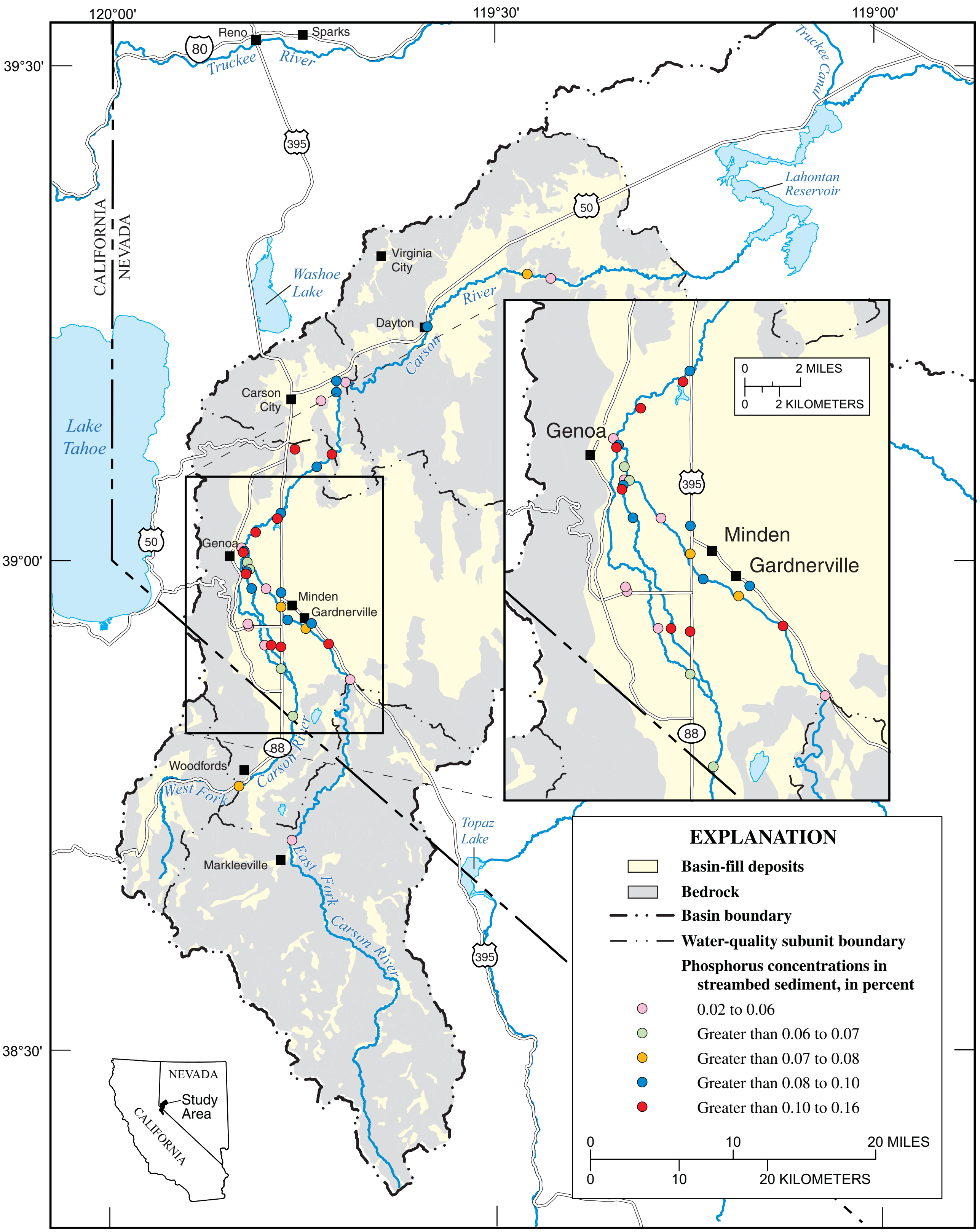


Base from U.S. Geological Survey digital data, 1:100,000- and 1:24,000-scale, 1979-82
Universal Transverse Mercator projection, zone 11
North American Datum 1927

Figure 29. Phosphorus concentrations in streambed-sediment samples in the Carson River Basin upstream from Lahontan Reservoir, 2001–02.

methods for determining the two differ. The SSC method is a measure of all of the sediment and all of the water in a sample to determine concentration; whereas, the TSS method is a measure of a subsample of the original sample (Gray and others, 2000). NDEP uses the TSS method and water-quality standards for Nevada rivers and streams are based on the TSS.

A statistically significant relation between SSC and TSS ($R^2 = 0.79$; $p < 0.001$) exists for TSS concentrations greater than 10 mg/L. Although TSS concentrations less than 10 mg/L are reported in appendix 1, they are less than the laboratory reporting limit and are considered estimates. For concurrently collected samples in the Carson River Basin, TSS almost always underestimates SSC (fig. 30) for two possible reasons. First, the difference could result from how samples were composited; SSC samples were composited instream; whereas, TSS samples were composited in a churn-splitter. Second, the process by which TSS samples are subsampled in the laboratory may result in subsamples that are different from the original sample.

Studies indicate that, for particle sizes less than 250 µm and SSC values less than 1,000 mg/L, SSC does not differ for instream and churn-splitter compositing of samples (Wilde and others, 1998). Hence, the difference in SSC and TSS values probably is the result of subsampling during TSS analysis. Figure 31 shows that the difference between SSC and TSS decreases as the amount of clay and silt in the sample increases. A national study (Gray and others, 2000) reported that SSC was more reliable at representing the true concentration of suspended material in the stream than TSS, particularly when the amount of sand in a sample exceed about a quarter of the dry sediment mass.

Some of the TSS samples from the Carson River may accurately reflect the mass of suspended matter in the river; however, such samples cannot be identified reliably nor is there a reliable procedure to correct TSS biased data (Gray and others, 2000). None of the TSS samples collected by NDEP from the Carson River were analyzed for the amount of sand. These results indicate that historical TSS data collected by NDEP could be used to calculate estimates for fluvial-sediment loads because there is a statistically significant relation between SSC and TSS. Use of uncorrected TSS values would be biased low compared to the actual concentration of suspended material in the stream. The bias likely would be greatest during periods of high discharge.

## Changes Across Specific Reaches

Data were collected in five synoptic surveys during winter, spring, and summer of 2002. Along the Carson River, about 25 sites were sampled during four synoptic surveys and 12 sites were sampled during an abbreviated spring synoptic survey. Previous results from this study showed changes in phosphorus concentration, composition, and loads across Carson, Eagle, and Dayton–Churchill Valleys. The purpose of the synoptic surveys was to identify specific reaches where changes in water quality occur and to identify the possible causes for those changes. Results of the synoptic surveys for discharge, phosphorus concentration, phosphorus load, and suspended-sediment concentrations are shown in figures 32–36.

For the purposes of data interpretation, the Carson River was broken into four reaches (figs. 5 and 16):

1. West Fork/Brockliss Slough: West Fork Carson River at Woodfords (site 1) to Brockliss Slough above confluence Carson River near Genoa (site 15).
2. West Fork Ditch: West Fork Carson River from the split with Brockliss Slough to the West Fork Carson River above confluence East Fork Carson River near Genoa (site 9).
3. East Fork: East Fork Carson River below Markleeville Creek (site 16) to East Fork Carson River above confluence West Fork Carson River near Genoa (site 25).
4. Mainstem: Carson River near Genoa (site 28) to Carson River near Silver Springs (site 43).

Sampling locations within those reaches were chosen on how useful the data obtained from them would be in characterizing phosphorus contributions from different lands and land-use categories.

The synoptic surveys in 2002 took from 4 days to 3 weeks to complete:

1. Winter: February 19–28
2. Spring 1: April 24–May 15
3. Spring 2: May 28–31
4. Summer 1: July 1–12
5. Summer 2: August 21–29.

Sampling within specific reaches was done in as short a time as possible to minimize changes in discharge and upstream water quality. Spring 2 was completed in 4 days because a reduced number of sites were sampled.

### West Fork/Brockliss Slough

During all of the synoptic surveys, total-phosphorus concentrations increased substantially between West Fork Carson River at Woodfords (site 1) and Brockliss Slough above confluence Carson River (site 15). At site 15, total-phosphorus concentrations were always greater than the water-quality standard, ranging from 0.12 mg/L during winter to 0.38 mg/L during summer. During all the synoptic surveys, the largest increases in total-phosphorus concentration and load occurred in the nearly 12 mi reach between Brockliss Slough at Highway 88 (site 10) and Brockliss Slough above confluence Carson River (site 15). During the winter and summer surveys, about two-thirds of the increase in total-phosphorus concentration between sites 10 and 15 is due to increases in orthophosphate. During the winter survey, almost 31 percent of the total-phosphorus load measured at Carson River near Genoa (site 28) originated in this reach. During summer surveys, 10–22 percent of the total-phosphorus load measured at the Carson River near

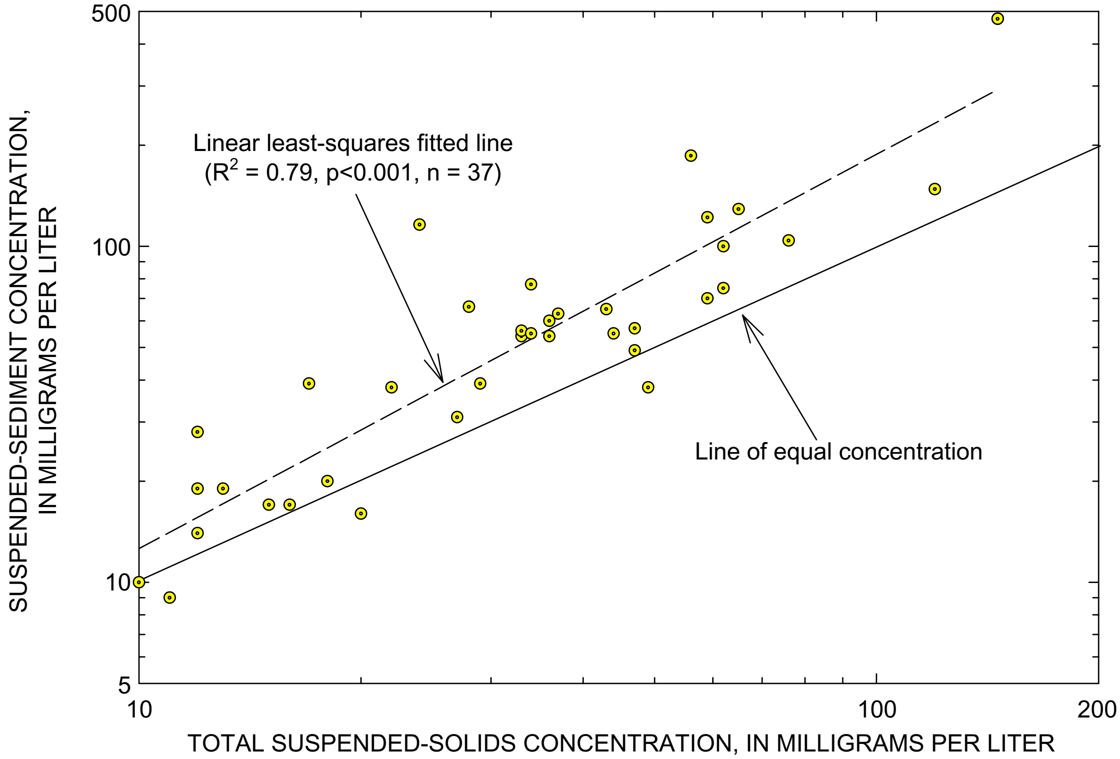


Figure 30. Relation between suspended-sediment concentration and total-suspended solids in samples from the Carson River Basin upstream from Lahontan Reservoir, 2002.

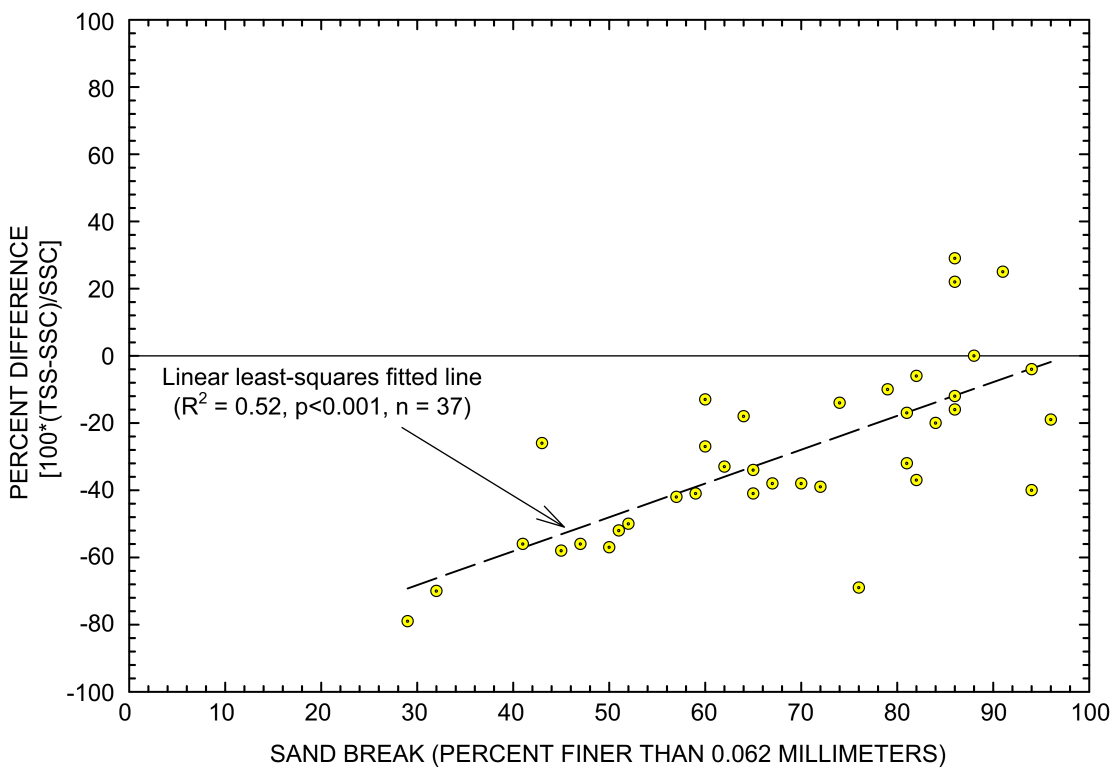


Figure 31. Relation between sand break and percent difference between suspended-sediment concentration and total-suspended solids in samples from the Carson River Basin upstream from Lahontan Reservoir, 2002.

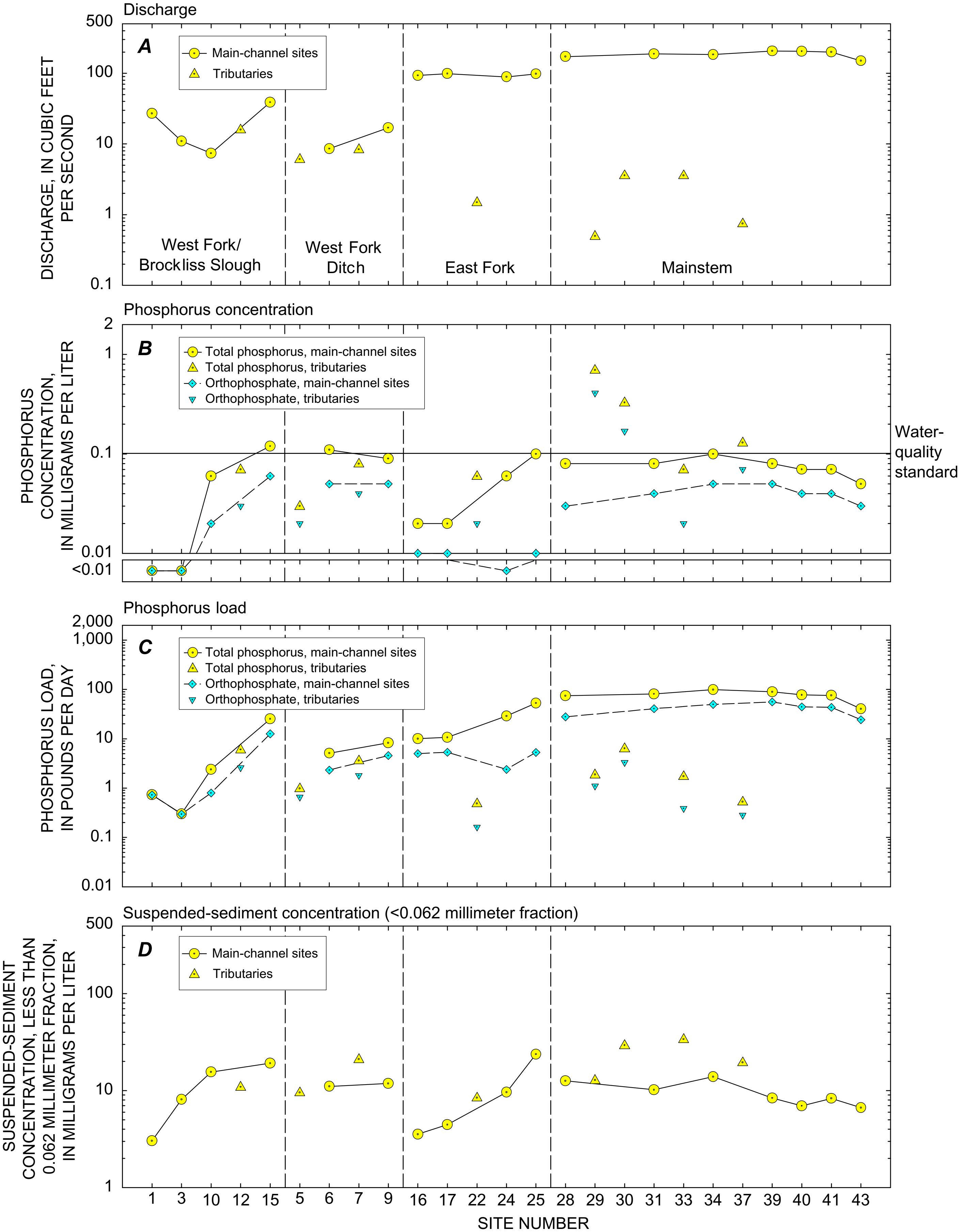


Figure 32. Discharge, phosphorus concentrations and loads, and suspended sediment (<0.062 millimeter fraction) at sites sampled during Winter synoptic survey (February 19–28, 2002).

