channel floodplain system cannot transport except in the highest flows. When excessive coarse sediment is deposited in a channel, the channel expands its width and depth by erosion into softer materials (i.e. in case of UTR, meadow alluvial sediments) to compensate for the loss of flow capacity due to the obstructing coarse sediment deposit. This process becomes self-reinforcing. As each reach adjusts by erosion it releases more coarse sediment downstream that overwhelms the next reach. This process appears to be the best explanation for the channel widening and downcutting along the Christmas Valley reach of the UTR observed by long time residents. The 1940 aerials (Figure 2.6) show four bridge crossings over the UTR in alluvial reaches and each of these has the same characteristics of fill in the floodplain and forcing all flow through a small bridge opening.

Besides grazing, logging in the UTR watershed was another important land use. Logging created roads and soil disturbance, which likely increased sediment supply to the river and to Lake Tahoe. Intensive logging was confined to the area surrounding the UTR corridor below the Meyers Highway 50 crossing; this included clear cutting and hauling. One method of log transport that may have had an impact on the UTR was the creation of "splash dams." Splash dams were temporary structures that impounded river flow and created a pond where logs could be floated. Once filled, the dam would be breached sending logs downstream to Lake Tahoe where they could be floated to the sawmill. Figure 2.9 shows such an operation near the Highway 50 Elks Club bridge, just downstream of the existing Lake Tahoe Golf Course (LTGC). Splash dams would have sent a large volume of flow instantly down the channel with logs bumping banks along the way. This method of transport would certainly have benefited from deepening and straightening the channel; old timber "bumpers" have been found in the UTR channel below the Highway 50 crossing in South Lake Tahoe.

Later land use activities, such as the channelization of the UTR near the Lake Tahoe Airport and construction of the LTGC, drove further channel incision in the 1960s. These events formed eroding headcuts which have migrated upstream. The 1940 aerials show two recently cut off meanders that appear to have been excavated by machinery such as bulldozers, which became more readily available in the 1940s (Figure 2.6). The second phase of channel straightening and deepening in the 1950s and 60s reinforced the earlier phases, and the results were similar: increased bank instability, chronic supply of sediment from bank erosion, a lowered water table and a decrease in wetland and riparian vegetation cover within the river corridor. The areas of significant channel de-stabilization and erosion led to the installation of rip rap revetments to protect bridges, sewer lines roads, structures and golf course facilities. The rip rap revetments were generally successful at reducing bank erosion locally, but they resulted in erosion at nearby locations, possess barren low value habitat and are an expensive long-term solution system wide.

In the early 1990s, several projects were attempted along the LTGC to stabilize banks through use of bioengineered structures, incorporating logs and root wads into more naturalistic cobble revetments. These were partially successful, but suffered from channel profile instability due to headcut migration and the lack of scour protection at the toe. Preventing scour would have

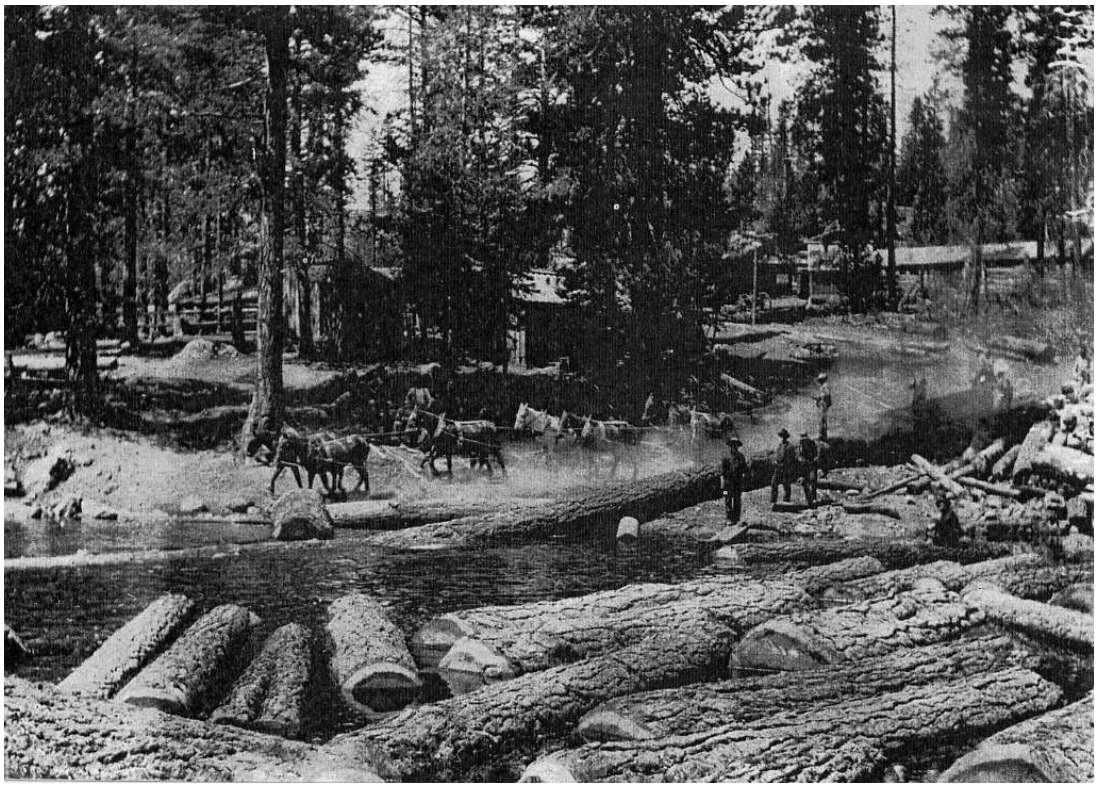

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FIGURE 2.9: Photo of loggers using splash dam to transport logs. Saw logs were floated down the Upper Truckee River to Lake Tahoe. The site may be near the confluence of Angora Creek and the Upper Truckee River. (Photograph courtesy of Special Collections Department, University of Nevada, Reno.)

required excavation below the streambed, which was a construction method not in practice in the Lake Tahoe Basin at that time.

Between 1998 and 2002, two stream restoration projects were completed on Angora Creek yielding 7,000 linear feet of restored channel and floodplain. These projects involved reconstruction of the channel and/or re-occupation of old remnant channels, but the main objective was to overcome historic incision. The mouth of Angora Creek was relocated to near its original location.

II.3 Impacts to Ecosystem

The ecological effects of the UTR channel deepening over the last 140 years have been profound. While grazing, clearing land, controlling drainage, hunting and fishing directly impacted wildlife habitat and populations, the change in channel morphology negatively affected habitat-forming processes that sustained the original ecosystem. As described above, the original pre-1860s hydrologic conditions in the Holocene floodplain and riparian zone were controlled by groundwater levels that in turn were set by riffles in the low flow channel. With the channel incision, the groundwater table dropped, which eliminated wetland vegetation species in favor of drier upland species. Remnant channel oxbows show an abundance of wetter vegetation communities that have survived lowering the groundwater table by extending roots; the absence of saplings or young riparian plants and the invasion of species that favor drier conditions (lodgepole pine) indicate that the hydrologic conditions favoring their regeneration are gone. Many areas have converted from wet gaminoid meadows and obligate sedge wetland to dry meadow and lodgepole forest.

The native fisheries of Lahontan Cutthroat Trout and Mountain Whitefish have been largely extirpated from the UTR and the Lake Tahoe Basin, due to over-fishing and the introduction of competitive game fish, such as rainbow trout, brown trout, and brook trout. Lake trout and Kokannee have also been introduced into Lake Tahoe.

Aside from the direct effects of introduced species and over-fishing, the incision of the UTR has had several effects. First the straightening of the channel reduced channel length and available habitat between Meyers and Elk's Club by two miles. The incision of the channel bed introduced an increased supply of fine sediment, eroded from unstable banks into the low flow channel; this often reduces substrate quality affecting spawning habitat and macroinvertebrate production (i.e. fish food), however this has been partially offset by recruitment of gravel from bank erosion and complex deposition patterns in the low flow channel. Perhaps most importantly, straightening and incision has produced sections of channel that are homogenous in geometry and grain size without pool development, riparian cover, gravel substrate, or the hydraulic characteristics that favor foraging, refuge, spawning and rearing.

Terrestrial wildlife was also affected by historic changes in land use. The early reclamation of marsh areas for grazing reduced the available foraging areas for deer, bear and other mammals. Vegetation clearing and reduction in riparian plants has reduced songbird and other avian habitats; logging in the surrounding areas would has negatively impacted raptor and owl habitats as well.

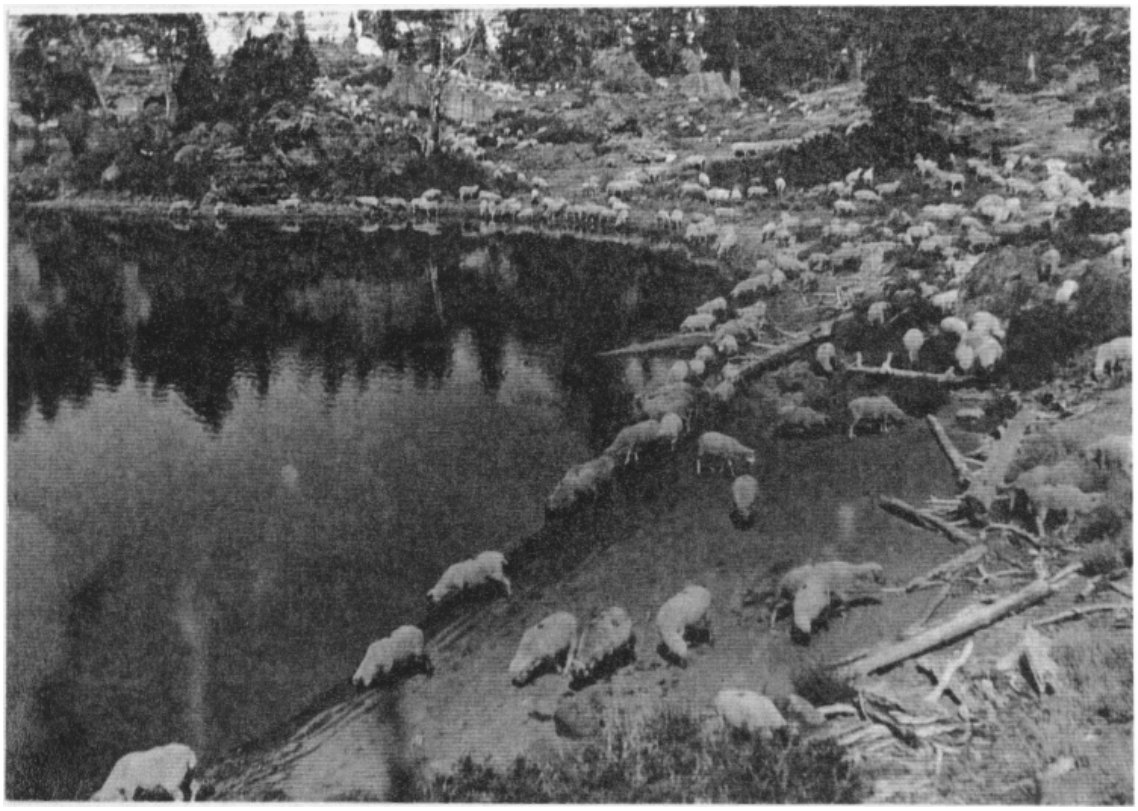
II.4 Water Quality Impacts

The water quality of runoff from the UTR discharged into Lake Tahoe has degraded as a result of early land use changes. The introduction of grazing to the floodplain meadow areas and the watershed introduced pathogens, elevated nutrient levels and increased areas of soil disturbance and erosion. Grazing in the UTR project corridor occurred between the 1850s and the 1960s; in the Upper Watershed grazing could have started in the 1840s, and at some periods, included sheep grazing as well as cattle (Figures 2.10 & 2.11). Grazing along stream zones where the water course was the main supply of drinking water often resulted in "chiseled" banks with barren soils, a lack of vegetation cover and trampled substrate. The 1940s aerials indicate many barren streambanks, a wide channel with fresh bars of sediment and little indication of recent vegetation colonization. These features all suggest grazing impacts were significant in 1940.

Watershed conditions during the Comstock Era were also significantly affected by grazing and logging. As described above, sheep and cattle grazing were seasonal uses in the Upper Watershed area, particularly concentrated in meadows and lakes. Logging was intensive in the late 1800s and early 1900s in the lower project area surrounding the UTR below Meyers in what is now Washoe Meadows State Park. Historical accounts and the extensive stands of old growth Jeffrey Pine, red fir and white fir indicate that Christmas Valley and the Upper Watershed were not logged extensively. Shirley Taylor (2003) reports that her ancestors rejected a proposal to extend a rail line into the Christmas Valley for increased logging access.

The history of Lake Tahoe suggests that the clarity of the Lake was not seriously affected, or it recovered from Comstock Era logging and grazing. The period between the end of the Comstock boom and the 1950s was relatively quiet in the basin with the unique exception of the introduction of beaver into the watershed in the 1930s. Beavers are discussed in greater detail below. Although the landscape changed forever after the Comstock Era, it appears to have been fairly resilient to the effects of early land uses. That changed in the 1950s when the tourism economy began its mercurial rise.

