CHERRY CREEK RESERVOIR

2002 ANNUAL AQUATIC BIOLOGICAL AND NUTRIENT MONITORING STUDY

MARCH 2003

Chadwick Ecological Consultants, Inc.

5575 S. Sycamore St., Suite 101, Littleton, CO 80120
Ph: (303) 794-5530 Fax: (303) 794-5041 Chadeco@aol.com

CHERRY CREEK RESERVOIR

2002 ANNUAL AQUATIC BIOLOGICAL

AND NUTRIENT MONITORING STUDY

MARCH 2003

Submitted To:

Cherry Creek Basin Water Quality Authority
Fiddler's Green Center, Building 1
6399 South Fiddler's Green Circle, Suite 102
Greenwood Village, Colorado 80111-4974

Prepared By:

Chadwick Ecological Consultants, Inc.
5575 South Sycamore Street, Suite 101
Littleton, Colorado 80120-1141
(303) 794-5530
www.chadwickecological.com

TABLE OF CONTENTS

INTRODUCTION

An inter-governmental agreement was executed in 1985 by several local governmental entities within the Cherry Creek basin to form the Cherry Creek Basin Water Quality Authority (CCBWQA). This Authority was created for the purpose of coordinating and implementing the investigations necessary to maintain the quality of water resources of the Cherry Creek basin while allowing for further economic development. Based on a clean lakes water study (Denver Regional Council of Governments [DRCOG] 1984), the Colorado Water Quality Control Commission (CWQCC) set standards for phosphorus, and a TMDL for phosphorus. An in-lake phosphorus standard of 35 µg/L was adopted to maintain a seasonal mean chlorophyll *a* goal of 15 µg/L. Subsequently, a phosphorus TMDL was prepared for the reservoir allocating loads among point sources, background, and nonpoint sources within a net annual load of 14,270 lbs total phosphorus.

The Cherry Creek Basin Master Plan (DRCOG 1985), approved by the CWQCC in 1985, was adopted in part as the "Regulations for Control of Water Quality in Cherry Creek Reservoir" (Section 4.2.0, 5C.C.R.3.8.11). An annual monitoring program (In-Situ, Inc. 1986, as amended, ASI 1994 a and b) was implemented at the end of April 1987 to assist in the assessment of several aspects of the Master Plan. These monitoring studies have included long-term monitoring of 1) nutrient levels within the reservoir and from tributary streams during base flows and stormwaters, 2) nutrient levels in precipitation, and 3) chlorophyll *a* levels within the reservoir. In addition, a number of incidental studies have been conducted using such methods as benthic respirometers and limnocorrals.

In September 2000, following a hearing before the CWQCC, the standard for Cherry Creek Reservoir was changed to a July - September value of 15 µg/L of chlorophyll *a* to be met nine out of ten years, with an underlying total phosphorus goal of 40 µg/L, also as a July - September mean. In May 2001 at the CWQCC hearing, a new control regulation was adopted for the Cherry Creek Reservoir which maintained the annual allowable total phosphorus load (TMAL) of 14,270 lbs/year as part of a “phased-TMDL” for the reservoir.

In 1994, Chadwick Ecological Consultants, Inc. (CEC) was retained by the CCBWQA to conduct annual aquatic biological and nutrient analyses on Cherry Creek Reservoir and selected tributaries. Results have been summarized in annual monitoring reports (CEC 1995 - 2002). Additionally, in past years, these data have been reviewed by Dr. John Jones of the University of Missouri-Columbia and presented to the Authority in his annual reports (Jones 1994 - 1999, 2001). The present study was designed to continue the characterization of the potential relationships between nutrient loading (both in-lake and external) and reservoir productivity. The specific objectives of this annual monitoring study include the following:

- Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus compounds, in Cherry Creek Reservoir and various streams flowing into the reservoir, and the reservoir outflow.

- Determine the pounds of phosphorus entering Cherry Creek Reservoir from streams and precipitation and leaving the reservoir through its outlet.

- Determine biological productivity in Cherry Creek Reservoir, as measured by algal biomass (chlorophyll *a* concentrations) and algal densities. In addition, determine species composition of the algal community.

- Determine potential relationships between the nutrient levels and biological productivity in Cherry Creek Reservoir through correlation of the various measurements made during the study.

Note that in past reports, CEC used provision (preliminary) inflow estimates from the COE when estimating inflows and loads to the reservoir. In 2002, CEC became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, CEC revised inflow and load estimates for 1992 - 2001 to match the more accurate, and finalized, inflow values from the COE.

STUDY AREA

Cherry Creek Reservoir was impounded in 1950 by the U.S. Army Corps of Engineers (COE) to protect the City of Denver from flash floods that may originate in the reservoir's 995 km^2 drainage basin. The reservoir has maintained a surface area of approximately 350 ha (approximately 850 acres) since 1959. The reservoir and surrounding state park have also become an important recreational site, providing opportunities for activities which include fishing, boating, swimming, bicycling, bird watching, and hiking.

Sampling Sites

Sampling in 2002 was conducted at ten sites, including three sites in Cherry Creek Reservoir, six sites on tributary streams, and one site on Cherry Creek downstream of the reservoir (Fig. 1). The sampling sites are summarized below:

Cherry Creek Reservoir

CCR-1 This site is also called the Dam site, and was established in 1987. CCR-1 corresponds to the northwest trident within the lake (Knowlton and Jones 1993). Sampling was discontinued at this site in 1996 following determination that this site exhibited similar characteristics to the other two sites in this well-mixed reservoir. Sampling recommenced in July 1998 at the request of consultants for Greenwood Village.

CCR-2 This site is also called the Swim Beach site, and was established in 1987. Site CCR-2 corresponds to the northeast trident within the lake (Knowlton and Jones 1993).

CCR-3 This site is also called the Inlet site and was established in 1987, corresponding to the south trident within the lake (Knowlton and Jones 1993).

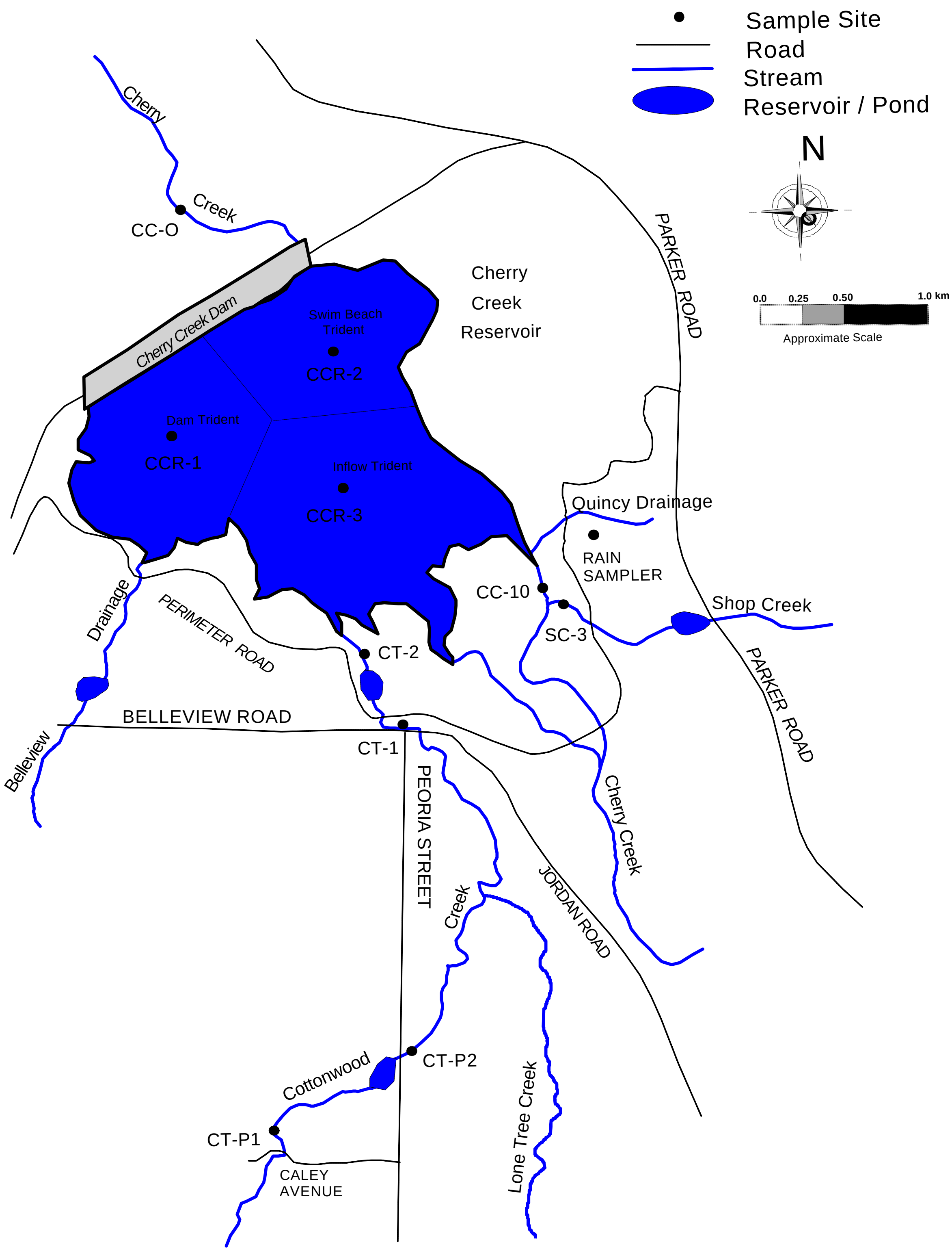


FIGURE 1: Sampling sites on Cherry Creek Reservoir and selected streams, 2002.

Shop Creek

SC-3 This site was established on Shop Creek in 1990 upstream of the Perimeter Road and downstream of the new Shop Creek detention pond and most of the wetland system. This site was moved just downstream of the Perimeter Road in 1994 and again farther downstream to a location just upstream of its confluence with Cherry Creek in 1997. This site serves to monitor the water quality of Shop Creek as it joins Cherry Creek.

Cherry Creek

CC-10 This site was originally established in 1987 on Cherry Creek near the historic USGS "Melvin" gage (roughly due west of the intersection of Parker Road and Orchard Road). This location is in an area of Cherry Creek that frequently becomes dry during summer months as a result of the natural geomorphology and alluvial pumping for domestic water supply (Halepaska & Associates, Inc. [JCHA] 1999, 2000).

In 1995, this site was relocated farther downstream between the Perimeter Road and the reservoir, approximately ½ km upstream of the reservoir. This site was moved still farther downstream in 1996, just upstream of the confluence with Shop Creek and closer to the reservoir. In 1999, it was moved below the confluence with Shop Creek to eliminate the effect of a stream crossing on the CC-10 hydrograph. Since 1995, Cherry Creek has been monitored in a reach with perennial flow, allowing for more accurate monitoring of water quality and surface flows in Cherry Creek before it enters the reservoir.

This site was previously called CC-I, but was renamed CC-10 to place it in context with concurrent monitoring in Cherry Creek upstream (JCHA 1999 - 2002). Since 1994, monthly surface flow and water quality data have been collected at ten sites on Cherry Creek upstream of the Perimeter Road (JCHA 1999 - 2002). These ten sites extend from the Castlewood site in Castlewood Canyon downstream to Site CC-9 at the Perimeter Road.

CC-O This site was established in 1987 on Cherry Creek downstream of Cherry Creek Reservoir and upstream of the Hampden Avenue-Havana Street junction in the Kennedy Golf Course (near the USGS gage). Site CC-O monitors the water quality of Cherry Creek downstream of the reservoir outlet.

Cottonwood Creek

CT-1 This site on Cottonwood Creek was established in 1987 where the Cherry Creek Park Perimeter Road crosses the stream. It was chosen to monitor the water quality of Cottonwood Creek before it enters the reservoir. During the fall/winter of 1996, a pollutant reduction facility (PRF), consisting of a water quality/detention pond and wetland system, was constructed downstream of this site. As a result of the back-flow from this pond, this site was relocated farther upstream near Belleview Avenue in 1997.

CT-2 This site was established in 1996 and is located downstream from the PRF on Cottonwood Creek. This site monitors the effectiveness of this structure on water quality and monitors the quality of Cottonwood Creek before it enters the reservoir.

CT-P1 This site was established in 2002 and is located just north of where Caley Avenue crosses Cottonwood Creek, west of Peoria Street. This site monitors the water quality of Cottonwood Creek before it enters a wetland PRF, also created in 2001/2002 on the west side of Peoria Street.

CT-P2 This site was established in 2002 and is located downstream from the PRF, on the east side of Peoria Street. This site monitors the effectiveness of the PRF on water quality.

METHODS

Sampling Methodologies

Reservoir Sampling

The general sampling schedule included regular sampling trips to the reservoir at varying frequencies over the annual sampling period, as outlined below, with increased sampling frequency during the summer growing season. Sampling was not conducted in February and December 2002 due to unsafe ice conditions on the reservoir.

Sampling Trips per Sampling Period

Sampling Period	Frequency	Trips/Period
Oct - Apr	Monthly	5
May - Sept	Bi-Monthly	11
	Total	16

During each sampling episode on the reservoir, three main tasks were conducted, including 1) determining water clarity, 2) taking depth profile measurements for temperature, dissolved oxygen, pH, conductivity, and oxygen-reduction potential, and 3) collecting water samples for chemical and biological analyses.

Water Clarity

First, transparency was determined at each reservoir site using a Secchi disk. The Secchi reading was taken from the shaded side of the boat or, if this was not possible, sunglasses or other shading was used to reduce glare. The disk was lowered slowly until the white quadrants disappeared, at which point the depth was recorded to the nearest 3 cm. The disk was then lowered approximately 0.5 m farther and slowly brought back up until the white quadrants reappeared and again the depth was recorded. The Secchi disk depth was recorded as the average of these two readings. The final Secchi depth is often considered to be roughly half the euphotic zone, i.e. the zone where ambient light allows photosynthetic activity (Cole 1979). In this report, however, Secchi depth is simply used as a measure of transparency and all discussion is based on Secchi depth alone without the transformation to a photic zone depth.

Beginning in 1998, a second method to measure the depth of the euphotic zone was used by determining the depth at which 1% of the light penetrates the water column. This is considered the point at which, on average, light no longer can sustain photosynthesis in excess of oxygen consumption from respiration (Goldman and Horne 1983). This was accomplished by using a double-deck photometer. One photocell remained on the surface, and the other was lowered into the water on the sunny side of the boat. Both photocells were attached to a data logger, which records the amount of light in micromoles per second per square meter. The underwater photocell is lowered until the value displayed on the data logger is 1% of the value of the surface photocell, and then the depth is recorded. This method was employed from May through November. From January to April, the data logger and photocells appeared to be malfunctioning, and were sent for repairs.

Profile Measurements

The second task involved taking dissolved oxygen, temperature, conductivity, pH, and oxidation-reduction potential measurements every meter from the surface to near the bottom of the reservoir to develop depth profiles for each site during each sampling episode. Readings were taken with a YSI meter, Model #600 XL multi-probe meter. This meter was calibrated monthly to ensure accurate measurements.

Water Sampling

Water samples for nutrient, phytoplankton, and chlorophyll *a* analyses were collected with a horizontal Van Dorn water sampler, which has a sample volume of approximately 3 liters. To sample, the open Van Dorn sampler was lowered to the appropriate depth. A “messenger” was sent to “trip” the sampler closed and the water was brought to the surface and transferred to a clean plastic bucket for splitting into aliquots as described below. The sampler was rinsed thoroughly, with lake water, between samples and between sites.

At each reservoir site, a photic composite sample was taken, which was composed of four equally contributed samples collected with the Van Dorn at depths of 0, 1, 2, and 3 m. The photic zone was defined as the top 3 m in the new Control Regulation. Approximately 80 mL from each photic composite were combined in one 250 mL bottle (preserved with 2.5 mL of 25% gluteraldehyde solution) by Chadwick & Associates, Inc. (C&A) and sent to Aquatic Analysts in Wilsonville, Oregon, for determination of algal species and counts.

A second photic composite sample was also taken from each reservoir site for chlorophyll *a* concentrations, and a third photic composite sample was taken for nutrient analysis. The samples were comprised of an equal volume of water collected from depths of 0, 1, 2, and 3 m at each site.

Following the collection of the photic composite samples, individual depth profile samples for nutrient analysis were collected at Site CCR-2 during every sampling trip in 2002. Samples were collected every meter beginning at four meters, the lower depth of the main reservoir pool according to the dynamic lake model (LaZerte and Nürnberg 2000), and progressing down to just above the bottom (approximately 7 m) representing the smaller, less frequently mixed bottom reservoir pool (LaZerte and Nürnberg 2000) (i.e., samples at 4, 5, 6, and 7 m). The Van Dorn sampler was lowered to the appropriate depth and “tripped” to take the sample. As before, the Van Dorn sampler was rinsed thoroughly with lake water before each sample was taken. Once collected, the sample was transferred to a 1 L container and delivered to C&A.

All samples were immediately placed on ice in a cooler and kept in the dark. Nutrient, chlorophyll *a*, and algal samples were returned to C&A, and one randomly selected sample was sent to the University of Colorado (CU) via overnight mail for nutrient analysis. This nutrient analysis by another laboratory provided a quality assurance for corresponding samples.

In the laboratory, nutrient samples were transferred to polyethylene bottles and stored at 4EC (±1EC). Dissolved nutrient samples were filtered through Gelman A/E glass fiber filters prior to storage. Nutrient samples were analyzed as summarized below, using flow injection analysis methods developed by Zellweger Analytics (1999), which are modifications of methods described in APHA (1998), which have recently been approved by USEPA for analysis of water. The chlorophyll *a* samples were filtered through Gelman A/E glass fiber filters and analyzed using the spectrophotometric method following a hot-ethanol extraction (APHA 1998). Algal samples were analyzed according to the methods described in APHA (1998).

Fish Population Data

As in the past, this monitoring study has also reviewed fish stocking and population data collected by the Colorado Division of Wildlife (CDOW). As part of their sampling schedule to reduce mortality to a walleye brood-stock population in Cherry Creek Reservoir, CDOW has begun sampling fish populations every two to three years. No sampling took place in 2002.