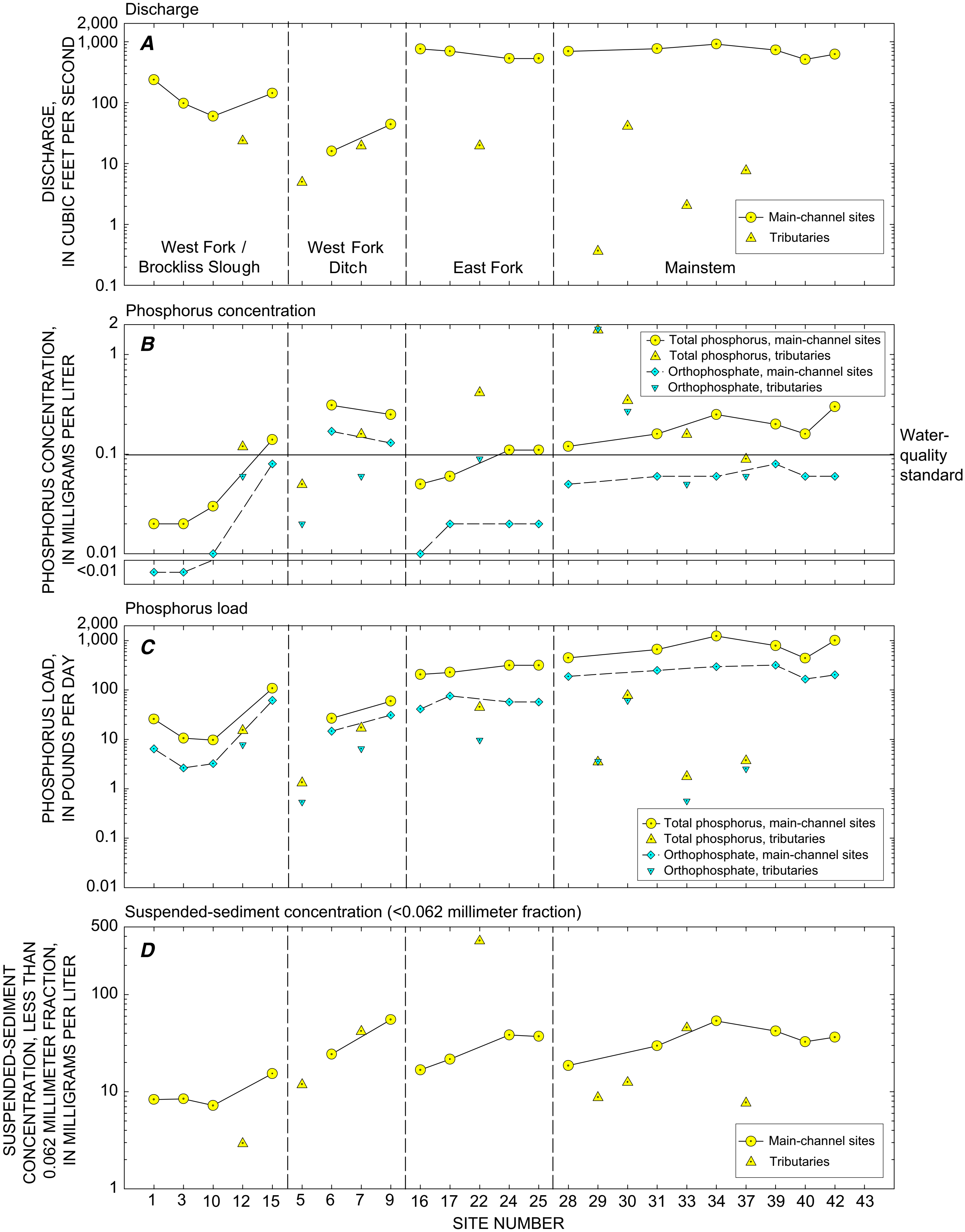


Figure 33. Discharge, phosphorus concentrations and loads, and suspended sediment (<0.062 millimeter fraction) at sites sampled during Spring 1 synoptic survey (April 24–May 15, 2002).

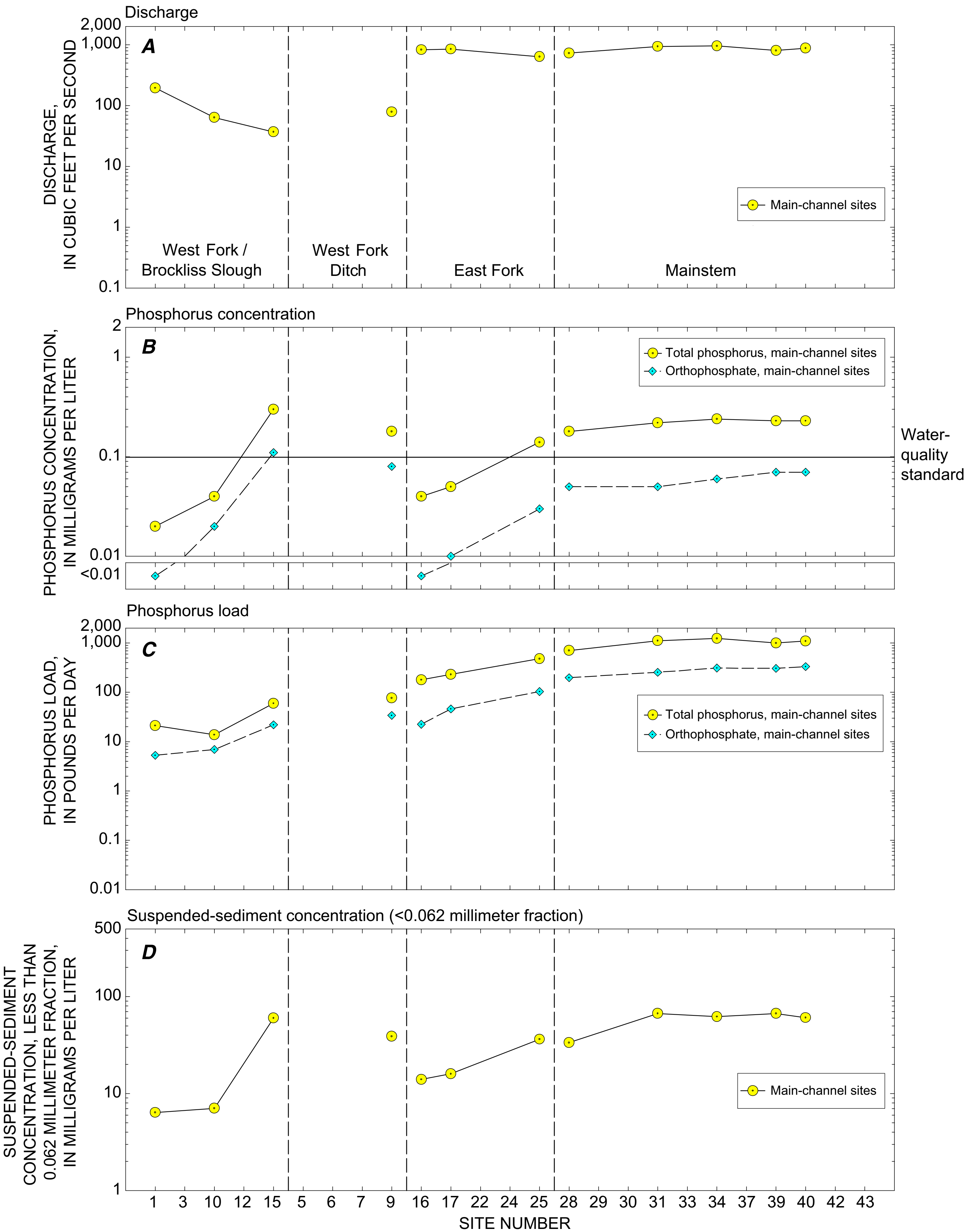


Figure 34. Discharge, phosphorus concentrations and loads, and suspended sediment (<0.062 millimeter fraction) at sites sampled during Spring 2 synoptic survey (May 28–31, 2002).

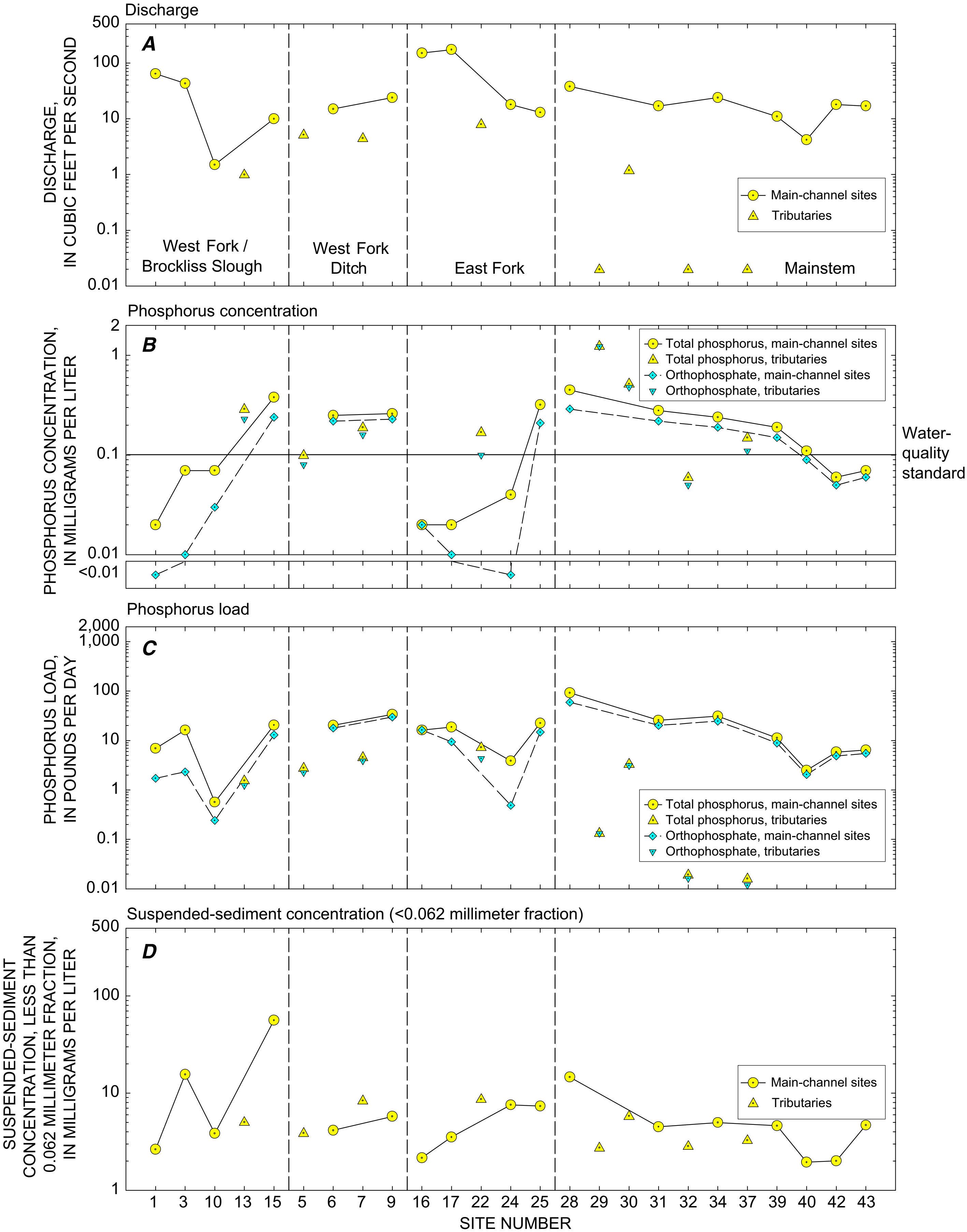


Figure 35. Discharge, phosphorus concentrations and loads, and suspended sediment (<0.062 millimeter fraction) at sites sampled during Summer 1 synoptic survey (July 1–12, 2002).

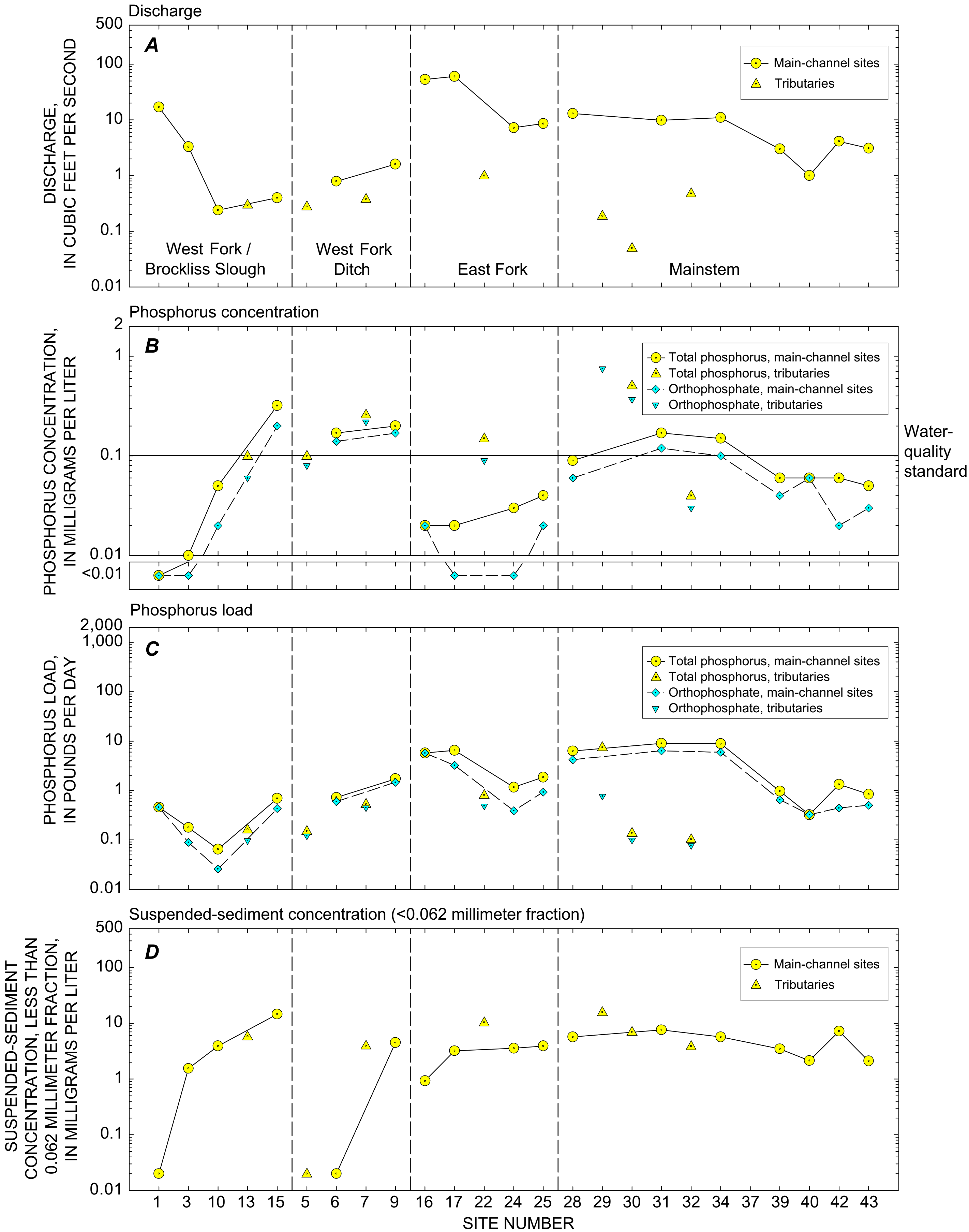


Figure 36. Discharge, phosphorus concentrations and loads, and suspended sediment (<0.062 millimeter fraction) at sites sampled during Summer 2 synoptic survey (August 21–29, 2002).

Genoa (site 28) originated in this reach. During spring surveys, 6–22 percent of the total-phosphorus load measured at Carson River near Genoa (site 28) originated in this reach.