The expansion of tourism in the 1950s led to the development of summer homes and cabins in the South Shore and Meyers area surrounding the UTR. The Tahoe Paradise development included moderate density residential subdivisions, modeled after city suburban developments that had expanded in the post-war boom. This style of development resulted in many roads criss-crossing the landscape, including roads crossing steep terrain. Roads are the primary cause of watershed disturbance, since their construction involves soil disturbance and erosion. Modification of



1910

2003

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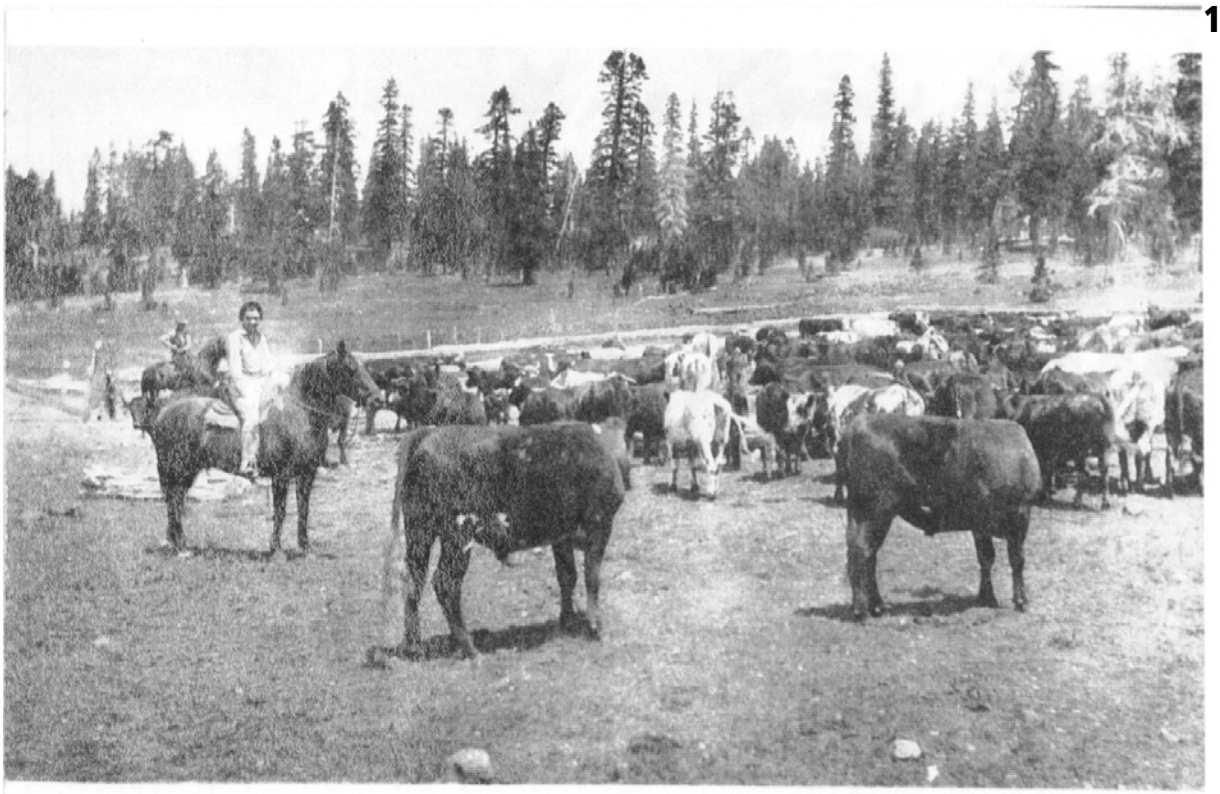
FIGURE 2.10: Photos of Round Lake taken in 1910 and 2003. Notice the heavy sheep grazing in the 1910 photo.

1910



2003

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FIGURE 2.11: Photos of Meiss Meadow taken in 1910 and 2003. Notice the heavy cattle grazing in the 1910 photo.

drainage patterns and localized hydraulic effects at road crossings that were often fill and culvert structures caused significant hydrologic and ecologic disruption. Road crossings often sever the continuity of streamflow and the riparian vegetation corridor and form barriers to the migration of aquatic wildlife. The roads are a component of urban hardscape that hydrologically generate more runoff than the natural landscape. Finally, roads provide access to undeveloped areas and lead to construction of more structures and greater hydrologic modification.

Urban development requires the expansion of infrastructure, such as highways, sewer and utility systems and dense commercial development. The Highway 50 corridor includes a commercial strip of gas stations, restaurants, stores and other businesses. The emphasis on recreational uses has led to construction of two golf courses, one in Meyers (i.e. Tahoe Paradise Golf Course) and the other located at the downstream end of the project area (i.e. LTGC). These uses have led to significant physical changes to the UTR and tributary streams, and perhaps more importantly, the introduction of new pollutant sources of sediment, nutrients and urban toxins, such as hydrocarbons and heavy metals.

The network of roads, commercial and residential development expanded quickly in the UTR Upper Reach project area between the late 1950s and early 1970s. Over 2,500 acres of the land within one mile of the UTR river corridor became developed urban land. Since the 1970s, the density has increased with infill developments in both commercial and residential areas.

It became apparent in the mid 1960s that the rapid urbanization led to a significant decline in the clarity of Lake Tahoe. The apparent resilience of the Lake to remain unaffected by land use impacts was lost, and with greater understanding of the rate of clarity loss and the projected limnological trends, the future of the Lake's legendary clarity was at risk. The loss of clarity has been attributed to an increase in algae growth induced by excessive nutrient and fine sediment delivery. Nutrient inputs from the surrounding urban land use stimulate algal growth in this naturally oligotrophic Lake. In the late 1960s, it was also apparent that treated and untreated wastewater effluent discharged to the Lake was a contributing factor. In response, all of the wastewater generated in the Tahoe Basin was exported, including construction of an export line along the UTR and over Luther Pass. Other measures taken include restrictions on development and development and implementation of Best Management Practices (BMPs) for water quality protection on all existing and proposed development. A list of BMPs can be found in Table 2.2.

In addition to implemented and planned BMPs for roads and structures within the UTR watershed (Figure 2.12A&B) and the greater Lake Tahoe Basin, the planning and implementation of stream restoration projects along the UTR began in 1993 with the Cove East Project sponsored by CTC. These projects are focused on water quality improvements, as well as ecosystem restoration. The first phase of the Cove East or Lower West Side project was implemented in 2001 with the removal of 82,400 yards of fill and restoration of a portion of the marsh destroyed in the late 1950s by the Tahoe Keys development. The second phase is investigating the restoration of the lower three miles of the UTR, including what was once a deltaic/lagoon system near the mouth.

ID	Problem Description
1	Culvert FAP89-P002 is plugged from roadway sand. The water is forced through Culvert FAP89-C01. Neither culvert has treatment.
2	Sand accumulating on side of road. No current treatment for this area.
3	Culvert 2312-P001 has tendency to freeze in winter. Excess flow goes over roadway and onto parcel across the street (APN-036-554-11).
4	Water pools during storm events. Sand from culvert FAP89-P002 is deposited here. Excess back water from culvert 2312-P001 also pools here.
5	Roadside pull-out may be oversized for the amount of use occurring.
6	Roadside pull-out may be oversized for the amount of use occurring.
7	Runoff from HW 89 flows through this area and into culvert 2312-P002.
8	Culvert 2312-P002 experiences debris jams during storm events. Channel leading into 2312-P002 may be too small creating sheet flow across Grass Lake Road.
9	Evidence of eroding channel leading into natural rock lined channel. Also evidence of overflow during high events.
10	Water is flowing over the road and pooling at road side pull-out.
11	Road side pull-out that may be unnecessary.
12	Channel is eroding and may not be sized correctly.
13	Discharge from culvert 2312-P004 is directed at side of channel, causing erosion during high flow.
14	Outlet channel for culvert 2312-P004 requires treatment.
15	Potential livestock pollution form property (APN 036-502-01) upstream of culvert 2312-P005.
18	Culvert 2312-P006 backs up during high flow events. Culvert is also not located in a localized topographic low.
19	Roadside channel not sized correctly.
20	Grass Lake Creek may been diverted upstream creating excess flow for culvert 2312-P008. During high flow events water flows over sand bags placed just to the north of the inlet, down roadside ditch to culvert 2312-P007.
21	Roadway flooding from multiple sources: down Grass Lake Road, from roadside ditch on side of Grass Lake Road, overflowing roadside channel containing re-directed Grass Lake Creek flow.
22	Culvert 2313-P001 culvert may be undersized.
23	Culvert 2313-P002 is squashed with some flow occurring underneath the culvert. The culvert may also not be sized correctly.
24	Cut bank forming on side of Creek, which may infringe on Grass Lake Road.
25	Snowplow turn-around area creating shoulder erosion.
26	Two culverts in place where one may be more appropriate. During dry season water flows through culvert 2312-P010 and during storm events water also flows through culvert 2312-P009.
27	Sheet flow down road during high flow events.
28	Sheet flow from road flows through pullout and into river without treatment.
29	Denuded area
30	Three denuded areas on east side of Grass Lake Road. May be directly on top of export line.
31	Denuded area on west side of Grass Lake Road.
32	Denuded area in front to Forest Service Parcel (APN 036-48-102).
33	Cleared area on east side of Grass Lake Road across from southern boundary of APN 036-554-11.

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TABLE 2.2: Identified road-related problems in El Dorado County. Taken from Christmas Valley Erosion Control Project Phase 1: Existing Conditions Report. February, 2003. Refer to Figure 2.12B.

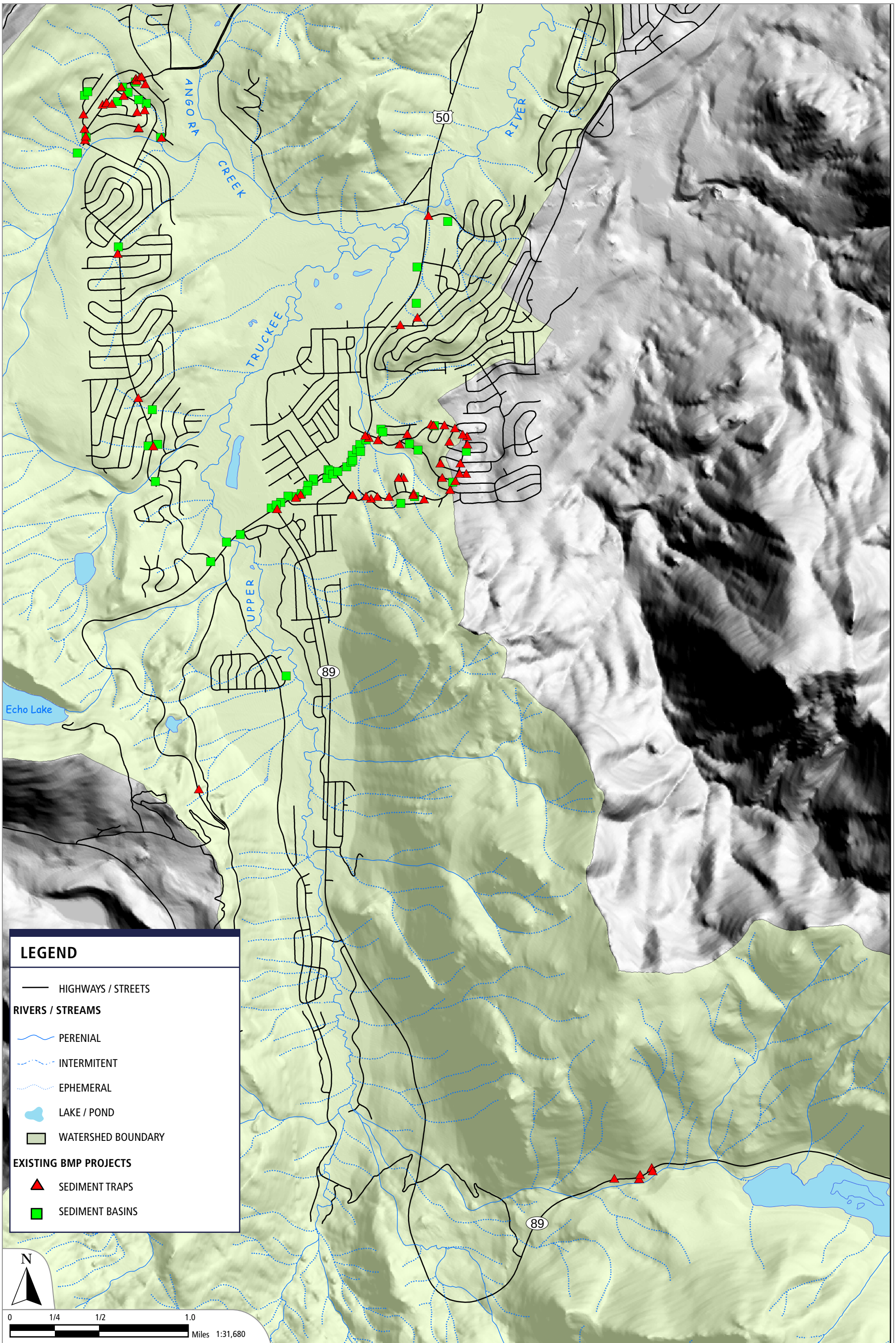

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FIGURE 2.12A: Map indicating existing BMP projects for the Upper Truckee River Watershed.
Data source: www.dot.ca.gov/dist3/projects/tahoe.