Stream Sampling

Low-Flow/Ambient Sampling. Standard sampling was conducted according to the schedule below during the regular reservoir sampling trips to Cherry Creek Reservoir. This sampling was performed in order to provide information during non-storm event periods, corresponding to the low-flow ambient samples collected in past studies. Monthly samples are assumed to be representative of non-storm, low-flow events.

Sampling Trips per Sampling Period

Sampling Period	Frequency	Trips/Period
Jan - Dec	Monthly	12

During these sampling episodes, water was collected from each of the seven stream sampling sites (sites on tributary streams and on Cherry Creek downstream of the reservoir) and analyzed for nutrients. Flows were sufficient at each site through the year to obtain all scheduled samples. Two samples were collected for chemical and suspended solids analysis from each of the stream sampling sites and consisted of a mid-stream, mid-column grab sample using two 1 L bottles. After collecting water samples, dissolved oxygen, temperature, conductivity, pH, and oxidation-reduction potential readings were taken at each stream site. Readings were taken with a YSI meter, model #600 XL multi-probe meter.

Storm Sampling. Storm events were sampled at Site CC-10 on Cherry Creek, Sites CT-1, CT-2, CT-P1, and CT-P2 on Cottonwood Creek, and Site SC-3 on Shop Creek during the 2002 sampling season (Table 1). Storm samples were collected with ISCO automatic samplers, which collect samples when the water level reaches a pre-set level. Pre-set levels vary seasonally with flow, and are set to approximately 0.5 ft above seasonally-adjusted non-storm levels for each individual stream site. Once the pre-set level is reached, the ISCO collects a sample every 15 minutes for approximately 2.5 hours (timed composite) at Sites CC-10, CT-1, CT-2, SC-3, CT-P1, and CT-P2. Personnel from CEC retrieved the samples collected by the automatic samplers, transferred them to water bottles, and immediately delivered the samples to the C&A laboratory for nutrient analysis. Peak storm flows generally occurred in the evening (often between 10:00 p.m. and midnight). Thus, sample retrieval was made the following morning (usually between 8:00 a.m. and 9:00 a.m.).

TABLE 1: Number of storm samples taken from tributary streams to Cherry Creek Reservoir, 2002.

	Site						
	SC-3	CC-10	CC-O	CT-1	CT-2	CT-P1	CT-P2
Number of Storm Samples	5	5	0	7	7	7	8

Precipitation Sampling

Precipitation samples were collected during six storm events in 2002. The precipitation sampler consisted of a clean, inverted plastic trash can lid used to funnel rain into a 1-gallon container. This sampler was located adjacent to the Quincy Drainage within the State Park boundary (Fig. 1). The sampler was checked weekly to assure that any small precipitation events would not contaminate a sample collected at a later date. Between precipitation events, dryfall also accumulates in the sampler. Subsequently, it would be washed into the sample and combined with the precipitation sample. As such, even with the weekly cleaning, precipitation samples include both wet and dry fall material. After each storm, the sample bottle was removed from the sampler and taken directly to the C&A laboratory for analysis of total phosphorus and total nitrogen. Sufficient volume remained in five of the six samples to measure total dissolved phosphorus, orthophosphate, total dissolved nitrogen, nitrate-nitrite, and ammonia.

Surface Hydrology

Pressure transducers attached to ISCO Series 4200 or 6700 flowmeters measured and recorded water levels (stage) at six sites on three tributaries to Cherry Creek Reservoir (Fig. 1). These flow meters recorded water depth in 15-minute intervals year round. Streamflow (discharge) was estimated at these six sites using stage-discharge relationships developed for each stream site. Discharge measurements were taken using a Marsh McBirney Model 2000 flowmeter. For a complete description of streamflow determination, see Appendix C.

Laboratory Procedures

Nutrient Laboratory Analysis

Nutrient analyses for the water collected in the study, as described above, were conducted by the C&A laboratory in Littleton, Colorado. Randomly selected water samples were sent to James Saunders, CU, from mid-June through November for chemical analyses as a quality assurance check. C&A conducted quality assurance analyses from January through early June. Table 2 lists the parameters analyzed and the methods that were used. Detailed methodologies are available from C&A.

TABLE 2: Parameter list, laboratory, method number, and detection limits for chemical and biological analyses of water collected from Cherry Creek Reservoir and tributaries, 2002.

Parameter	Lab	Method	Detection Limit
Total Phosphorus	C&A	QC 10-115-01-1-U	2 µg/L
Total Dissolved Phosphorus	"	QC 10-115-01-1-U	2 µg/L
Orthophosphorus	"	QC 10-115-01-1-T	3 µg/L
Total Nitrogen	"	APHA 4500-N B (modified)	4 µg/L
Total Dissolved Nitrogen	"	APHA 4500-N B (modified)	4 µg/L
Ammonia	"	QC 10-107-06-3-D	3 µg/L
Nitrate and Nitrite	"	QC 10-107-04-1-B	5 µg/L
TSS	"	APHA 2540D	4 mg/L
TVSS	"	APHA 2540E	4 mg/L
Chlorophyll *a*	"	APHA 10200 H (modified)	1 µg/L

Biological Laboratory Analysis

Biological analyses of the samples collected in the study were conducted by C&A and Aquatic Analysts (Wilsonville, OR). These analyses included species identifications and counts for phytoplankton, and analysis of chlorophyll *a*. The methods for these analyses, with appropriate QA/QC procedures, are available from C&A. These analyses provided cell counts per unit volume (cells/mL) and chlorophyll *a* concentrations in µg/L.

Quality Assurance/Quality Control

To ensure data quality, a number of quality assurance checks were used. During December through early June, a duplicate sample was taken at Sites CC-10 and CT-2, resulting in approximately 14% of the samples having a QA duplicate. These samples were analyzed by C&A. In mid-June, the TAC requested a change in the QA program. From mid-June through November, one randomly selected reservoir duplicate was shipped to James Saunders for analysis at his laboratory at CU. No duplicate samples were taken from stream sites. This resulted in approximately 7% of the samples having a QA duplicate, and provided an independent assessment of lake water analyses conducted by C&A.

In addition, field sampling quality control included the use of a field blank. This field blank contained laboratory grade deionized water in a sample container identical to those used in the field collections and was carried through the entire sampling episode. The cap of this container was removed at each reservoir site and left open during the regular sampling effort at that site. Upon completion of sampling at that site, the cap was replaced. One field blank was used for every sampling trip. The field blanks and duplicate samples were analyzed for all the parameters, identical to a routine sample. Chain of custody procedures were observed during the field sampling and delivery of samples to C&A, and for samples shipped to James Saunders.

Detailed methods and results of QA/QC checks performed on the water quality data from the reservoir for 2002, with comparison between labs, are located in Appendix E. This analysis showed that results from the analytical labs were quite similar. As such, all values reported herein are based on the average of results from both laboratories, unless otherwise noted.

Calculation of Phosphorus Loading

Phosphorus loading to Cherry Creek Reservoir from streams and precipitation was estimated for the 2002 calendar year using data on streamflow and precipitation, and their respective concentrations of phosphorus. Detailed discussion of the streamflow measurements and derivation of loads can be found in Appendix C.

Note that in past reports, CEC used provision (preliminary) inflow estimates from the COE when estimating inflows and loads to the reservoir. In 2002, CEC became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, CEC revised inflow and load estimates for 1992 - 2001 to match the more accurate, and finalized, inflow values from the COE.

Calculation of Long-Term Trends in Cherry Creek Reservoir

Long-term analyses for Secchi depth, total phosphorus, and chlorophyll *a* levels were determined by averaging yearly seasonal (July to September) values from each reservoir site between 1987 and 2002. Yearly values were compared using linear regression analysis (described below). Additionally, annual results were analyzed using a 95% confidence interval. These analyses were used to determine if there were any significant increasing or decreasing trends in Secchi depth, total phosphorus, and chlorophyll *a* levels over time.

Statistical analyses to determine the relationship between total phosphorus concentration and flow, stage discharge relationship, QA/QC between labs, and comparisons of biological and physical parameters for each site were conducted using NCSS 2000 statistical software (Hintze 2001). Natural log transformations were performed to obtain a linear relationship and more constant variance to satisfy assumptions of statistical tests chosen for the different analysis. In most cases, the natural log transformation did not improve the relationship and therefore, the non-transformed values were used in a linear regression to provide estimates of certain data. The least-squares linear regression was used to estimate slope and then an ANOVA was used to determine if the slope was significantly different than zero. A probability level of ≤ 0.05 was used to indicate statistical significance. In the cases of the linear regressions, the R^2 value provided a measure of how well variance is explained by the regression equation. R^2 values measure the proportion of total variation that is explained or accounted for by the fitted regression line, i.e., it is a measure of the strength of the straight-line relationship.

RESULTS AND DISCUSSION

Reservoir Water Quality

Transparency

The whole-reservoir mean Secchi depth varied from a low of 0.62 m in early May and mid-October to a high of 1.09 m in late June. The whole-reservoir mean was 0.91 m (standard deviation of 0.16 m) between July and September 2002. This value is greater than 2001, but lower than 1997 through 2000 (Fig. 2). The whole-reservoir mean maximum depth of 1% light transmittance ranged from a high of 3.75 m in mid-July to a low of 1.23 m in late August. Deepest recorded 1% transmittance values were observed March - July (mean = 3.31 m, median = 3.50 m). The whole-reservoir mean 1% transmittance depth was 2.84 m (standard deviation of 0.91 m) between July and September 2002. No significant relationship could be determined between Secchi depth, chlorophyll *a*, and 1% transmittance concentrations and phytoplankton densities (Fig. 3).

Long-Term Secchi Transparency Trends in Cherry Creek Reservoir

In general, seasonal mean (July to September) Secchi depths increased from 1987 to 1996, then decreased from 1996 to 2002. There is not, however, a statistically significant long-term upward or downward trend ($p > 0.05$, $R^2 = 0.07$) for seasonal mean Secchi depths over the period of record (Fig. 2).

Dissolved Oxygen and Temperature

Analysis of past Cherry Creek Reservoir temperature profiles indicates that stratification occurs when there is a >2EC difference between surface and bottom temperatures (Jones 1998). Differences of approximately 1EC suggest a recent mixing event (Jones 1998). Using the above criteria, Cherry Creek Reservoir was investigated for periods of potential stratification and anoxic levels (Figs. 4 - 9).

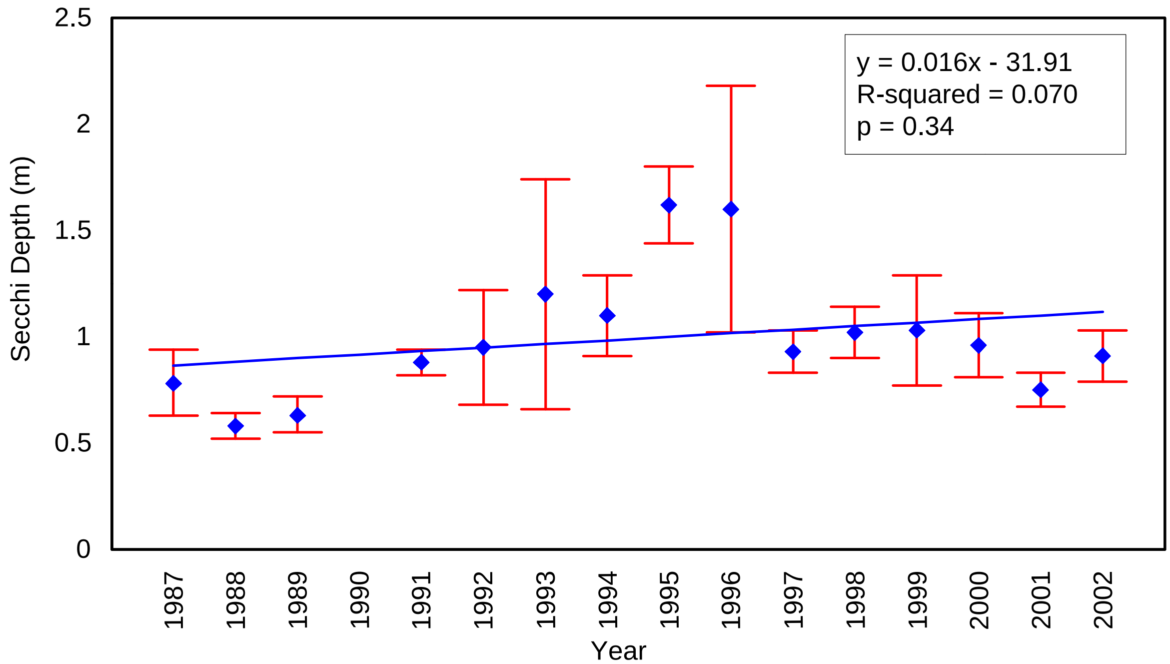


FIGURE 2: Seasonal mean (July to September) Secchi depths (m) measured in Cherry Creek Reservoir (1987 to 2002). Error bars represent a 95% confidence interval around each mean.

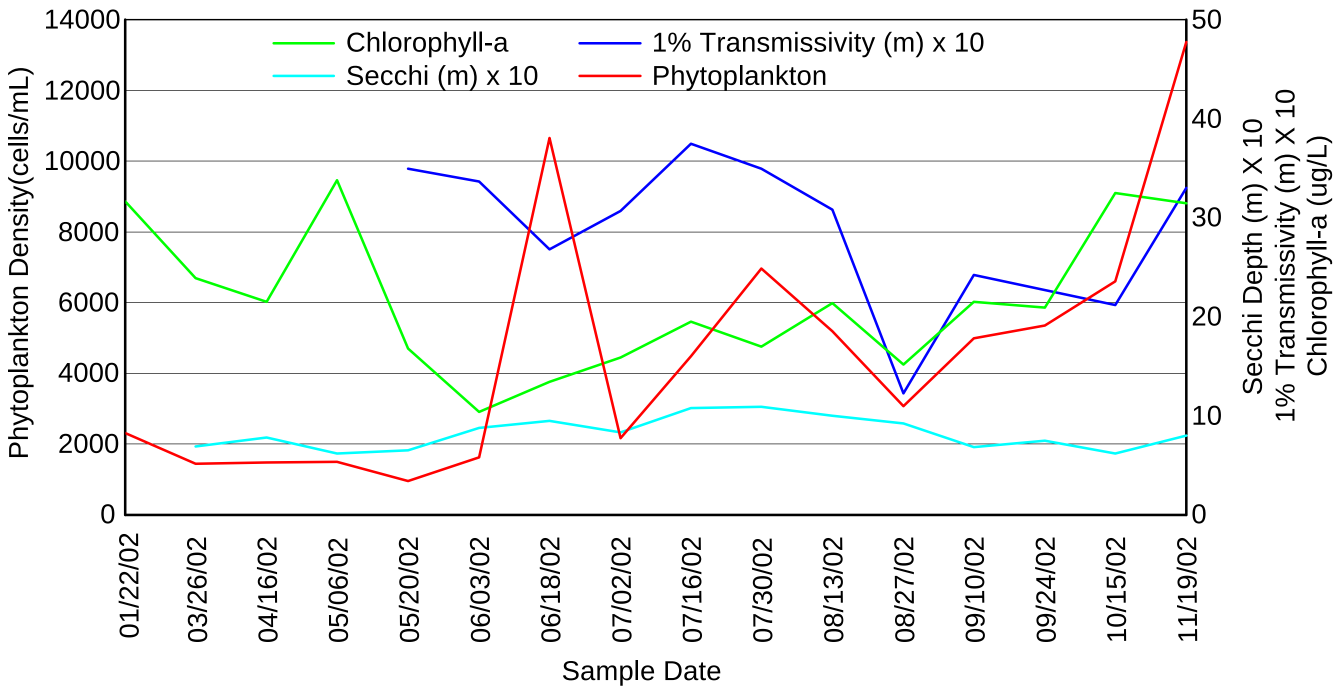


FIGURE 3: Relationship between phytoplankton density, Secchi depth (× 10), 1% transmissivity (× 10), and chlorophyll *a* in Cherry Creek Reservoir, 2002.

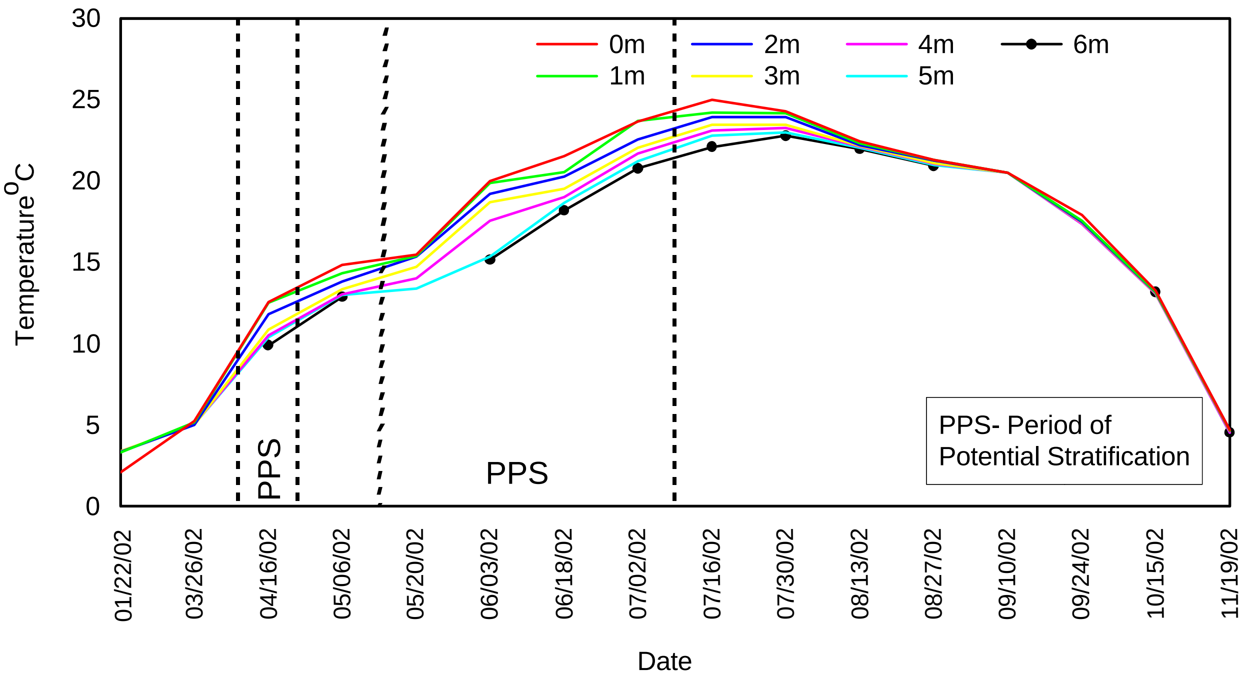


FIGURE 4: Temperature (EC) profiles recorded during routine monitoring at Site CCR-1 in 2002.