Big Ditch at Waterloo Lane (site 12) and Johnson Slough below confluence Big Ditch (site 13) carry return flows from fields irrigated with treated effluent in Alpine County and, except during winter, total-phosphorus concentrations at these sites always exceeded the water-quality standard. Although the total-phosphorus concentrations at the two sites are high, the data collected during this study show that Big Ditch/Johnson Slough was a minor contributor to the observed increase of loads across the reach between sites 10 and 15. This may indicate that the source of phosphorus is along the channel itself, or that unsampled tributaries are the source. Surface-water inflows to this reach include Wally's Hot Springs, streams from the east side of the Carson Range, and a complex of sloughs along the west side of the valley.

## West Fork Ditch

Concentrations of total phosphorus at West Fork Carson River at Muller Lane (site 6) and West Fork Carson River above confluence East Fork Carson River (site 9) were similar and almost always exceeded the water-quality standards. Although total-phosphorus concentrations were similar, phosphorus loads increased over the reach because of increases in streamflow.

During the winter survey, about 11 percent of the total-phosphorus load measured at Carson River near Genoa (site 28) originated in the West Fork Ditch section of the river; whereas, during summer surveys, 27–36 percent of the load originated in the West Fork Ditch and its tributaries. West Fork Ditch was dry at Highway 88 during the summer, therefore, in summer all of the phosphorus load in the West Fork Ditch originates in the 8.7 mi reach downstream of Highway 88 and its tributaries. During the spring surveys, 11–13 percent of the load measured at site 28 was from the West Fork Ditch system.

Two principal tributaries, Rocky and Home Sloughs, contributed substantial amounts of phosphorus to West Fork Ditch. Total-phosphorus concentrations and loads were substantially higher in Home Slough above confluence West Fork Carson River (site 7) than in Rocky Slough at Highway 88 (site 5). Rocky Slough connects the East and West Forks and, ultimately, agricultural returns from the Rocky Slough diversions reach the West Fork. Home Slough also is influenced by agriculture and runs along the edge of a field irrigated with treated effluent. Phosphorus from Home Slough (site 7) accounted for between 14 and 44 percent of the load at West Fork Carson River above confluence East Fork Carson River (site 9).

During winter and spring surveys, the orthophosphate concentration is about half of the total-phosphorus concentration in the West Fork Ditch system. However, during the summer surveys, almost all of the phosphorus is comprised of orthophosphate.

## East Fork

Little change in suspended-sediment and phosphorus concentrations and loads exists between East Fork Carson River below Markleeville Creek (site 16) and East Fork Carson River near Dresslerville (site 17) during all the synoptic surveys. This implies that phosphorus and sediment entering Carson Valley in the East Fork originated upstream from site 16. The source of the phosphorus may be the intrusive granitic rocks found high in the headwater areas (fig. 2). Susfalk (2000) observed that extractable phosphorus in granite derived soils was much greater than from andesite derived soils.

During the synoptic surveys, total-phosphorus concentrations increased between East Fork Carson River near Dresslerville (site 17) and the East Fork Carson River above confluence West Fork Carson River (site 25). Total-phosphorus concentrations typically increased from below the water-quality standard to at or above the standard. During winter and spring surveys, the increase was almost entirely due to increases in particulate phosphorus, which is consistent with increases in the suspended-sediment concentration (figs. 32–34). The increase in particulate phosphorus likely is due to unstable streambanks in this reach (fig. 11), and urban or agricultural runoff. During the Summer 1 survey, the increase was principally due to orthophosphate although particulate phosphorus also increased substantially during this period (fig. 35). During the Summer 2 survey, total-phosphorus concentration slightly increased (fig. 36).

In the East Fork section of the river, the reach that contributed the largest phosphorus load to the Carson River during the summer and winter surveys was the 1.5 mi reach between the East Fork Carson River at Muller Lane (site 24) and the East Fork Carson River above confluence West Fork Carson River (site 25). During the winter survey, 32 percent of the total-phosphorus load at Carson River near Genoa (site 28) could be accounted for from within this short reach and, during the summer surveys, 11–20 percent of the load at site 28 could be accounted for from within the reach. The likely source of the phosphorus in this reach is agricultural land where treated effluent is used for irrigation (fig.13). During the Spring 1 survey, total-phosphorus load did not increase within this reach (fig. 33). During the spring surveys, the reach from site 17 to site 25 accounted for 19–36 percent of the load at site 28.

The principal inflow to the East Fork downstream of site 17 is Cottonwood Slough, which contributes a much larger portion of the streamflow in the East Fork Carson River at Muller Lane (site 24) during summer (14–44 percent) than during winter and spring surveys (2–4 percent). Cottonwood Slough flows through agricultural land and also receives urban runoff from the Minden–Gardnerville area. Total-phosphorus concentrations in Cottonwood Slough at Highway 88 (site 22) generally were high and, except in winter, exceeded the water-quality standard. During spring and summer surveys, Cottonwood Slough accounted for between 8 and 13 percent of the phosphorus load at Carson River near Genoa (site 28), but less than 1 percent during the winter survey. Other surface water inflows to this reach include Indian Creek, and possibly a few storm drains and ditches. These tributaries may be important sources of phosphorus, but no samples were collected. No water-quality data were collected for Indian Creek during this study, even though Indian Creek is listed for total-phosphorus on Nevada's 303(d) list of impaired waters.

## Mainstem

The maximum total-phosphorus load measured in the mainstem of the Carson River was 4,588 lb/d on April 15, 2002, at Carson River at Cradlebaugh Bridge (site 31). During the synoptic surveys, the largest total-phosphorus load measured was 1,240 lb/d during the Spring 2 survey at Carson River near Carson City (site 34). Total-phosphorus loads increased substantially in the reach between Carson River near Genoa (site 28) and Carson River near Carson City (site 34) during the spring synoptic surveys and either decreased or increased slightly during the winter and summer surveys. The large increase in total-phosphorus concentration and load between the Carson River at Cradlebaugh Bridge (site 31) and Carson River near Carson City (site 34) during the Spring 1 survey was due to large increases in particulate-phosphorus and suspended-sediment concentrations.

Of the three tributaries that were measured between site 28 and site 34, only Ambrosetti Pond Outlet (site 30) was observed to contribute substantial amounts of phosphorus. Although Williams Slough (site 29) has very high concentrations of total phosphorus, it contributes small amounts of phosphorus to the river due to its low streamflow. The combined loads from Ambrosetti Pond Outlet and Williams Slough contributed between 6.7 and 11 percent of the load at Carson River near Carson City (site 34) during the winter, spring, and Summer 1 synoptic surveys. Clear Creek (sites 32 and 33) accounted for less than 2 percent of the load at Carson River near Carson City (site 34) during the synoptic surveys.

Estimated total-phosphorus loads computed using statistical regressions indicated that a large increase in load occurred across the Carson Valley during the winter months (see section Phosphorus Loads). This was observed during the winter synoptic survey when only 12 percent of the instantaneous total-phosphorus load leaving Carson Valley (site 34) could be attributed to headwater reaches upstream from Carson Valley (sites 1 and 17). The regression results indicated that during spring and summer much of the total-phosphorus load leaving Carson Valley could be attributed to headwater reaches. During the summer surveys, instantaneous total-phosphorus load in the headwater reaches (sites 1 and 17) were from 78 to 83 percent of the instantaneous load at Carson River near Carson City (site 34); however, during the spring surveys only about 20 percent was observed. Rapid changes in streamflow during the spring may cause large variations in load, which add uncertainty in estimating change in load across Carson Valley.

Estimated total-phosphorus loads computed using statistical regressions indicated that decreases in phosphorus load occurred across Eagle and Dayton–Churchill Valleys, which is supported by data from the synoptic surveys. Total-phosphorus loads decreased in the reach between Carson River near Carson City (site 34) and Carson River at Deer Run Road (site 39) in all synoptic surveys. The decrease can be attributed to decreases in discharge and total-phosphorus concentrations as the Carson River crossed Eagle Valley. Even though the total-phosphorus concentrations were relatively high in Eagle Valley Creek above confluence Carson River (site 37), less than 1 percent of the load at site 39 could be attributed to Eagle Valley Creek (site 37). The creek was dry and no flow entered the Carson River from it during the summer.

Total-phosphorus loads decreased between the Carson River at Deer Run Road (site 39) and Carson River at Dayton (site 40) during all the synoptic surveys. For the three synoptic surveys where Carson River near Silver Springs (site 43) was sampled, there was an overall decrease in total-phosphorus load and concentration between sites 39 and 43 (fig. 4).

## Storm Runoff

Compared with average years, little summer precipitation occurred during the study period and, as a result, few data were collected that could be used to evaluate the effects of storm runoff from urban areas and no data were collected to evaluate the effects of storm runoff from agricultural fields. The best set of data to evaluate the effects of summer storms from an urban area was collected in July 2002 at Clear Creek at Center Street near Carson City (site 32). On July 10, the total-phosphorus concentration was 0.06 mg/L and the discharge was about 0.02 $ft^3/s$ at site 32 (app. 1). During a rainstorm on July 18, the total-phosphorus concentration was 0.45 mg/L and the discharge was 2.4 $ft^3/s$. Almost the entire increase in phosphorus concentration was due to particulate phosphorus which, together with a great increase in suspended-sediment concentration, indicates erosion is the source of the phosphorus. During the study period, substantial amounts of construction and earthmoving occurred in areas adjacent to Clear Creek upstream of the site. Similar results have been found for other urban streams in the West (Anderson and Rounds, 2003, p. 36).

## Phosphorus Sources

A two-step process was used to assess sources of phosphorus to the Carson River. First, reaches where significant changes in phosphorus loading and concentration occur were identified. Second, once tributaries or reaches of river were identified as being associated with significant increases in phosphorus, types of land use, transport processes, and biochemical and physical processes that could have caused the increases were investigated.

During the winter and spring surveys, the East Fork was the largest contributor to the phosphorus load measured at Carson River near Genoa (site 28), and the West Fork Ditch was a relatively minor contributor. During the summer surveys, the contribution of phosphorus load from the West Fork Ditch increased almost threefold more than during the winter and spring surveys, and the West Fork Ditch was the largest contributor of phosphorus load to the mainstem during the Summer 1 survey.

An important finding was that, on an annual basis, the estimated total-phosphorus load contributed from headwater reaches of the East and West Forks was about the same as that contributed by Carson Valley. The data indicate that particulate phosphorus is the principal component of phosphorus entering Carson Valley during at least half of the year, and that the East Fork upstream from East Fork Carson River below Markleeville Creek (site 16) is the primary source of that phosphorus. This indicates that erosion of soils in the reach upstream from site 16 is an important contributor to phosphorus loading in the Carson River. The principal land uses in that reach are forest and rangeland (fig. 9), which typically do not contribute large loads of phosphorus. The watershed upstream from East Fork Carson River near Dresslerville (site 17) has soils that are much greater in clay content and erodibility than headwater reaches in the West Fork (fig. 3). This difference likely explains why phosphorus yield from the East Fork was nearly twice that from the West Fork (table 8); however, it does not explain the similarity between sites 16 and 17 on the East Fork. Soil erodibility and clay content are slightly greater in the reach between the two sites than in the reach upstream from site 16. Historic logging during the Comstock era and forest fires within the last few decades may be the reason that forest and rangeland are contributing phosphorus; however, additional research is required.

Even though the estimated annual total-phosphorus loading upstream from and within Carson Valley are about the same, analyses indicate during summer the composition of the phosphorus changes from particulate phosphorus entering Carson Valley to orthophosphate leaving Carson Valley. This finding indicates that particulate phosphorus entering Carson Valley could be settling out and being replaced by orthophosphate from another source. Consumption of water for irrigation and changes in river velocity caused by diversion structures allow sediment to drop out during the irrigation season. Diversions also result in phosphorus and sediment being removed from the river and applied to irrigated fields where sediment and particulate phosphorus can drop out. The sediment and phosphorus may be resuspended and moved downstream during the following spring runoff. Alternatively, the particulate phosphorus could be converted to orthophosphate as it travels across Carson Valley, however, data collected during the study are not sufficient to distinguish between the possibilities.

During summer, large increases in total-phosphorus loads occur in the East Fork, West Fork/Brockliss Slough, and West Fork Ditch systems and the increase in load is caused principally by increases in orthophosphate. The principal source of orthophosphate in these reaches likely is agricultural return flows. In the West Fork/Brockliss Slough and West Fork Ditch reaches where the greatest increases occur, land use is almost exclusively agricultural. Land use principally is agricultural in the East Fork reaches. Nevertheless, decaying organic matter, urban runoff, and ground water contaminated by septic-system effluent are potential phosphorus sources that were not evaluated in detail as part of this investigation.

During winter, releases from Ambrosetti Pond may be the source of substantial amounts of the phosphorus load in the Carson River. In samples from Ambrosetti Pond Outlet (site 30), the median total-phosphorus concentration was 0.34 mg/L (app. 1) and discharge accounted for 11 percent of the streamflow at Carson River near Carson City (site 34) during November 1999–February 2000 (Garcia and others, 2002). On November 20, 2000, the total-phosphorus concentration was 0.17 mg/L when the instantaneous discharge was 27 $ft^3/s$ (site 30; app. 1), which corresponds to a phosphorus load of about 25 lb/d. Also, on this day, NDEP sampled at site 34 and the total-phosphorus concentration was 0.08 mg/L when the instantaneous discharge was 137 $ft^3/s$, which corresponds to a phosphorus load of about 59 lb/d (app. 1). Thus, on November 20, Ambrosetti Pond accounted for about 42 percent of the phosphorus load leaving Carson Valley.

Because treated effluent contains elevated phosphorus concentrations, drainwater from fields irrigated with effluent is an obvious and potentially large source of phosphorus. During the Summer 1 survey, a more than 20-fold increase in orthophosphate concentration occurred in the 1.5 mi reach between sites 24 and 25 on the East Fork. Land use in that reach is predominantly agricultural land irrigated with effluent, which potentially could contribute large amounts of phosphorus. Data from Williams Slough (site 29) and Ambrosetti Pond Outlet (site 30) also support this conclusion. Orthophosphate concentration in Williams Slough, which drains fields irrigated with effluent, during the Summer 1 survey was 1.23 mg/L (app. 1); however, the load to the river was small because the discharge was small. Ambrosetti Pond, which stores water from fields irrigated with effluent, contributed almost 11 percent of the phosphorus load measured at Carson River near Carson City (site 34) during the Summer 1 survey even though Ambrosetti Pond Outlet was only discharging 1.2 $ft^3/s$ at the time.

The potential phosphorus contribution to the Carson River from treated effluent used for irrigation was estimated using a mass-balance approach. Such an approach requires information about the amount of effluent used for irrigation and its phosphorus content. In 1999, the average total-phosphorus content of raw influent to the STPUD wastewater treatment plant was 4.63 mg/L and was 2.65 mg/L in the treated effluent (Terry Powers, South Tahoe Public Utility District, oral commun., April 16, 2003). The median total-phosphorus concentration in 117 samples of treated effluent collected by STPUD from Harvey Place Reservoir (fig. 5) between February 1989 and July 2000 was 2.45 mg/L and the maximum observed concentration was 5.1 mg/L. The average total-phosphorus concentration in effluent from Incline Village General Improvement District in 2001 was 4 mg/L, however, beginning in 2003 a change in treatment process greatly lowered concentrations to approximately 0.5 mg/L (Ed Pollock, Incline Village General Improvement District, written commun., April 2003). A sample of the effluent from the Douglas County Sewer Improvement District No. 1 in February 2001 contained 2.6 mg/L total phosphorus (John Homenick, Douglas County Sewer Improvement District, written commun., April 2003). Between 1999 and 2001, nine samples of effluent were collected from the Carson City Wastewater Reclamation Plant and the average for total phosphorus was 4 mg/L (Kelvin Ikehara, Carson City Wastewater Reclamation Plant, written commun., April 10, 2003).

An estimated 55 tons of phosphorus from treated effluent are applied annually to fields in the study area and more than 30 tons to fields in Carson Valley (table 9). For comparison, the estimated total gain in phosphorus across Carson Valley was about 14 tons in 2001 and 18 tons in 2002 (table 8). Although the potential load from effluent is greater than the observed gain in load across Carson Valley, the actual amount of the observed gain in load that can be attributed to effluent reuse is not known and cannot be determined with data collected during this investigation.

# SUMMARY

The Carson River watershed extends from its headwaters in the eastern Sierra Nevada of California to its terminus in the Carson Desert of Nevada. Discharge of treated effluent to the river ceased in 1987, resulting in a substantial decrease in phosphorus concentrations in the Carson River. However, concentrations of total phosphorus and suspended sediment still commonly exceed beneficial-use criteria established for the Carson River. Potential sources of phosphorus in the study area include natural inputs from undisturbed soils, erosion of soils and streambanks, construction of low-head dams and their destruction during floods, manure production and grazing by cattle along streamsides, drainage from fields irrigated with streamwater and treated effluent, ground-water seepage, and urban runoff including inputs from golf courses.