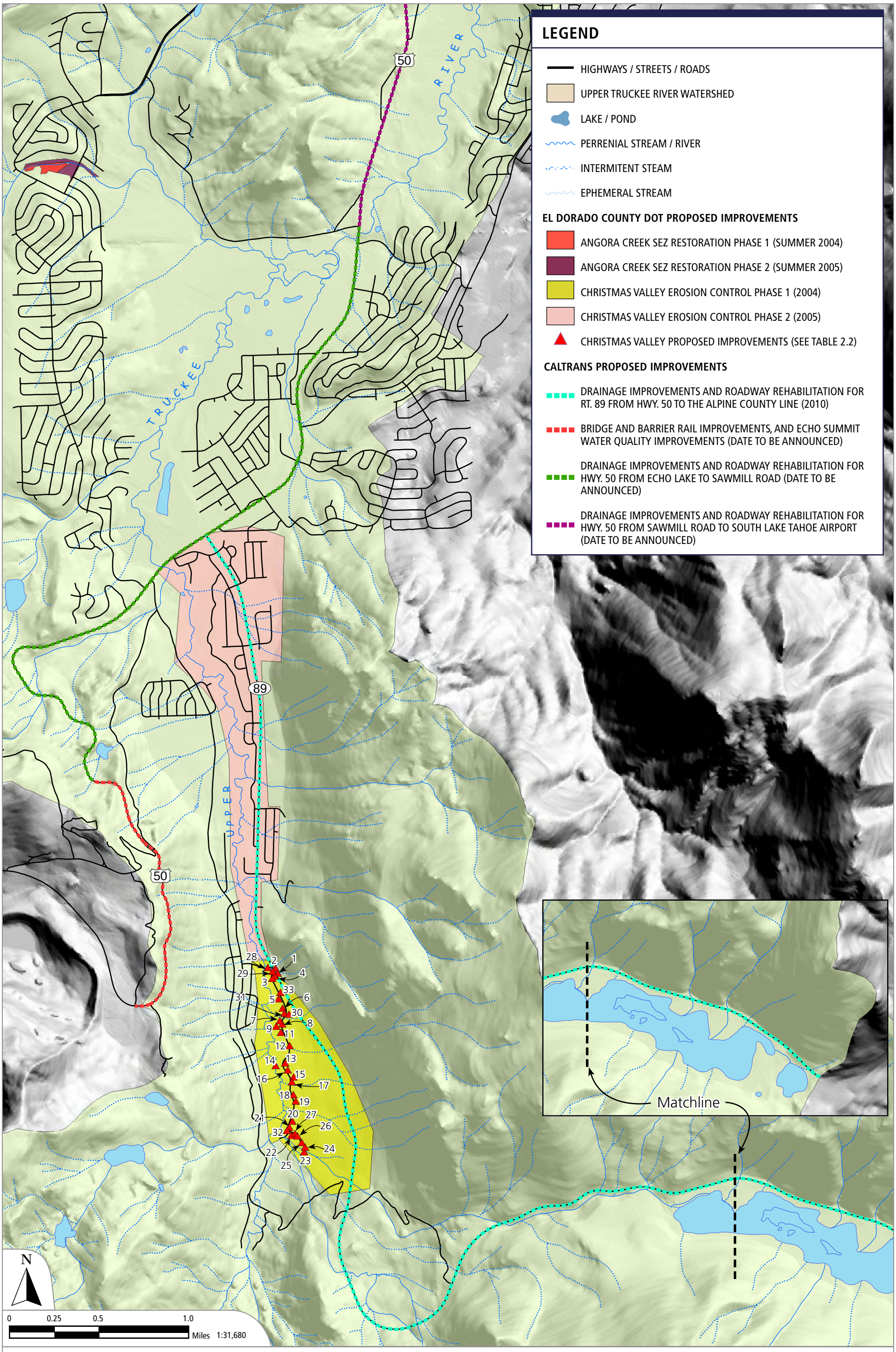

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FIGURE 2.12B: Map indicating road-related drainage, erosion, and sediment control projects proposed by CalTrans and El Dorado County for the Upper Truckee River Watershed. Data source: www.dot.ca.gov/dist3/projects/tahoe and County of El Dorado Department of Transportation.

A plan for restoring or enhancing the Middle Reach of the UTR between the lower Highway 50 crossing and Sunset Ranch was completed in January of 2003 and is set to enter a design phase by January of 2004; project construction may begin as early as summer of 2005. The restoration or enhancement of the UTR Upper Reach is the focus of this report.

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III. Existing Conditions

The preceding discussion of historical changes to ecosystem function leads to the present conditions and the baseline conditions for any environmental restoration or enhancement projects. The following chapter presents existing conditions information and data for individual areas of concern to be used in the evaluation of the impacts and benefits of potential alternatives. Each section below provides a description of present conditions and the opportunities and constraints for development of restoration and enhancement options.

III.1 Hydrology, Water Quality and Geomorphology

The UTR experiences cool dry summers and wet, cold winter seasons. The average precipitation for the UTR is around 32.8 inches, most of which occurs as snow between November and April. Table 3.1 shows the average monthly precipitation data for the station operated by NCDC near Tahoe City over the past 30 years. Although the bulk of precipitation occurs as snowfall, there are periods during El Nino years when large warm rainstorms occur in the middle of winter and melt the existing snowpack to create the highest peak streamflows of record. These events are referred to as 'Pineapple express' storms for the entrained subtropical jet stream that delivers warm moisture to the Lake Tahoe Basin following a winter snowfall. Outside of the main winter snow season, there are periods of rainfall during summer thunderstorms and the beginning and end of the winter season when the weather is warmer. Thunderstorms can be intense, as demonstrated by the storms of August 21, 2003, when nearly 1 inch of rain fell in South Lake Tahoe within a few hours.

Table 3.1: Mean monthly and annual weather data for the Lake Tahoe Basin area. Mean maximum and minimum temperature and mean precipitation provided by the NCDC Tahoe station near Tahoe City for 1971-2000 (www.wrcc.dri.edu)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Mean Max. Temperature (F)	40.5	42.0	45.1	51.4	60.1	69.2	77.5	77.0	70.1	60.0	47.9	41.4	**56.9**
Mean Min. Temperature (F)	20.1	21.3	24.3	27.7	33.5	39.6	44.7	44.8	39.6	32.3	25.5	20.6	**31.2**
Mean Precipitation (in.)	6.01	5.71	4.57	1.82	1.21	0.77	0.33	0.46	0.90	1.95	4.25	4.68	**32.74**

III.1.A Hydrology

A USGS stream gage in the Study Area of the Upper Truckee River is located 1000 feet downstream of the Meyers Highway 50 crossing. USGS gage #10336600 operated from 1960-1986 above Echo Creek and the current stream gage, USGS gage #103366092 located below Echo Creek (see Figure 3.1 for locations), has been collecting data since 1991. Figure 3.2A shows the average annual and annual peak discharges measured at the two gages since 1960. The average annual discharge is 72 cfs over the 38 years of record. Figure 3.2B shows the average annual hydrograph as measured at the gages. Figure 3.3 is the monthly probability of exceedence for the Upper Truckee River at Meyers and shows the variance in monthly flow between wet and dry years.

Streamflow on the UTR is dominated by snowmelt runoff in the late spring-early summer months. The flow duration curves for spring (March through July) and winter (August through February) periods presented in Figure 3.4 show that the spring series has higher flows for the bulk of discharges (50 to 99.9% of time flow exceeded), but the winter series has higher peaks during the less frequent events (1 to 10% of time flow exceeded). The flood of record occurred on January 1, 1997 and resulted in a peak flow of 5,120 cfs at the Meyers USGS gage. This storm occurred after a series of snowstorms that left several feet of snowpack at lake level (6200 feet MSL). The storm of December 31, 1996 and January 1, 1997 was a classic "Pineapple express" storm with the resulting storm producing rainfall below elevation 8,000 feet. The rainfall rapidly melted the snow and essentially doubled runoff volumes. Flood damage and geomorphic change was unusually light in most reaches of the UTR, although in many areas significant bank erosion occurred, as well as channel incision and localized channel avulsions in Christmas Valley.

The annual and partial duration series peak flood frequency analyses for the Meyers gage is shown in Table 3.2. The partial duration analysis incorporates all flows exceeding 200 cfs for the period of record, in contrast to an annual series, which includes the single highest flow each year of record. When the rainfall events are separated from snowmelt significant differences are revealed between snowmelt and the rain on snow events, which produce the largest floods. For example, a 50-year discharge for the rain on snow events is 4160 cfs versus 1550 cfs for snowmelt (using the partial duration analysis). This difference is significant from a geomorphic perspective, as the landforms and geomorphic work produced by these two events are distinctly different; this is discussed in greater detail below; evidence shows that the channel forming processes are more related to annual snowmelt flow than large rain on snow events, which have occurred in 1997, 1986, 1974, 1964 and 1955.

III.1.B Water Quality

The main water quality concerns on the UTR are sediment, nutrients (nitrogen and phosphorous), iron, and to a lesser extent other urban runoff pollutants such as heavy metals, pesticides and hydrocarbons. The water quality data reviewed for this project was limited to fine sediment, nutrients, and iron data collected and provided by other sources.

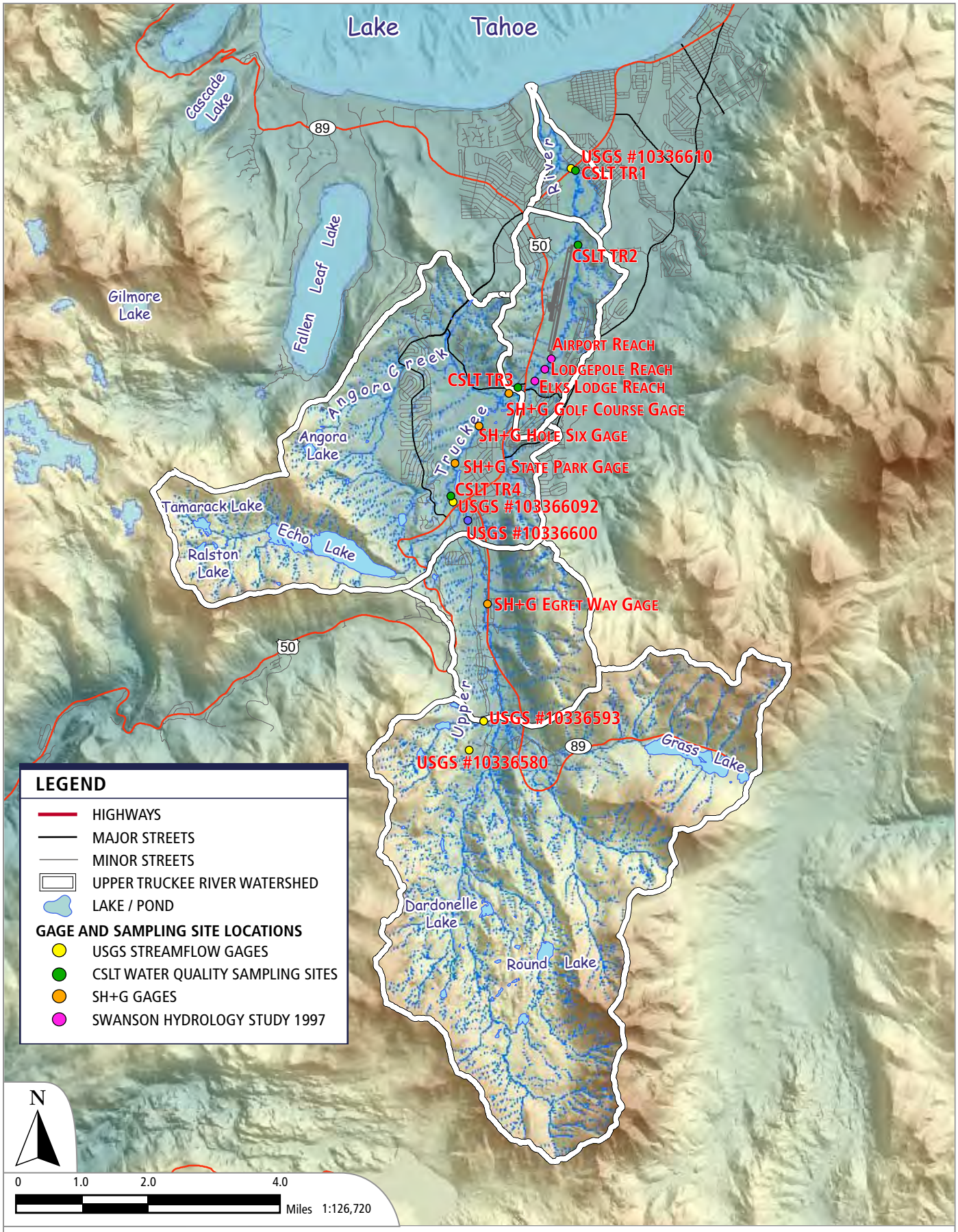

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FIGURE 3.1: Location of water quality and streamflow gages in the Upper Truckee River Watershed.