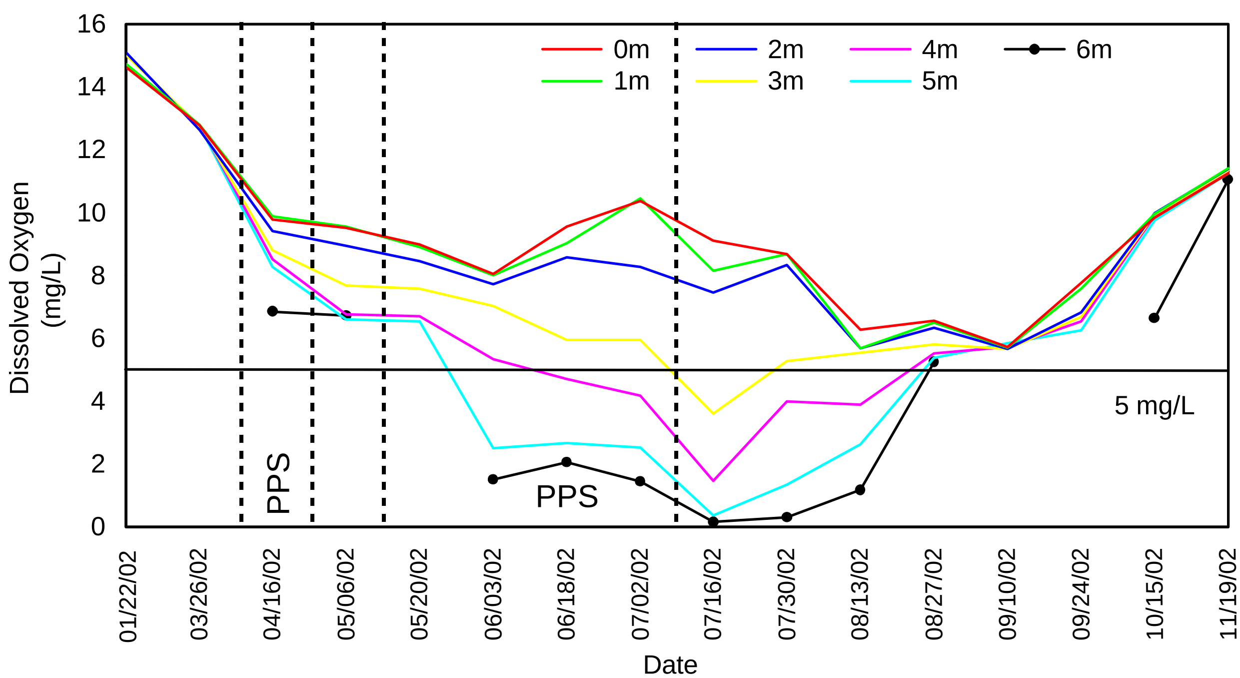


FIGURE 5: Dissolved oxygen (mg/L) profiles recorded during routing monitoring at Site CCR-1 in 2002.

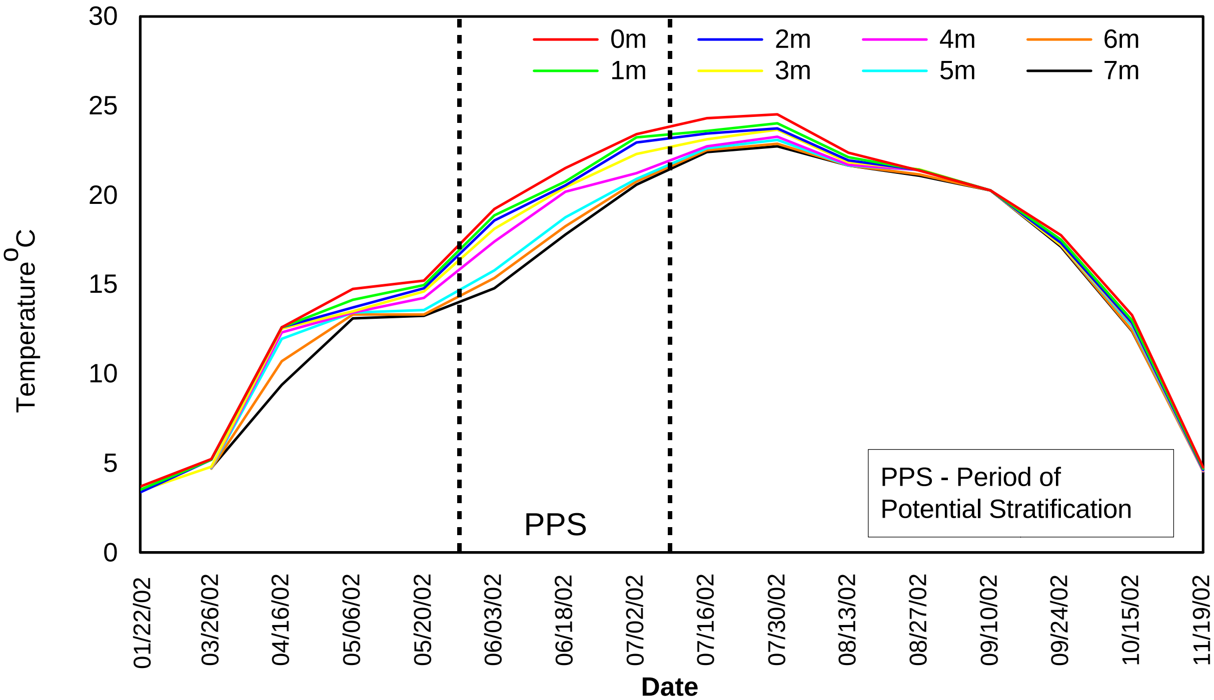


FIGURE 6: Temperature (EC) profiles recorded during routine monitoring at Site CCR-2 in 2002.

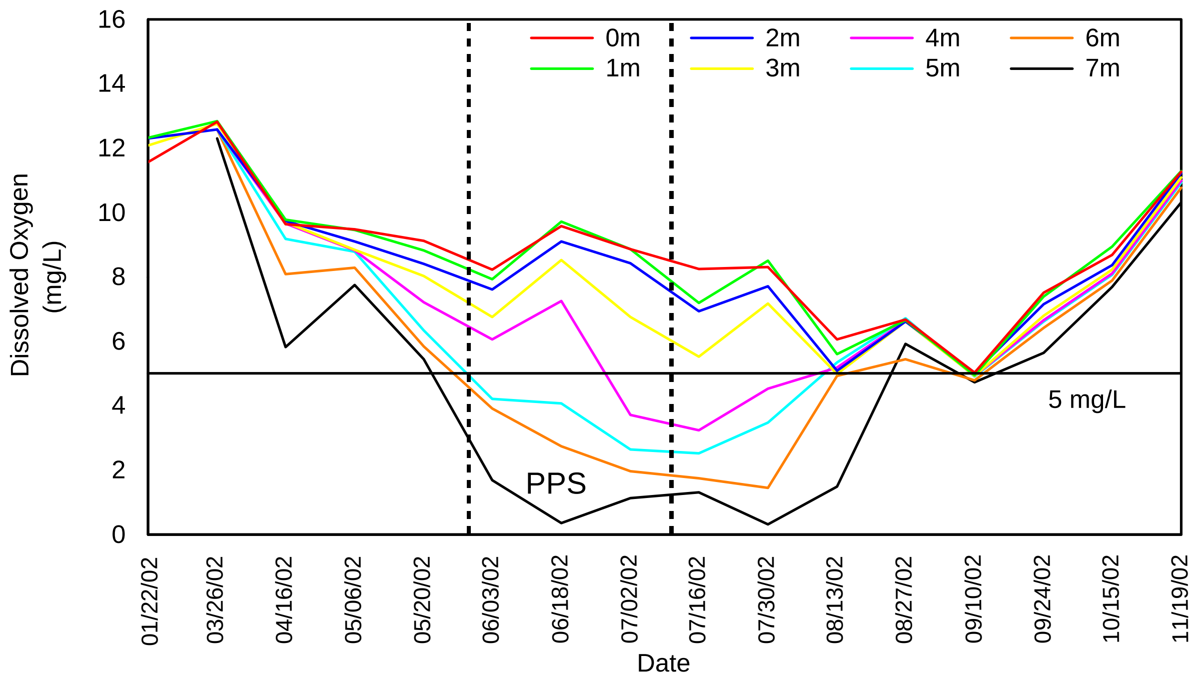


FIGURE 7: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-2 in 2002.

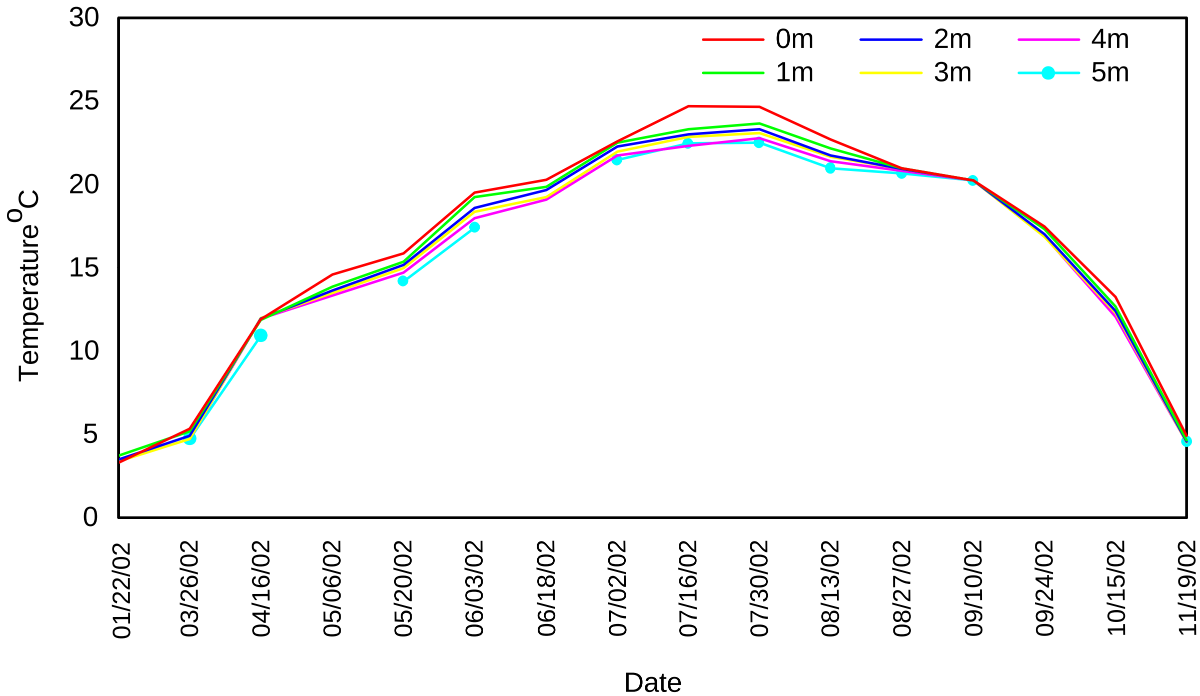


FIGURE 8: Temperature (EC) profiles recorded during routine monitoring at Site CCR-3 in 2002.

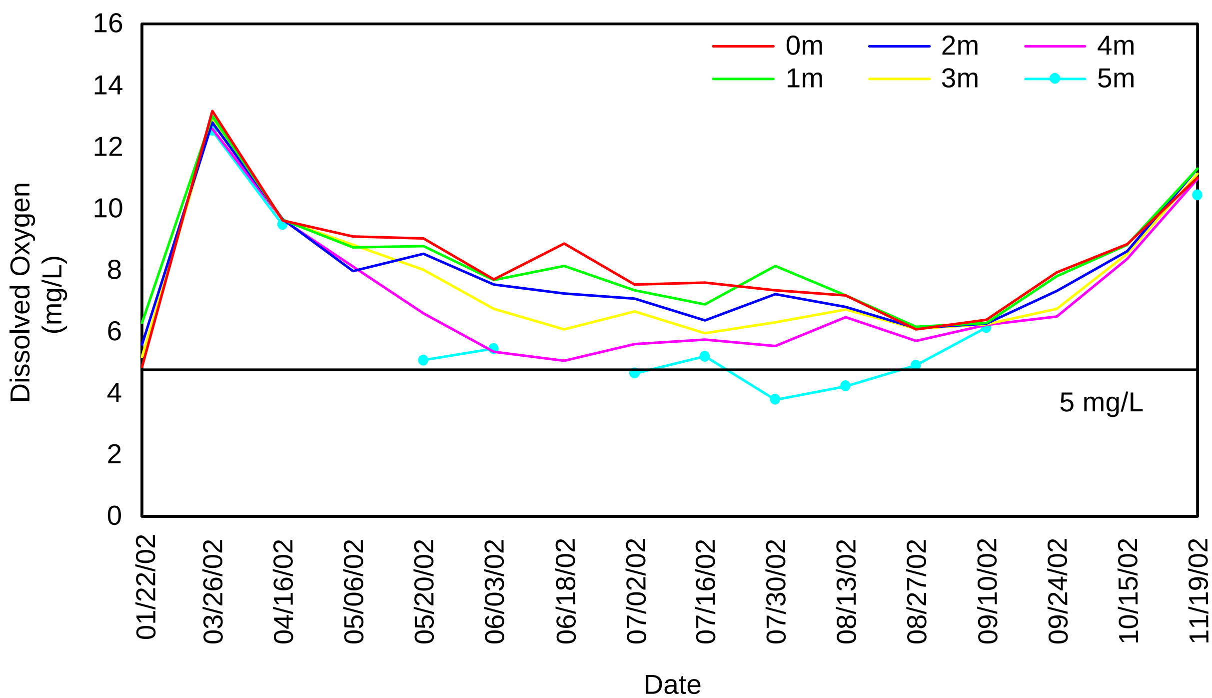


FIGURE 9: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-3 in 2002.

The temperature in Cherry Creek Reservoir ranged from a high of 25.01EC in mid-July to a low of 2.11EC in late January. As in previous years, periods of thermal stratification were observed in the reservoir. These stratification periods were observed at Sites CCR-1 and CCR-2 (Figs. 4 and 6). No periods of stratification were observed at Site CCR-3, which is a much shallower site (Fig. 8). The first period of potential stratification at Site CCR-1 occurred during April, while the second period of stratification occurred from mid-May through early July. One period of potential stratification was observed at Site CCR-2, lasting from late May to early July.

The concentration and depth distribution of dissolved oxygen were similar at the two deep-water sites, CCR-1 and CCR-2 (Figs. 5 and 7). The DO concentrations at Site CCR-3 followed the same trend as was observed at the deep-water sites, but because of the lesser stratification and shallow depth at this site, the magnitude of DO change was less than that at the deep-water sites (Fig. 9).

The reservoir was examined for periods of depressed dissolved oxygen levels, those below 5 mg/L. This value has been set by the Colorado Department of Public Health and Environment ([CDPHE] 2001) as the year round warmwater aquatic life standard. For lakes, this criteria is intended to apply to the upper levels when the lake is stratified, i.e., the epilimnion and metalimnion (CDPHE 2000). As such, during those periods when the lake appears to be stratified (i.e., greater than a 2EC difference from surface to bottom), the 5 mg/L criteria would apply primarily to the middle and upper depths (perhaps 4-5 m). However, the 5 mg/L standard applies throughout the water column during mixed conditions.

DO concentrations were highest in the spring, fall, and winter as would be expected. During periods of stratification, the lower layers of the reservoir experienced depressed DO concentrations. At Site CCR-1, the DO concentration dropped below 5.0 mg/L at levels at and below 4 m from mid-June to mid-August. This DO depression extended as shallow as 3 m during mid-July at Site CCR-1. Similar concentrations were observed at Site CCR-2 at levels at and below 6 m from early June to mid-August. Additionally, concentrations below 5.0 mg/L were observed at 4 m through the month of July and at 5 m from early June to late July. During July, which had extensive periods with DO < 5 mg/L in the deeper waters, 17.7% of the whole-lake volume experienced DO depletion below 5.0 mg/L. DO depletion occurred in no more than 8.8% of the whole-lake volume for the rest of the year at Site CCR-2. One extended period of DO depletion was observed at Site CCR-3. This occurred from late July to late August.

Reservoir Nutrients

Monitoring at Cherry Creek Reservoir has focused on the concentrations of phosphorus and nitrogen. Phosphorus and nitrogen are inorganic nutrients in aquatic systems and are necessary for life. Often, these nutrients are the limiting factor in the growth of algae (Cole 1979, Goldman and Horne 1983, Wetzel 2001, Cooke *et al*. 1993). Excessive amounts of these nutrients in aquatic systems may result in algal blooms which create aesthetic problems as well as potentially hazardous conditions for aquatic life.

In 2002, the whole reservoir mean concentration of total phosphorus in the photic zone ranged from 54 to 95 µg/L with an overall annual mean of 70 µg/L (Fig. 10). Between July and September the concentration of total phosphorus in the photic zone ranged from 58 to 90 µg/L, with a mean of 74 µg/L. These values are similar to those observed in 1997 through 2001 (Table 3). Although some peak values appeared related to inflow events (e.g., late September), others occurred during periods of no significant inflow (e.g., early May and July). Over the year, total phosphorus concentration in the photic zone was not significantly related to inflow ($p > 0.05$, $R^2 = 0.25$).