**Table 9.** Mass-balance calculations for the study area showing potential phosphorus loads from treated sewage effluent used for irrigation, 2000–02

[Abbreviation: mg/L, milligram per liter. Symbol: --, data not available]

| Source of water | Effluent provided for irrigation (acre-feet) | Total-phosphorus concentration (mg/L) | Potential phosphorus load (tons per year) |
|---|---|---|---|
| South Tahoe Public Utility District | [a]4,910 | 2.5 | 16.7 |
| Incline Village General Improvement District | [b]205 | [c]4.0 | 1.1 |
| Douglas County Sewer Improvement District #1 | [d]2,200 | 2.6 | 7.8 |
| Douglas County North Valley | [e]0 | -- | 0 |
| Indian Hills General Improvement District | [f]323 | -- | [g]1.1 |
| Minden-Gardnerville Sanitation District | [h]1,800 | -- | [g]6.0 |
| Carson City Wastewater Reclamation Plant | [i]4,500 | 4.0 | 24.5 |

[a]Reported as an average of 1.6 billion gallons annually (Ross Johnson, South Tahoe Public Utility District, oral commun., July 11, 2003).

[b]Reported as 66.822 million gallons for 2000 (Harvey Johnson, Incline Village General Improvement District, oral commun., July 17, 2003). The majority of effluent (445.185 million gallons in 2000) is delivered to their wetlands and not used for irrigation.

[c]A new treatment process starting in 2003 has reduced total-phosphorus concentrations in treated effluent to 0.3–0.5 mg/L.

[d]Reported as 721.92 million gallons for 2001 (John Hastie, Douglas County Sewer Improvement District, oral commun., July 17, 2003).

[e]In 2000, 33.591 million gallons of effluent were delivered to Incline Village General Improvement District wetlands but were not used for irrigation (Carl Ruschmeyer, Douglas County Community Development, written commun., July 25, 2003).

[f]The amount of effluent produced is not measured. Reported value is for 105.154 million gallons of influent to treatment facility in 2002 (Noel Huber, Indian Hills General Improvement District, written commun., July 16, 2003).

[g]Value based on estimated phosphorus concentration of 2.5 mg/L.

[h]The amount of effluent produced is not measured. Reported value is for influent to treatment facility in 2002 (David LaBarbara, Minden–Gardnerville Sanitation District, oral commun., July 15, 2003).

[i]Records of effluent used for irrigation are for 2001 (Kelvin Ikehara, Carson City Wastewater Reclamation Facility, written commun., July 15, 2003).

The USGS, in cooperation with CWSD, began an investigation in 2000 of the watershed with two specific goals: (1) Identify those reaches of the Carson River upstream from Lahontan Reservoir where the greatest increases in phosphorus and suspended-sediment concentrations and loading occur, and (2) identify the most important sources of phosphorus within the reaches of the Carson River where the greatest increases in concentration and loading occur.

Agriculture is by far the largest use of Carson River water, with almost all of the water diverted from the East and West Forks during summer for irrigation. Water supply for irrigation in Carson Valley comes from direct diversions of surface water through an extensive system of ditches, stored water in mountain reservoirs, treated effluent from sewage treatment plants within the Carson River Basin, and imported treated effluent from the Lake Tahoe Basin. About 47,000 acres are irrigated in Carson Valley and much smaller areas are irrigated in Eagle and Dayton–Churchill Valleys. About 8,900 acres of agricultural fields, golf courses, and parks in the study area are permitted for irrigation using treated effluent.

In late summer, diversions for irrigation and consumption of water by evapotranspiration results in periods of low flow in the main channel of the river downstream of Carson Valley. Peak flows along the Carson River occur during periods of snowmelt runoff in spring, and during winter floods caused by rain on snow.

Total-phosphorus concentrations in surface-water samples collected by USGS in the study area during WY 2001–02 ranged from <0.01 to 1.78 mg/L; orthophosphate concentrations ranged from <0.01 to 1.81 mg/L. In water entering Carson Valley from headwater areas in the East Fork, the majority of samples exceeding the water-quality standard of 0.1 mg/L for total phosphorus occur in March, April, and May during spring runoff. Downstream from Carson Valley, almost all samples exceed the phosphorus water-quality standard, with the greatest concentrations observed during the spring and summer months.

The composition of phosphorus in the Carson River changes in a downstream direction. During spring runoff and at least half of the year, particulate phosphorus is the dominant form of phosphorus in water entering Carson Valley from headwater reaches in the East Fork. Downstream from Carson Valley, particulate phosphorus is the predominant form only during spring runoff; during the remainder of the year orthophosphate is the predominant form.

During summer the predominant form of phosphorus entering Carson Valley is particulate phosphorus while the predominant form leaving Carson Valley is orthophosphate. Particulate phosphorus entering Carson Valley could be settling out when water is applied to fields for example and be replaced by orthophosphate from other sources. Alternatively, the particulate phosphorus could be converted to orthophosphate as it travels across Carson Valley. Data collected during the study are not sufficient to distinguish between the two possibilities.

Data collected by USGS, NDEP, and STPUD during WY 1988–2002 were used to develop regressions between discharge and total-phosphorus loads at five gaged sites along the West Fork, East Fork, and mainstem of the Carson River. Total-phosphorus loads for WY 2001–02 were estimated using the regression equations and daily mean discharge for the five gaged sites. Estimated annual loads were greater at all sites during 2002 than 2001 due to increased streamflow. Annual loads ranged from 1.33 tons at the West Fork Carson River at Woodfords to 43.41 tons at the Carson River near Carson City. Loads were the greatest during spring runoff, followed by fall and winter, and least during summer, largely due to similar patterns in the amount of streamflow in the Carson River.

During WY 2001–02, about 58 percent of the total-phosphorus load leaving Carson Valley on an annual basis could be attributed to headwater reaches upstream of Carson Valley. The relative contribution from the headwaters reaches changes over the year. During the period April 1–September 30 for the 2 years, about 85 percent of the total-phosphorus load leaving Carson Valley could be attributed to headwater reaches upstream of Carson Valley, whereas, during the period October 1–March 31 only about 17 percent could be attributed to headwater reaches.

Eagle Valley and Dayton–Churchill Valleys may act as sinks for phosphorus in the Carson River. On an annual basis (WY 2001–02), only about 90 percent and 85 percent of the phosphorus entering Eagle Valley and Dayton–Churchill Valleys, respectively, remained in the river. During flood events, however, the phosphorus may be mobilized and moved downstream.

Five synoptic surveys were conducted during winter, spring, and summer to identify specific reaches where changes in water quality occur and to identify the possible causes for those changes. During all of the synoptic surveys, total-phosphorus concentrations increased substantially between West Fork Carson River at Woodfords and Brockliss Slough above confluence Carson River. In this section of the river, the largest increases in total-phosphorus concentration and load were observed in the reach between Brockliss Slough at Highway 88 and Brockliss Slough above confluence Carson River. In this reach, most of the increase in phosphorus concentration during winter and summer surveys was due to increases in orthophosphate. During the summer surveys, 10–22 percent of the total-phosphorus load measured at Carson River near Genoa originated in this reach and its tributaries. Surface water inflows to the West Fork/Brockliss Slough include Wally's Hot Springs, streams from the east side of the Carson Range, and a complex of sloughs along the west side of the valley.

During the summer synoptic surveys, 27–36 percent of the total-phosphorus load measured at Carson River near Genoa originated in the West Fork Ditch part of the river. Because the ditch was dry at Highway 88 during the summer, all load in West Fork Ditch originated in the 8.7 mi reach downstream of Highway 88 and its tributaries.

Little change in water quality occurred between the East Fork below Markleeville Creek and Dresslerville during all the synoptic surveys. This indicates that phosphorus and sediment entering Carson Valley in the East Fork originates upstream from the Markleeville site. The source of the phosphorus may be soils derived from granitic rocks high in the headwaters. In addition, the headwaters of the East Fork have soils that are more erodible and have a greater clay content than the headwaters of the West Fork, which may explain why the phosphorus yield from the East Fork (0.167 lb/acre) is greater than that from the West Fork (0.091 lb/acre).

The reach of the East Fork that contributes the largest phosphorus load to the Carson River during the winter and summer surveys is the 1.5 mi reach between the East Fork Carson River at Muller Lane and the East Fork Carson River above confluence West Fork Carson River. During the summer synoptic surveys, 11–20 percent of the total-phosphorus load at Carson River near Genoa may be attributed to this short reach. The likely source of the phosphorus in this reach is erosion or agricultural return flows from land where treated effluent is used for irrigation. Data are not available to determine whether surface-water runoff to the river occurs in this reach or whether phosphorus is migrating through ground water.

During the winter and spring surveys, the East Fork is the major contributor to the phosphorus load measured at Carson River near Genoa, and the West Fork Ditch is a relatively minor contributor. During the summer surveys, the contribution of phosphorus load from the West Fork Ditch increases almost threefold more than winter and spring, and was the largest contributor of phosphorus load to the mainstem during the Summer 1 survey.

The maximum total-phosphorus load measured on the mainstem of the Carson River during the synoptic surveys was 1,240 lb/d during spring 2002 at Carson River near Carson City. The largest total-phosphorus load measured was 4,588 lb/d on April 15, 2002, at Carson River at Cradlebaugh Bridge. During all of the synoptic surveys, total-phosphorus load and concentration decreased as the Carson River crossed Eagle Valley and tended to decrease as the Carson River crossed Dayton–Churchill Valley.

Ambrosetti Pond can contribute substantial amounts of phosphorus to the mainstem of the river, particularly during winter when flow in the mainstem is low. About 42 percent of the phosphorus load on November 20, 2000, at Carson River near Carson City came from Ambrosetti Pond. Although Williams Slough has very high concentrations of total phosphorus, it contributes small loads due to its low streamflow. Clear Creek above confluence Carson River accounted for less than 2 percent of the load at Carson River near Carson City during the synoptic surveys.

Data collected during this study are insufficient to determine specific phosphorus sources within a given reach; nevertheless, some general conclusions can be reached about the types of land use associated with phosphorus contributing areas. An important finding was that, on an annual basis, the total-phosphorus load contributed from headwater reaches of the East and West Forks was about the same as that contributed by sources within Carson Valley. Particulate phosphorus is the principal form of phosphorus entering Carson Valley during spring and summer, and upstream from East Fork Carson River below Markleeville Creek is the source of that phosphorus. Erosion of soils in the reach upstream from the Markleeville site is an important contributor to phosphorus loading in the Carson River.

During summer, large increases in phosphorus loads occur in the East Fork, West Fork/Brockliss Slough, and West Fork Ditch systems and the increase in load is caused principally by increases in orthophosphate. The principal source of orthophosphate in these reaches is most likely associated with agriculture, either return flows from irrigated lands or animal grazing. In the West Fork/ Brockliss Slough, and West Fork Ditch reaches where the greatest increases occur, land use is almost exclusively agricultural. Land use principally is agricultural in the East Fork reaches. Because treated effluent contains elevated phosphorus concentrations, drainwater from fields irrigated with effluent is a potentially large source of phosphorus. In 2002, during the Summer 1 survey, a more than 20-fold increase in orthophosphate concentration occurred in the 1.5 mi reach between East Fork Carson River at Muller Lane and East Fork Carson River above confluence West Fork Carson River. In that reach, agricultural lands are irrigated almost exclusively with effluent, indicating a potentially large contribution of phosphorus.

Phosphorus contributions from urban runoff and cattle grazing near the river were not evaluated in detail as part of this investigation. Ground-water samples were not collected to evaluate natural or anthropogenic sources of phosphorus to the river.

The importance of measures to control streambank and channel erosion is demonstrated by the observation that concentrations of particulate phosphorus alone can exceed the State water-quality standard for phosphorus when suspended-sediment concentrations exceed about 50 mg/L.

# FUTURE DIRECTIONS

The principal goal of this project has been to define sources and source areas of phosphorus so that measures can be taken by resource-management agencies to attain water-quality standards for the Carson River. Of the various forms of phosphorus, orthophosphate is immediately bioavailable. As a result, it may contribute to nuisance algal growth in stream or river settings. Particulate phosphorus in suspension, however, tends not to be immediately bioavailable though it can become available later through desorption, decomposition, or other processes. Particulate phosphorus may ultimately contribute to eutrophication in Lahontan Reservoir or lakes in the Carson Desert. This study has shown that particulate phosphorus and orthophosphate have different sources, different seasonality, and may have different effects on the watershed.

The Carson River has been placed on Nevada's 303(d) list because total-phosphorus concentrations commonly exceed the State water-quality standard of 0.1 mg/L. As Gburek and others (2000) noted, phosphorus problems such as nuisance algal growth occur when a phosphorus source is available and a mechanism exists for its transport to a sensitive location. To effectively use the data collected during this investigation to solve actual problems and focus future research, it will be necessary to determine exactly what types of water-quality problems are being caused by these elevated phosphorus concentrations and where they are occurring.

Two major findings of this study show the need for additional research to provide State and Federal managers with the information needed to solve present and future problems. The first major finding is that headwater reaches of the river contribute up to 58 percent of the phosphorus leaving Carson Valley on an annual basis. Rangeland and forested areas in the watershed above the East Fork Carson River near Dresslerville site contributed sufficient phosphorus that the Nevada water-quality standard was exceeded in about 18 percent of the samples. Information is needed to identify why phosphorus yields from these headwaters reaches are much greater than expected for rangeland and forest. Specific headwater reaches where large increases in phosphorus loading occur need to be identified so the economics and feasibility of remediation can be evaluated.

The second major finding is that reaches of the river in Carson Valley where the largest increases in phosphorus loading occur are associated with agriculture, and in particular, fields permitted for use of treated effluent. Information gained from detailed investigations within these reaches is required to identify the importance of the source of water on phosphorus yield from irrigated fields. As the study area and surrounding areas become increasingly urban, the rapidly growing population will generate additional treated effluent, and areas which are now on septic systems may need to be connected to municipal wastewater treatment plants to protect ground-water resources. Managers will be faced with an increase in the amount of wastewater generated and a reduced capacity to reuse it as the number and area of fields where effluent can be safely used decreases because of population growth.

Several pieces of information are needed to effectively evaluate the contribution of phosphorus loads to the Carson River from reuse of treated effluent. Basic information needs include monitoring of phosphorus concentrations in treated effluent prior to land application, the amount of effluent applied to the land, and the time of year that effluent is used. Maps showing the area of effluent use, how the water is routed, and the associated drainage system to collect runoff and percolated effluent would help determine whether downstream water quality could be affected by the effluent use. Because Ambrosetti Pond receives drainage from fields irrigated with effluent, these data also are required to evaluate the importance of the pond as a phosphorus source. Additional data about phosphorus concentrations in water discharged from Ambrosetti Pond are required so that annual phosphorus loads from the pond to the river can be estimated.

It will be important to test the degree to which phosphorus binds to soils in areas where treated effluent is used to assess the potential for transport of phosphorus offsite or percolation to ground water. If phosphorus binding sites in the soil have become saturated, phosphorus may move through the soil profile. On the other hand, if phosphorus in effluent is effectively bound by soils, phosphorus concentrations in surficial soils might become elevated, leading to increases in phosphorus concentrations in runoff, particularly during high intensity rainstorms. Phosphorus loads in runoff during storms from fields irrigated with effluent should be compared with that from fields irrigated with stream water.

The composition of phosphorus changes during the summer from mostly particulate phosphorus entering Carson Valley to orthophosphate leaving it. More information is needed to understand what is happening to particulate phosphorus entering Carson Valley. If particulate phosphorus entering Carson Valley is deposited in fields during irrigation and remains there, then the actual phosphorus loading from Carson Valley may be greater than what was estimated in this study. Detailed analyses on the composition of particulate phosphorus are needed to determine how fast and under what environmental conditions the particulate phosphorus will release orthophosphate.

This study did not evaluate the effects of urban runoff, primarily because the locations of such discharges to the Carson River system are poorly known. Estimates of the amount of runoff and measurements of phosphorus concentrations in the runoff are needed to estimate the potential phosphorus load to the river from commercial and residential areas.

Additional research is needed to determine the areas of and conditions when ground water discharges to the Carson River system. Sampling of ground water known to discharge to the Carson River system is needed to quantify any phosphorus loading from ground water. For example, ground-water inflows to the Carson River account for increases in flow across the Carson Valley during the winter, but the extent to which that ground water influences the observed increase in phosphorus load is unknown. This investigation was a first step towards quantifying phosphorus sources and loads to the Carson River, but additional research is still needed to fill in the remaining gaps.