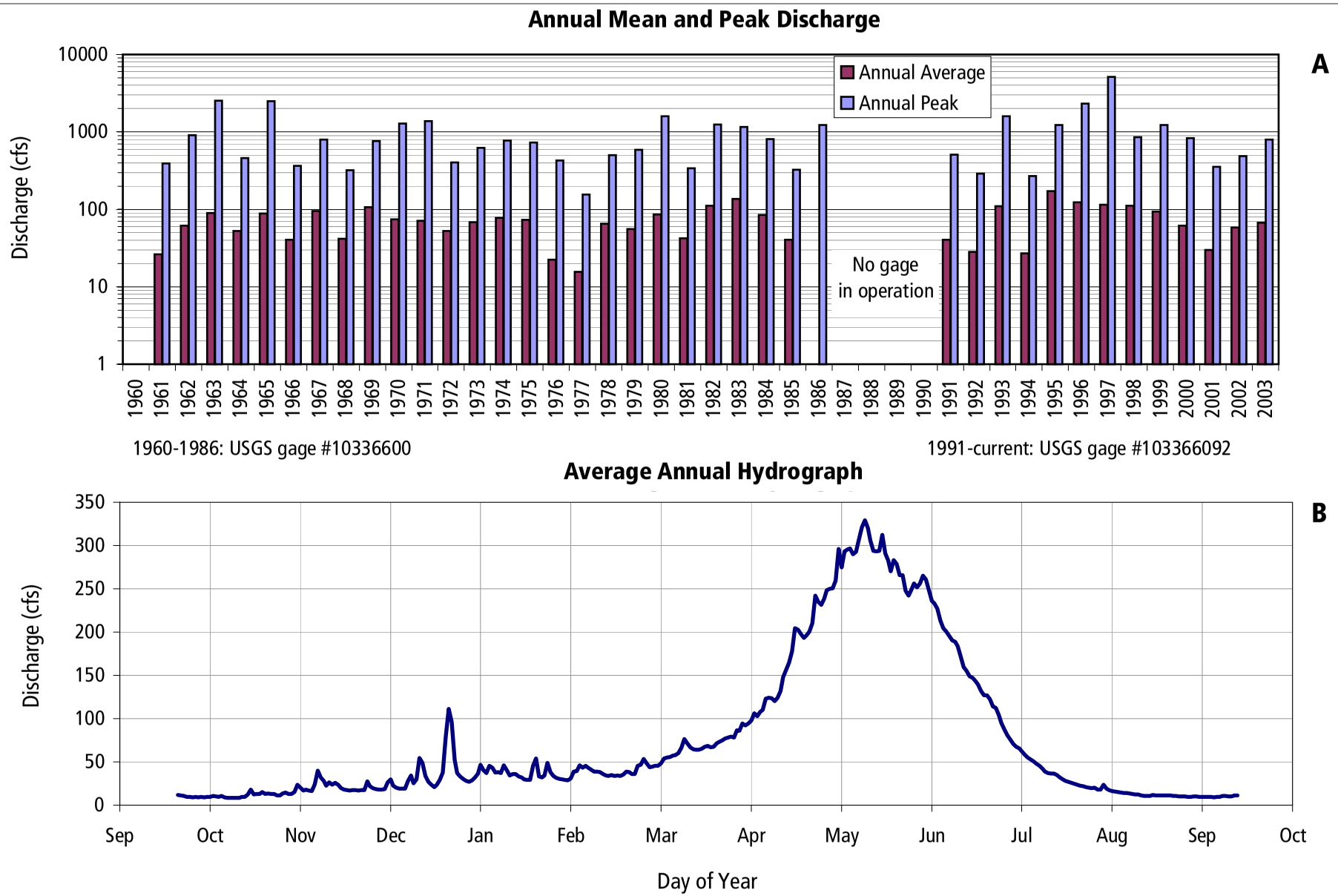

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FIGURE 3.2: Hydrology summary for Upper Truckee River at Meyers using data from USGS gages #10336600 and #103366092. A: Annual mean discharge and annual peak discharge for years of record (1961-1986, 1991-2003). The average annual discharge was calculated to be 72 cfs. B: Average annual hydrograph based on 38 years of daily streamflow data.

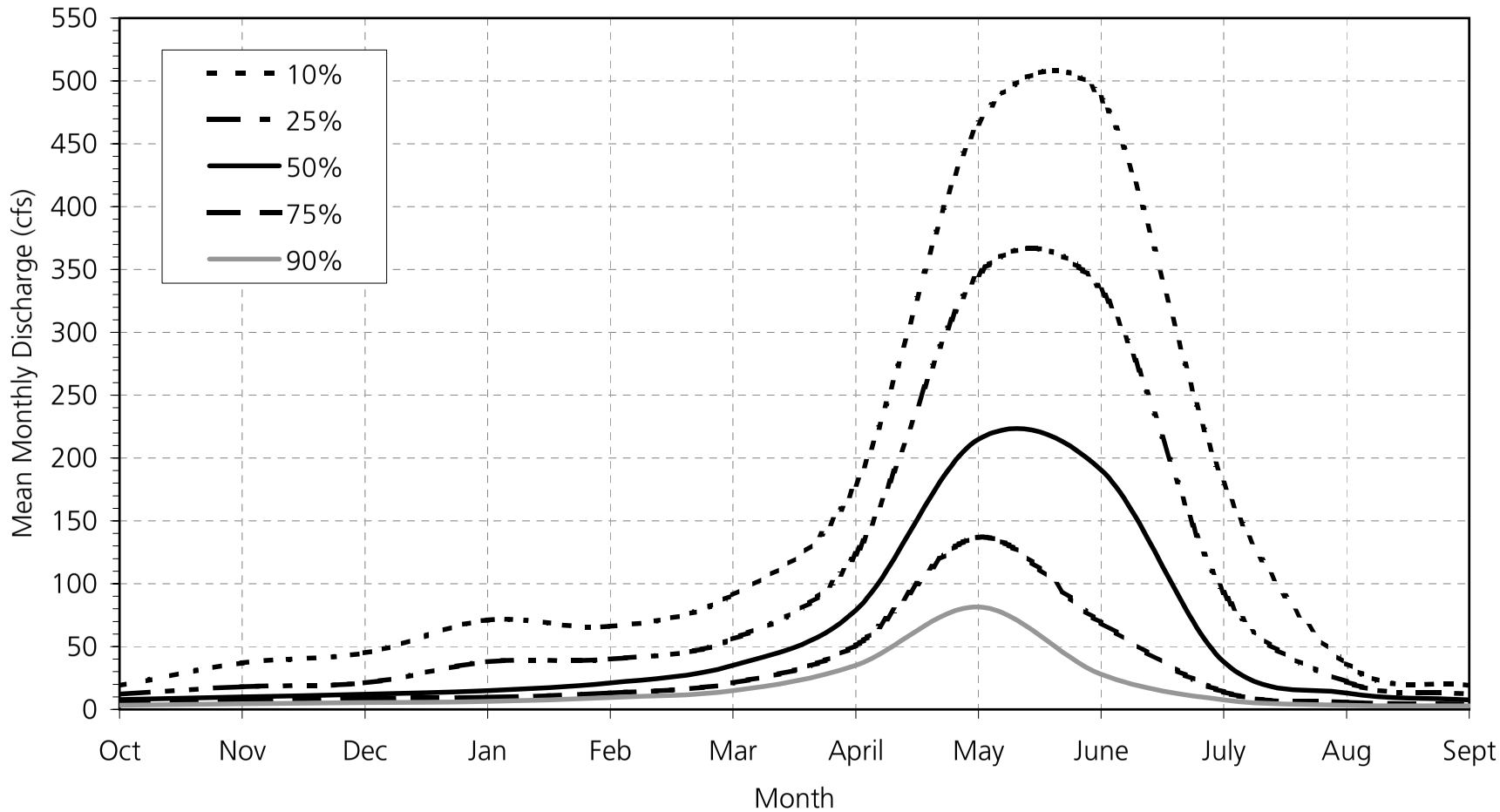

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FIGURE 3.3: Percent exceedence of discharge per month for Upper Truckee River at Meyers. This is a cumulative distribution of flows by month, illustrating the magnitude of flows greater than 10, 25, 50, 75, and 90% of all the mean daily flows of record. Data from USGS #10336600 (1961-85) and #103366092 (1990-2001) are combined.

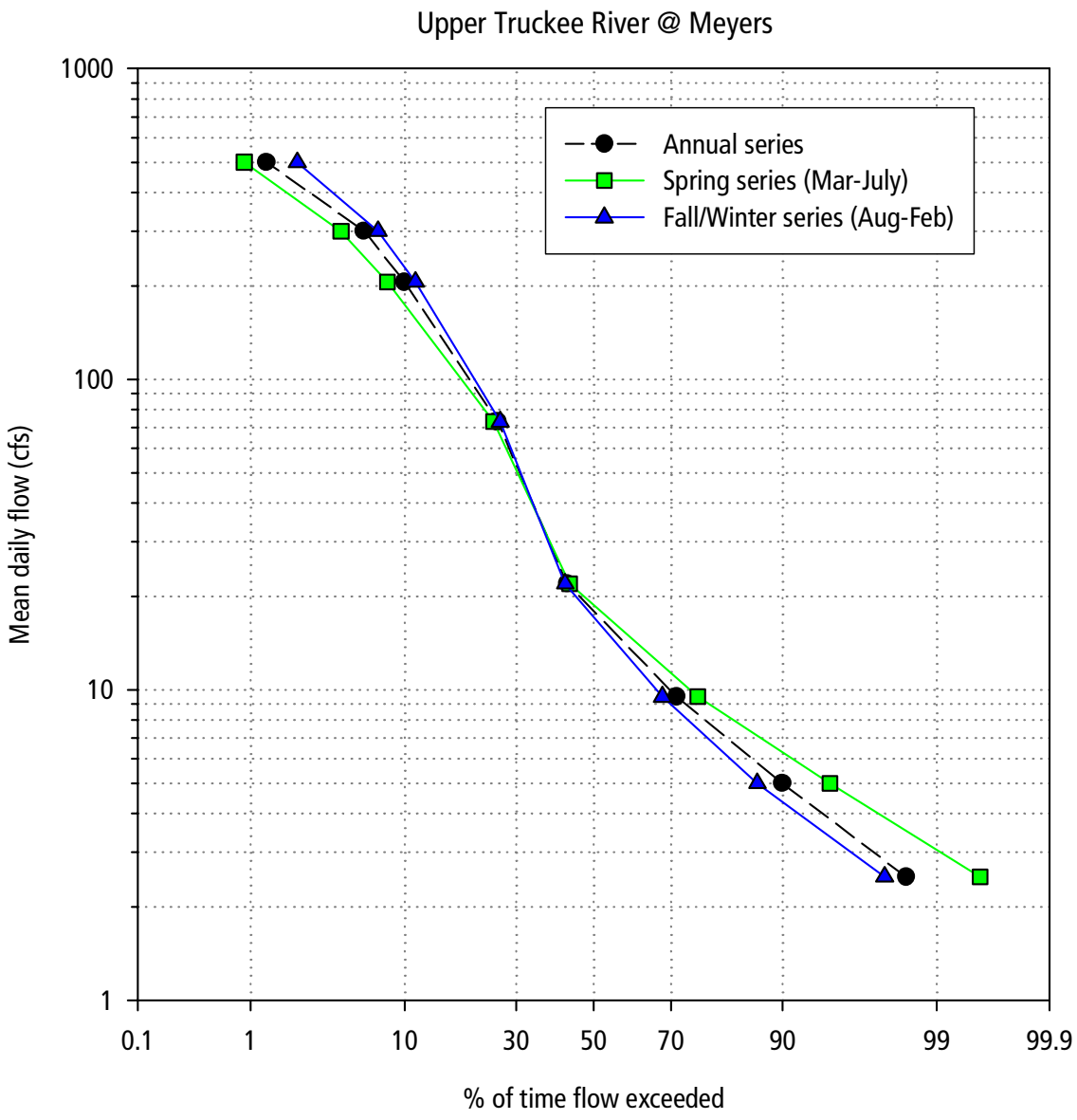

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FIGURE 3.4: Flow duration curves for the annual, spring, and winter series for the USGS streamflow gages on Upper Truckee River at Meyers, #10336600 (1961-1986) and #103366092 (1990-2001). Data is compiled from mean daily discharges.

Analysis Type	All Data					Spring Series (Mar-Jun)					Fall/Winter Series (Aug-Feb)				
	n	Bankfull (1.5 return year) (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)	n□	Bankfull (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)	n□	Bankfull (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)
Annual Peaks	39➶	502	1950	3780	4830	38	460	1310	2030	2380	38	146	1430	4520	6930
Partial Duration ♌	129➶	336	1120	2250	2960	96	344	938	1550	1860	32	346	1720	4160	5830

♌ A base discharge of 200 cfs was used for partial duration analysis.

□ Peak winter and spring discharge for each year were either taken from the annual series or identified by peak mean daily flow and instantaneous peak discharge

➶ Peak discharge data for Water Year 1961 did not include the date of the event. Consequently it was not used in the spring and winter series analysis.