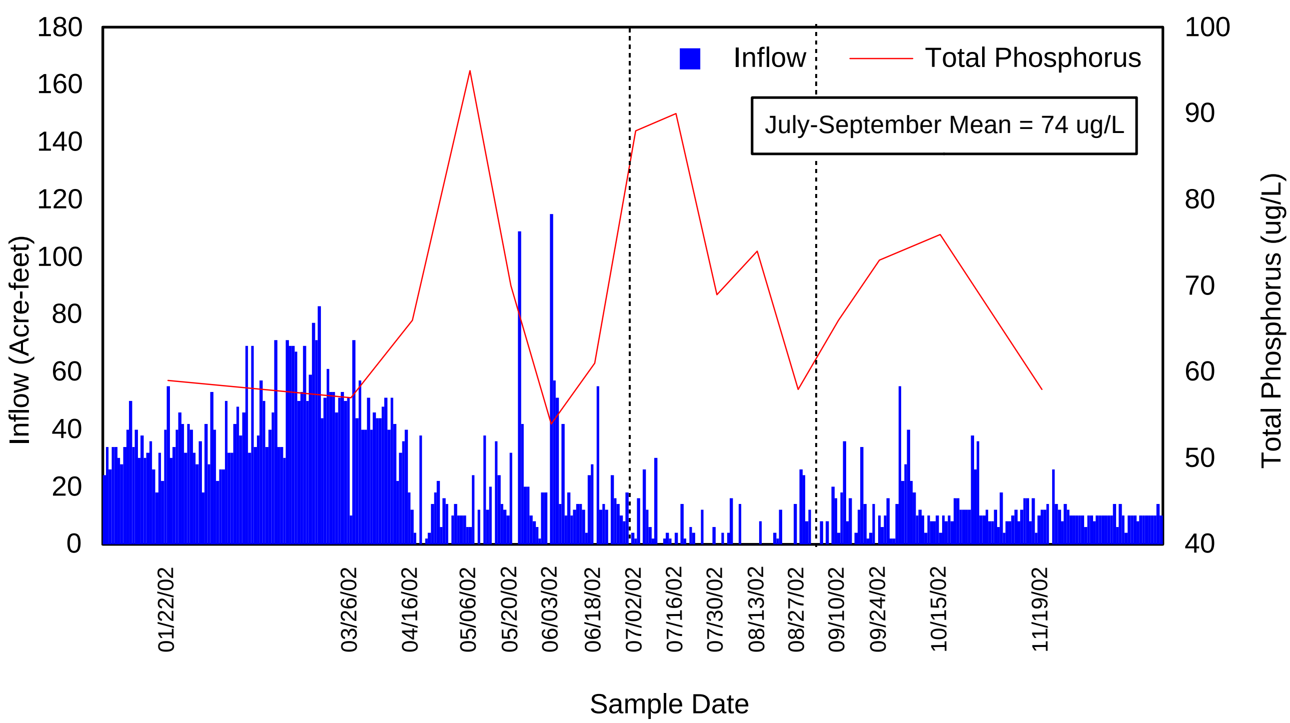


FIGURE 10: Relationship between TP (µg/L) and inflow (AF) in Cherry Creek Reservoir, 2002.

TABLE 3: Comparison of annual mean (monitoring period) and July-September mean phosphorus, nitrogen, and chlorophyll *a* levels in Cherry Creek Reservoir, 1987-2002. Annual means based on January through December sampling.

Year	Source of Data	Total Nitrogen (µg/L)		Total Phosphorus (µg/L)		Mean Chlorophyll *a* (µg/L)	
		Annual	July-Sept.	Annual	July-Sept.	Annual	July-Sept.
1987	In-Situ 1987	1,580	741	86	93	11.1	8.3
1988	In-Situ 1988	902	1,053	52	49	21.8	31.8
1989	ASI 1990	803	828	45	39	8.5	5.6
1990	ASI 1991a	600	--	58	55	2.3	8.6
1991	ASI 1991b	1,067	1,237	86	56	9.7	9.8
1992	ASI 1993	790	970	54	66	12.1	17.0
1993	ASI 1994a	790	826	50	62	12.5	14.4
1994	CEC 1995	1,134	1,144	86	59	8.8	10.0
1995	CEC 1996	910	913	48	48	10.2	9.4
1996	CEC 1997	889	944	54	62	16.9	20.5
1997	CEC 1998	976	1,120	75	96	16.1	22.3
1998	CEC 1999	850	880	82	89	20.4	26.5
1999	CEC 2000	715	753	80	81	20.8	28.9
2000	CEC 2001	784	802	81	81	22.0	25.2
2001	CEC 2002	740	741	81	87	26.7	26.1
2002	Present Study	847	858	70	74	21.7	18.8
Long-term average		899	921	68	69	15.1	17.7
Median 849		880	73	64	14.3	17.9	

Regression analyses were also performed to determine if correlations exist between total phosphorus and other parameters measured in the reservoir. The whole reservoir mean concentration of phosphorus in the photic zone was not significantly ($P > 0.05$) related to chlorophyll *a* (slope = 0.13, $R^2 = 0.05$), Secchi depth (slope = 0.00, $R^2 = 0.00$), 1% transmittance (slope = 0.02, $R^2 = 0.09$), or phytoplankton density (slope = -53.7, $R^2 = 0.04$).

Nutrient profile samples collected in 2002 showed a well-mixed reservoir in spring and fall (Fig. 11). It appears there were brief periods of nutrient release from bottom sediments through the summer as evidenced by increasing TP concentrations with increasing depth (Fig. 11), despite little or no surface inflow to the reservoir (Fig. 10).

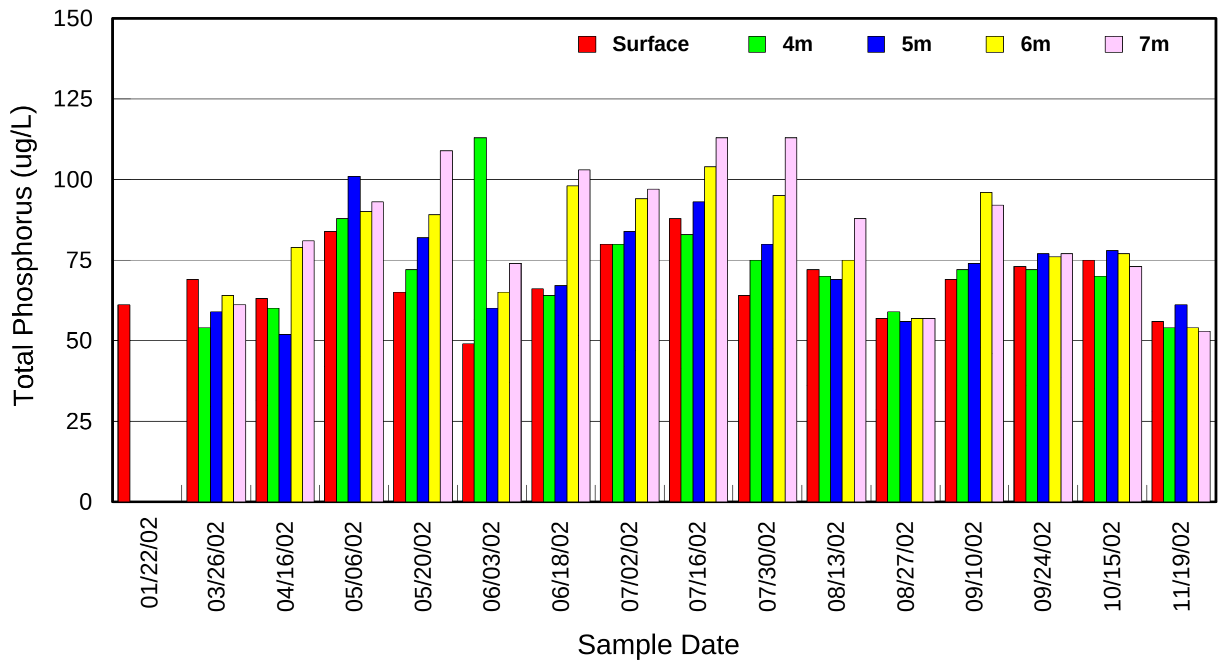


FIGURE 11: Phosphorus concentrations from profile samples at Site CCR-2, Cherry Creek Reservoir, 2002.

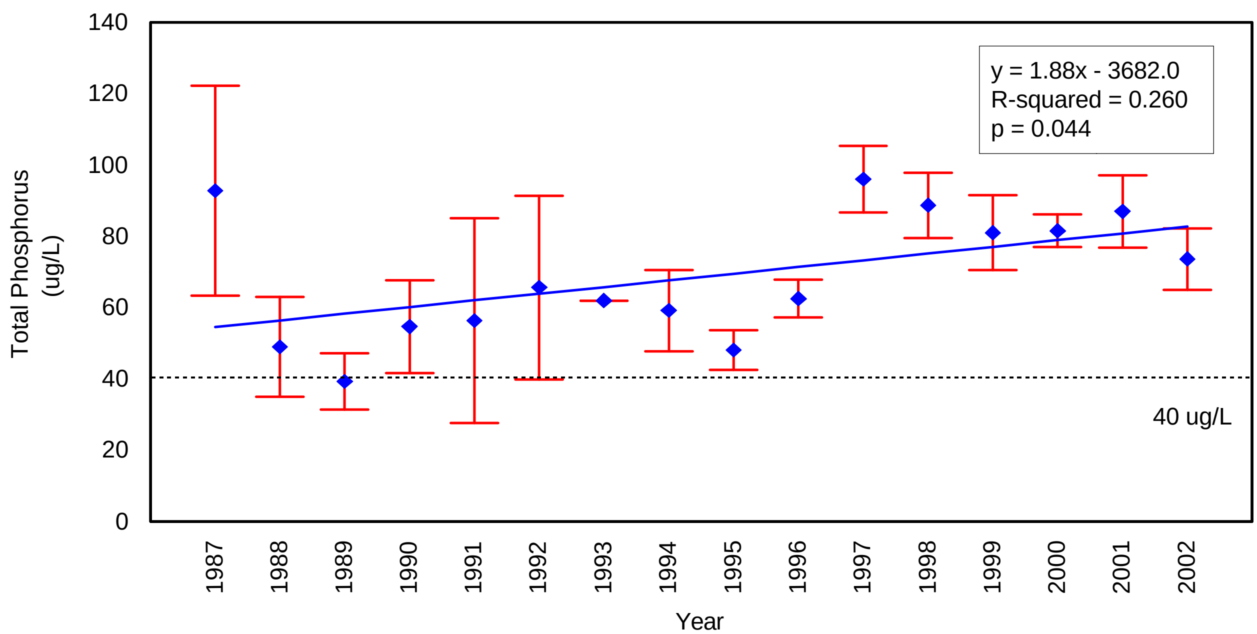


FIGURE 12: Seasonal mean (July to September) total phosphorus concentrations (μg/L) measured in Cherry Creek Reservoir, 1987-2002. Error bars represent a 95% confidence interval around each mean.

The whole reservoir mean concentration of total nitrogen in the photic zone ranged from 642 to 1,107 µg/L, with a mean of 847 µg/L in 2002 (Table 3). During the July to September period the whole reservoir mean total nitrogen concentration ranged from 682 to 1,107 µg/L, with a mean concentration of 858 µg/L (Table 3). Total nitrogen was not significantly ($P > 0.05$) related to chlorophyll *a* (slope = 0.00, $R^2 = 0.00$) or Secchi depth (slope = 0.00, $R^2 = 0.07$).

Long-Term Phosphorus Trends in Cherry Creek Reservoir

Routine monitoring data collected since 1987 indicates a generally increasing trend in summer mean concentration of total phosphorus (Fig. 12). In 2002, the summer mean concentration of total phosphorus was 74 µg/L. This value is lower than the 1999 and 2000 value of 81 µg/L, and the 2001 value of 87 µg/L. Statistical analyses performed on 1987-2002 seasonal mean TP data indicates a significant ($p = 0.044$, slope = 1.88, $R^2 = 0.26$) upward trend. There appears to be a slight decreasing trend in July - September mean TP over the past six years (Fig. 12). With the exception of 1989, seasonal mean TP values in Cherry Creek Reservoir have consistently exceeded the goal of 40 µg/L.

Chlorophyll *a* Levels

The mean whole reservoir concentration of chlorophyll *a* showed a general decreasing trend from January through mid-April (Fig. 13). Concentrations spiked to their highest annual level in early May (33.8 µg/L). Following the spike, concentrations of chlorophyll *a* dropped until mid-June. From mid-June through December, concentrations of chlorophyll *a* showed a general increasing trend. The reservoir experienced its lowest concentration, 10.4 µg/L, in early June. The annual mean chlorophyll *a* concentration of 21.7 µg/L is lower than the 2001 value (26.7 µg/L). The July to September mean chlorophyll *a* concentration of 18.8 µg/L was the lowest value observed since 1995 (Table 3), but still exceeded the standard of 15 µg/L chlorophyll *a* for the reservoir.

Long-Term Chlorophyll *a* Trends in Cherry Creek Reservoir

July to September mean chlorophyll *a* concentrations have met the standard of 15 µg/L four out of the past 16 years (Fig. 14). Since 1987, there has been a slight but insignificant ($p > 0.05$) increasing trend

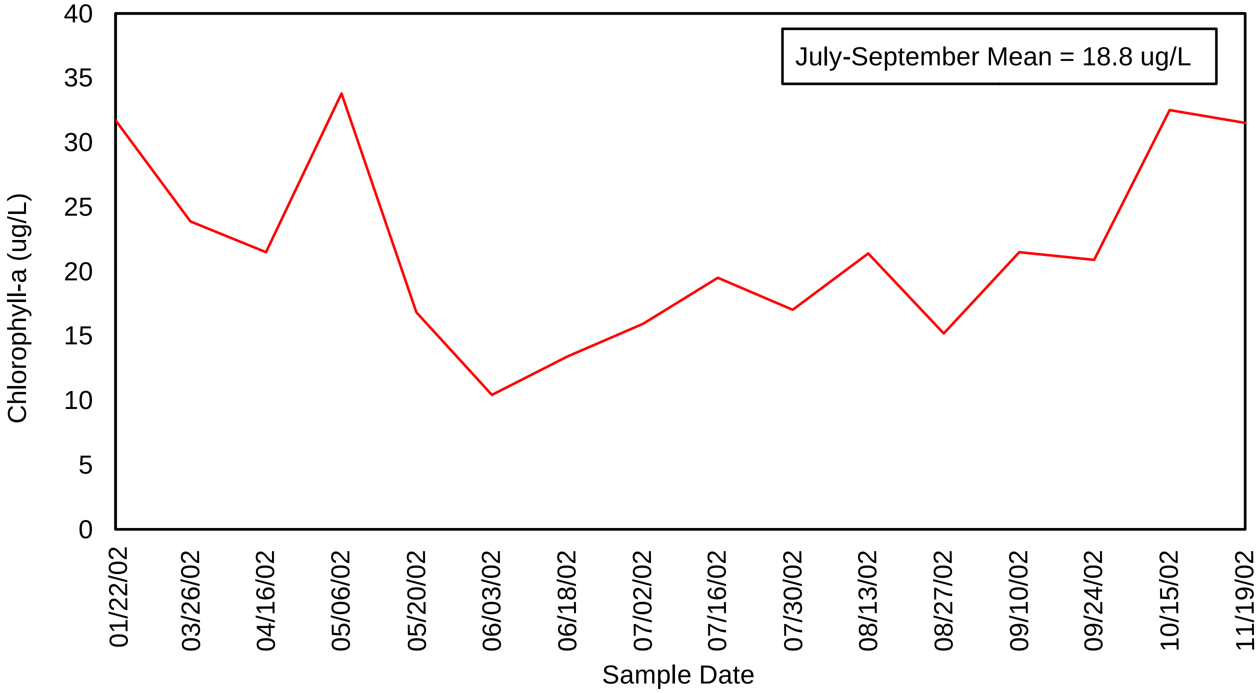


FIGURE 13: Concentration of chlorophyll *a* (µg/L) in Cherry Creek Reservoir, 2002.

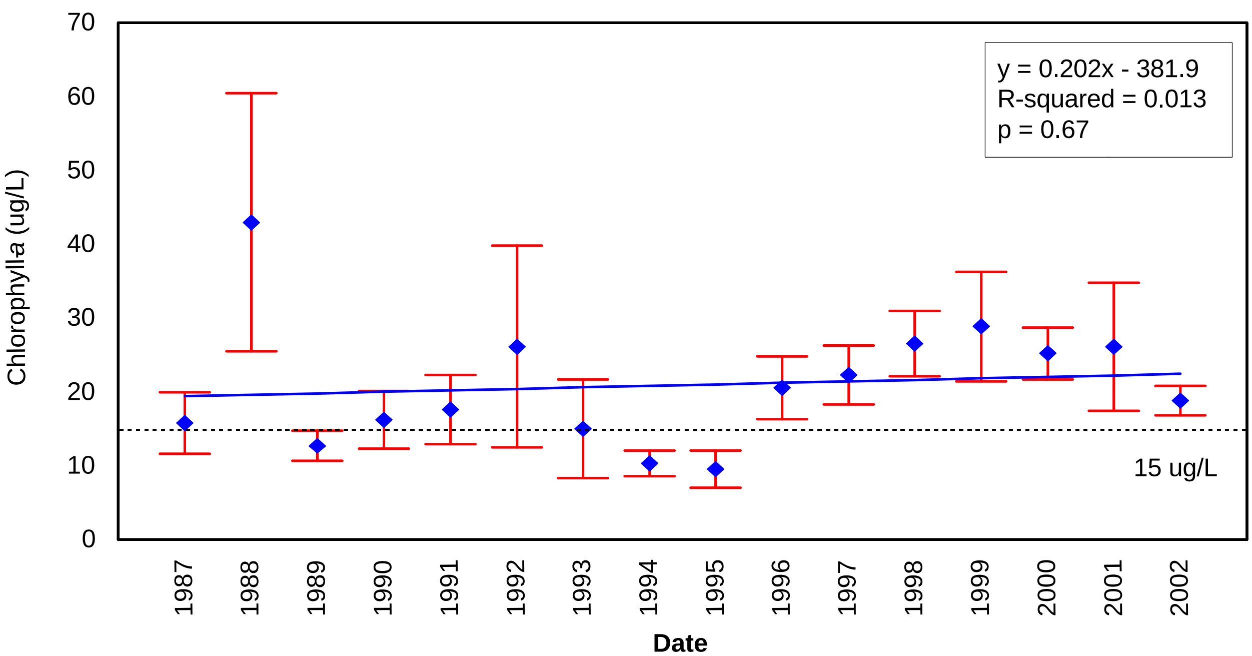


FIGURE 14: Seasonal mean (July to September) chlorophyll *a* concentrations measured in Cherry Creek Reservoir, 1987 to 2002. Error bars represent 95% confidence interval around each mean.