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# APPENDIXES

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | Field measurements: pH | Field measurements: Water tem-perature (°C) | Field measurements: Dis-solved oxygen (mg/L) | Field measurements: Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Phosphorus: Total (mg/L as P) | Phosphorus: Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Suspended sediment: Sand break[a] (%) | Suspended sediment: TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **West Fork Carson River and tributaries** | | | | | | | | | | | | | | | | | |
| 1 | 10310000 | 01/03/01 | 0930 | S | 16 | 77 | 7.3 | 0.7 | -- | 0.37 | E | S | <0.01 | <0.01 | -- | -- | 0.42 |
| | | 01/04/01 | 1310 | U | 20 | 76 | -- | -- | -- | -- | E | H | 0.01 | <0.01 | -- | -- | -- |
| | | | | | | | | | | | R | H | 0.04 | <0.01 | -- | -- | -- |
| | | 02/01/01 | 0825 | S | e22 | 78 | 6.9 | 0.3 | 9.1 | 0.48 | E | S | <0.01 | <0.01 | -- | -- | 0.64 |
| | | 03/06/01 | 0908 | S | 22 | 77 | 7.4 | 2.2 | 9.4 | 0.35 | E | S | <0.01 | 0.04 | -- | -- | 0.91 |
| | | 03/20/01 | 0925 | U | 42 | 74 | -- | 3.5 | -- | -- | E | H | 0.03 | <0.01 | -- | -- | -- |
| | | 04/03/01 | 0915 | S | 82 | 56 | 7.5 | 2.8 | 11.4 | 2.8 | E | S | 0.02 | <0.01 | -- | -- | 6.4 |
| | | 04/26/01 | 1230 | U | 218 | 45 | -- | 6.0 | -- | -- | E | H | 0.05 | <0.01 | 29 | 62 | -- |
| | | | | | | | | | | | R | H | 0.04 | <0.01 | -- | -- | -- |
| | | 05/01/01 | 0919 | S | 288 | 41 | 7.0 | 4.6 | 10.5 | 7.9 | E | S | 0.05 | <0.01 | -- | -- | 24 |
| | | 05/02/01 | 1135 | U | 264 | 41 | -- | 3.0 | -- | -- | E | H | 0.03 | <0.01 | 30 | 28 | -- |
| | | 05/09/01 | 0815 | U | 285 | 37 | -- | 4.5 | -- | -- | E | H | 0.04 | <0.01 | 24 | 58 | -- |
| | | 06/05/01 | 0923 | S | 63 | 58 | 7.4 | 10.2 | 9.0 | 1.5 | E | S | 0.01 | <0.01 | -- | -- | 3.8 |
| | | 07/05/01 | 0830 | S | 26 | 66 | 7.2 | 15.5 | 8.0 | 1.0 | E | S | 0.02 | <0.01 | -- | -- | 4.7 |
| | | 08/01/01 | 0830 | S | 18 | 81 | 7.2 | 11.9 | 8.7 | 0.72 | E | S | 0.02 | 0.07 | -- | -- | 1.1 |
| | | 09/05/01 | 0835 | S | 11 | 84 | 7.0 | 13.1 | 8.6 | 0.50 | E | S | 0.01 | <0.01 | -- | -- | 0.40 |
| | | 10/02/01 | 0820 | S | 12 | 89 | 6.9 | 9.4 | 9.2 | 0.33 | E | S | <0.01 | <0.01 | -- | -- | 0.70 |
| | | 11/14/01 | 0840 | S | 18 | 79 | 6.6 | 4.2 | 9.9 | 0.56 | E | S | 0.01 | <0.01 | -- | -- | 0.84 |
| | | 12/04/01 | 0900 | S | 18 | 81 | 7.0 | 0.9 | 11.5 | 0.62 | E | S | 0.01 | <0.01 | -- | -- | 2.2 |
| | | 01/02/02 | 0930 | S | 28 | 80 | 7.5 | 2.4 | 10.3 | 0.90 | E | S | <0.01 | <0.01 | -- | -- | 1.1 |
| | | 02/05/02 | 0923 | S | 22 | 84 | 7.5 | 1.0 | -- | 0.50 | E | S | <0.01 | <0.01 | -- | -- | 0.46 |
| | | 02/19/02 | 0910 | U | 27 | 78 | 6.6 | 2.0 | 11.4 | 0.94 | E | H | <0.01 | <0.01 | 4 | 76 | <10 |
| | | 03/05/02 | 0906 | S | 37 | 81 | 7.0 | 1.4 | 11.8 | 0.90 | E | S | <0.01 | <0.01 | -- | -- | 1.2 |
| | | 04/02/02 | 0907 | S | 155 | 56 | 6.9 | 1.9 | 11.4 | 6.4 | E | S | 0.03 | <0.01 | -- | -- | 12 |

**Appendix 1.** Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; $^{o}C$, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | Field measurements: pH | Field measurements: Water tem-perature (°C) | Field measurements: Dis-solved oxygen (mg/L) | Field measurements: Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Phosphorus: Total (mg/L as P) | Phosphorus: Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Suspended sediment: Sand break[a] (%) | Suspended sediment: TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 04/17/02 | 1245 | U | 261 | 45 | 7.4 | 2.0 | 12.1 | 6.1 | E | H | 0.03 | <0.01 | 23 | 64 | -- |
| | | 04/24/02 | 1025 | U | 239 | 46 | 7.3 | 4.3 | 11.5 | 3.2 | E | H | 0.02 | <0.01 | 16 | 52 | -- |
| | | 05/01/02 | 0827 | S | 184 | 54 | 7.5 | 2.4 | 11.1 | 1.5 | E | S | 0.01 | <0.01 | -- | -- | 2.4 |
| | | 05/28/02 | 1030 | U | 196 | 42 | 7.3 | 7.5 | 9.3 | 2.9 | E | H | 0.02 | <0.01 | 9 | 71 | 4 |
| | | 06/04/02 | 0755 | S | 190 | 42 | 6.9 | 8.9 | 9.5 | 2.8 | E | S | 0.02 | <0.01 | -- | -- | 5.7 |
| | | 07/01/02 | 1000 | U | 64 | 56 | 7.0 | 14.5 | 9.4 | 1.6 | E | H | 0.02 | <0.01 | 4 | 66 | <10 |
| | | 07/02/02 | 0816 | S | 60 | 58 | 7.5 | 14.1 | 8.0 | 1.4 | E | S | 0.02 | <0.01 | -- | -- | 3.9 |
| | | 08/13/02 | 0900 | S | 17 | 78 | 7.5 | 12.0 | 8.6 | 0.10 | E | S | 0.01 | 0.01 | -- | -- | 0.46 |
| | | 08/21/02 | 0906 | U | 17 | 74 | 7.4 | 10.0 | -- | 0.22 | E | H | <0.01 | <0.01 | <1 | -- | 3 |
| | | 09/03/02 | 1005 | S | 12 | 78 | 7.8 | 13.1 | 8.9 | 0.13 | E | S | 0.01 | <0.01 | -- | -- | 0.70 |
| 2 | 10310200 | 11/20/00 | 1015 | U | 9.7 | 91 | -- | 3.0 | -- | -- | E | H | 0.08 | 0.06 | -- | -- | -- |
| | | 03/20/01 | 1045 | N | 37 | -- | -- | -- | -- | -- | E | H | 0.04 | [c]<0.01 | -- | -- | -- |
| 3 | 10310220 | 08/08/01 | 1410 | U | 0.93 | -- | -- | 24.0 | -- | -- | E | H | 0.06 | <0.01 | -- | -- | -- |
| | | 02/19/02 | 1200 | U | 11 | 96 | 7.6 | 2.5 | 12.2 | 0.89 | E | H | <0.01 | <0.01 | 9 | 90 | -- |
| | | | | | | | | | | | R | H | <0.01 | <0.01 | -- | -- | -- |
| | | 04/17/02 | 1625 | U | 157 | 54 | 7.8 | 6.1 | 11.0 | 4.9 | E | H | 0.04 | <0.01 | 14 | 63 | -- |
| | | 04/24/02 | 1300 | U | 98 | 54 | 7.7 | 8.8 | 10.2 | 2.8 | E | H | 0.02 | <0.01 | 13 | 64 | -- |
| | | 07/01/02 | 1225 | U | 43 | 69 | 7.2 | 19.5 | 7.8 | 7.5 | E | H | 0.07 | 0.01 | 19 | 82 | 12 |
| | | 08/21/02 | 1345 | U | 3.3 | 104 | 8.5 | 18.0 | 9.4 | 0.91 | E | H | 0.01 | <0.01 | 2 | 77 | 1.5 |
| 5 | 10309082 | 08/10/01 | 1135 | U | 0.81 | -- | -- | 21.0 | -- | -- | E | H | 0.09 | 0.06 | -- | -- | -- |
| | | 02/20/02 | 0910 | U | 6.1 | 209 | 7.7 | 6.0 | 11.0 | 4.5 | E | H | 0.03 | 0.02 | 10 | 96 | -- |
| | | 04/25/02 | 0920 | U | 5.0 | 104 | 7.5 | 10.5 | 10.8 | 7.3 | E | H | 0.05 | 0.02 | 13 | 92 | -- |
| | | 07/02/02 | 0815 | U | 5.2 | 188 | 6.8 | 16.0 | 8.3 | 2.6 | E | H | 0.10 | 0.08 | 4 | 97 | 4.0 |
| | | 08/21/02 | 1550 | U | 0.28 | 292 | 7.4 | 16.5 | 8.6 | 0.58 | E | H | 0.10 | 0.08 | 1 | -- | 0.5 |
| 6 | 10310358 | 03/20/01 | 1330 | N | 0.22 | 284 | 8.3 | 15.0 | 10.0 | 6.9 | E | H | 0.16 | 0.09 | -- | -- | 7.0 |
| | | 02/20/02 | 1130 | U | 8.6 | 253 | 7.7 | 9.0 | 10.8 | 8.0 | E | H | 0.11 | 0.05 | 13 | 85 | -- |

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collecting agency | Discharge ($ft^3/s$) | Field measurements: Specific conductance (µS/cm) | pH | Water temperature (°C) | Dissolved oxygen (mg/L) | Turbidity (NTU) | Analysis type | Phosphorus: Lab | Total (mg/L as P) | Orthophosphate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 04/25/02 | 1155 | U | 16 | 197 | 8.5 | 17.5 | 12.4 | 16 | E | H | 0.31 | 0.17 | 29 | 84 | -- |
| | | | | | | | | | | | R | H | 0.31 | 0.18 | -- | -- | -- |
| | | 07/02/02 | 1150 | U | 15 | 199 | 7.6 | 23.5 | 12.4 | 1.8 | E | H | 0.25 | 0.22 | 6 | 69 | 4 |
| | | 08/22/02 | 1015 | U | 0.79 | 324 | 7.7 | 16.0 | 6.4 | 1.2 | E | H | 0.17 | 0.14 | 1 | -- | 1 |
| 7 | 10309114 | 08/06/01 | 1015 | U | 0.43 | -- | -- | 19.0 | -- | -- | E | H | 0.32 | 0.20 | -- | -- | -- |
| | | 02/20/02 | 1440 | U | 8.4 | 232 | 7.9 | 12.2 | 10.5 | 12 | E | H | 0.08 | 0.04 | 22 | 96 | -- |
| | | 04/25/02 | 1430 | U | 20 | 148 | 8.4 | 16.6 | 9.7 | 22 | E | H | 0.16 | 0.06 | 44 | 96 | -- |
| | | 07/02/02 | 1500 | U | 4.5 | 248 | 8.1 | 25.0 | 11.4 | 3.0 | E | H | 0.19 | 0.16 | 10 | 84 | 4 |
| | | 08/22/02 | 1250 | U | 0.38 | 357 | 9.1 | 21.0 | 19.0 | 1.2 | E | H | 0.26 | 0.22 | 5 | 79 | 0.5 |
| 8 | 103103588 | 08/06/01 | 1130 | U | 1.6 | -- | -- | 27.0 | -- | -- | E | H | 0.31 | 0.23 | -- | -- | -- |
| 9 | 10310359 | 02/21/02 | 0950 | U | 17 | 237 | 7.7 | 7.5 | 11.0 | 6.6 | E | H | 0.09 | 0.05 | 13 | 91 | -- |
| | | 04/25/02 | 1630 | U | 44 | 167 | 8.9 | 19.8 | 11.2 | 24 | E | H | 0.25 | 0.13 | 71 | 78 | -- |
| | | 05/28/02 | 1430 | U | 79 | 130 | 8.6 | 19.5 | 12.5 | 16 | E | H | 0.18 | 0.08 | 54 | 72 | 33 |
| | | 07/03/02 | 0800 | U | 24 | 213 | 7.3 | 19.0 | 5.7 | 3.0 | E | H | 0.26 | 0.23 | 9 | 64 | 6 |
| | | | | | | | | | | | R | H | 0.26 | 0.23 | -- | -- | 2 |
| | | 08/22/02 | 1435 | U | 1.6 | 337 | 9.2 | 27.0 | 14.0 | 2.2 | E | H | 0.20 | 0.17 | 5 | 90 | 2.5 |
| | | | | | | | | Brockless Slough and tributaries | | | | | | | | | |
| 10 | 10310240 | 02/20/02 | 1410 | U | 7.4 | 138 | 7.8 | 11.0 | 10.1 | 9.0 | E | H | 0.06 | 0.02 | 19 | 82 | -- |
| | | 05/02/02 | 0940 | U | 60 | 80 | 7.6 | 7.8 | 10.7 | 6.1 | E | H | 0.03 | 0.01 | 8 | 90 | 7 |
| | | 05/28/02 | 1222 | U | 64 | 74 | 7.6 | 14.3 | 8.8 | 3.3 | E | H | 0.04 | 0.02 | 8 | 88 | 3 |
| | | 07/01/02 | 1540 | U | 1.5 | 206 | 7.1 | 24.0 | 7.0 | 2.2 | E | H | 0.07 | 0.03 | 4 | 96 | 2 |
| | | 08/21/02 | 1135 | U | 0.24 | 220 | 7.3 | 14.5 | 6.6 | 2.4 | E | H | 0.05 | 0.02 | 4 | 98 | 6.5 |
| 12 | 10310255 | 02/21/02 | 1445 | U | 16 | 153 | 8.0 | 10.9 | 8.6 | 5.5 | E | H | 0.07 | 0.03 | 12 | 91 | -- |
| | | 05/02/02 | 1150 | U | 24 | 218 | 7.9 | 12.1 | 13.2 | 4.1 | E | H | 0.12 | 0.06 | 5 | 59 | 2 |
| 13 | 10310265 | 07/12/02 | 0852 | U | <1 | 240 | 7.2 | 21.5 | 3.5 | 2.9 | E | H | 0.29 | 0.23 | 6 | 84 | 7 |
| | | 08/23/02 | 1100 | U | e0.3 | 213 | 8.4 | 14.0 | 5.0 | 3.0 | E | H | 0.10 | 0.06 | 7 | 83 | 3 |
| 14 | 10310403 | 03/20/01 | 1340 | N | 51 | 146 | 8.0 | 8.8 | 11.8 | 21 | E | H | 0.12 | 0.04 | -- | -- | 42 |

**Appendix 1.** Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| | | | | | | Field measurements | | | | | | Phosphorus | | | Suspended sediment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Specific conduc-tance (µS/cm) | pH | Water tem-perature (°C) | Dis-solved oxygen (mg/L) | Tur-bidity (NTU) | Anal-ysis type | Lab | Total (mg/L as P) | Ortho-phos-phate (mg/L as P) | SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
| 15 | 10310404 | 08/07/01 | 1120 | U | 0.64 | -- | -- | 25.0 | -- | -- | E | H | 0.36 | 0.16 | -- | -- | -- |
| | | 02/22/02 | 0950 | U | 39 | 213 | 7.8 | 7.3 | 11.7 | 12 | E | H | 0.12 | 0.06 | 20 | 96 | -- |
| | | 05/09/02 | 1000 | U | 143 | 142 | 7.7 | 12.2 | 8.8 | 7.9 | E | H | 0.14 | 0.08 | 19 | 81 | 13 |
| | | 05/29/02 | 1100 | U | 37 | 246 | 7.3 | 18.0 | 5.9 | 29 | E | H | 0.30 | 0.11 | 70 | 86 | 59 |
| | | 07/03/02 | 1051 | U | 10 | 330 | 7.6 | 22.0 | 6.6 | 22 | E | H | 0.38 | 0.24 | 60 | 94 | 36 |
| | | 08/23/02 | 0820 | U | e0.4 | 399 | 7.6 | 16.5 | 6.1 | 13 | E | H | 0.32 | 0.20 | 16 | 91 | 20 |
| | | | | | | | | | | | R | H | 0.32 | 0.19 | -- | -- | 14 |
| East Fork Carson River and tributaries | | | | | | | | | | | | | | | | | |
| 16 | 10308200 | 10/16/01 | 1210 | U | 29 | 168 | -- | 10.0 | -- | 0.6 | E | U | <0.06 | -- | 1 | -- | -- |
| | | 01/16/02 | 1315 | U | 89 | 161 | 7.9 | 1.0 | 11.4 | 1.3 | E | U | <0.06 | -- | 2 | -- | -- |
| | | 02/19/02 | 1110 | U | 93 | 161 | -- | 4.0 | -- | 0.76 | E | H | 0.02 | 0.01 | 5 | 71 | -- |
| | | 04/23/02 | 1245 | U | 434 | 76 | 8.0 | 6.5 | 10.1 | 5.7 | E | U | <0.06 | -- | 20 | -- | -- |
| | | 05/06/02 | 1030 | U | 762 | 57 | 7.7 | 5.8 | 10.4 | 9.0 | E | H | 0.05 | 0.01 | 39 | 43 | 29 |
| | | 05/28/02 | 1135 | U | 832 | 49 | 7.7 | 10.0 | 14.7 | 6.8 | E | H | 0.04 | <0.01 | 28 | 50 | 12 |
| | | 07/08/02 | 0940 | U | 151 | 85 | 7.2 | 14.0 | 9.0 | 1.4 | E | H | 0.02 | 0.02 | 3 | 72 | 3 |
| | | 07/10/02 | 0925 | U | 138 | 88 | 8.0 | 14.5 | 9.5 | 3.1 | E | U | <0.06 | -- | 3 | -- | -- |
| | | 08/26/02 | 1050 | U | 53 | 119 | 7.9 | 13.5 | 9.2 | 0.83 | E | H | 0.02 | 0.02 | 1 | -- | <10 |
| | | 09/10/02 | 1115 | U | 52 | 125 | 8.3 | 11.3 | -- | 1.9 | E | U | 0.02 | -- | 4 | -- | -- |
| 17 | 10309010 | 11/20/00 | 0900 | U | e64 | 224 | -- | 0.0 | -- | -- | E | H | 0.19 | 0.18 | -- | -- | -- |
| | | 11/20/00 | 1005 | N | e71 | 227 | 8.2 | 0.2 | 16.0 | 3.4 | E | H | 0.02 | 0.01 | -- | -- | 2 |
| | | 11/21/00 | 1025 | U | e60 | 224 | 7.8 | 0.8 | 12.1 | -- | E | U | 0.02 | e0.02 | 4 | 77 | -- |
| | | 12/20/00 | 1010 | U | 76 | 225 | 7.9 | 1.2 | 11.9 | -- | E | U | 0.02 | e0.01 | 4 | 54 | -- |
| | | 01/04/01 | 1055 | U | e116 | 233 | -- | -- | -- | -- | E | H | 0.02 | 0.02 | -- | -- | -- |
| | | | | | | | | | | | R | U | 0.02 | e0.01 | -- | -- | -- |
| | | | | | | | | | | | R | H | 0.02 | 0.02 | -- | -- | -- |

**Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued**

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collecting agency | Discharge ($ft^3/s$) | Field measurements: Specific conductance (µS/cm) | pH | Water temperature (°C) | Dissolved oxygen (mg/L) | Turbidity (NTU) | Analysis type | Phosphorus: Lab | Total (mg/L as P) | Orthophosphate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 01/09/01 | 1015 | N | e62 | 223 | 8.2 | 1.5 | 8.6 | 1.2 | E | H | 0.03 | 0.02 | -- | -- | 0 |
| | | 01/16/01 | 1100 | U | 60 | 220 | 7.9 | 0.1 | 12.0 | -- | E | U | 0.02 | e0.01 | 4 | 62 | -- |
| | | 02/23/01 | 1100 | U | 72 | 232 | 8.0 | 0.5 | 12.0 | -- | E | U | 0.02 | <0.02 | 4 | 89 | -- |
| | | 03/20/01 | 1010 | N | e268 | 172 | 7.5 | 7.7 | 10.3 | 55 | E | H | 0.21 | 0.02 | -- | -- | 111 |
| | | 03/20/01 | 1120 | U | 293 | 171 | 8.0 | 8.2 | 10.5 | -- | E | U | 0.20 | e0.01 | 87 | 55 | -- |
| | | 04/19/01 | 1045 | U | 362 | 106 | 7.7 | 6.7 | 10.5 | -- | E | U | 0.04 | <0.02 | 14 | 50 | -- |
| | | 04/25/01 | 1310 | U | e674 | 97 | -- | 11.0 | -- | -- | E | H | 0.23 | 0.02 | 123 | 65 | -- |
| | | 04/27/01 | 1130 | U | e1,060 | 72 | -- | 7.5 | -- | -- | E | H | 0.33 | 0.02 | 251 | 65 | -- |
| | | 05/02/01 | 0910 | U | e1,200 | 58 | -- | 5.0 | -- | -- | E | H | 0.27 | 0.02 | 129 | 52 | -- |
| | | | | | | | | | | | R | H | 0.25 | 0.02 | -- | -- | -- |
| | | 05/09/01 | 1010 | U | e1,280 | 50 | -- | 7.0 | -- | -- | E | H | 0.31 | 0.02 | 195 | 62 | -- |
| | | 05/11/01 | 0945 | U | e1,270 | 50 | -- | 8.0 | -- | -- | E | H | 0.21 | 0.02 | 110 | 56 | -- |
| | | 05/15/01 | 1155 | U | 1,110 | 55 | 7.4 | 9.6 | 10.3 | -- | E | H | 0.12 | 0.02 | 52 | 19 | -- |
| | | | | | | | | | | | R | U | 0.17 | e0.01 | -- | -- | -- |
| | | 05/29/01 | 1050 | N | e614 | 70 | 6.3 | 12.5 | 9.5 | 7.2 | E | H | 0.05 | 0.01 | -- | -- | 13 |
| | | 06/18/01 | 1015 | U | 163 | 114 | 7.9 | 14.8 | 9.3 | -- | E | U | 0.02 | e0.01 | 7 | 62 | -- |
| | | 07/17/01 | 1035 | N | e79 | 171 | 8.4 | 14.2 | 8.8 | 1.4 | E | H | 0.02 | [c]<0.01 | -- | -- | 3 |
| | | 07/24/01 | 1040 | U | 70 | 172 | 8.0 | 17.7 | 9.2 | -- | E | H | 0.03 | 0.01 | 4 | 79 | -- |
| | | | | | | | | | | | R | U | 0.02 | <0.02 | -- | -- | -- |
| | | 08/22/01 | 1045 | U | 41 | 247 | 8.4 | 16.4 | 9.9 | -- | E | U | 0.02 | <0.02 | 4 | 63 | -- |
| | | 09/10/01 | 1018 | U | 38 | 270 | 8.2 | 14.5 | 9.2 | -- | E | U | 0.01 | <0.02 | 8 | 71 | -- |
| | | 09/25/01 | 1030 | N | e36 | 290 | 9.1 | 14.0 | 9.5 | 5.5 | E | H | 0.11 | 0.06 | -- | -- | 10 |
| | | 10/15/01 | 1000 | U | e44 | 270 | 8.2 | 8.9 | 10.4 | -- | E | U | 0.01 | <0.02 | 2 | 91 | -- |
| | | 11/19/01 | 1000 | U | e42 | 242 | 8.2 | 3.5 | 11.6 | -- | E | U | 0.02 | <0.02 | 5 | 73 | -- |
| | | 11/27/01 | 1930 | N | e75 | 240 | 8.4 | -- | -- | 4.3 | E | H | 0.08 | 0.06 | -- | -- | 12 |

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | Field measurements: pH | Field measurements: Water tem-perature (°C) | Field measurements: Dis-solved oxygen (mg/L) | Field measurements: Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Phosphorus: Total (mg/L as P) | Phosphorus: Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Suspended sediment: Sand break[a] (%) | Suspended sediment: TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12/18/01 | 1030 | U | e68 | 207 | 8.1 | 0.2 | 11.8 | -- | E | U | 0.02 | <0.02 | 4 | 82 | -- |
| | | 01/08/02 | 1050 | N | e191 | 180 | 8.4 | 3.5 | 12.3 | 7 | E | H | 0.04 | 0.02 | -- | -- | 11 |
| | | 01/24/02 | 1025 | U | e92 | 212 | 7.4 | 0.0 | 12.7 | -- | E | U | 0.02 | 0.03 | 38 | 39 | -- |
| | | 02/19/02 | 1030 | U | e99 | 197 | 7.9 | 5.0 | 11.1 | 1.7 | E | H | 0.02 | 0.01 | 5 | 89 | <10 |
| | | | | | | | | | | | R | U | 0.02 | <0.02 | -- | -- | -- |
| | | 03/20/02 | 1015 | N | e164 | 190 | 8.4 | 5.5 | 10.6 | 2.6 | E | H | 0.03 | 0.01 | -- | -- | 8 |
| | | 03/21/02 | 0950 | U | e170 | 175 | 7.3 | 6.2 | 11.2 | -- | E | U | 0.03 | <0.02 | 13 | 52 | -- |
| | | 04/16/02 | 1110 | U | 1,110 | 72 | 6.9 | 3.8 | 11.8 | -- | E | U | 0.08 | e0.01 | 42 | 60 | -- |
| | | 05/06/02 | 1530 | U | 703 | 65 | 7.8 | 12.0 | 9.3 | 12 | E | H | 0.06 | 0.02 | 38 | 57 | 22 |
| | | 05/15/02 | 1220 | U | 1,530 | 60 | 7.2 | 10.5 | 9.8 | -- | E | H | 0.09 | 0.02 | 46 | 81 | -- |
| | | | | | | | | | | | R | U | 0.07 | <0.02 | -- | -- | -- |
| | | 05/20/02 | 1000 | U | e1,140 | 52 | 7.5 | 7.5 | 11.3 | 22 | E | H | 0.12 | 0.02 | 77 | 47 | 34 |
| | | 05/20/02 | 1230 | U | e1,100 | 52 | 7.4 | 7.5 | -- | 19 | E | H | 0.10 | 0.02 | 116 | 29 | 24 |
| | | 05/28/02 | 1540 | U | e851 | 59 | 7.4 | 14.0 | 12.4 | 9.8 | E | H | 0.05 | 0.01 | 39 | 41 | 17 |
| | | 05/28/02 | 1600 | N | e837 | 61 | 7.7 | 14.0 | 9.6 | 12 | E | H | 0.06 | 0.01 | -- | -- | 30 |
| | | 06/10/02 | 1200 | U | 737 | 61 | 7.6 | 9.4 | 9.9 | -- | E | U | 0.04 | e0.01 | 12 | 87 | -- |
| | | 07/09/02 | 1030 | U | e174 | 110 | 8.0 | 18.9 | 8.1 | 1.2 | E | H | 0.02 | 0.01 | 4 | 88 | 3 |
| | | | | | | | | | | | R | U | 0.03 | e0.01 | -- | -- | -- |
| | | 07/16/02 | 1110 | N | e130 | 140 | 8.6 | 20.7 | 8.3 | 2.3 | E | H | 0.03 | 0.01 | -- | -- | 8 |
| | | 08/20/02 | 0950 | U | e62 | 180 | 7.8 | 15.0 | 9.6 | -- | E | U | 0.02 | <0.02 | 5 | 72 | -- |
| | | 08/26/02 | 1330 | U | e60 | 186 | 8.8 | 20.5 | 8.6 | 1.8 | E | H | 0.02 | <0.01 | 4 | 80 | 0.5 |
| | | 09/05/02 | 1015 | U | e66 | 202 | 7.7 | 15.8 | 9.4 | -- | E | U | 0.04 | e0.01 | 6 | 90 | -- |
| | | 09/17/02 | 1000 | N | e56 | 220 | 8.4 | 13.7 | 8.4 | 6 | E | H | 0.03 | [c]<0.01 | -- | -- | 2 |
| 18 | 10309089 | 08/08/01 | 0915 | U | 25 | -- | -- | 20.0 | -- | -- | E | H | 0.04 | 0.02 | -- | -- | -- |
| 21 | 1030909018 | 05/31/01 | 0905 | U | 4.8 | -- | -- | 15.0 | -- | -- | E | H | 0.04 | 0.02 | 8 | 78 | -- |
| | | 08/08/01 | 1015 | U | 5.0 | -- | -- | 22.0 | -- | -- | E | H | 0.04 | 0.02 | -- | -- | -- |

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | pH | Water tem-perature (°C) | Dis-solved oxygen (mg/L) | Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Total (mg/L as P) | Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 1030909020 | 05/31/01 | 1038 | U | 4.4 | -- | -- | 15.0 | -- | -- | E | H | 0.09 | 0.04 | 10 | 72 | -- |
| | | 08/08/01 | 1205 | U | 2.7 | -- | -- | 24.0 | -- | -- | E | H | 0.14 | 0.07 | -- | -- | -- |
| | | 02/19/02 | 1540 | U | 1.5 | 202 | -- | 12.0 | -- | 6.1 | E | H | 0.06 | 0.02 | 11 | 77 | -- |
| | | 05/07/02 | 0930 | U | 20 | 123 | 7.5 | 12.5 | 9.0 | 70 | E | H | 0.42 | 0.09 | 475 | 76 | 146 |
| | | 07/08/02 | 1310 | U | 8.0 | 180 | 7.2 | 25.0 | 7.8 | 4.9 | E | H | 0.17 | 0.10 | 17 | 51 | 8 |
| | | 08/27/02 | 0830 | U | 1.0 | 255 | 7.4 | 12.0 | 7.2 | 4.6 | E | H | 0.15 | 0.09 | 14 | 74 | 12 |
| 24 | 10309120 | 03/20/01 | 1250 | N | 232 | -- | -- | -- | -- | -- | E | H | 0.22 | 0.02 | -- | -- | -- |
| | | 02/20/02 | 1130 | U | 89 | 213 | 8.7 | 9.5 | 13.4 | 5.6 | E | H | 0.06 | <0.01 | 13 | 74 | -- |
| | | 05/07/02 | 1205 | U | 531 | 70 | 7.8 | 11.0 | 10.4 | 22 | E | H | 0.11 | 0.02 | 55 | 70 | 34 |
| | | 07/08/02 | 1525 | U | 18 | 233 | 8.9 | 27.0 | 17.5 | 1.8 | E | H | 0.04 | <0.01 | 9 | 84 | 4 |
| | | 08/28/02 | 0850 | U | 7.2 | 311 | 8.0 | 14.2 | 11.1 | 1.0 | E | H | 0.03 | <0.01 | 4 | 89 | 8 |
| | | | | | | | | | | | R | H | 0.03 | 0.01 | -- | -- | 4 |
| 25 | 10309130 | 08/06/01 | 1330 | U | 3.3 | -- | -- | 27.0 | -- | -- | E | H | 0.17 | 0.09 | -- | -- | -- |
| | | 02/21/02 | 1155 | U | 98 | 214 | 8.2 | 8.5 | 11.9 | 11 | E | H | 0.10 | 0.01 | 33 | 72 | -- |
| | | 05/08/02 | 1100 | U | 531 | 71 | 7.8 | 9.4 | 10.4 | 20 | E | H | 0.11 | 0.02 | 63 | 59 | 37 |
| | | 05/29/02 | 1225 | U | 639 | 70 | 7.3 | 15.0 | 10.3 | 18 | E | H | 0.14 | 0.03 | 56 | 65 | 33 |
| | | | | | | | | | | | R | H | 0.12 | 0.03 | -- | -- | 37 |
| | | 07/08/02 | 1750 | U | 13 | 441 | 7.9 | 27.5 | 9.2 | 3.4 | E | H | 0.32 | 0.21 | 11 | 67 | 9 |
| | | 08/28/02 | 1040 | U | 8.6 | 346 | 8.3 | 19.6 | 8.8 | 1.5 | E | H | 0.04 | 0.02 | 4 | 98 | 7 |
| **Mainstem Carson River and tributaries** | | | | | | | | | | | | | | | | | |
| 26 | 10310405 | 03/21/01 | 1315 | N | 298 | -- | -- | -- | -- | -- | E | H | 0.39 | 0.03 | -- | -- | -- |
| | | 08/06/01 | 1500 | U | 4.3 | -- | -- | 29.5 | -- | -- | E | H | 0.28 | 0.18 | -- | -- | -- |
| 27 | 10310406 | 08/07/01 | 1300 | U | 5.0 | -- | -- | 30.0 | -- | -- | E | H | 0.17 | 0.13 | -- | -- | -- |
| 28 | 10310407 | 02/25/02 | 0940 | U | 172 | 199 | 7.9 | 4.0 | -- | 7.0 | E | H | 0.08 | 0.03 | 18 | 70 | -- |
| | | 05/09/02 | 1325 | U | 697 | 100 | 7.5 | 13.1 | 9.8 | 14 | E | H | 0.12 | 0.05 | 31 | 60 | 27 |
| | | 05/29/02 | 1400 | U | 730 | 90 | 7.5 | 17.7 | 9.1 | 19 | E | H | 0.18 | 0.05 | 54 | 62 | 36 |
| | | | | | | | | | | | R | H | 0.14 | 0.05 | -- | -- | 34 |