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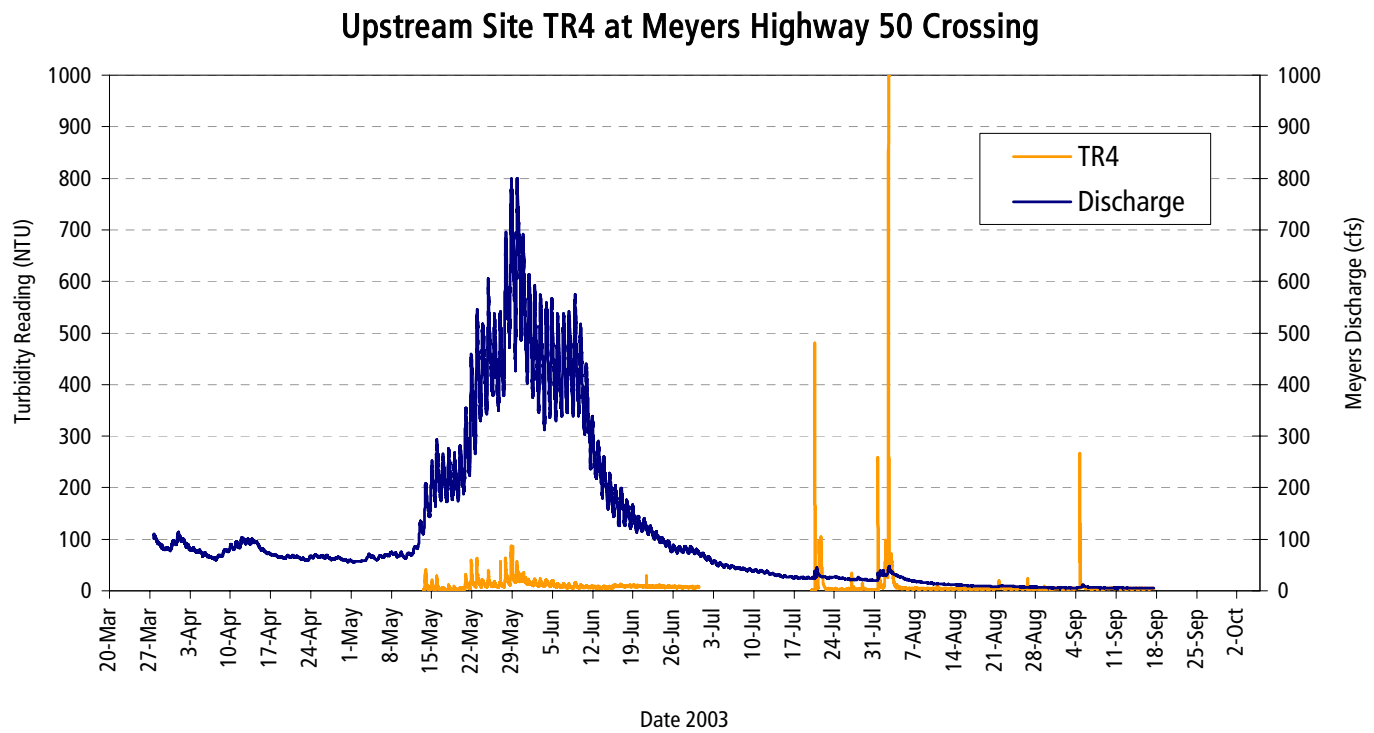
TABLE 3.2: Flood Frequency Analysis results for Upper Truckee River near Highway 50 in Meyers, CA. The data records for USGS gage #10336600 (1961 to 1986) and #103366092 (1991 to 2003) were combined for this analysis. Data provided by USGS website, Earthinfo USGS Peak Values software, and Kip Allander of the USGS. Analysis was performed using HEC-FFA.

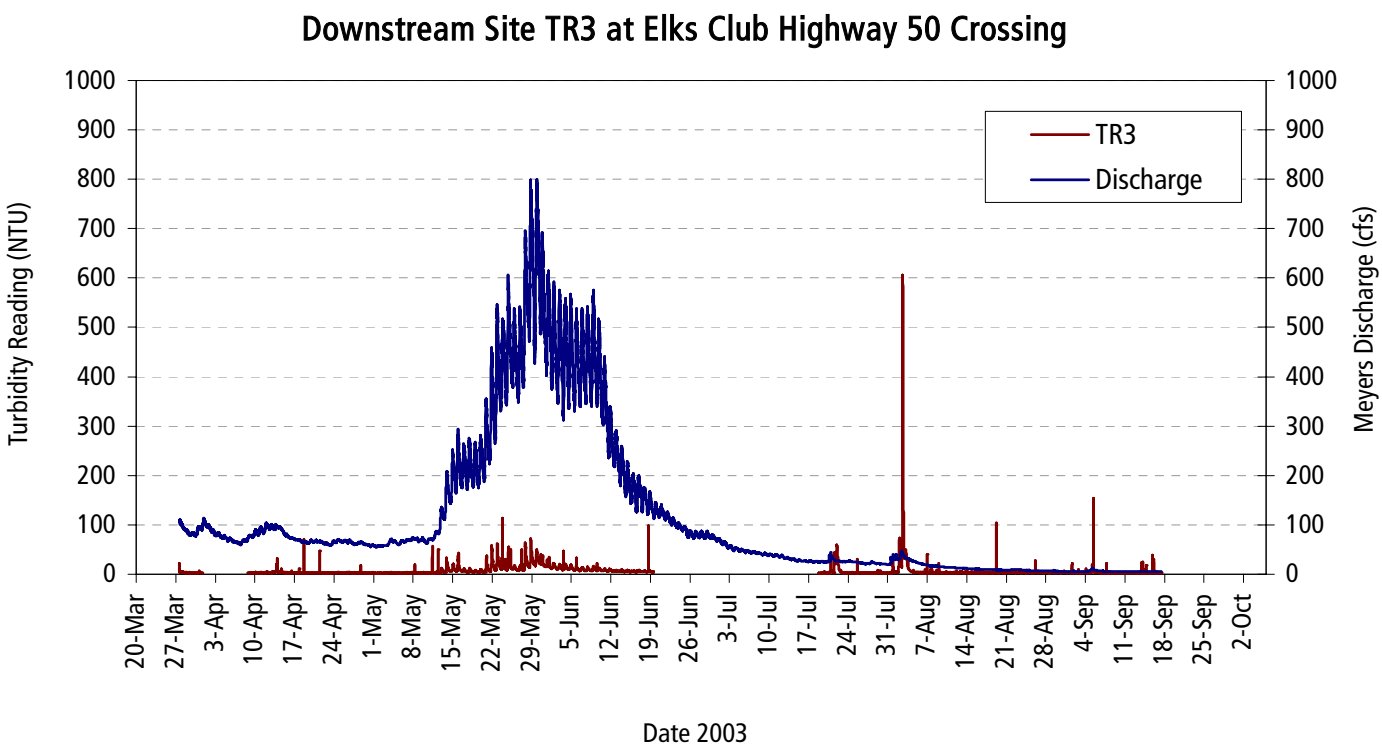
SEDIMENT

The UTR transports a wide range of sediment sizes from boulder to fine silts and clays and dissolved constituents (wash load). In general, the coarser sediments (cobble to gravel and sand sizes) can affect channel stability and substrate quality when released in excessive quantity; these effects are discussed further in the geomorphology and aquatic habitat sections. Fine sediment discharge (ranging from fine sand to clay sizes) has the greatest impact on the clarity of Lake Tahoe. Fine clay particles have a high affinity for adsorption by phosphorous and iron, thus transporting these nutrients to the Lake, where disassociation process can release these nutrients into solution at a later time. Also, fine sediments originating from volcanic rocks can become dispersive clays and remain in suspension in the water column for long periods of time. Excessive fine sediments also originate from soil disturbance areas along roads and developed areas (an assessment of erosion along roads in developed areas is presented in Section III.1.C).

A recent study by the USDA (Simon et al 2003) was conducted on the relative annual fine sediment sources to Lake Tahoe. The USDA Study found that the UTR is responsible for the highest annual sediment delivery to Lake Tahoe (2200 T/yr) followed by Blackwood (1930 T/yr) and Second Creek (1410 T/yr). These findings are not surprising given that the UTR has the largest drainage area of all Basin streams. The Upper Truckee River was also found to be the greatest contributor of fine sediment with an annual load of 1010 T/yr and the majority of the fine sediment sources in the UTR were found to originate within the channel due to increasing land use disturbances and channel instability (Simon et al 2003).

Continuous fine sediment measurements in the UTR have been collected at four locations in the UTR by R. Wigart of the City of South Lake Tahoe (CSLT) (see Figure 3.1 for CSLT TR monitoring locations). At each of these locations the CSLT has installed YSI data loggers complete with turbidity probes, capable of measuring stream turbidity on 15-minute intervals. The turbidity readings (NTU) can be calibrated to total suspended sediment (TSS) concentrations when instrument readings are correlated to grab sample TSS concentrations. The CSLT provided all of the available turbidity and grab TSS data to SH+G for interpretation. Only data from the monitoring stations TR4 and TR3 are discussed in this report, since these sites border the upstream and downstream ends of Reaches 1-4 (Elks Club Highway 50 crossing to Meyers Highway 50 crossing). Figure 3.5 presents the 2003 real-time turbidity data from TR4 (Meyers Highway 50 crossing) and TR3 (Elks Club Highway 50 crossing) along with 15-min streamflow data and illustrates that spring snowmelt delivers and carries a consistent fine sediment load, while flashy summer thunderstorms can mobilize high amounts of sediment in short periods of time. Based on TSS grab samples, a rating curve was created for each runoff event type and the real-time turbidity data can be converted to TSS loads (Figures 3.6 and 3.7A). Figure 3.7B presents the upstream and downstream instantaneous fine sediment loads measured during the 2003 snowmelt event. Figure 3.8 compares the total and daily peak snowmelt and thunderstorm fine sediment loads upstream and downstream of the Study Area. Two important findings are illustrated in this data: (1) The sustained elevated flows produced during spring snowmelt result in a total fine sediment load of over 900 tons over a 37-day period in 2003, an order of magnitude more sediment than that the summer thunderstorm series (69 days), and (2) Based on visual observations of the stream





Turbidity data provided by CSLT
Discharge data provided by USGS gage #103366092

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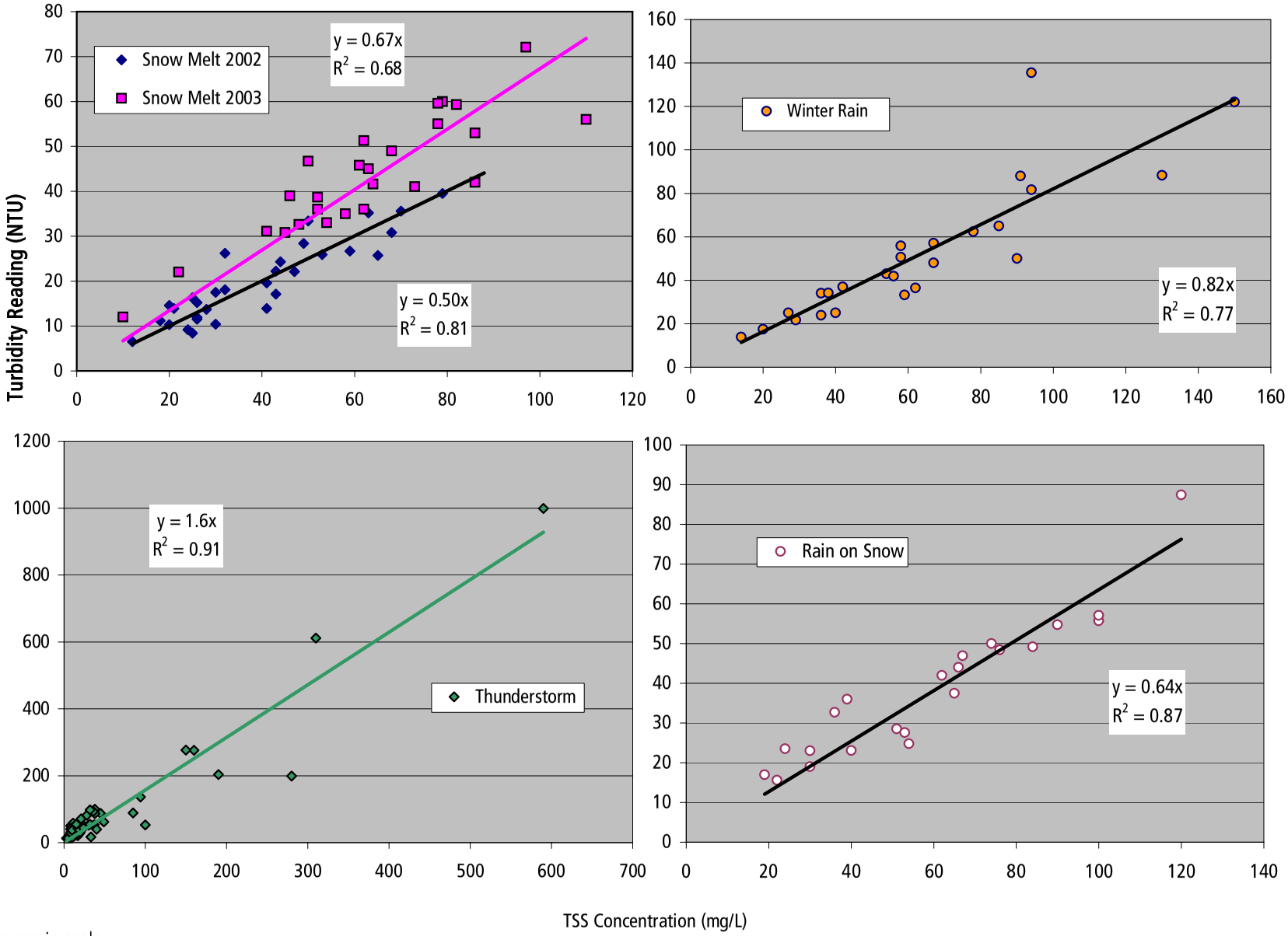
FIGURE 3.5: Continuous real-time turbidity data collected by deployed YSI data loggers at sites TR3 and TR4 by City of South Lake Tahoe. Upper Truckee River at Meyers discharge recorded by USGS streamflow gages is also plotted. See Figure 3.1 for site locations.



*Note changes in scale

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FIGURE 3.6: Correlation of CSLT turbidity readings to TSS sample concentrations over two years of data collection in Upper Truckee River at stations TR1, TR2, TR3 and TR4. See Figure 3.1 for station locations. The above relationships suggest that the type of storm event drives the fine sediment concentrations mobilized within the Upper Truckee River.