(slope = 0.20, R^2 = 0.013) in the July-to-September mean concentration of chlorophyll *a* in Cherry Creek Reservoir (Fig. 14). To obtain further statistical analysis of these data, a one-way analysis of variance was performed. Results of this test indicate that there is no statistically significant difference between seasonal mean chlorophyll *a* concentrations, from 1996 through 2002.

Reservoir Biology

Phytoplankton

Phytoplankton Populations

The photic density of phytoplankton in Cherry Creek Reservoir ranged from 947 cells/mL on May 20 to 13,366 cells/mL on November 19 (Table 4). The number of taxa present in the reservoir ranged from a low of 14 on April 16, and reached a high of 32 on October 15. Phytoplankton abundances were highest in the spring, summer, and fall months. Annually, the community was dominated by green algae. Diatoms were the second most prevalent group. The June and November spikes do not appear to be related to a concurrent total phosphorus concentration spike (Fig. 15). Regression analysis found no significant correlation ($p > 0.05$) between phytoplankton density and total phosphorus concentration during 2002. Additionally, no significant relationship could be determined between phytoplankton density and chlorophyll *a* or total nitrogen concentrations.

Historical Phytoplankton

The phytoplankton community was dominated by green algae in 2002 (Table 5). The proportion of total phytoplankton abundance accounted for by green algae in 2002 (44%) was greater than all values dating back to 1984. Additionally, the proportions of the phytoplankton community comprised by diatoms, dinoflagellates, and cryptomonads were greater than all values observed since 1984. The proportions of the community made up of golden brown algae and euglenoids were similar to those observed in recent years. Historically, micro blue-green algae have dominated the phytoplankton community in Cherry Creek Reservoir. In 2002, the blue-green algae comprised only 21% of the phytoplankton community.

TABLE 4: Density (cells/mL) of phytoplankton and total number of taxa collected from all three sites on Cherry Creek Reservoir, 2002.

Taxa	22 Jan	26 Mar	16 Apr	6 May	20 May	3 June	18 June	2 July	16 July
Diatoms									
Centrics	0	33	96	139	62	35	136	69	149
Pennates	34	109	53	56	34	9	54	42	409
Green Algae	1,665	984	712	998	586	635	902	1,542	2,690
Blue-Green Algae	0	0	0	0	0	487	7,927	83	297
Golden-Brown Algae	0	11	0	0	0	9	0	0	0
Euglenoids	87	11	0	9	0	0	0	0	19
Dinoflagellates	52	11	0	0	20	96	1,448	262	575
Cryptomonads	417	271	626	279	245	357	192	152	352
Miscellaneous	52	11	0	19	0	0	0	14	0
Total Density	**2,307**	**1,441**	**1,487**	**1,500**	**947**	**1,628**	**10,659**	**2,164**	**4,491**
Total Taxa	**15**	**19**	**14**	**22**	**18**	**20**	**16**	**20**	**21**

Taxa	30 July	13 Aug.	27 Aug.	10 Sept.	24 Sept.	15 Oct.	19 Nov.
Diatoms							
Centrics	313	327	229	781	421	515	1,004
Pennates	920	267	105	251	240	396	8,352
Green Algae	1,214	2,315	2,235	3,564	3,396	4,707	3,425
Blue-Green Algae	4,248	1,484	84	84	90	277	0
Golden-Brown Algae	20	30	42	28	120	119	167
Euglenoids	20	59	21	56	30	40	0
Dinoflagellates	157	119	63	0	0	40	251
Cryptomonads	78	534	292	223	1,052	435	167
Miscellaneous	0	59	0	0	0	79	0
Total Density	**6,970**	**5,194**	**3,071**	**4,987**	**5,349**	**6,608**	**13,366**
Total Taxa	**25**	**26**	**24**	**26**	**24**	**32**	**17**

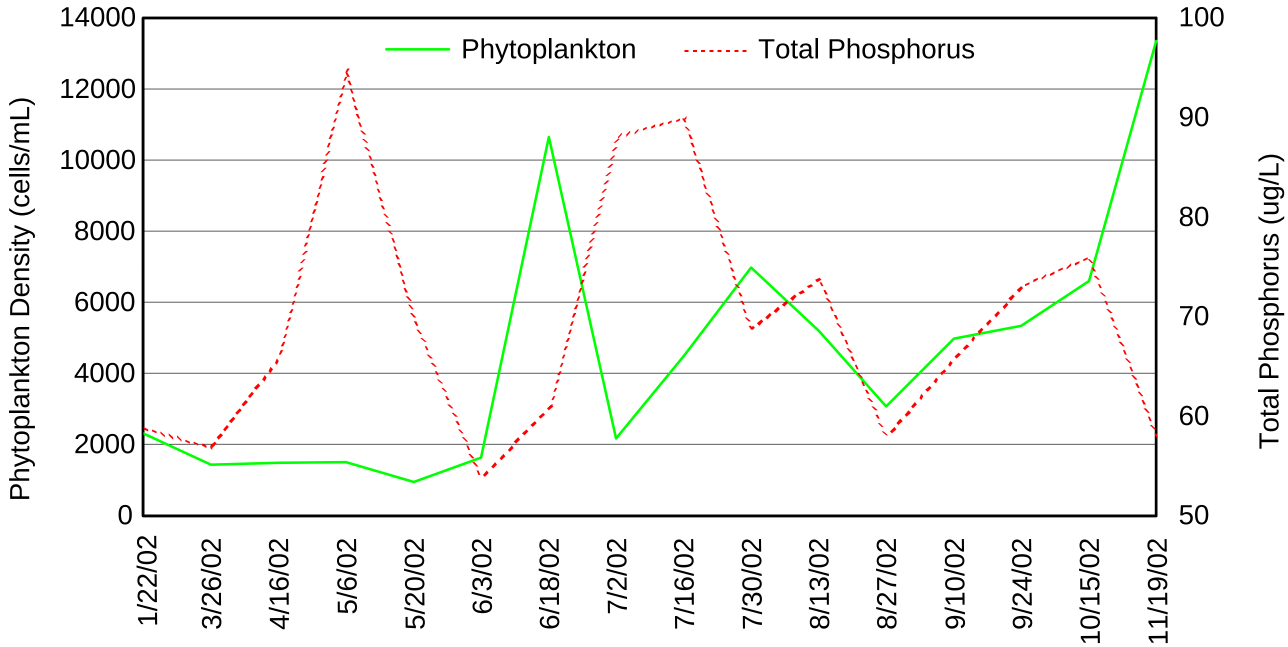


FIGURE 15: Comparison of photic phytoplankton densities from the three reservoir sampling sites to mean total phosphorus concentrations from three sites in Cherry Creek Reservoir, 2002.

Fish Populations

Historically, the fish community in Cherry Creek Reservoir has been composed of many species, including omnivores, insectivores, zooplanktivores, and piscivores. Fish can exert a strong influence on the structure and productivity of phytoplankton and zooplankton communities through food web pathways between different levels (phytoplankton, zooplankton, and fish) of the aquatic ecosystem (Carpenter *et al.* 1985). In addition, these trophic dynamics can affect the variability, distribution, and ratios of limiting nutrients, such as phosphorus and nitrogen (Vanni *et al*. 1996). Mechanisms that may possibly result because of fish predation include decreased herbivory by zooplankton when fish are abundant, modification of nutrient recycling rates by herbivorous zooplankton as fish abundance varies, and nutrient recycling by fish (Vanni and Layne 1996).

TABLE 5: Reservoir mean phytoplankton density (cells/mL) and number of taxa in Cherry Creek Reservoir, 1984 to 2002.

Density, Richness	1984	1985	1986	1987	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Blue-Green Algae																		
Density	71,780	66,496	99,316	168,259	155,180	273,175	307,691	77,516	15,708	10,015	18,194	16,599	19,716	44,951	15,263	164,290	148,691	941
Taxa Richness	7	7	6	18	24	24	14	16	7	3	7	9	10	11	8	19	12	3
Green Algae																		
Density	5,864	11,760	25,595	11,985	19,177	55,415	18,688	41,899	1,198	314	355	738	2,461	1,809	898	43,881	33,217	1,973
Taxa Richness	11	10	13	58	76	66	46	48	16	2	11	11	1,518	18	18	71	56	27
Diatoms																		
Density	1,776	3,863	5,428	10,677	12,880	9,311	4,160	1,243	946	194	2,189	2,354	1,109	628	838	12,019	5,256	978
Taxa Richness	6	4	7	34	30	31	21	11	15	2	15	13	8	18	16	34	22	24
Golden-Brown Algae																		
Density	--	7	125	469	56	505	821	93	158	3	63	249	227	56	--	391	1,346	34
Taxa Richness	--	1	1	6	4	7	5	4	1	1	2	4	2	2	--	14	13	3
Euglenoids																		
Density	514	135	208	251	276	108	89	23	231	196	304	409	838	698	1,252	126	91	22
Taxa Richness	2	1	1	9	9	6	3	5	2	1	2	3	3	3	1	6	4	3
Dinoflagellates																		
Density	--	13	19	19	83	28	23	54	--	31	5	21	--	18	45	80	157	193
Taxa Richness	--	1	1	2	4	3	2	2	--	1	2	4	--	2	2	8	6	5
Cryptomonads																		
Density	1,513	718	1,113	1,090	2,689	1,689	628	529	332	450	919	1,104	1,487	1,393	559	2,472	2,851	355
Taxa Richness	2	3	3	6	4	5	2	3	1	1	1	1	1	1	1	4	6	4
Miscellaneous																		
Density	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,923	5,714	15
Taxa Richness	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	1
Total Density	**81,447**	**82,992**	**131,804**	**192,750**	**190,341**	**340,231**	**329,773**	**121,357**	**18,573**	**11,203**	**22,029**	**21,474**	**25,838**	**49,453**	**18,855**	**225,182**	**197,323**	**4,510**
Total Taxa	**28**	**27**	**32**	**133**	**151**	**142**	**93**	**89**	**42**	**11**	**40**	**45**	**39**	**55**	**46**	**157**	**120**	**70**

Stocking data from the Colorado Division of Wildlife (CDOW) shows that ten species and two hybrids have been stocked in Cherry Creek Reservoir from 1985 to 2002 (Table 6). The two stocked hybrids were the wiper, a cross between the striped bass and the white bass, and the tiger musky, a cross between a northern pike and a muskellunge. Of these 12 stocked fish taxa, rainbow trout and walleye have been stocked every year. Channel catfish were stocked every year until 2002. Only three fish species were stocked in 2002 (Table 6).

The size of stocked fish has been variable both between species and within a given species. For example, channel catfish are stocked as fingerlings, rainbow trout as juveniles and adults, and walleye as fry (Table 6). Tiger musky are stocked as juveniles. Wipers have been stocked mostly as fry, but the CDOW did stock 10-inch long wipers in 1992. Other popular gamefish species stocked in smaller quantities and less regular intervals included largemouth bass and bluegill.

The CDOW did not conduct any fish population sampling in Cherry Creek Reservoir in 2002. The Division had planned to sample every two to three years, but has not yet fulfilled that goal.

TABLE 6: Quantity and size of fish stocked in Cherry Creek Reservoir, 1985 to 2002.

Year	Species	Size (inches)	Number
1985	Black crappie	5	7,234
	Channel catfish	2-8	116,784
	Rainbow trout	8-12	75,753
	Walleye	0.3	2,346,000
	Yellow perch	2	90,160
1986	Bluegill	1	111,968
	Channel catfish	4	25,594
	Cutthroat trout	6	52,228
	Rainbow trout	2-18	414,136
	Tiger musky	5-6	4,723
	Walleye	0.3	1,734,000
	Wiper	0.2	80,000
1987	Bluegill	0.2	70,000
	Channel catfish	4	25,600
	Largemouth bass	5	10,000
	Rainbow trout	2-26	129,715
	Tiger musky	7	4,000
	Walleye	0.2	1,760,000
1988	Channel catfish	3	16,000
	Largemouth bass	5	10,000
	Rainbow trout	9-10	293,931
	Tiger musky	8	4,500
	Walleye	0.2	1,760,000
1989	Channel catfish	2-4	10,316
	Largemouth bass	6	8,993
	Rainbow trout	8-22	79,919
	Walleye	0.2	1,352,000
	Wiper	0.2	99,000
1990	Channel catfish	3-4	25,599
	Rainbow trout	9-15	74,986
	Tiger musky	8	2,001
	Walleye	0.2	1,400,000
	Wiper	1	8,996
1991	Channel catfish	3	13,500
	Rainbow trout	9-10	79,571
	Tiger musky	5-8	6,500
	Walleye	0.2	1,300,000
	Wiper	1	9,000
1992	Blue catfish	3	9,000
	Channel catfish	4	13,500
	Rainbow trout	9-10	101,656
	Tiger musky	7	4,940
	Walleye	0.2	2,600,000
	Wiper	10	15,520
1993	Channel catfish	4	13,500
	Rainbow trout	9-10	92,601
	Tiger musky	9	4,500
	Walleye	0.2	2,600,000
	Wiper	1	9,003

TABLE 6: Continued.

Year	Species	Size (inches)	Number
1994	Blue catfish	3	21,000
	Channel catfish	4	23,625
	Cutthroat trout	9	9,089
	Flathead catfish	1	148
	Tiger musky	8	900
	Walleye	0.2	2,600,000
	Wiper	1-4	26,177
	Rainbow trout	9-18	62,615
1995	Channel catfish	4	18,900
	Rainbow trout	9-20	139,242
	Tiger musky	8	4,500
	Walleye	0.2	2,600,000
	Wiper	1	4,500
1996	Channel catfish	3	8,100
	Cutthroat trout	9-10	85,802
	Tiger musky	7	3,500
	Rainbow trout	4-22	163,007
	Walleye	0.2	3,202,940
	Wiper	1	8,938
1997	Channel catfish	3	13,500
	Cutthroat trout	3-9	22,907
	Rainbow trout	10-24	74,525
	Tiger musky	6	4,500
	Walleye	0.2	2,600,000
	Wiper	1	9,000
1998	Channel catfish	4	7,425
	Rainbow trout	10-12	59,560
	Tiger musky	7	4,000
	Walleye	1.5	40,000
	Wiper	1.3	9,000
1999	Channel catfish	3.5	13,500
	Rainbow trout	10-19	32,729
	Tiger musky	7	3,000
	Walleye	0.2	2,400,000
	Wiper	1.3	9,000
2000	Channel catfish	4.1	13,500
	Northern pike	–	46
	Rainbow trout	4.5-20.3	180,166
	Rainbow/Cutthroat trout hybrid	–	5,600
	Tiger musky	8	4,086
	Walleye	0.23	2,400,000
2001	Channel catfish	3.5	13,500
	Rainbow trout	10-19	23,065
	Tiger musky	7	4,000
	Walleye	0.2	2,400,000
2002	Rainbow trout	10	13,900
	Tiger musky	7	4,000
	Walleye	0.2	2,519,660

Phosphorus Concentration in Streams

The mean annual concentration of total phosphorus ranged from a low of 51 µg/L at CT-P2 to a high of 205 µg/L at CC-10 (Table 7). At most stream sites, the summer (July to September) mean concentration of total phosphorus was higher than the annual mean. The summer mean concentration of total phosphorus ranged from a low of 66 µg/L at Site CT-1 to a high of 180 µg/L at Site SC-3. As expected, the concentration of total phosphorus measured in the storm flows in these streams was considerably higher than that observed under base flow conditions. The mean concentration of total phosphorus in storm samples ranged from a low of 208 µg/L at Site CT-P1 to a high of 287 µg/L at Site CT-1.

TABLE 7: Comparison of mean baseflow and mean stormflow concentrations of total phosphorus (TP) and total suspended solids (TSS) in tributaries to Cherry Creek Reservoir, 2002.

	Baseflow				Stormflow	
	Summer		Annual		May - September	
Stream, Site	TP (µg/L)	TSS (mg/L)	TP (µg/L)	TSS (mg/L)	TP (µg/L)	TSS (mg/L)
Cherry Creek						
CC-10	176	36	205	34	253	41
CCO	96	31	91	27	--	--
Cottonwood Creek						
CT-1	66	26	63	35	287	293
CT-2	103	64	98	67	221	99
CT-P1	94	34	68	26	208	112
CT-P2	83	37	51	27	229	125
Shop Creek						
SC-3	180	20	187	15	214	21

Long-Term Trends in Phosphorus Concentrations in Cherry Creek Reservoir Tributaries

Additional analyses were performed on data from the three main tributaries at Cherry Creek Reservoir (Sites CC-10, SC-3, and CT-2) to determine trends in phosphorus and orthophosphate concentrations from 1995 to 2002. Over this period, mean phosphorus concentration was highest at Site CC-10 (232 µg/L) and lowest at Site CT-2 (101 µg/L) (Table 8). Mean orthophosphate concentration was also highest at Site CC-10

(182 µg/L) and lowest at Site CT-2 (46 µg/L). Orthophosphate comprised 78% of the total phosphorus concentrations measured at Sites CC-10 and SC-3. At Site CT-2, orthophosphate made up only 46% of total measured phosphorus (Fig. 16).

TABLE 8: Comparison of annual total phosphorus and orthophosphate concentrations for Sites CC-10, SC-3, and CT-2 from 1995 to 2002.

		Stream Site		
		CC-10	SC-3	CT-2
Total Phosphorus (µg/L)	Minimum	22	0.1	0.1
	Maximum	553	456	415
	Mean	232	120	101
Orthophosphate (µg/L)	Minimum	0.1	0.1	3
	Maximum	362	401	175
	Mean	182	95	46

Concentrations of total phosphorus exhibited significant increasing trends over time at Sites CC-10 ($p = 0.04$, $R^2 = 0.037$, slope = 0.51) and SC-3 ($p < 0.01$, $R^2 = 0.188$, slope = 1.03) (Figs. 17 and 19). Concentrations of orthophosphate at Site CC-10 (Fig. 18) were not significantly related to time ($p > 0.05$, $R^2 = 0.000$). The relationship between orthophosphate concentration and time was significant and indicated a slight upward trend at Site SC-3 ($p < 0.01$, $R^2 = 0.159$, slope = 0.78) (Fig. 20). Both the total phosphorus and orthophosphate show a decreasing trend at Site CT-2 (Figs. 21 and 22), with the trend statistically significant for orthophosphate ($p < 0.01$, $R^2 = 0.411$, slope = -0.82). The observed downward trend in phosphorus concentrations at Site CT-2 from 1995-2002 may be an indication of the increasing effectiveness of the Cottonwood Creek PRF, which was installed in 1996. There appears to be a seasonal pattern in phosphorus concentration at all sites, which was not specifically addressed in the trend analysis.