**Appendix 1.** Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; $^oC$, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collecting agency | Discharge ($ft^3/s$) | Field measurements: Specific conductance (µS/cm) | pH | Water temperature (°C) | Dissolved oxygen (mg/L) | Turbidity (NTU) | Analysis type | Phosphorus: Lab | Total (mg/L as P) | Orthophosphate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 07/09/02 | 1048 | U | 38 | 351 | 7.4 | 23.0 | 6.6 | 9.5 | E | H | 0.45 | 0.29 | 17 | 86 | 15 |
| | | 08/28/02 | 1220 | U | 13 | 352 | 8.3 | 23.3 | 9.3 | 2.7 | E | H | 0.09 | 0.06 | 6 | 95 | 4 |
| 29 | 10310419 | 02/28/02 | 1530 | U | e0.5 | 605 | 8.9 | 14.8 | -- | 15 | E | H | 0.70 | 0.41 | 13 | 98 | -- |
| | | 05/10/02 | 0840 | U | e0.37 | 440 | 8.0 | 9.5 | 5.9 | 9.5 | E | H | 1.78 | 1.81 | 10 | 88 | 10 |
| | | 07/09/02 | 1230 | U | e0.02 | 379 | 7.0 | 21.5 | 5.8 | 1.6 | E | H | 1.25 | 1.23 | 5 | 55 | 4 |
| | | | | | | | | | | | R | H | 1.25 | 1.23 | -- | -- | 4 |
| | | 08/27/02 | 1035 | U | 0.19 | 462 | 7.6 | 15.5 | 6.2 | 17 | E | H | 7.32 | 0.75 | 20 | 79 | 18 |
| 30 | 10310448 | 11/20/00 | 1445 | U | 27 | 428 | -- | 4.5 | -- | -- | E | H | 0.17 | 0.07 | -- | -- | -- |
| | | 01/04/01 | 0930 | U | 9.5 | 483 | -- | -- | -- | -- | E | H | 0.12 | 0.10 | -- | -- | -- |
| | | 03/21/01 | 1447 | U | 7.6 | 483 | -- | 16.0 | -- | -- | E | H | 0.25 | 0.11 | -- | -- | -- |
| | | 05/31/01 | 1208 | U | 9.5 | -- | -- | 22.0 | -- | -- | E | H | 0.39 | 0.30 | 12 | 81 | -- |
| | | 02/25/02 | 1300 | U | 3.6 | 468 | 8.7 | 7.7 | 14.0 | 29 | E | H | 0.33 | 0.17 | 31 | 95 | -- |
| | | 05/10/02 | 1045 | U | 42 | 332 | 8.0 | 14.0 | 7.8 | 8.5 | E | H | 0.35 | 0.27 | 15 | 84 | 8 |
| | | 07/09/02 | 1500 | U | 1.2 | 423 | 8.3 | 20.0 | 6.9 | 3.3 | E | H | 0.52 | 0.48 | 6 | 97 | 7 |
| | | 08/27/02 | 1245 | U | e<0.05 | 530 | 8.3 | 19.0 | 8.3 | 4.8 | E | H | 0.51 | 0.37 | 7 | 99 | 6 |
| 31 | 10310450 | 11/20/00 | 1255 | U | 103 | 277 | -- | 5.0 | -- | -- | E | H | 0.09 | 0.04 | -- | -- | -- |
| | | 03/21/01 | 1200 | N | 346 | 186 | 7.8 | 11.5 | 12.8 | 45 | E | H | 0.20 | 0.04 | -- | -- | 102 |
| | | 08/07/01 | 0830 | U | 5.4 | -- | -- | 16.0 | -- | -- | E | H | 0.29 | 0.25 | -- | -- | -- |
| | | 02/25/02 | 1520 | U | 188 | 218 | 7.9 | 8.0 | 12.0 | 6.6 | E | H | 0.08 | 0.04 | 30 | 34 | 9 |
| | | 04/15/02 | 1530 | U | 1,330 | 82 | 6.9 | 8.5 | -- | -- | E | H | 0.64 | 0.04 | 656 | 41 | -- |
| | | 05/13/02 | 1140 | U | 770 | 119 | 7.5 | 12.0 | 8.7 | 14 | E | H | 0.16 | 0.06 | 66 | 45 | 28 |
| | | 05/30/02 | 0920 | U | 939 | 94 | 6.7 | 16.5 | 7.7 | 32 | E | H | 0.22 | 0.05 | 129 | 52 | 65 |
| | | 07/10/02 | 0955 | U | 17 | 387 | 7.4 | 23.5 | 6.8 | 3.4 | E | H | 0.28 | 0.22 | 6 | 75 | 6 |
| | | 08/27/02 | 1400 | U | 9.8 | 384 | 8.4 | 25.0 | 10.8 | 4.5 | E | H | 0.17 | 0.12 | 8 | 95 | 8 |
| 32 | 10310525 | 08/10/01 | 0810 | U | 0.29 | -- | -- | 14.0 | -- | -- | E | H | 0.06 | 0.04 | -- | -- | -- |
| | | 07/10/02 | 1255 | U | e0.02 | 177 | 7.4 | 29.5 | 6.3 | 3.6 | E | H | 0.06 | 0.05 | 3 | 95 | 4 |
| | | 07/18/02 | 1435 | U | 2.4 | 162 | 7.5 | 16.2 | 7.4 | -- | E | H | 0.45 | 0.06 | 148 | 96 | 120 |

**Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued**

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; $^{o}C$, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | pH | Water tem-perature (°C) | Dis-solved oxygen (mg/L) | Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Total (mg/L as P) | Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 08/27/02 | 1550 | U | 0.48 | 168 | 8.4 | 19.0 | 8.1 | 3.3 | E | H | 0.04 | 0.03 | 4 | 97 | 4 |
| 33 | 10310550 | 03/05/01 | 1055 | U | 5.8 | 203 | -- | -- | -- | -- | E | H | 0.04 | 0.01 | -- | -- | -- |
| | | | | | | | | | | | R | H | 0.04 | 0.01 | -- | -- | -- |
| | | 07/11/01 | 1120 | U | 0.92 | -- | -- | 26.0 | -- | -- | E | H | 0.17 | 0.06 | 26 | 63 | -- |
| | | 08/10/01 | 0927 | U | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 02/26/02 | 0930 | U | 4.6 | 183 | 8.0 | 3.5 | 12.1 | 17 | E | H | 0.07 | 0.02 | 35 | 97 | -- |
| | | 05/13/02 | 1400 | U | 2.1 | 176 | 8.2 | 24.7 | 7.9 | 36 | E | H | 0.16 | 0.05 | 49 | 94 | 47 |
| | | | | | | | | | | | R | H | 0.16 | 0.05 | -- | -- | <10 |
| | | 07/10/02 | 1255 | U | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08/27/02 | 1550 | U | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 34 | 10311000 | 11/20/00 | 1320 | N | 137 | 305 | 8.3 | 5.0 | 11.3 | 10 | E | H | 0.08 | 0.04 | -- | -- | 10 |
| | | 11/21/00 | 0915 | U | 128 | 320 | -- | 1.0 | -- | -- | E | H | 0.09 | 0.05 | -- | -- | -- |
| | | 01/04/01 | 1430 | U | 103 | 323 | -- | -- | -- | -- | E | H | 0.06 | 0.06 | -- | -- | -- |
| | | 01/09/01 | 0855 | N | 118 | 311 | 9.0 | 2.7 | 8.0 | 6.2 | E | H | 0.07 | 0.04 | -- | -- | 9 |
| | | 03/21/01 | 1135 | N | 306 | 212 | 8.0 | 12.1 | 12.2 | 40 | E | H | 0.21 | 0.05 | -- | -- | 84 |
| | | 05/21/01 | 1045 | U | 652 | -- | -- | 16.0 | -- | -- | E | H | [d]e0.21 | 0.07 | 78 | 50 | -- |
| | | 05/29/01 | 1400 | N | 335 | 155 | 7.9 | 20.5 | 7.8 | 14 | E | H | 0.13 | 0.06 | -- | -- | 35 |
| | | 07/17/01 | 1455 | N | 14 | 568 | 8.4 | 26.1 | 6.2 | 10 | E | H | 0.30 | 0.21 | -- | -- | 24 |
| | | 09/25/01 | 1355 | N | 4.7 | 780 | 8.9 | 24.0 | 7.7 | 8.9 | E | H | 0.18 | 0.05 | -- | -- | 16 |
| | | 11/27/01 | 1310 | N | 89 | 300 | 8.2 | -- | -- | 9 | E | H | 0.10 | 0.11 | -- | -- | 13 |
| | | 01/08/02 | 1410 | N | 278 | 240 | -- | 6.2 | 11.5 | 15 | E | H | 0.10 | 0.03 | -- | -- | 27 |
| | | 02/26/02 | 1355 | U | 184 | 248 | 8.1 | 9.5 | 10.8 | 8.9 | E | H | 0.10 | 0.05 | 17 | 82 | 16 |
| | | 03/20/02 | 1300 | N | 182 | 260 | 8.0 | 13.0 | 8.3 | 11 | E | H | 0.10 | 0.04 | -- | -- | 21 |
| | | 05/15/02 | 1445 | U | 919 | 104 | 7.8 | 16.5 | -- | 25 | E | H | 0.25 | 0.06 | 105 | 51 | -- |
| | | 05/28/02 | 1220 | N | 712 | 120 | 8.1 | 16.0 | 7.9 | 25 | E | H | 0.16 | 0.05 | -- | -- | 65 |

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; $^oC$, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | Field measurements: pH | Field measurements: Water tem-perature (°C) | Field measurements: Dis-solved oxygen (mg/L) | Field measurements: Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Phosphorus: Total (mg/L as P) | Phosphorus: Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Suspended sediment: Sand break[a] (%) | Suspended sediment: TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 05/30/02 | 1100 | U | 959 | 108 | 7.8 | 17.5 | 9.0 | 28 | E | H | 0.24 | 0.06 | 122 | 51 | 59 |
| | | 07/10/02 | 1500 | U | 24 | 469 | 8.0 | 32.0 | 9.3 | 4.0 | E | H | 0.24 | 0.19 | 6 | 83 | 6 |
| | | 07/17/02 | 1105 | N | 22 | 510 | 8.5 | 23.2 | 8.3 | 11 | E | H | 0.40 | 0.31 | -- | -- | 27 |
| | | 08/28/02 | 1410 | U | 11 | 500 | 8.5 | 27.7 | 8.4 | 4.6 | E | H | 0.15 | 0.10 | 6 | 95 | 6.5 |
| | | 09/17/02 | 1335 | N | 9.1 | 510 | 8.4 | 22.9 | 10.9 | 6 | E | H | 0.15 | 0.11 | -- | -- | 10 |
| 35 | 10311008 | 05/15/02 | 0830 | U | 779 | 114 | 7.6 | 13.8 | 8.3 | 21 | E | H | 0.18 | 0.07 | 55 | 84 | 44 |
| 36 | 10311300 | 03/05/01 | 1200 | U | 3.8 | 836 | -- | -- | -- | -- | E | H | 0.27 | 0.05 | -- | -- | -- |
| | | 04/23/01 | 1330 | U | 1.2 | 1,259 | -- | 19.5 | -- | -- | E | H | 0.28 | 0.17 | 20 | 81 | -- |
| 37 | 10311325 | 04/23/01 | 1520 | U | 11 | 442 | -- | 19.5 | -- | -- | E | H | 0.19 | 0.10 | -- | -- | -- |
| | | 07/11/01 | 1410 | U | [e]1.4 | -- | -- | 28.0 | -- | -- | E | H | 0.27 | 0.11 | 16 | 84 | -- |
| | | 08/09/01 | 1400 | U | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 02/27/02 | 0905 | U | e0.75 | 1,120 | 8.7 | 5.5 | 9.4 | 16 | E | H | 0.13 | 0.07 | 20 | 98 | -- |
| | | 05/14/02 | 1100 | U | 7.8 | 201 | 8.4 | 19.5 | 9.4 | 8.4 | E | H | 0.09 | 0.06 | 9 | 86 | 11 |
| | | 07/11/02 | 0750 | U | [e]e0.02 | 446 | 7.6 | 19.5 | 6.3 | 2.2 | E | H | 0.15 | 0.11 | 4 | 82 | 8 |
| | | 08/29/02 | 0830 | U | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 38 | 391057-119422301 | 03/05/01 | 1300 | U | 0.13 | 1,829 | -- | -- | -- | -- | E | H | 0.14 | 0.06 | -- | -- | -- |
| | | 04/23/01 | 1410 | U | e0.1 | 1,929 | -- | -- | 17.0 | -- | E | H | 0.20 | 0.13 | 98 | 15 | -- |
| 39 | 10311400 | 11/20/00 | 1340 | N | 120 | 345 | 8.3 | 4.5 | 11.2 | 8.4 | E | H | 0.07 | 0.04 | -- | -- | 6 |
| | | 11/21/00 | 1105 | U | 125 | 326 | -- | 3.5 | -- | -- | E | H | 0.08 | 0.04 | -- | -- | -- |
| | | 01/08/01 | 1130 | N | 109 | 366 | 8.0 | 3.1 | 7.7 | 7.2 | E | H | 0.07 | 0.04 | -- | -- | 8 |
| | | 03/21/01 | 1105 | N | 308 | 239 | 8.0 | 11.9 | 13.1 | 27 | E | H | 0.16 | 0.05 | -- | -- | 54 |
| | | 04/27/01 | 0910 | U | 664 | 155 | -- | 13.0 | -- | -- | E | H | 0.35 | 0.07 | 153 | 83 | -- |
| | | 05/02/01 | 1405 | U | 898 | 123 | -- | 12.0 | -- | -- | E | H | 0.48 | 0.06 | 168 | 70 | -- |
| | | 05/09/01 | 1225 | U | 955 | 121 | -- | 15.5 | -- | -- | E | H | 0.35 | 0.07 | 173 | 57 | -- |
| | | 05/11/01 | 1255 | U | 1,030 | 117 | -- | 15.5 | -- | -- | E | H | 0.33 | 0.07 | 141 | 67 | -- |

**Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued**

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | pH | Water tem-perature (°C) | Dis-solved oxygen (mg/L) | Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Total (mg/L as P) | Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Sand break[a] (%) | TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 05/29/01 | 1430 | N | 299 | 148 | 8.0 | 20 | 8.5 | 14 | E | H | 0.13 | 0.07 | -- | -- | 29 |
| | | 07/17/01 | 1530 | N | 8.5 | 528 | 8.6 | 26 | 7.2 | 2.7 | E | H | 0.22 | 0.18 | -- | -- | 4 |
| | | 11/27/01 | 1330 | N | 132 | 300 | 8.2 | -- | -- | 15 | E | H | 0.12 | 0.06 | -- | -- | 24 |
| | | 01/08/02 | 1450 | N | 268 | 250 | 8.8 | 5.3 | 12.8 | 16 | E | H | 0.10 | 0.03 | -- | -- | 39 |
| | | 02/27/02 | 1200 | U | 207 | 264 | 8.1 | 7.0 | 11.1 | 6.2 | E | H | 0.08 | 0.05 | 10 | 84 | 7 |
| | | 03/20/02 | 1330 | N | 201 | 280 | 8.2 | 10.0 | 10.2 | 8 | E | H | 0.08 | 0.04 | -- | -- | 14 |
| | | 05/14/02 | 1430 | U | 735 | 138 | 7.8 | 16.3 | 8.7 | 19 | E | H | 0.20 | 0.08 | 65 | 65 | 43 |
| | | 05/20/02 | 1550 | U | 1,100 | 96 | 7.8 | 12.7 | 8.5 | 37 | E | H | 0.25 | 0.06 | 104 | 60 | 76 |
| | | 05/20/02 | 1700 | U | 1,100 | 94 | 7.7 | 12.7 | -- | 35 | E | H | 0.23 | 0.06 | 186 | 32 | 56 |
| | | 05/28/02 | 1120 | N | 593 | 120 | 8.1 | 16.0 | 8.3 | 22 | E | H | 0.16 | 0.06 | -- | -- | 45 |
| | | 05/30/02 | 1230 | U | 806 | 119 | 7.4 | 19.1 | 7.0 | 29 | E | H | 0.23 | 0.07 | 100 | 67 | 62 |
| | | 07/11/02 | 0900 | U | 11 | 516 | 7.7 | 22.5 | 6.1 | 3.7 | E | H | 0.19 | 0.15 | 6 | 77 | 5 |
| | | | | | | | | | | | R | H | 0.19 | 0.15 | -- | -- | 5 |
| | | 07/17/02 | 1130 | N | e9.0 | 550 | 8.3 | 25.2 | 7.5 | 11 | E | H | 0.24 | 0.16 | -- | -- | 39 |
| | | 08/29/02 | 0955 | U | 3.0 | 624 | 8.0 | 21.0 | 8.8 | 2.0 | E | H | 0.06 | 0.04 | 4 | 87 | 1.5 |
| | | | | | | | | | | | R | H | 0.06 | 0.04 | -- | -- | 3 |
| | | 09/17/02 | 1415 | N | 1.4 | 570 | 8.2 | 20.0 | -- | 2.0 | E | H | 0.06 | 0.05 | -- | -- | 4 |
| 40 | 10311700 | 11/21/00 | 1210 | U | 110 | 354 | -- | 4.5 | -- | -- | E | H | 0.06 | 0.03 | -- | -- | -- |
| | | 03/21/01 | 0945 | N | 284 | -- | -- | -- | -- | -- | E | H | 0.14 | 0.05 | -- | -- | -- |
| | | 05/21/01 | 1300 | U | 613 | -- | -- | 17.5 | -- | -- | E | H | [d]e0.17 | 0.08 | 47 | 83 | -- |
| | | 08/09/01 | 0845 | U | 1.6 | -- | -- | 20.0 | -- | -- | E | H | 0.07 | 0.05 | -- | -- | -- |
| | | 02/27/02 | 1500 | U | 205 | 280 | 8.0 | 9.5 | 10.2 | 4.8 | E | H | 0.07 | 0.04 | 8 | 87 | -- |
| | | | | | | | | | | | R | H | 0.07 | 0.04 | -- | -- | -- |
| | | 05/15/02 | 0930 | U | 513 | 118 | 7.9 | 14.5 | 9.1 | 20 | E | H | 0.16 | 0.06 | 38 | 86 | 49 |
| | | 05/31/02 | 0945 | U | 883 | 102 | 7.8 | 18.5 | 8.2 | 37 | E | H | 0.23 | 0.07 | 75 | 81 | 62 |
| | | 07/11/02 | 1130 | U | 4.2 | 530 | 7.5 | 25.0 | 7.7 | 1.4 | E | H | 0.11 | 0.09 | 3 | 65 | 4 |