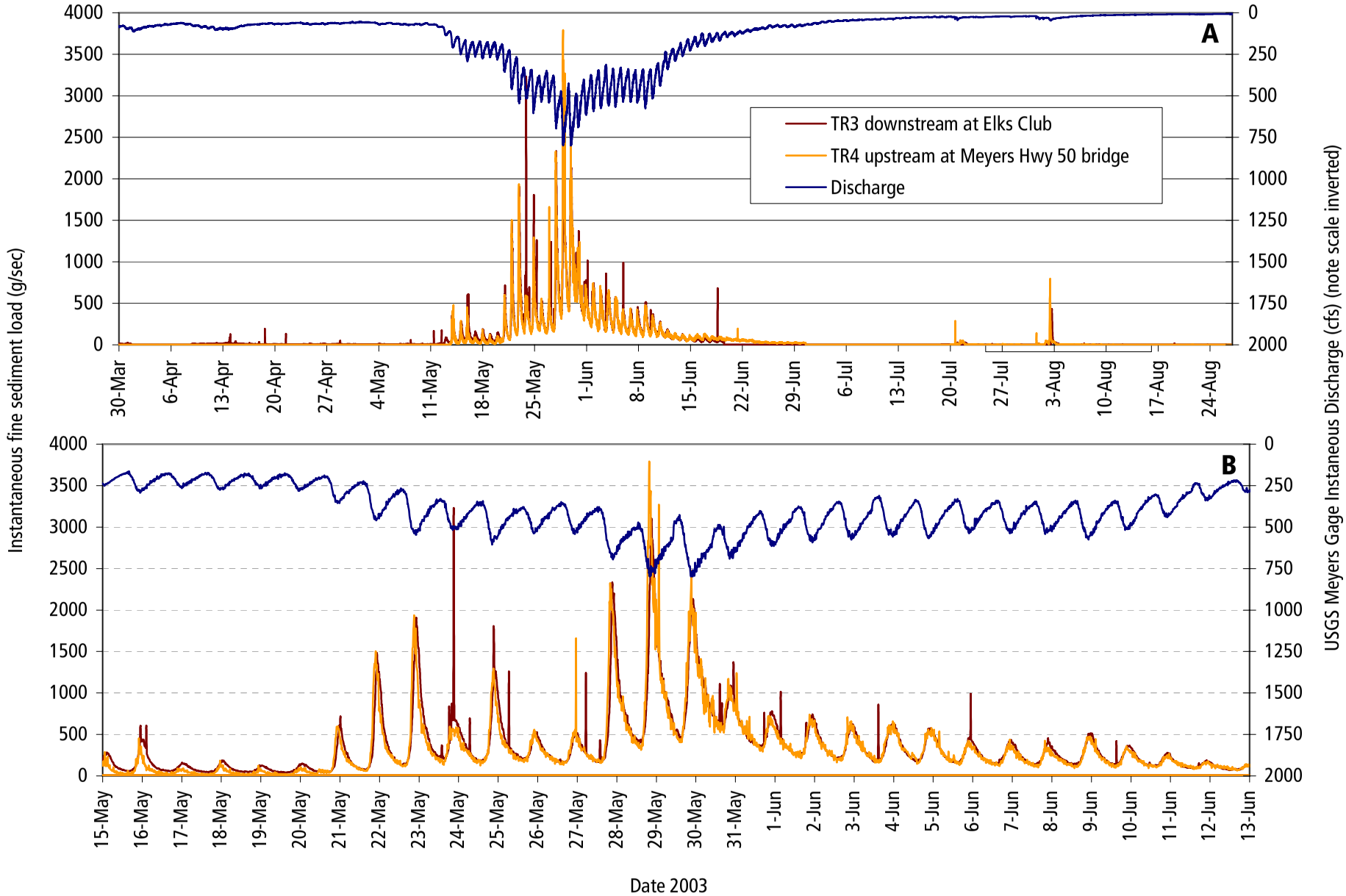

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FIGURE 3.7A & B: A: Continuous turbidity data for sites TR3 and TR4 converted to instantaneous fine sediment loads for 2003 data collection period (March 30 - August 31). B: Sediment loads at each site are compared for the snowmelt season (May 15 - June 13). Sediment data provided by City of South Lake Tahoe. Stream discharge data provided by USGS.

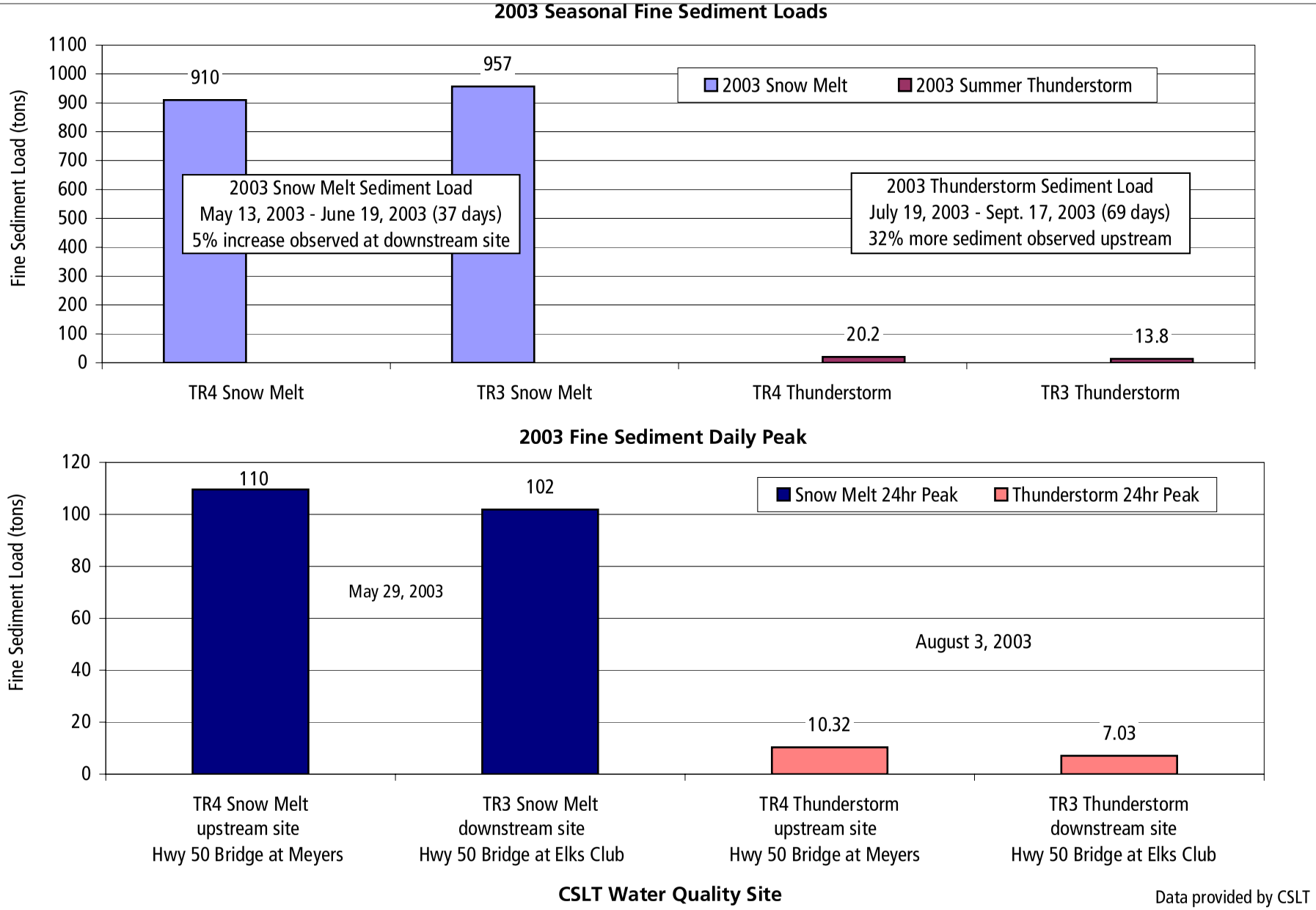

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FIGURE 3.8: Comparison of the upstream and downstream sediment loads observed in the Upper Truckee River during 2003 spring snow melt and 2003 summer thunderstorm season. Lower graph compares the upstream and downstream sediment loads during the 48-hour peak discharge for each type of event. See Figure 3.1 for station locations.

bank conditions and the data presented in Figure 3.8, the fine sediment loads may increase downstream through the project Reaches 1-4 as result of channel bank erosion, a finding similar to the results presented by Simon et al (2003) on the fine sediment source in the UTR.

Nutrient and Iron Data

Over the past 30 years, Lake Tahoe has shifted from a nitrogen-limited oligotrophic system to a phosphorous limited mesotrophic system (Goldman 1988). The clarity of Lake Tahoe has significantly been impacted by the delivery of phosphorous and potentially iron (Fe) (Chang et al 1992) from the surrounding land uses. The shift of the nutrient that limits primary productivity from N to P has profound implications on the future management of nutrient inputs to the Lake to reduce the annual rate of clarity decline of 1 foot per year, as estimated by researchers at Tahoe Research Group. The reduction of biologically and particulate P to the Lake will have the greatest immediate benefit on the metabolic rates of the phytoplankton in the Lake. Event based nutrient sampling conducted by SH+G in cooperation with the TRPA wetland efficiency study (SH+G 2003) found that ground surfaces subjected to the application of anthropogenic fertilizers can result in two orders of magnitude higher concentrations and runoff loads of biologically available P levels than runoff emanating from residential or industrial surfaces. The above SH+G findings lent to current efforts by TRPA to significantly reduce the concentration of P applied to manicured grass surfaces, thereby increasing the fertilizer management requirements of golf courses and recreational facilities. Based on the available surface water nutrient data available for the UTR (CSLT and the USGS), no definitive findings can be made to determine the water quality impact of the LTGC or other land use practices at this time. The data that is available is presented below.

In addition to turbidity measurements, the CSLT collects periodic water samples for nitrogen (N) and phosphorous (P) constituent analyses during elevated flows in the UTR. Figures 3.9 and 3.10 provide the N and P sample concentration data for samples collected and analyzed from TR3 and TR4 since May 2002. The relatively high analytical detection limits for the biologically available N and P species does not provide enough meaningful data. The TKN concentrations appear to be relatively consistent over the array of sampling but TP values were significantly elevated relative to other events during the summer thunderstorm sampling in August 2003 and may be the result of the high fine sediment loads observed during this flashy event.

The additional water quality data available for the UTR system is the periodic nutrient grab sampling done by the USGS at each of their three streamflow monitoring stations (Figure 3.1). Figures 3.11A-C present the daily loads from each of the three sites of the biologically available dissolved nutrient constituents (dissolved phosphorous (DP), dissolved nitrate (NO^{3-}) and biologically reactive iron) that would have the greatest immediate impact on the phytoplankton growth once delivered to Lake Tahoe. The instantaneous streamflow at the time of sample collection is presented in Figure 3.11D, to illustrate the strong correlation between daily loads and discharge, thus the bulk of nutrient loads are delivered to the Lake along with the greatest streamflow volumes.

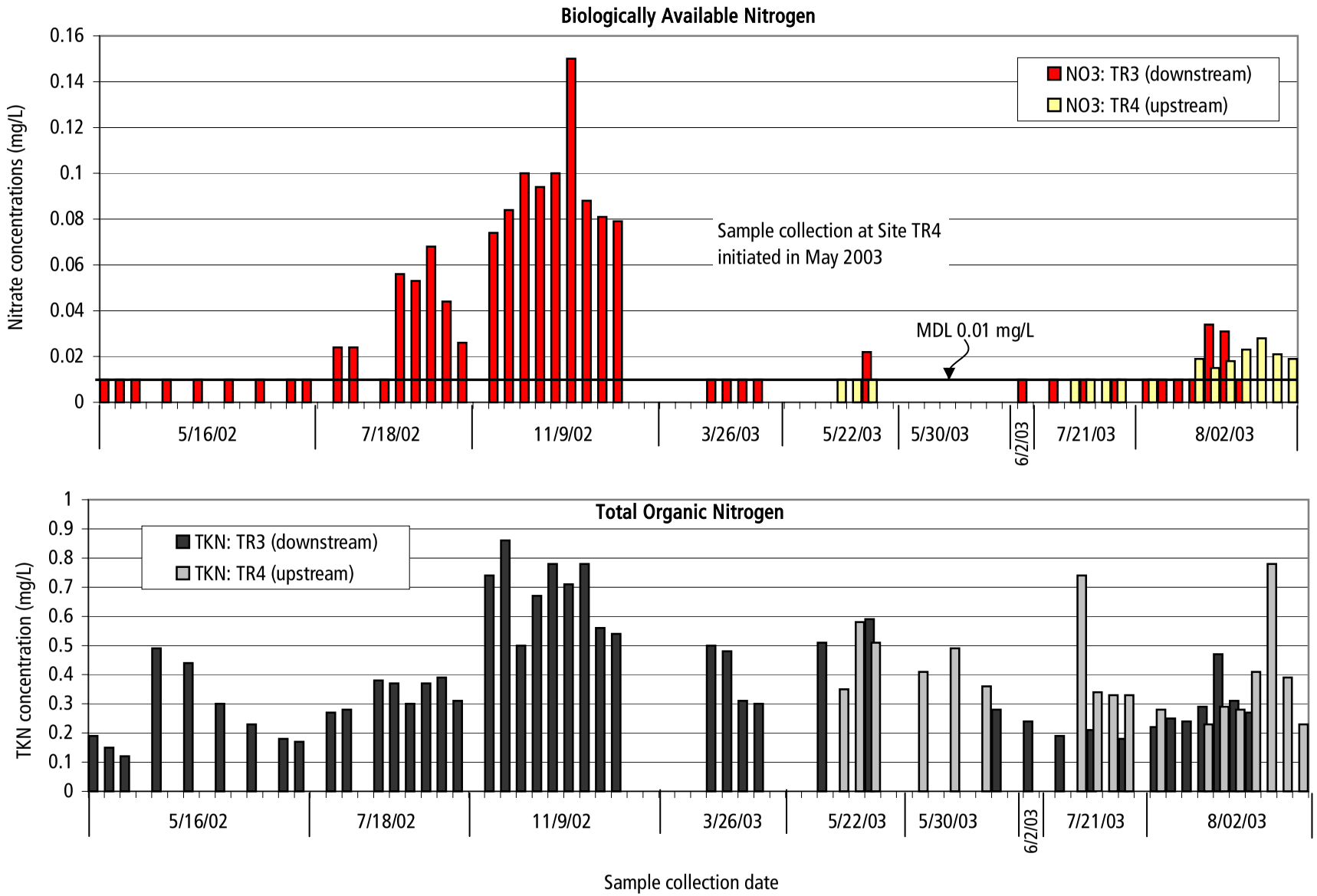

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FIGURE 3.9: Concentration data for Nitrate and TKN samples collected at stations TR3 and TR4 during the 2002 and 2003 collection periods. See Figure 3.1 for sample locations.