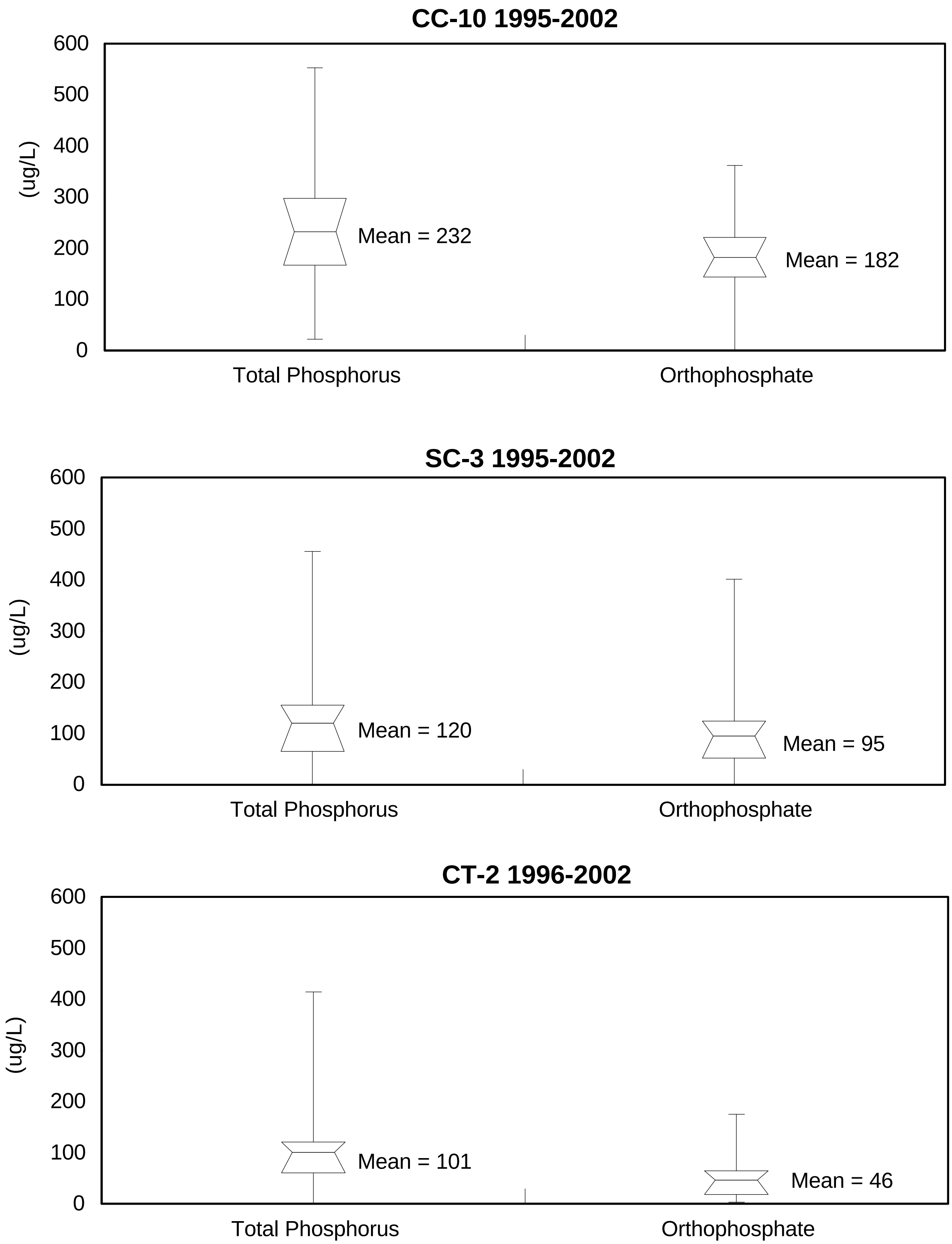


FIGURE 16: Total phosphorus and orthophosphate mean concentrations and box-plots in Cherry Creek Reservoir upstream tributaries (1995-2002).

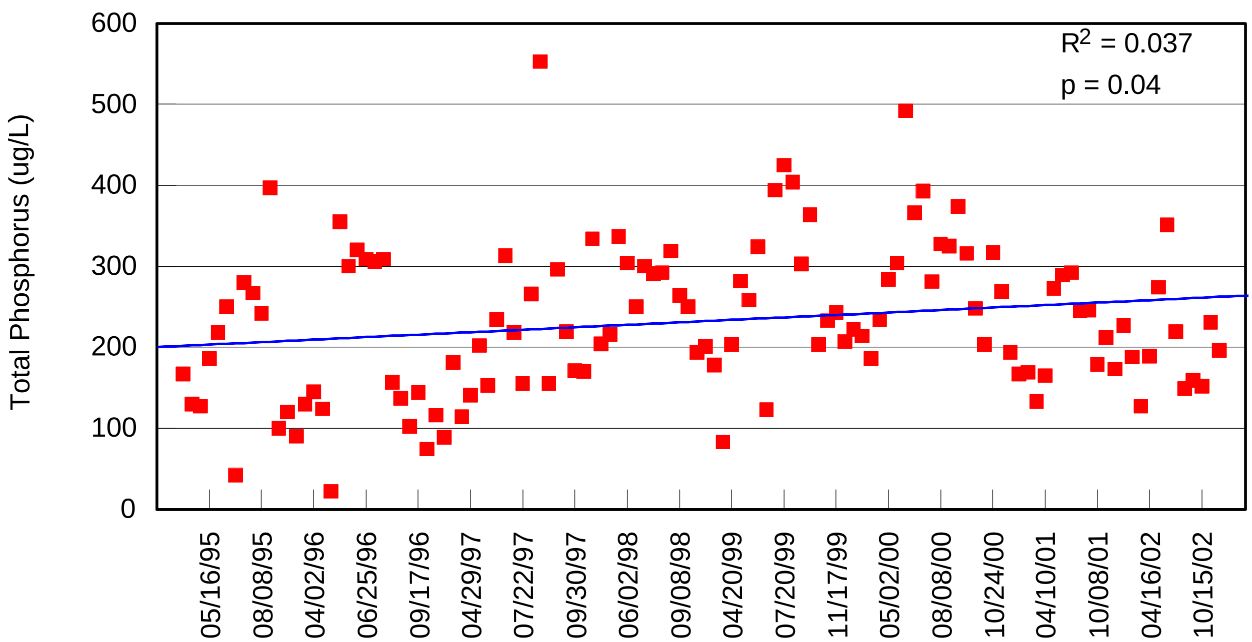


FIGURE 17: Mean total phosphorus concentrations measured in Site CC-10 (1995-2002).

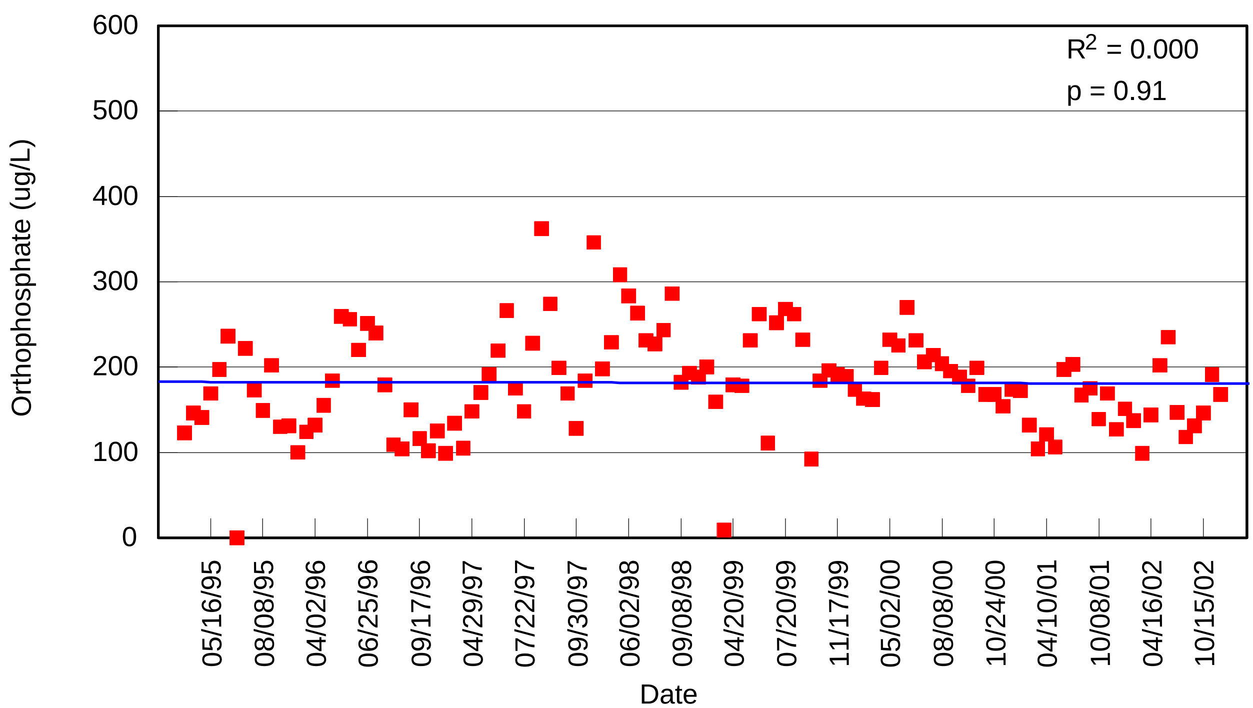


FIGURE 18: Mean orthophosphate concentrations measured in Site CC-10 (1995-2002).

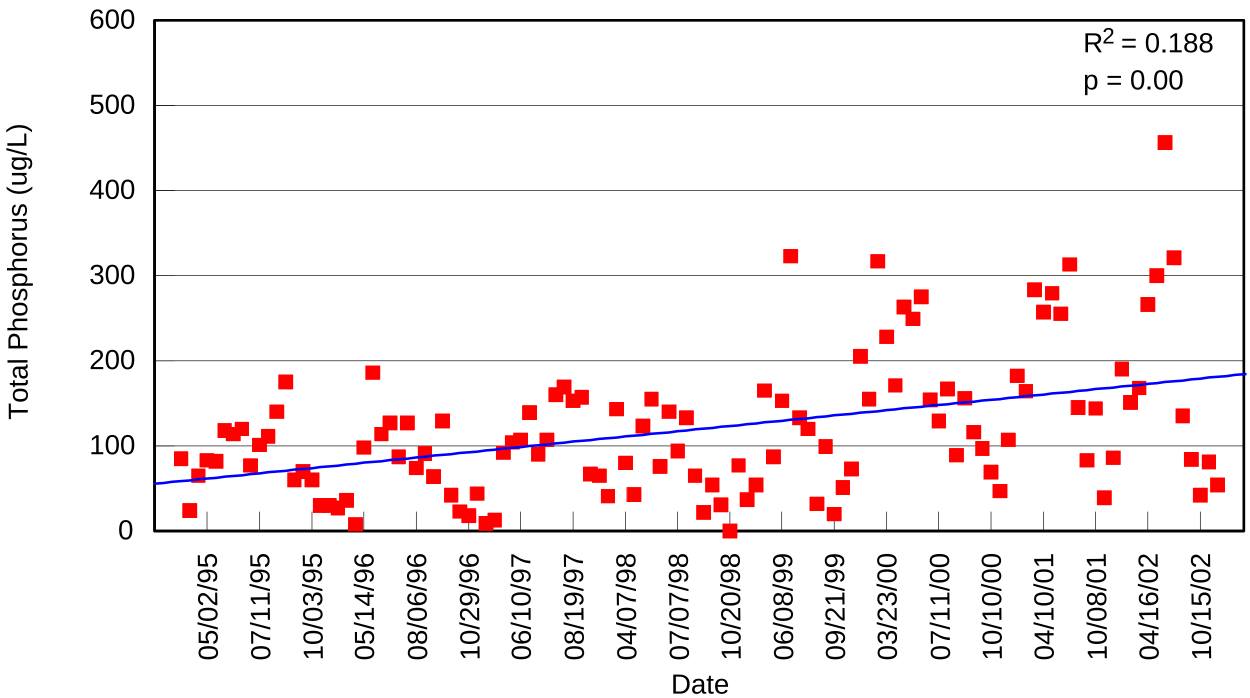


FIGURE 19: Mean total phosphorus concentrations measured in Site SC-3 (1995-2002).

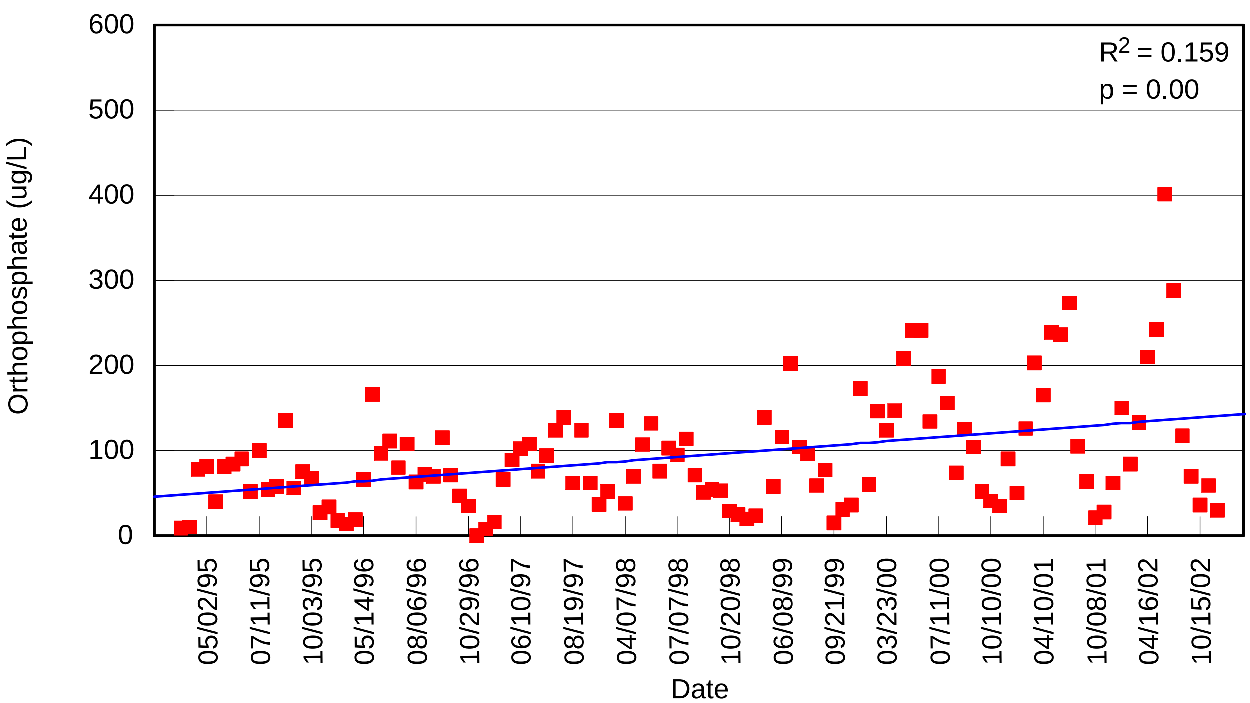


FIGURE 20: Mean orthophosphate concentrations measured in Site SC-3 (1995-2002).

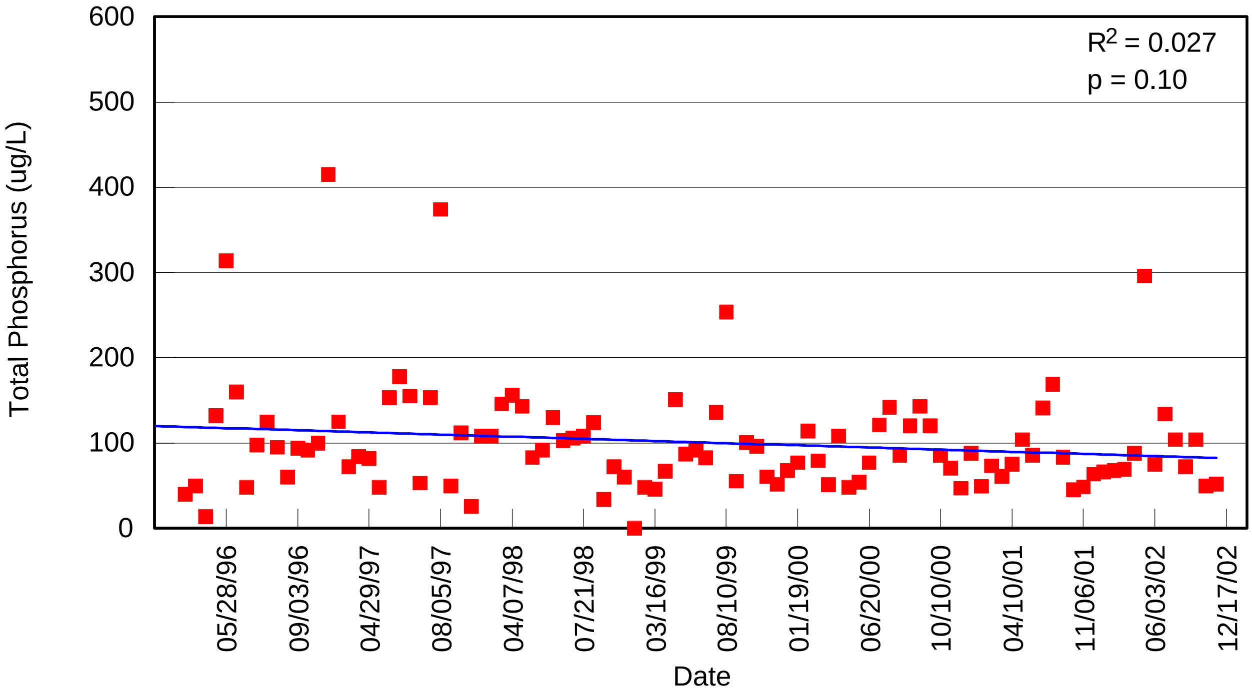


FIGURE 21: Mean total phosphorus concentrations measured in Site CT-2 (1995-2002).