Appendix 1. Field measurements and chemical and suspended-sediment analyses for surface-water samples collected from the study area, water years 2001–02—Continued

[Abbreviations and symbols: e, estimated; E, environmental; U, USGS; NTU, nephelometer turbidity units; R, replicate sample; H, Nevada State Health Laboratory; N, Nevada Division of Environmental Protection; S, South Tahoe Public Utility District; P, phosphorus; SSC, suspended-sediment concentration; TSS, total-suspended solids; $ft^3/s$, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius;%, percent; <, less than; --, data not collected or analyzes]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Collect-ing agency | Dis-charge ($ft^3/s$) | Field measurements: Specific conduc-tance (µS/cm) | Field measurements: pH | Field measurements: Water tem-perature (°C) | Field measurements: Dis-solved oxygen (mg/L) | Field measurements: Tur-bidity (NTU) | Anal-ysis type | Phosphorus: Lab | Phosphorus: Total (mg/L as P) | Phosphorus: Ortho-phos-phate (mg/L as P) | Suspended sediment: SSC (mg/L) | Suspended sediment: Sand break[a] (%) | Suspended sediment: TSS[b] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 08/29/02 | 1140 | U | 1.0 | 586 | 7.6 | 23.0 | 7.7 | 0.71 | E | H | 0.06 | 0.06 | 3 | 71 | 0.5 |
| 41 | 10311860 | 08/09/01 | 1110 | U | 4.8 | -- | -- | 26.0 | -- | -- | E | H | 0.05 | 0.03 | -- | -- | -- |
| | | 02/28/02 | 1135 | U | 200 | 309 | 8.1 | 7.5 | 11.1 | 4.4 | E | H | 0.07 | 0.04 | 16 | 52 | -- |
| 42 | 10311870 | 05/15/02 | 1315 | U | 626 | 148 | 7.4 | 18.0 | 8.1 | 23 | E | H | 0.30 | 0.06 | 57 | 64 | 47 |
| | | | | | | | | | | | R | H | 0.49 | 0.06 | -- | -- | 46 |
| | | 07/11/02 | 1430 | U | 18 | 610 | 7.8 | 32.5 | 7.7 | 1.5 | E | H | 0.06 | 0.05 | 3 | 67 | 1 |
| | | 08/29/02 | 1355 | U | 4.1 | 667 | 8.4 | 29.0 | 10.4 | 4.7 | E | H | 0.06 | 0.02 | 24 | 30 | 7.5 |
| 43 | 10312020 | 11/20/00 | 1530 | N | 122 | 427 | 8.4 | 6.0 | 11.6 | 3.4 | E | H | 0.06 | 0.04 | -- | -- | 2 |
| | | 01/08/01 | 1020 | N | 111 | 418 | 8.0 | 1.5 | 8.0 | 4.9 | E | H | 0.06 | 0.04 | -- | -- | 7 |
| | | 03/21/01 | 0945 | N | 209 | 358 | 7.7 | 12.3 | 11.3 | 12 | E | H | 0.11 | 0.04 | -- | -- | 28 |
| | | 04/26/01 | 1220 | U | 390 | 301 | 8.1 | 18.0 | 8.0 | -- | E | H | 0.26 | 0.08 | 94 | 75 | -- |
| | | 05/17/01 | 1330 | U | 1,010 | 124 | 7.6 | 18.5 | 7.8 | -- | E | H | [d]e0.31 | 0.06 | 161 | 59 | -- |
| | | 05/29/01 | 1535 | N | 386 | 209 | 8.0 | 23.4 | 7.0 | 16 | E | H | 0.14 | 0.07 | -- | -- | 40 |
| | | 07/18/01 | 1005 | N | 6.6 | 576 | 8.2 | 20.0 | 9.6 | 0.8 | E | H | 0.04 | 0.03 | -- | -- | 0 |
| | | 11/27/01 | 1435 | N | 148 | 340 | 8.1 | -- | -- | 15 | E | H | 0.12 | 0.06 | -- | -- | 23 |
| | | 01/09/02 | 1040 | N | 260 | 310 | 8.7 | 3.9 | 13.0 | 11 | E | H | 0.08 | 0.03 | -- | -- | 19 |
| | | 02/21/02 | 1150 | U | 150 | 388 | 8.1 | 10.5 | 9.7 | 3.3 | E | H | 0.05 | 0.03 | 9 | 74 | -- |
| | | 03/20/02 | 1440 | N | 185 | 340 | 8.2 | 9.8 | 12.0 | 4.5 | E | H | 0.07 | 0.03 | -- | -- | 9 |
| | | 05/20/02 | 1320 | U | 1,340 | 110 | 7.6 | 12.5 | 8.7 | 89 | E | H | 0.30 | 0.06 | 735 | 23 | -- |
| | | 05/28/02 | 1030 | N | 661 | 180 | 8.1 | 17.8 | 8.3 | 32 | E | H | 0.20 | 0.06 | -- | -- | 72 |
| | | 07/11/02 | 1000 | U | 17 | 539 | 7.7 | 23.5 | 7.2 | 2.1 | E | H | 0.07 | 0.06 | 6 | 78 | 2 |
| | | 07/17/02 | 1240 | N | 3.9 | 530 | 8.1 | 26.6 | 7.6 | 1.8 | E | H | 0.07 | 0.05 | -- | -- | 5 |
| | | 08/29/02 | 1030 | U | 3.1 | 522 | 7.9 | 20.5 | 8.0 | 0.99 | E | H | 0.05 | 0.03 | 7 | 30 | 1 |
| | | 09/17/02 | 1530 | N | 1.2 | 540 | 8.4 | 21.2 | 8.7 | 1.8 | E | H | 0.05 | 0.04 | -- | -- | 1 |

[a]The sand break indicates the percent of material in the sample, by weight, that is finer than 0.062 millimeter (sand). Sand break is not reported when suspended-sediment concentration is less than or equal to 1 mg/L.

[b]The detection limit for total suspended-solids values from Nevada State Health Lab is 10 mg/L; values less than the detection limit are estimates.

[c]Nevada Division of Environmental Protection reports value as zero. Detection limit confirmed with Nevada State Health Lab.

[d] Sample sat in laboratory beyond recommended holding time before analysis. Value is considered an estimate.

[e]Discharge at site was zero at time of sample collection; data and sample were collected about 300 feet upstream of regular site above a retention basin.

Appendix 2. Chemical analyses for streambed- and streambank-sediment samples collected from the study area, water years 2001–02

[Abbreviations: P, phosphorus; E, environmental; R, replicate; mg/kg, milligrams per kilogram. Symbol: --, data not collected or analyzed]

| Site no. (see fig. 16) | USGS station no. | Date sampled | Time | Sample type | Total phosphorus (mg/kg as P) | |
|---|---|---|---|---|---|---|
| | | | | | Streambed sediment | Streambank sediment |
| **West Fork Carson River and tributaries** | | | | | | |
| 1 | 10310000 | 07/12/01 | 1245 | E | 730 | 630 |
| 3 | 10310220 | 08/08/01 | 1410 | E | 690 | -- |
| 4 | 10310356 | 09/05/01 | 1210 | E | 1,600 | -- |
| | | 09/05/01 | 1210 | R | 1,400 | -- |
| 5 | 10309082 | 08/10/01 | 1135 | E | 1,200 | -- |
| 6 | 10310358 | 09/04/02 | 1430 | E | 900 | 590 |
| | | 09/04/02 | 1430 | R | 1,000 | -- |
| 7 | 10309114 | 08/06/01 | 1015 | E | 910 | -- |
| 8 | 103103588 | 08/06/01 | 1130 | E | 1,100 | -- |
| 9 | 10310359 | 09/04/02 | 1530 | E | 290 | 720 |
| **Brockliss Slough and tributaries** | | | | | | |
| 10 | 10310240 | 09/05/01 | 1115 | E | 660 | -- |
| | | 09/04/02 | 0945 | E | -- | 460 |
| 11 | 10310258 | 09/05/01 | 1155 | E | 480 | -- |
| 12 | 10310255 | 09/04/02 | 1100 | E | 300 | -- |
| | | 09/04/02 | 1100 | R | 320 | -- |
| 13 | 10310265 | 09/04/02 | 1135 | E | 400 | -- |
| 15 | 10310404 | 08/07/01 | 1120 | E | 1,100 | 670 |
| **East Fork Carson River and tributaries** | | | | | | |
| 16 | 10308200 | 09/05/02 | 1010 | E | 360 | 650 |
| | | 09/05/02 | 1010 | R | -- | 740 |
| 17 | 10309010 | 07/12/01 | 1115 | E | 340 | 480 |
| 18 | 10309089 | 08/08/01 | 0915 | E | 1,400 | -- |
| 19 | 10309098 | 09/05/01 | 1035 | E | 800 | -- |
| 20 | 10309100 | 09/05/01 | 1300 | E | 820 | 350 |
| 21 | 1030909018 | 07/12/01 | 1010 | E | 870 | 580 |
| 22 | 1030909020 | 07/12/01 | 0910 | E | 760 | 830 |
| 23 | 1030909042 | 09/05/01 | 1000 | E | 1,000 | -- |
| 24 | 10309120 | 09/04/02 | 1330 | E | 450 | -- |
| 25 | 10309130 | 08/06/01 | 1330 | E | 670 | 850 |
| **Carson River and tributaries** | | | | | | |
| 26 | 10310405 | 08/06/01 | 1500 | E | 630 | -- |
| 27 | 10310406 | 08/07/01 | 1300 | E | 880 | -- |
| 28 | 10310407 | 09/05/02 | 1240 | E | 220 | 940 |
| 29 | 10310419 | 09/05/02 | 1410 | E | 1,500 | -- |
| 30 | 10310448 | 08/10/01 | 1415 | E | 1,100 | -- |
| 31 | 10310450 | 08/07/01 | 0830 | E | 890 | 590 |
| 32 | 10310525 | 08/10/01 | 0810 | E | 1,200 | -- |
| 33 | 10310550 | 07/11/01 | 1120 | E | 810 | 1,200 |
| 34 | 10311000 | 08/28/01 | 1230 | E | 1,100 | 550 |
| | | 08/28/01 | 1230 | R | 630 | 660 |
| 36 | 10311300 | 08/28/01 | 1100 | E | 490 | -- |
| 37 | 10311325 | 07/11/01 | 1330 | E | 940 | 220 |
| 38 | 391057119422301 | 08/28/01 | 0930 | E | 850 | -- |
| 39 | 10311400 | 08/28/01 | 0815 | E | 510 | 430 |
| 40 | 10311700 | 08/09/01 | 0845 | E | 980 | 470 |
| 41 | 10311860 | 08/09/01 | 1110 | E | 750 | -- |
| 42 | 10311870 | 09/04/02 | 1920 | E | 500 | 330 |

Appendix 3. Chemical analyses for nitrogen species in surface-water samples collected from the study area, water year 2002

[Abbreviations: E, environmental; R, replicate; mg/L, milligrams per liter. Symbol: <, less than]

| Site no. (see fig. 16) | USGS station no. | Date | Time | Sample type | Nitrogen concentration (mg/L as N) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Nitrite plus nitrate[a] | Nitrite[b] | Ammonia[a] | Kjeldahl[a] |
| 1 | 10310000 | 07/01/02 | 1000 | E | 0.1 | <0.01 | <0.1 | 0.21 |
| | | 08/21/02 | 0906 | E | <0.1 | <0.01 | <0.1 | 0.17 |
| 3 | 10310220 | 07/01/02 | 1225 | E | 0.1 | <0.01 | <0.1 | 0.44 |
| | | 08/21/02 | 1345 | E | <0.1 | <0.01 | <0.1 | 0.19 |
| 5 | 10309082 | 07/02/02 | 0815 | E | 1.1 | 0.02 | <0.1 | 0.55 |
| | | 08/21/02 | 1550 | E | 0.3 | <0.01 | <0.1 | 0.36 |
| 6 | 10310358 | 07/02/02 | 1150 | E | 0.1 | 0.01 | <0.1 | 0.82 |
| | | 08/22/02 | 1015 | E | <0.1 | <0.01 | <0.1 | 0.34 |
| 7 | 10309114 | 07/02/03 | 1500 | E | <0.1 | <0.01 | <0.1 | 0.39 |
| | | 08/22/02 | 1250 | E | <0.1 | <0.01 | <0.1 | 0.49 |
| 9 | 10310359 | 07/03/02 | 0800 | E | 0.1 | <0.01 | <0.1 | 0.45 |
| | | | | R | 0.1 | <0.01 | <0.1 | 0.52 |
| | | 08/22/02 | 1435 | E | <0.1 | <0.01 | <0.1 | 0.46 |
| 10 | 10310240 | 07/01/02 | 1540 | E | <0.1 | <0.01 | <0.1 | 0.49 |
| | | 08/21/02 | 1135 | E | <0.1 | <0.01 | <0.1 | 0.37 |
| 13 | 10310265 | 07/12/02 | 0852 | E | <0.1 | <0.01 | <0.1 | 0.87 |
| | | 08/23/02 | 1100 | E | <0.1 | <0.01 | <0.1 | 0.90 |
| 15 | 10310404 | 07/03/02 | 1051 | E | 0.1 | <0.01 | 0.12 | 1.13 |
| | | 08/23/02 | 0820 | E | <0.1 | <0.01 | <0.1 | 0.56 |
| | | | | R | <0.1 | <0.01 | <0.1 | 0.60 |
| 16 | 10308200 | 07/08/02 | 0940 | E | 0.1 | <0.01 | <0.1 | 0.14 |
| | | 08/26/02 | 1050 | E | 0.1 | <0.01 | <0.1 | 0.13 |
| 17 | 10309010 | 07/09/02 | 1030 | E | <0.1 | <0.01 | <0.1 | 0.22 |
| | | 08/26/02 | 1330 | E | <0.1 | <0.01 | <0.1 | 0.16 |
| 22 | 1030909020 | 07/08/02 | 1310 | E | 0.1 | <0.01 | <0.1 | 0.91 |
| | | 08/27/02 | 0830 | E | 0.1 | <0.01 | 0.1 | 0.40 |
| 24 | 10309120 | 07/08/02 | 1525 | E | 0.2 | 0.01 | 0.1 | 0.64 |
| | | 08/28/02 | 0850 | E | 0.5 | 0.01 | <0.1 | 0.40 |
| | | | | R | 0.5 | 0.01 | <0.1 | 0.33 |
| 25 | 10309130 | 07/08/02 | 1750 | E | <0.1 | <0.01 | <0.1 | 1.08 |
| | | 08/28/02 | 1040 | E | <0.1 | <0.01 | <0.1 | 0.35 |
| 28 | 10310407 | 07/09/02 | 1048 | E | <0.1 | <0.01 | <0.1 | 1.34 |
| | | 08/28/02 | 1220 | E | <0.1 | <0.01 | <0.1 | 0.39 |
| 29 | 10310419 | 07/09/02 | 1230 | E | <0.1 | <0.01 | <0.1 | 1.13 |
| | | | | R | <0.1 | <0.01 | <0.1 | 1.03 |
| | | 08/27/02 | 1035 | E | <0.1 | <0.01 | 0.17 | 1.02 |
| 30 | 10310448 | 07/09/02 | 1500 | E | 0.1 | <0.01 | <0.1 | 1.29 |
| | | 08/27/02 | 1245 | E | <0.1 | 0.01 | 0.18 | 0.81 |
| 31 | 10310450 | 07/10/02 | 0955 | E | <0.1 | <0.01 | <0.1 | 0.74 |
| | | 08/27/02 | 1400 | E | 0.1 | <0.01 | <0.1 | 0.46 |
| 32 | 10310525 | 07/10/02 | 1255 | E | 0.1 | <0.01 | <0.1 | 0.23 |
| | | 07/18/02 | 1435 | E | 0.4 | 0.02 | 0.15 | 1.05 |
| | | 08/27/02 | 1550 | E | <0.1 | <0.01 | <0.1 | 0.14 |
| 34 | 10311000 | 07/10/02 | 1500 | E | <0.1 | <0.01 | <0.1 | 0.69 |
| | | 08/28/02 | 1410 | E | <0.1 | <0.01 | <0.1 | 0.39 |
| 37 | 10311325 | 07/11/02 | 0750 | E | 0.1 | <0.01 | <0.1 | 0.55 |
| 39 | 10311400 | 07/11/02 | 0900 | E | <0.1 | <0.01 | <0.1 | 0.55 |
| | | | | R | 0.1 | <0.01 | <0.1 | 0.54 |
| | | 08/29/02 | 0955 | E | <0.1 | <0.01 | <0.1 | 0.41 |
| | | | | R | <0.1 | <0.01 | <0.1 | 0.44 |
| 40 | 10311700 | 07/11/02 | 1130 | E | 0.1 | <0.01 | <0.1 | 0.42 |
| | | 08/29/02 | 1140 | E | <0.1 | <0.01 | <0.1 | 0.32 |
| 42 | 10311870 | 07/11/02 | 1430 | E | <0.1 | <0.01 | <0.1 | 0.29 |
| | | 08/29/02 | 1355 | E | 0.1 | <0.01 | <0.1 | 0.34 |

[a]Concentrations are for unfiltered samples.

[b]Concentrations are for filtered samples.