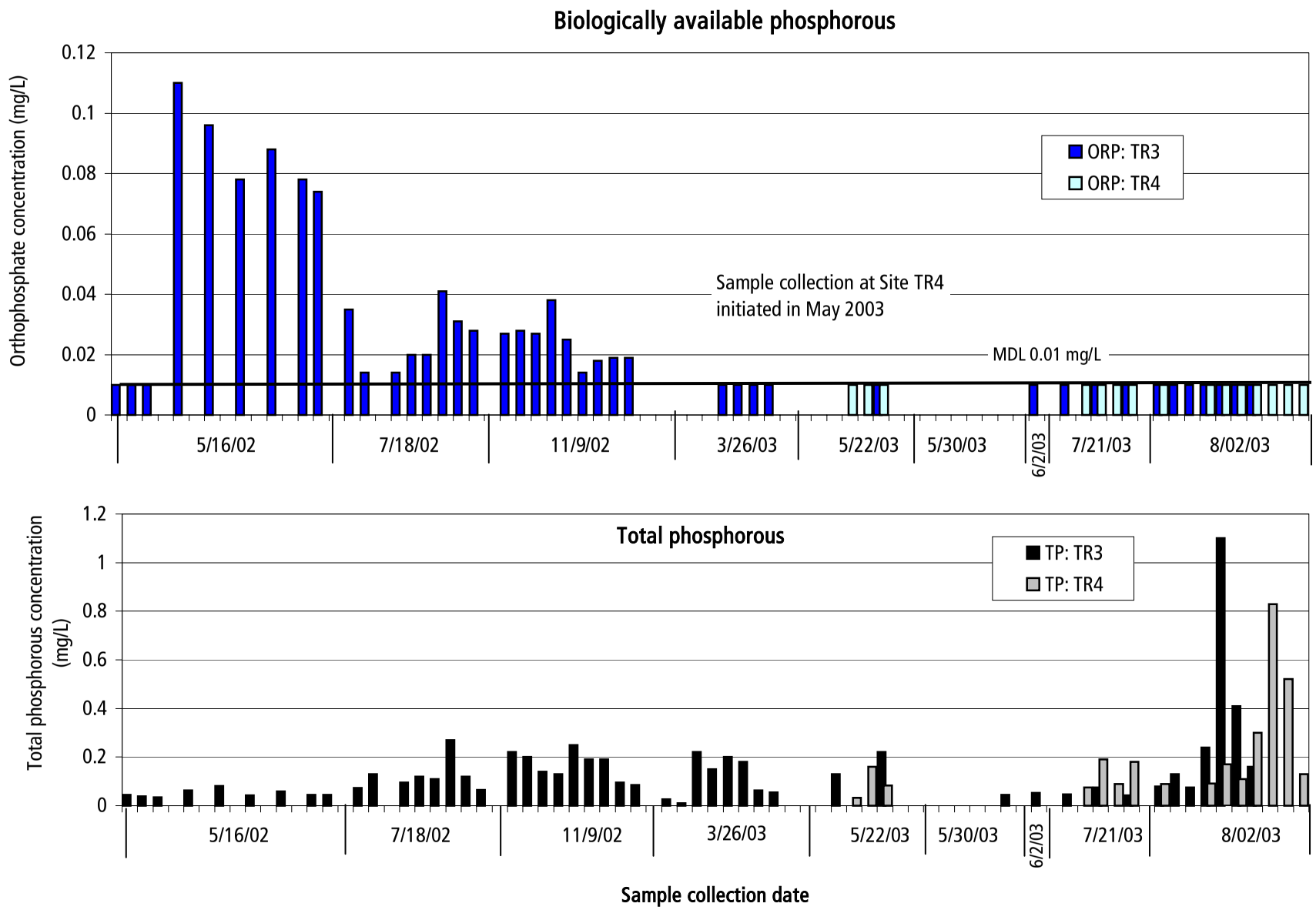

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FIGURE 3.10: Concentration data for orthophosphate and total phosphorous samples collected at stations TR3 and TR4 during the 2002 and 2003 collection periods. See Figure 3.1 for sample locations.

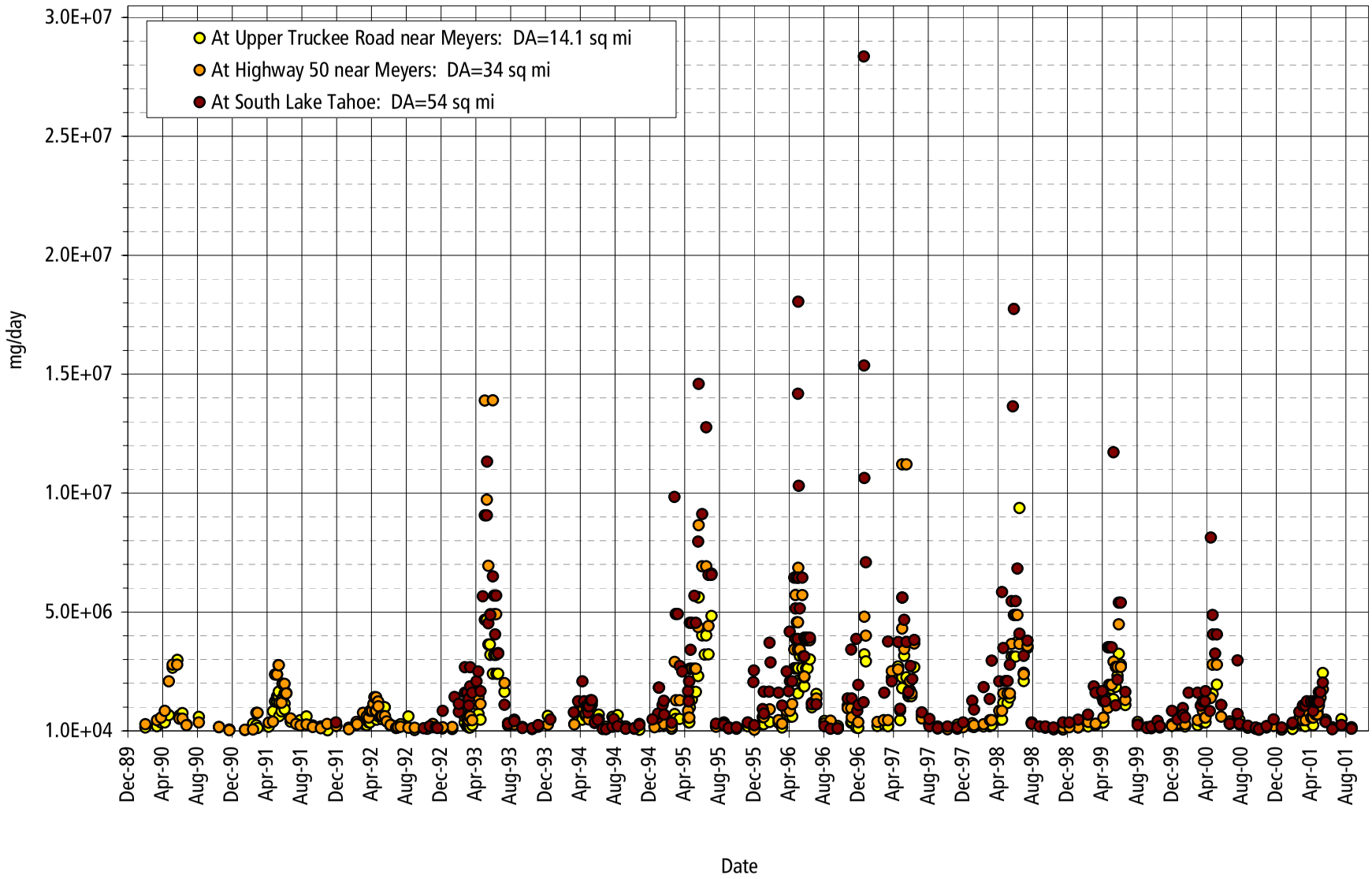

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FIGURE 3.11A: Daily dissolved phosphorous loads as measured at the three USGS streamflow monitoring stations.

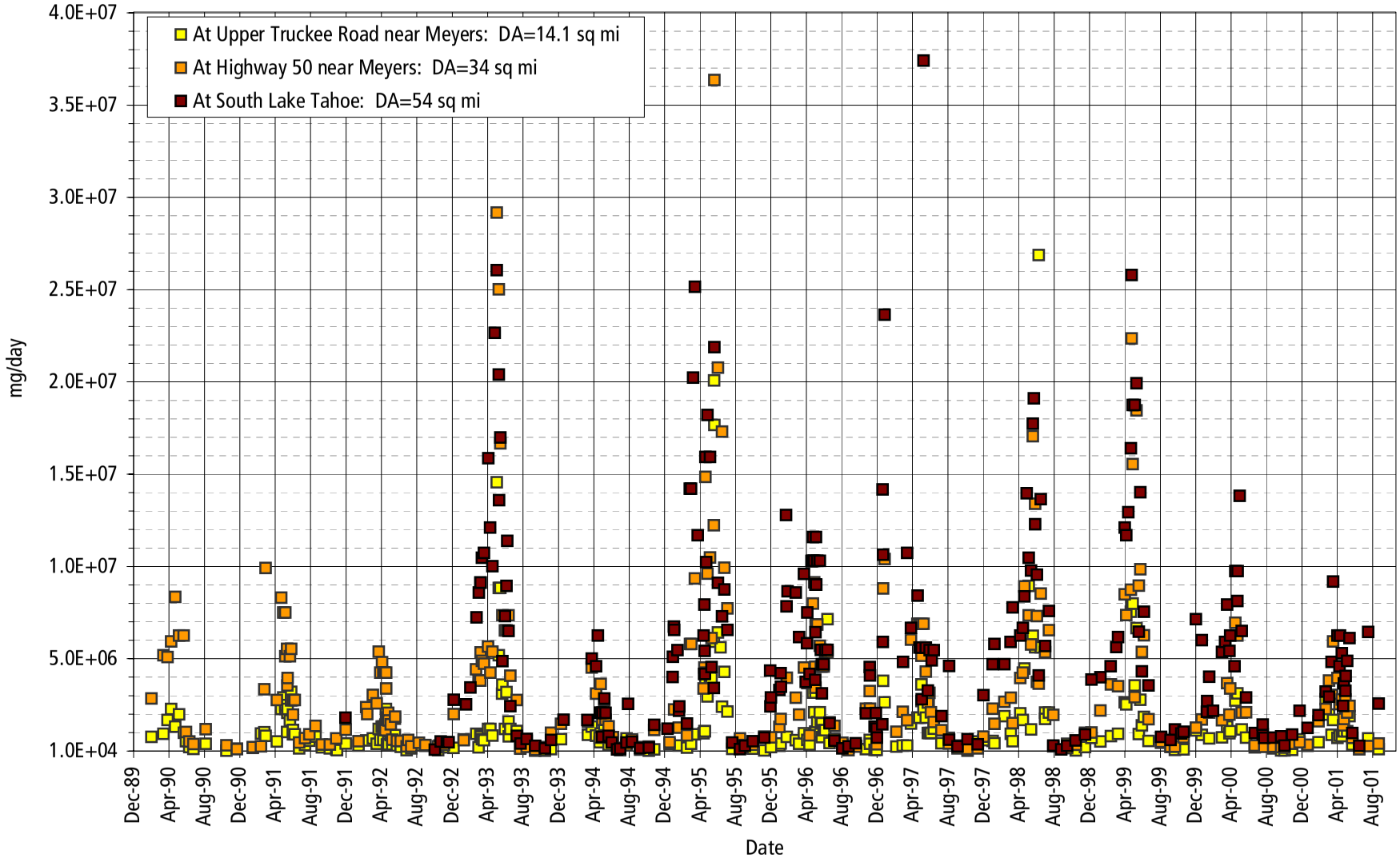

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FIGURE 3.11B: Daily dissolved nitrate loads as measured at the three USGS streamflow monitoring stations.