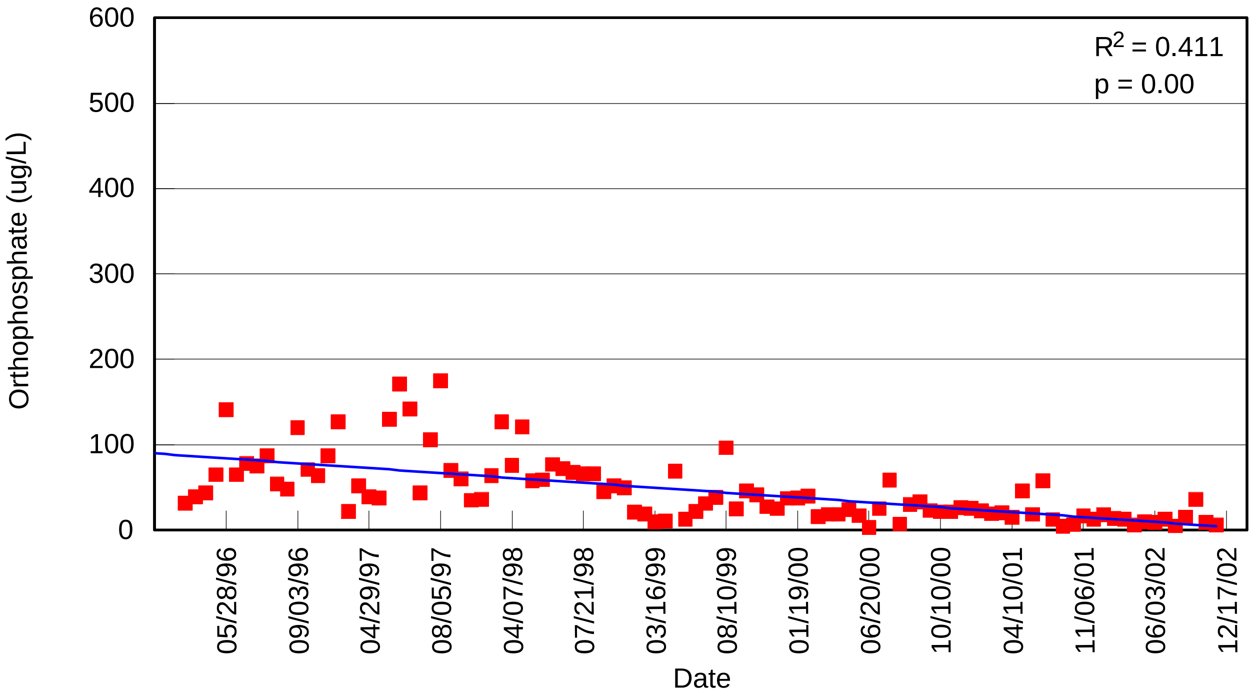


FIGURE 22: Mean orthophosphate concentrations measured in Site CT-2 (1995-2002).

Long-Term Trends in Phosphorus Concentrations in Cherry Creek Reservoir Alluvium

Data for alluvial phosphorus concentrations from Site MW-9 were obtained from Halepaska (2002 unpublished). These data were used to estimate loadings from alluvial flows to the reservoir, as summarized below. Regression analyses were performed on data from Site MW-9 to determine trends in alluvial total dissolved phosphorus and orthophosphate concentrations from 1994 to 2002 (Figs. 23 and 24). Total dissolved phosphorus was used because total phosphorus is not measured at Site MW-9. Alluvial concentrations of total dissolved phosphorus exhibited a significant increasing trend over time at Site MW-9 ($p = 0.02$, $R^2 = 0.059$, slope = 0.12) (Fig. 23), although this regression explains less than 6% of the observed variance. Total dissolved phosphorus concentrations ranged from 158 µg/L to 230 µg/L, with a mean of 186 µg/L. Alluvial concentrations of orthophosphate at Site MW-9 (Fig. 24) were significantly correlated to time ($p < 0.01$, $R^2 = 0.249$, slope = 0.33) and indicated a slight upward trend. Orthophosphate concentrations at Site MW-9 ranged from 140 µg/L to 220 µg/L, with a mean concentration of 183 µg/L.

Historic Trends in Total Phosphorus Concentration and Discharge

Total phosphorus concentration was plotted against discharge for the three upstream tributaries (Figs. 25 - 27). Flow did not appear to track with total phosphorus concentrations at Site CC-10. At Sites SC-3 and CT-2, total phosphorus concentration appears to be somewhat better matched with discharge. Statistical analyses performed on data sets from Sites CC-10 and SC-3 indicate that there is no significant relationship between total phosphorus concentration and discharge ($p > 0.05$) at these two sites. The relationship between total phosphorus concentration and discharge was significant, and indicated a positive correlation at Site CT-2 ($p < 0.01$, $R^2 = 0.108$, slope = 3.51).

Phosphorus Loading to Reservoir

Nutrients which can limit or enhance algal growth in a reservoir have many sources, both within the reservoir (internal loading) or from outside the reservoir (external loading). Fish and plankton excrement, direct sediment resupply, and the decay of organic matter are all internal sources of nutrients in a reservoir (Goldman and Horne 1983). Net internal phosphorus loading to Cherry Creek Reservoir has been estimated to be 4,000 lbs/year (Nürnberg and LaZerte 2000). Note that the phased TMAL of 14,270 lbs/year set in the May 2001 hearing does not include these internal loads.

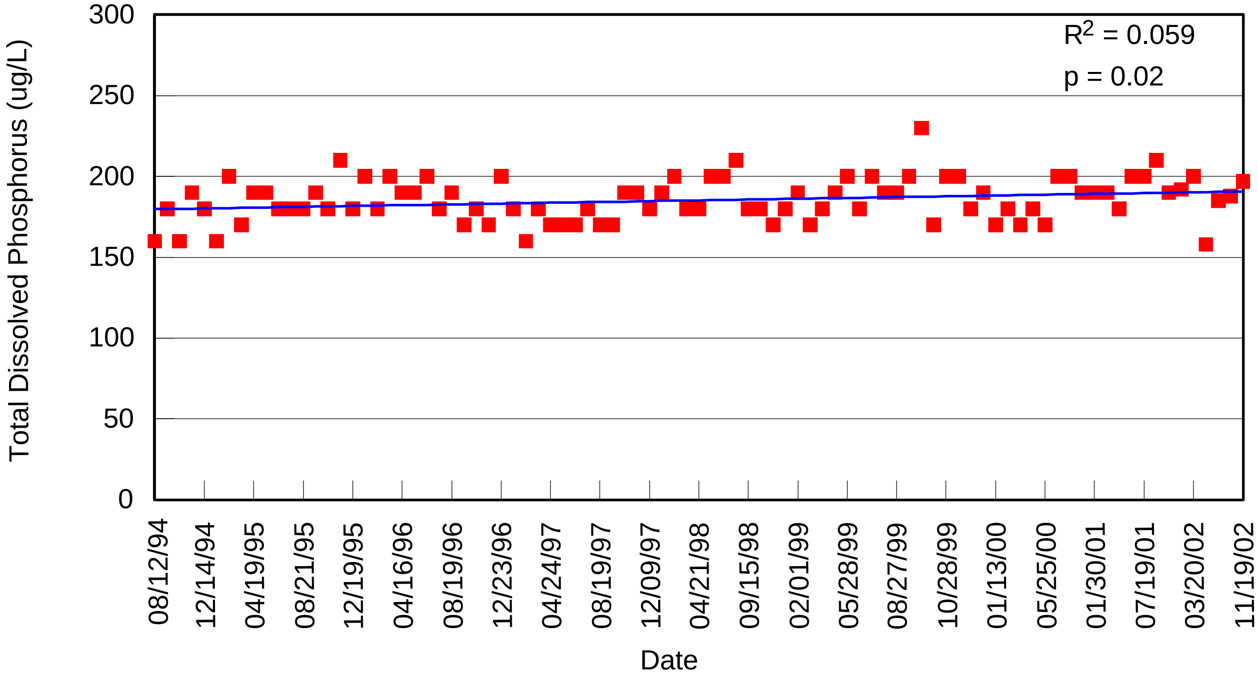


FIGURE 23: Mean total dissolved phosphorus concentrations measured at Site MW-9 (1994-2002).

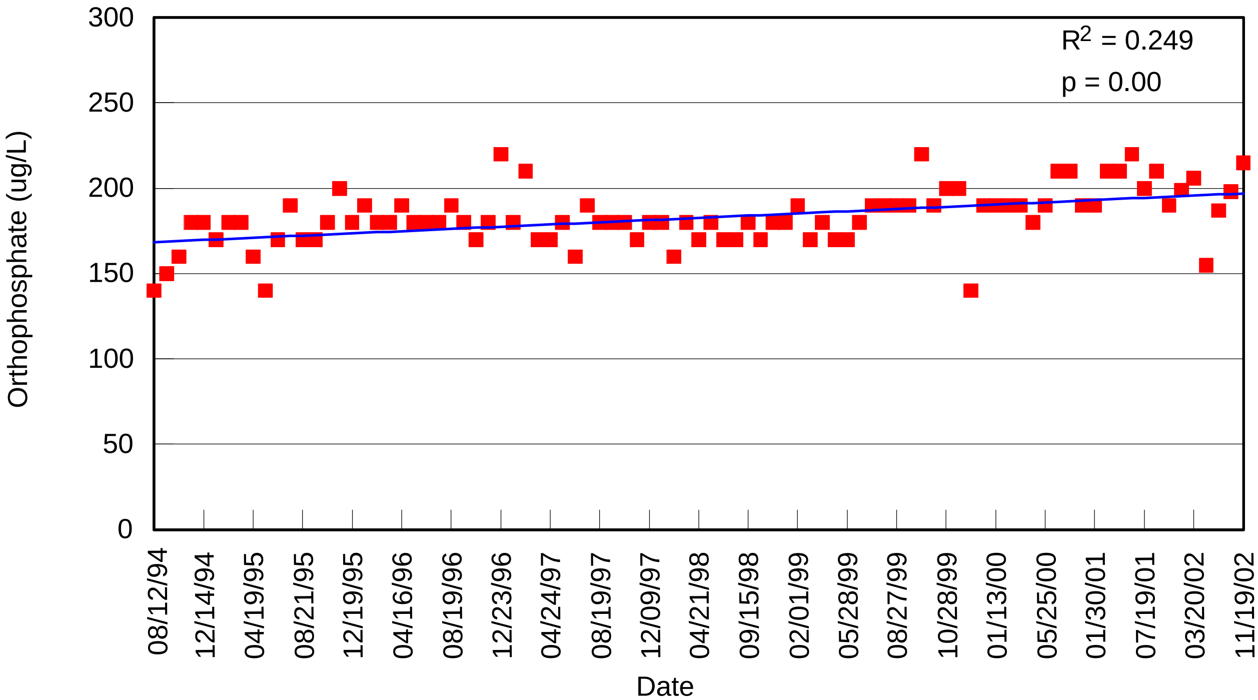


FIGURE 24: Mean orthophosphate concentrations measured at Site MW-9 (1994-2002).

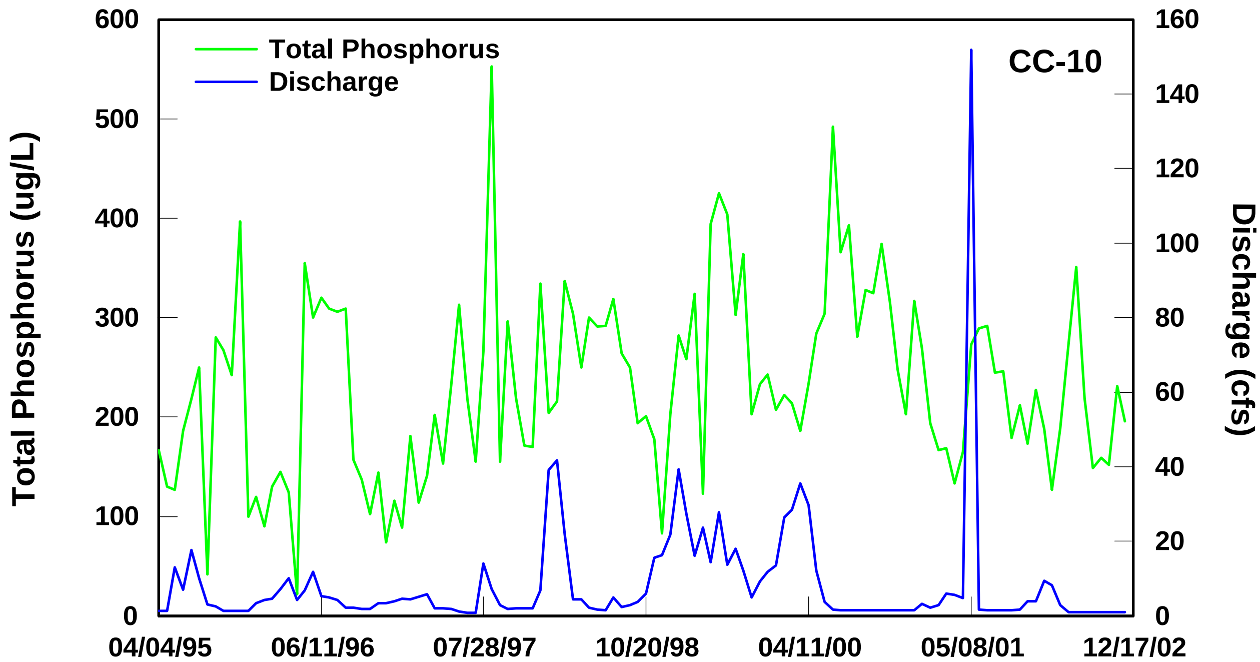


FIGURE 25: Relationship between total phosphorus concentrations and discharge measurements in Site CC-10, 2002.

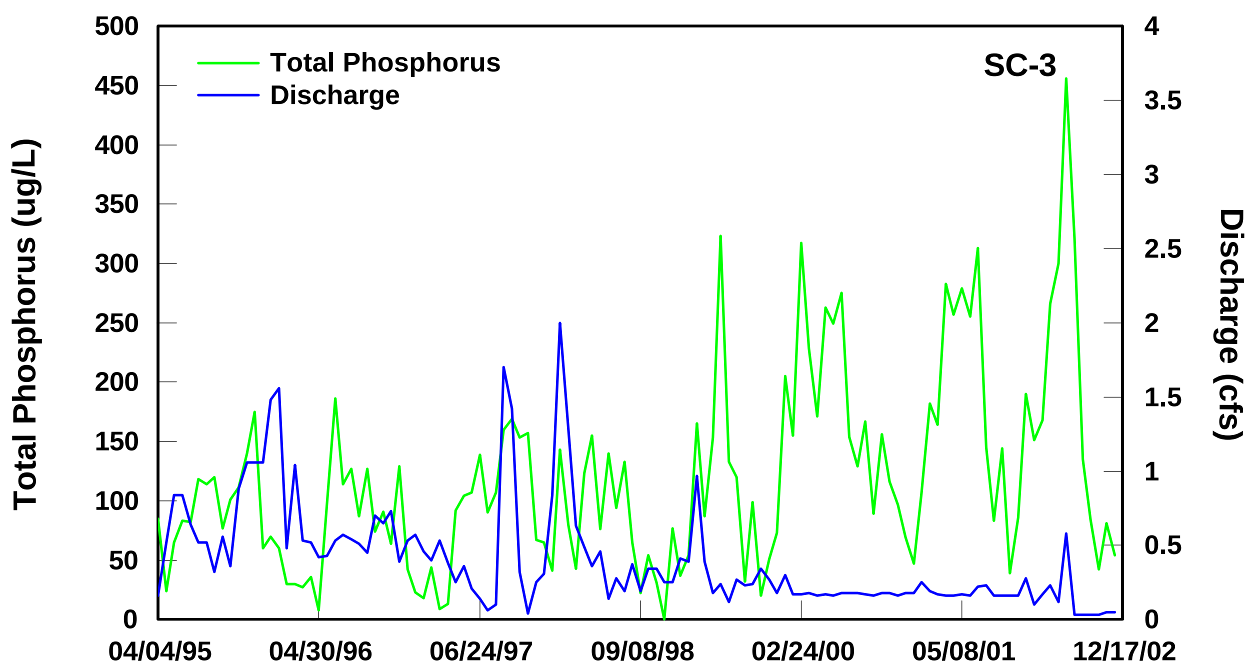


FIGURE 26: Relationship between total phosphorus concentrations and discharge measurements in Site SC-3, 2002.

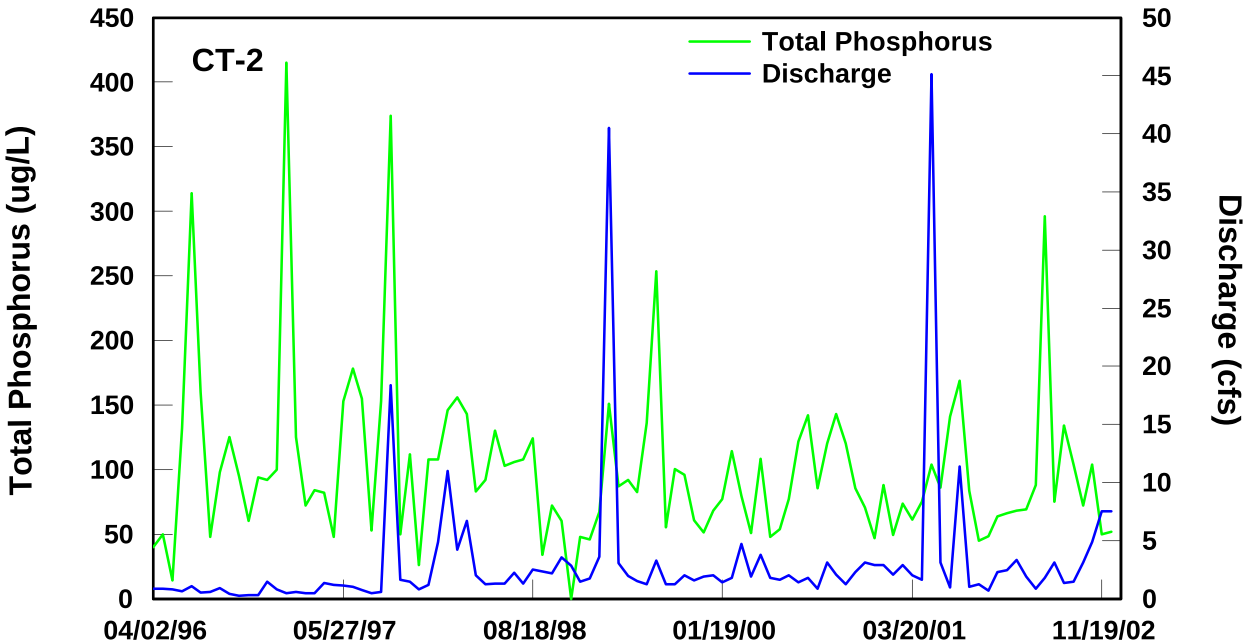


FIGURE 27: Relationship between total phosphorus concentrations and discharge measurements in Site CT-2, 2002.

