2	--	0.07	5	97	--	--
Rhodes	9/15/09 0:00	0.1	14.13	0.614	9.22	8.08	0	1.1	--	0.2	5	406	--	--
Upper Whites Creek	9/23/08 0:00	2.1	4.62	0.073	7.73		<0.1	<0.3	--	0.06	5	97	--	--
Clean Water Way	1/10/06 0:00	--	--	--	--	--	--	--	--		5	558	--	--
NTD@ Orr	6/29/06 0:00	6.5	--	--	--	--	0.47	1.45	--	0.187	5	316	--	--
Upper Whites Creek	5/2/13 9:10	n/a	1.37	0.077	12.33	7.8	0.028	0.078	0.014	0.024	4.8	71	n/a	1
Upper Whites Creek	12/22/10 0:00	2.37	0.06	0.078	15.1	7	<0.02	0.1	--	0.05	4	63	--	--
Lower Whites Creek	12/22/10 0:00	2.37	0.46	0.082	12.8	7.02	--	0.1	--	0.04	4	63	--	--
NTD@ Kleppe	6/26/07 0:00	10.5	17.9	0.846	6.74	7.06	0.484	1.164	--	0.149	4	523	--	--
Lower Whites Creek	4/21/09 0:00	1	9.54	0.07	11.68	7.62	--	0.36	--	0.05	4	75	--	--
Upper Whites Creek	1/10/06 0:00	4	2.18	0.094	11.93	7.66	0.006	0.126	--	0.026	4	90	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Thomas Creek	1/10/06 0:00	n/a	2.14	0.102	12.35	7.79	0.012	0.242	--	0.077	4	97	--	--
Narrows	6/25/13 13:40	3.8	21.33	2.073	11.39	8.15	0.005	0.41	0.296	0.285	3.8	1280	2.2	--
Lower Thomas Creek	5/2/13 11:05	0.420066	8.96	0.098	10.19	7.62	0.008	0.148	0.036	0.051	3.6	94	n/a	--
Rhodes	9/21/10 0:00	1.3	15.33	0.208	9.36	7.32	<0.02	0.3	--	0.11	3	175	--	--
Lower Thomas Creek	10/11/06 0:00	1.68	8.72	0.11	10.43	7.36	0.008	0.178	--	0.061	3	118	--	--
Upper Whites Creek	10/22/07 0:00	2	1.13	0.075	12.24	7.76	--	0.14	--	0.031	3	68	--	--
Upper Thomas Creek	9/28/05 0:00	1.6	7.38	0.092	10.34	7.77	0.005	0.145	--	0.062	3	93	--	--
Rhodes	9/28/05 0:00	1.9	11.36	0.372	9.32	7.78	0.074	1.104	--	0.132	3	251	--	--
NTD@ Kleppe	4/21/09 0:00	6	12.74	0.88	9.2	7.78	0.12	1.33	--	0.2	3	587	--	--
Rhodes	6/23/04 0:00	2.43	21.22	0.257	9.2	7.87	0.024	0.514	--	0.132	3	170	--	--
Lower Thomas Creek	1/28/08 0:00	11.44	0.2	0.127	13.41	7.88	<0.02	0.28	--	0.067	3	110	--	--
Rhodes	10/2/03 0:00	0.62	12.93	0.302	10.34	7.93	0.02	0.34	--	0.375	3	201	--	--
Upper Whites Creek	1/28/08 0:00	2.9	0.59	0.097	12.92	8	<0.02	0.22	--	0.027	3	72	--	--
NTD@ Orr	10/22/07 0:00	0.66	14.49	1.754	15.13	8.66		4.71	--	0.16	3	1181	--	--
Rhodes	6/25/03 0:00	7.5	--	--	--	--	0.012	0.552	--	0.127	3	184	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Lower Thomas Creek	12/9/03 0:00	--	--	--	--	--	0.01	0.23	--	0.055	3	108	--	--
Upper Thomas Creek	3/29/04 0:00	3.5	--	--	--	--	0	0.21	--	0.046	3	97	--	--
Lower Whites Creek	4/10/06 0:00	2.9	--	--	--	--	0.078157059	0.485	--	0.028	3	95	--	--
Upper Whites Creek	9/15/09 0:00	2.5	--	--	--	--	0	0.1	--	--	3	80	--	--
Rhodes	5/2/13 10:25	8.3	8.92	0.232	10.22	7.66	0.034	0.377	0.095	0.135	2.8	158	n/a	193.5
Upper Thomas Creek	5/2/13 9:40	3.055985	3.3	0.093	10.72	7.73	0.003	0.103	0.029	0.039	2.8	89	n/a	--
Narrows	6/21/13 11:21	4.1	18.27	1.62	9.69	8.05	0.008	0.45	0.25	0.209	2.4	999	2	--
Upper Whites Creek	6/26/07 0:00	3.8	8.1	0.08	9.12	6.05	0.008	0.228	--	0.038	2	65	--	--
Upper Thomas Creek	10/11/06 0:00	4.84	4.78	0.096	11.71	7.01	0.008	0.108	--	0.043	2	99	--	--