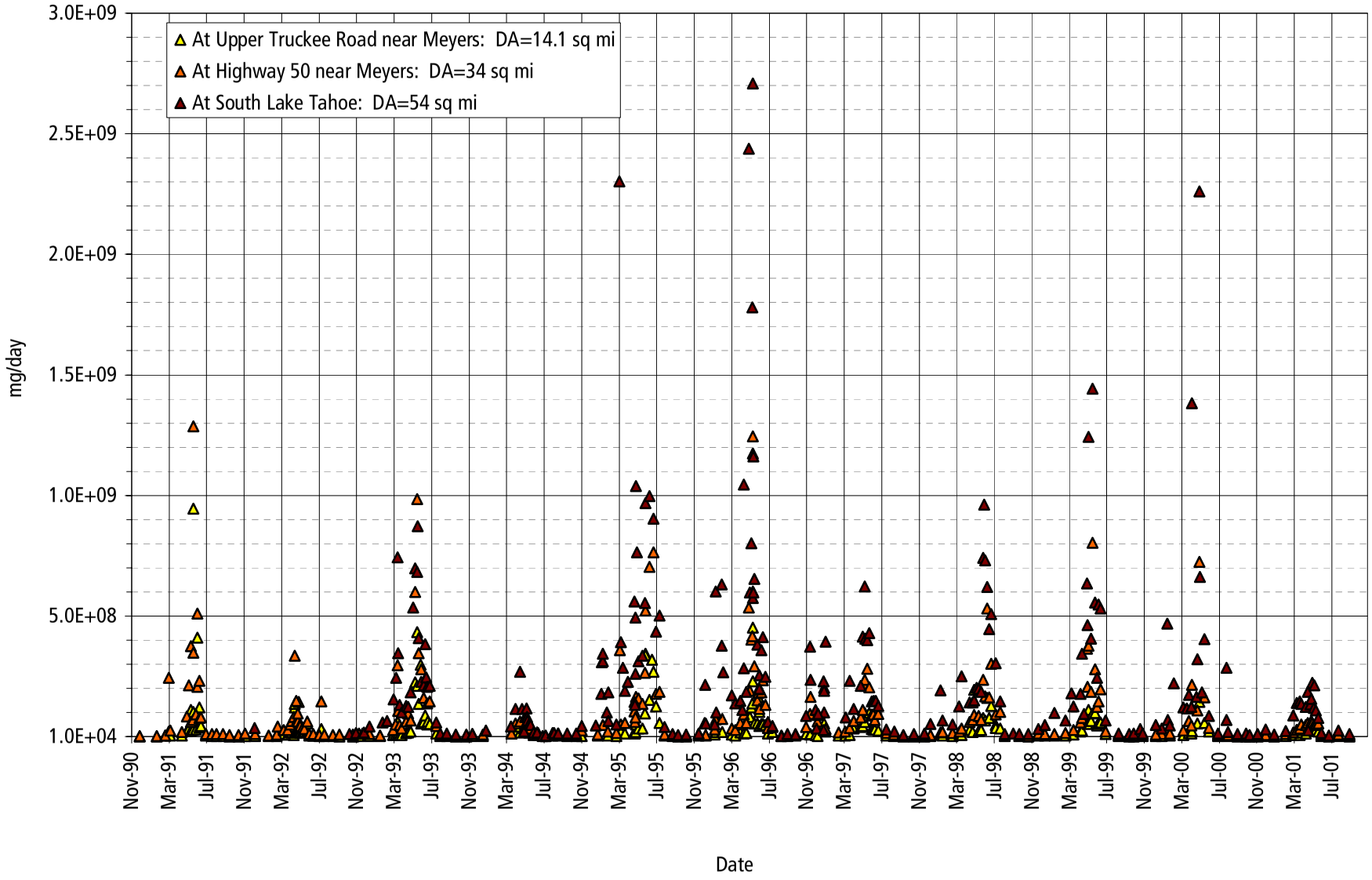

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FIGURE 3.11C: Daily biologically reactive iron loads as measured at the three USGS streamflow monitoring stations.

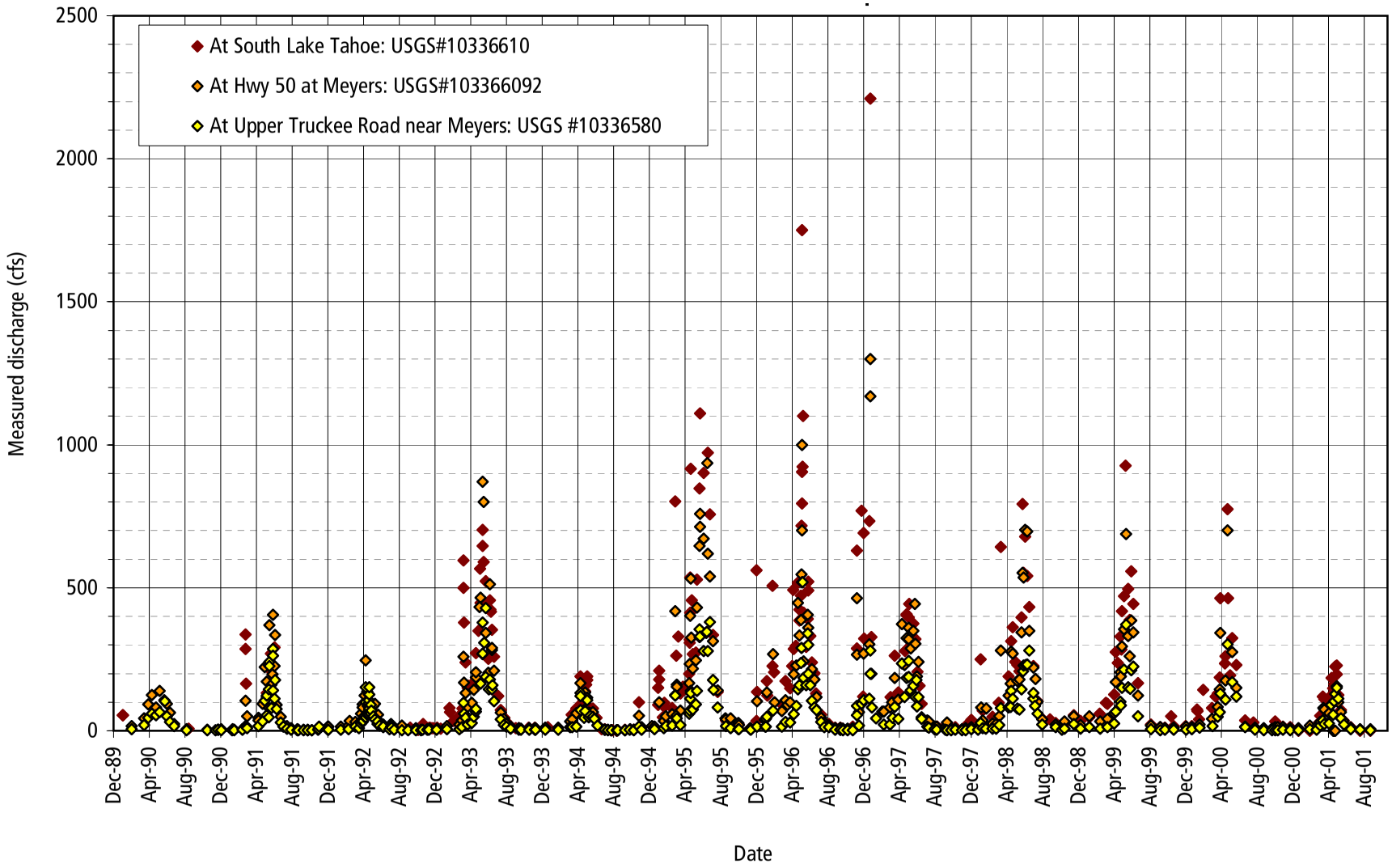

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FIGURE 3.11D: Instantaneous streamflow as measured at the three USGS streamflow monitoring stations. Samples were taken at the same time as the constituents shown in Figures 3.11 A-C.

In 2002, the USGS released a report comparing the streamflow and water quality data for selected watersheds throughout Lake Tahoe Basin (Rowe et. al. 2002). The UTR had the largest median monthly loads for six of the seven constituents analyzed (nitrite, ammonia, total nitrogen, total phosphorus, biologically reactive iron, and suspended sediment). However, it must be noted that the UTR was also one of the largest watersheds studied and had the highest annual runoff. The report found the following trends in seasonal and monthly loading in the UTR: the highest median seasonal loads occurred in the spring during snowmelt, the lowest median seasonal loads were in the summer months, the largest median monthly loads occurred in May, and the lowest median monthly loads occurred in August, September, or October, depending on the constituent.

III.1.C Geomorphology

The geomorphology of the UTR reflects the physical processes underlying ecosystem processes. Watersheds produce water, sediment and organic materials, all of which interact with biological processes to form aquatic habitat and riparian and wetland vegetation communities that in turn form wildlife habitats.

The geomorphic assessment for the UTR Upper Reach Study Area has been divided into three segments: the stability and geomorphic processes of the main UTR channel, the relative sediment production from urbanized subwatersheds in the Meyers Area and Christmas Valley, and the general geomorphic conditions in the Upper Watershed.

MAIN UTR CHANNEL MORPHOLOGY

The morphology of the UTR was analyzed using current and past aerial photographs, topographic maps, specific surveys of channel forming features, hydrologic monitoring of the stream, and the relation between geomorphic surfaces and flow. Based upon the results of these analyses, eleven distinctive reaches were identified along the project reach (Figures 3.12 and 3.13A-E).

Longitudinal Profile

A longitudinal profile was field surveyed in May 2003 between Elks Club Highway 50 crossing and Meyers Highway 50 crossing (Figure 2.5), which repeated and expanded profile surveys completed by CDPR in 1993, 1994 and 2002 to reveal recent changes, especially from the record January 1997 rain on snow event. The long profile of Christmas Valley reach from Meyers Highway 50 crossing to the South Upper Truckee Road crossing was created using the 2003 LIDAR topographic survey, which offers less detail (Figure 3.14), but still shows key details.

The 2003 longitudinal profile for the Elks Club Highway 50 crossing to Meyers Highway 50 crossing reach reveals several key features (Figure 2.5), including a flattened area in the lowermost reach, where meander cutoffs and channel deepening have been pronounced, followed by gradually steeper sections upstream. Two prominent grade control structures are found at station 2100 and 13000; the 2003 profile also reveals several significant active headcuts or knickpoints in

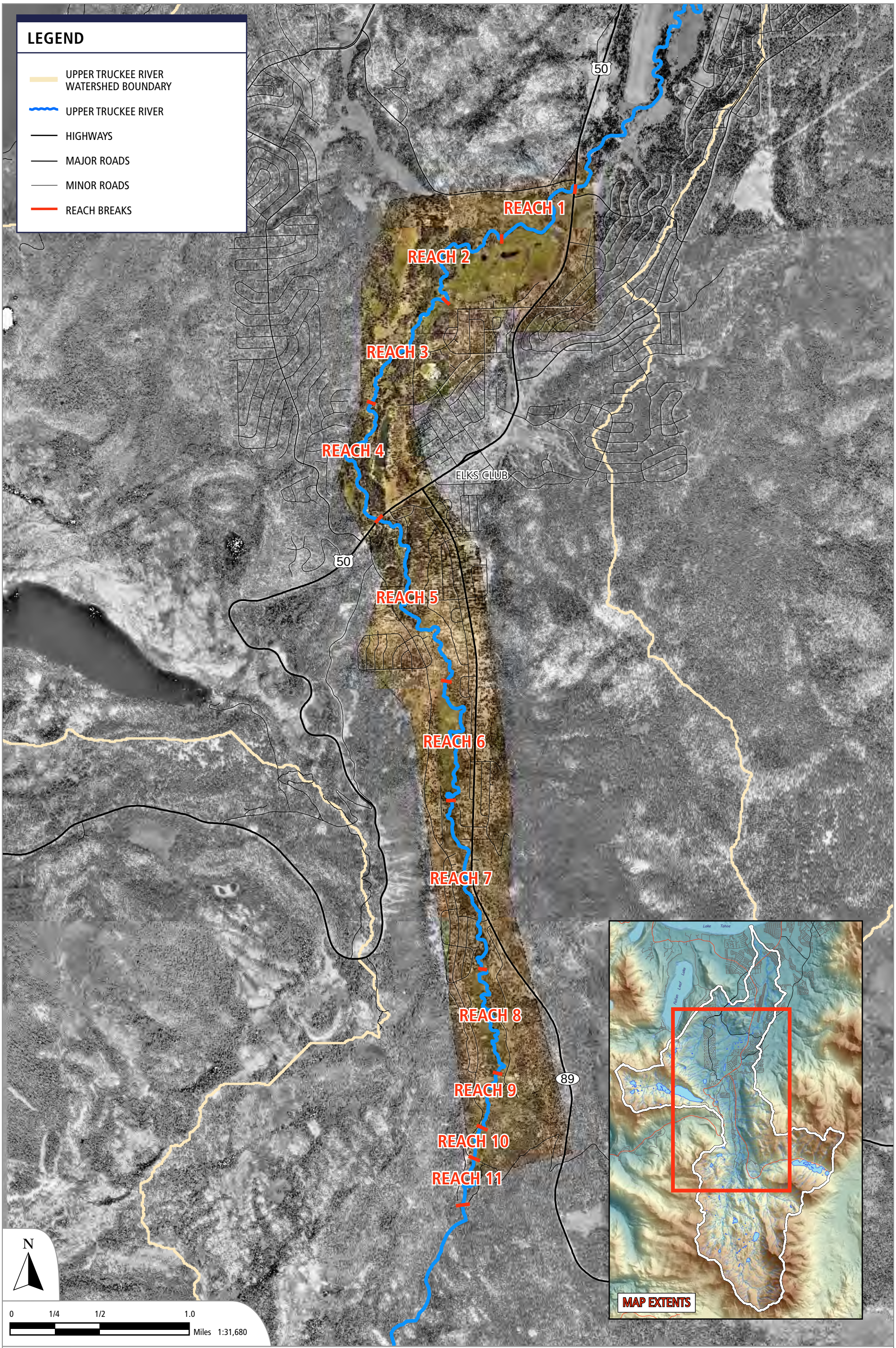

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FIGURE 3.12: Reach break designations for the Upper Truckee River Upper Reach Study Area. Reaches were identified based upon analysis of aerial photographs, topographic maps, surveys of channel forming features, hydrologic monitoring of the stream and relationships between geomorphic surfaces and flow.
Data sources: USGS DOQQ, 1998. Lidar survey, 2003.

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FIGURE 3.13A: Map indicating the location of underground utilities relative to the Upper Truckee River (Reaches 1-3).

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FIGURE 3.13B: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 4-5).

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FIGURE 3.13C: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reach 6).