Lower Whites Creek	2/2/09 0:00	0	0.01	0.077	13.03	7.47	--	<0.3	--	<0.04	2	76	--	--
Rhodes	4/23/08 0:00	4.15	7.83	0.278	9.76	7.48	<0.02	0.56	--	0.1	2	185	--	--
Upper Thomas Creek	4/23/08 0:00	6.95	3.79	0.089	10.45	7.59	<0.02	0.2	--	0.055	2	94	--	--
Lower Thomas Creek	4/21/09 0:00	1	11.16	0.09	11.17	7.7	<0.1	0.36	--	0.08	2	105	--	--
NTD@ Kleppe	1/10/06 0:00	--	6.32	0.873	11.46	7.8	1.8	3.07	--	0.384	2	519	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Whites Creek	10/2/03 0:00	2	7.28	0.073	12.25	7.94	0.015	0.195	--	0.029	2	71	--	--
Lower Whites Creek	10/2/03 0:00	0.55	13.87	0.77	10.8	7.94	0.03557 4937	0.202	--	0.033	2	73	--	--
Lower Thomas Creek	3/1/10 0:00	1.45	4.45	0.121	13.61	8	0.03	0.4	--	0.1	2	125	--	--
Rhodes	3/1/10 0:00	7.7	8.23	0.37	15.11	8.03	0.02	0.8	--	0.11	2	250	--	--
Lower Thomas Creek	10/2/03 0:00	0.15	16.23	0.166	11.56	8.65	0.148	0.508	--	0.08	2	125	--	--
Upper Thomas Creek	12/9/03 0:00	3	--	--	--	--	0.01	0.29	--	--	2	121	--	--
Lower Thomas Creek	4/10/06 0:00	2.18	--	--	--	--	0.008	0.468	--	0.062	2	116	--	--
Rhodes	6/25/13 12:34	1.7	16.37	0.352	9.62	7.78	0.031	0.413	0.1	0.148	1.9	226	1.8	1760
Chalk Creek	5/2/13 7:50	0.04	6.74	2.816	10.22	7.78	3.14	3.549	0.244	0.251	1.8	2580	n/a	8.5
Rhodes	1/10/06 0:00	15	7.5	0.323	10.76	7.72	1.01	1.57	--	0.121	1	234	--	--
Lower Whites Creek	1/10/06 0:00	2.5	2.46	0.098	12.37	7.72	0.16170 426	0.132	--	0.034	1	64	--	--
Upper Whites Creek	9/28/05 0:00	3.7	5.86	0.069	10.58	7.77	0.005	0.205	--	0.023	1	71	--	--
Lower Thomas Creek	1/10/06 0:00	--	3.76	0.116	11.71	7.86	0.253	0.663	--	0.056	1	99	--	--
Rhodes	4/10/06 0:00	14.7	8.1	0.249	12.27	8.4	0.228	0.718	--	0.039	1	147	--	--

Sample Site	Sample Date	Discharge (cfs)	Water Temp (°C)	SC (mS/cm)	DO (mg/L)	pH	NO3-N (mg/L)	TN (mg/L)	PO4-P (mg/L)	TP (mg/L)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	E. coli (#/100 mL)
Upper Whites Creek	4/10/06 0:00	6.5	--	--	--	--	0.005	0.275	--	0.023	1	94	--	--
Upper Thomas Creek	4/10/06 0:00	3.2	--	--	--	--	0.006	0.356	--	0.054	1	120	--	--
Lower Alum Creek	12/19/12 0:00	0	7.75	10.03	--	6.62	--	--	0.34	0.36	0	--	--	--
Rhodes	10/11/06 0:00	9.32	8.45	0.223	11.6	7.24	0.124	0.434	--	0.08	0	93	--	--
Upper Whites Creek	7/15/09 0:00	3	11.95	0.059	11.51	7.76	0	0.1	--	0.04	0	60	--	--
Lower Alum Creek	6/20/12 0:00	0.1	14.73		9.42	7.76	--	0.6	0.07	0.09	0	6	--	--
Upper Whites Creek	4/11/07 0:00	4.4	1.71	0.076	11.97	7.78	0.005	0.145	--	0.029	0	64	--	--
Lower Alum Creek	9/6/12 0:00	0.49	16.76	0.56	7.76	7.79	--	1.1	0.14	0.29	0	6	--	--
Rhodes	7/15/09 0:00	2	19.38	0.272	15.16	7.85	0	0.3	--	0.14	0	187	--	--
Upper Thomas Creek	4/11/07 0:00	6.57	2.84	0.092	11.8	7.91	0.007	0.167	--	0.05	0	84	--	--
Clean Water Way	4/11/07 0:00	4.4	13.13	0.69	8.46	8.16	0.602	1.632	--	0.261	0	431	--	--
NTD@ Kleppe	4/11/07 0:00	2.88	12.84	1.125	11.71	8.18	0.955	1.945	--	0.143	0	745	--	--
NTD@ Orr	4/11/07 0:00	0.8	10.93	1.905	18.48	8.93	1.73	3.98	--	0.206	0	1267	--	--

APPENDIX C: HISTORIC TRIBUTARY FIELD AND LAB DATA: 2003 TO 2013