External source of nutrients include inflow from streams and precipitation, which carry nutrients from soil erosion, agricultural runoff, treated waste water, and airborne particulates. While both phosphorus and nitrogen are potentially important, past analyses have concluded that Cherry Creek Reservoir is generally phosphorus limited (DRCOG 1985). In addition, phosphorus (unlike nitrogen) does not have a gas phase. Thus, phosphorus concentrations cannot be reduced by interactions with the atmosphere or gases within the water column. For these reasons, efforts in past years and during the present study have concentrated on the calculation of phosphorus loading. Phosphorus loading was determined for several primary sources in 2002, including the tributary streams Cottonwood Creek, Cherry Creek, and Shop Creek, as well as from precipitation and alluvium, as summarized below.

As noted earlier, in the past, CEC used provisional (preliminary) inflow estimates from the COE in preparation of monitoring report. In 2002, CEC became aware that these provisional estimates had been finalized by the COE and summarized on their website. To ensure accurate numbers, inflow and load estimates for 2002 used those finalized values and past calculations for 1992 - 2001 were revised to match the finalized inflow values from the COE for those years (Table 9).

TABLE 9: Estimated net phosphorus loading (lbs/year) into Cherry Creek Reservoir, 1992 to 2002. Note: 1992 - 2001 streamflow and alluvium load estimates were recalculated based on finalized COE inflow estimates - see text.

Source of Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Mean	% of Mean Total Load
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	107	1
Cherry Creek	2,894	1,727	2,142	2,795	2,347	2,041	7,666	8,745	8,306	3,412	1,105	3,925	48
Cottonwood Creek	1,081	177	321	2,184	553	646	1,143	1,822	1,087	1,292	789	1,009	12
Subtotal for Streamflows	**4,106**	**1,987**	**2,598**	**5,094**	**3,007**	**2,804**	**8,936**	**10,663**	**9,475**	**4,807**	**1,973**	**5,041**	
Cherry Creek Alluvium	874	1,387*	967	1,676	968	1,937	3,787	5,912	2,341	4,444	1,006	2,391	29
Direct Precipitation	877	736	484	1,202	740	1,020	854	896	777	586	1,267	858	10
Total Load	**5,857**	**4,110**	**4,049**	**7,972**	**4,715**	**5,761**	**13,577**	**17,471**	**12,593**	**9,837**	**4,246**	**8,199**	
Cherry Creek Outflow	1,314	711	993	2,049	992	996	4,207	9,650	3,688	4,842	1,501	2,813	
Net Load	**4,543**	**3,399**	**3,056**	**5,923**	**3,723**	**4,765**	**9,370**	**7,821**	**8,905**	**4,995**	**2,745**	**5,386**	

* Based on mean of 1994-1997 total alluvial loads.

<u>Phosphorus Loads from Tributary Streams</u>

The greatest proportion of the phosphorus load to the reservoir was from surface flows in the Cherry Creek mainstem (1,105 lbs). Because Cherry Creek is monitored downstream of Shop Creek, the 79 lbs contributed by Shop Creek has been subtracted from the total load calculated from the site. Additional phosphorus was contributed by Cottonwood Creek (789 lbs). The total phosphorus load to Cherry Creek Reservoir from tributary streams in 2002 was 1,973 lbs (Table 9).

Phosphorus Loads in Reservoir Outflow

The total outflow from Cherry Creek Reservoir as measured by the COE was 7,498 AF (Appendix C). The calculated phosphorus load leaving the reservoir in 2002 was determined to be 1,501 lbs (Table 9).

Phosphorus Loading from Precipitation

The mean concentration of total phosphorus in the rain samples collected in 2002 was 508 µg/L. This value is considerably (60%) higher than the 2001value and may reflect a greater influence of "dry fall" in 2002 despite weekly cleaning of the sampler (see Methods section). As a result, a year with below average annual precipitation, 12.9 inches, leads to a higher than average total phosphorus load of 1,267 pounds per year (Table 9, and Appendix C). The long-term mean estimated total phosphorus loading from rain samples collected at the reservoir between 1987 and 2002 is 848 lbs (Table 10).

Phosphorus Loading from Alluvium

The water quality of alluvial flows into Cherry Creek Reservoir was monitored by JCHA. CEC estimated the total alluvial flow into Cherry Creek Reservoir to be 1,977 AF based on the analysis summarized below and in Appendix C. The total alluvial addition to the reservoir was estimated to be 1,006 lbs total phosphorus in 2002 (Table 9).

The COE monitors inflow to Cherry Creek Reservoir as a function of change in storage, based on changes in reservoir level, measured outflow, precipitation, and evaporation, to provide daily and monthly inflow (AF). CEC monitors inflow to the reservoir using gaging stations on Cherry Creek, Cottonwood Creek, and Shop Creek (the three main surface inflows). Estimates of direct precipitation were provided by the COE, and estimates of alluvial phosphorus concentrations were provided by JCHA. From these data, CEC calculates an estimated total inflow (AF) and phosphorus loading (lbs) to the reservoir.

TABLE 10: Phosphorus loading into Cherry Creek Reservoir from precipitation, 1987 to 2002. Note that data from 1987-1991 are based on water years, while data for 1992 to present are based on calendar years.

Source of Data	Year	Annual Precipitation (in)	Estimated Annual Total Phosphorus from Precipitation (lbs)
In-Situ 1987	1987	18.1	870
In-Situ 1988	1988	23.3	1,119
ASI 1990	1989	13.0	625
ASI 1991a	1990	15.2	730
ASI 1991b	1991	16.5	793
ASI 1993	1992	18.5	877
ASI 1994a	1993	15.6	735
C&A 1995	1994	10.2	484
CEC 1996	1995	25.3	1,202
CEC 1997	1996	15.5	740
CEC 1998	1997	21.8	1,020
CEC 1999	1998	20.0	854
CEC 2000	1999	21.5	896
CEC 2001	2000	17.8	777
CEC 2002	2001	16.0	586
Present Study	2002	12.9	1,267
Mean		**17.6**	**848**

Given differences in the two methods for determining inflow, combined with the potential for unmonitored multiple Cherry Creek channels in the wetlands adjacent to the reservoir and the potential for the COE calculations to underestimate dam leakage (Lewis and Saunders 2002), an exact match between COE and CEC calculated inflows is not expected. In 2002, COE inflows were calculated at 7,498 AF, while CEC calculated inflows at 5,521 AF (see Appendix C). In past years, CEC adjusted (normalized) inflow values from the stream sites to account for this difference (i.e., added flow to the stream values). Those normalization procedures can be found in CEC (1998b, 1999, 2000, 2001, and 2002). In 2002, CEC did not “normalize” inflow data by adding flow to the surface stream site data. Instead, we based our adjustments on conclusions reached by Lewis and Saunders (2002). They believe the COE method results in a systematic underestimate of inflow to the reservoir from alluvium. When estimating inflow, the COE does not specifically quantify alluvial inflows or outflows although, functionally, these alluvial flows must account for a portion of the variations in reservoir storage. Based on the Lewis and Saunders (2002) analysis, CEC believes the difference in inflow values between the COE calculations and CEC streamflows could be attributed wholly to net alluvial inflow. Using this approach, alluvial inflow was estimated to be 1,977 AF in 2002. This flow and the mean phosphorus concentration of 0.187 µg/L were then used to calculate alluvial load the reservoir. Past estimates of alluvial load were similarly recalculated using the same approach (Table 9).

Mass Balance/Net Loading of Phosphorus to the Reservoir

There are three principle sources of phosphorus loading to Cherry Creek Reservoir: tributary streams, alluvial flows, and precipitation (Table 9). During 2002, the three tributary streams contributing phosphorus loads to the reservoir included Cherry Creek (1,105 lbs without Shop Creek), Cottonwood Creek (789 lbs), and Shop Creek (79 lbs). The net load of phosphorus to the reservoir from the Cherry Creek alluvium was estimated at 1,006 lbs. The estimated phosphorus load to the reservoir from precipitation was 1,267 lbs. The estimated total load of phosphorus entering the reservoir in 2002 was determined to be 4,246 lbs (Table 9), which meets the TMAL of 14,270 lbs per year. This is the lowest total load observed since 1994. The estimated phosphorus load leaving the reservoir in 2002 was determined to be 1,501 lbs. Using these two values, the net load of phosphorus to Cherry Creek Reservoir in 2002 was determined to be 2,745 lbs (Fig. 28, and Table 9).

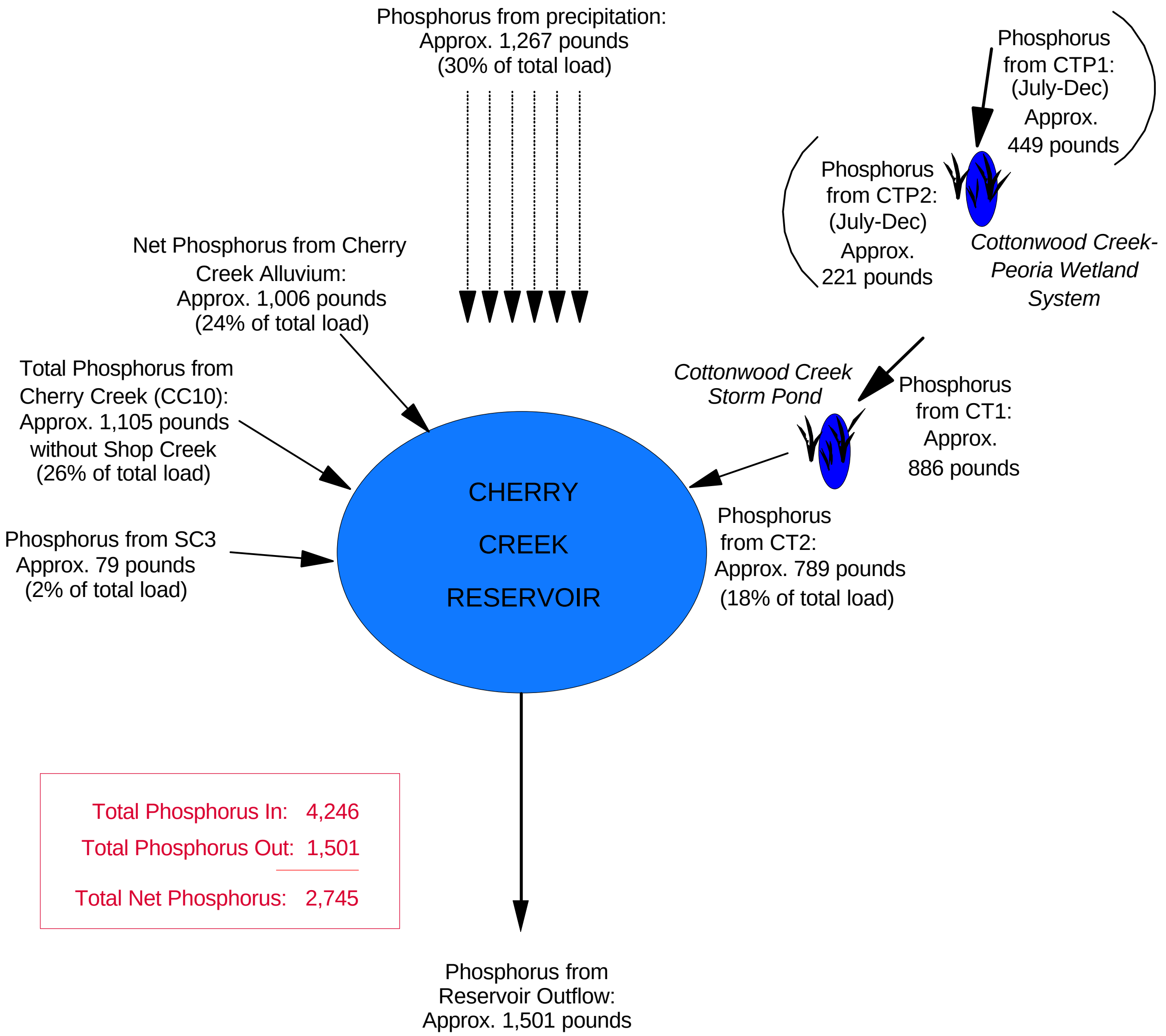


FIGURE 28: Mass balance diagram of phosphorus loading in Cherry Creek Reservoir, 2002.

Effectiveness of Pollutant Reduction Facilities

Cottonwood Creek Perimeter Pond

The effectiveness of the existing Cottonwood Creek stormwater "Perimeter Pond" in reducing pollutant loads to the reservoir can be gaged by comparing concentration of total phosphorus and TSS and the loads of total phosphorus upstream and downstream of the pond (Table 11). During 2002, the mean concentration of total phosphorus decreased from 146 to 143 µg/L after passing through the pond (Table 11). This represents a 2% reduction in phosphorus concentration, the second lowest reduction event since the pond's inception (Table 12). The load of total phosphorus was reduced from 886 lbs upstream of the pond to 789 lbs downstream of the pond, representing a 11% reduction in load (Table 12). This value is the lowest % reduction in TP loads observed since the construction of the pond (Table 12). The concentration of TSS was decreased by 39% from 130 mg/L upstream to 79 mg/L downstream of the pond (Table 11). However, statistical analysis (t-test) determined that these differences in mean total phosphorus or TSS concentrations between Sites CT-1 and CT-2 were not statistically significant ($p > 0.05$). Regardless, the load reduction indicates that this PRF continues to be effective in reducing the loads of suspended solids and total phosphorus to Cherry Creek Reservoir, although not as effective in 2002 when compared to past years.

TABLE 11: Annual phosphorus, flow and total suspended solids (baseflows and stormflows combined) in Cottonwood Creek stormwater detention pond, 2002. July through December total water volume and total phosphorus load and late May through December average total phosphorus and average total suspended solids for Cottonwood Creek-Peoria wetlands system (baseflows and stormflows combined), 2002.

Sampling Site	Total Water Volume (AF)	Total Phosphorus Load (lbs)	Average Total Phosphorus (µg/L)	Average Total Suspended Solids (mg/L)
Annual				
Cottonwood Creek				
CT-P1	432	449	138	66
CT-P2	422	221	152	79
CT-1	1,930	886	146	130
CT-2	2,622	789	143	79

TABLE 12: Annual historical (1997 to 2002) total phosphorus and total suspended solids concentrations through the Cottonwood Creek stormwater detention pond.

Parameter	Year	Data Source	Sampling Sites CT-1	Sampling Sites CT-2	Difference	% Reduction
Annual Average Total Phosphorus Concentration (µg/L) (baseflow, storm samples combined)	1997	CEC	200	133	-67	34
	1998	CEC	289	210	-79	27
	1999	CEC	158	157	- 1	0
	2000	CEC	187	149	-38	20
	2001	CEC	165	114	-51	31
	2002	CEC	146	143	- 3	2
	Mean		191	151	-40	19
Annual Average Total Suspended Solids (mg/L)	1997	CEC	207	87	-120	58
	1998	CEC	311	129	-182	59
	1999	CEC	267	68	-199	74
	2000	CEC	96	64	- 32	33
	2001	CEC	79	43	- 43	46
	2002	CEC	130	79	- 51	39
	Mean		182	78	-105	52
Annual Loading of Total Phosphorus (pounds)	1997	CEC	3,351	1,103	-2,248	67
	1998	CEC	3,209	1,930	-1,279	40
	1999	CEC	6,329	3,868	-2,461	39
	2000	CEC	3,243	1,712	-1,531	47
	2001	CEC	3,356	2,205	-1,151	34
	2002	CEC	886	789	- 97	11
	Mean		3,396	1,935	-1,461	40

Cottonwood Creek- Peoria Pond

As with the Cottonwood Creek Perimeter Pond, the effectiveness of the new Cottonwood Creek-Peoria Pond is gaged by monitoring the concentration of phosphorus and TSS and the loading of phosphorus upstream and downstream of the facility. As noted earlier, this structure came on-line during 2002. As such, these values represent less than a full calendar year (i.e., only July - December 2002). The mean concentration of total phosphorus increased 10% from 138 µg/L at Site CT-P1 to 152 µg/L at Site CT-P2 (Table 11). The mean concentration of TSS increased from 66 mg/L upstream of the pond/wetland system to 79 mg/L downstream of the pond/wetland system (Table 11). Conversely, the estimated load of phosphorus below the pond/wetland system was reduced 49% from 449 lbs at Site CT-P1 to 221 lbs at Site CT-P2. No difference ($p > 0.05$) in mean total phosphorus or mean TSS concentrations could be determined from statistical analysis (t-test) for Sites CT-P1 and CT-P2. Median values were also analyzed because means for total phosphorus and TSS at Site CT-P2 were driven by one particularly high data point from a storm event. Median total phosphorus concentration was reduced 4% from 98 µg/L at Site CT-P1 to 94 µg/L at Site CT-P2. The median concentration of TSS decreased 27% between Sites CT-P1 (34.6 µg/L) and CT-P2 (25.2 µg/L). Despite average the concentration of total phosphorus and TSS increasing downstream of the PRF, the estimated load of phosphorus was significantly reduced (48%) downstream of the PRF. This indicates that the new PRF was effective in reducing the pollutant load to the reservoir in 2002 (Table 13).

TABLE 13: Total phosphorus and total suspended solids concentrations through the Cottonwood Creek-Peoria wetlands system. Average total phosphorus concentration and average total suspended solids values were calculated from late May through December, 2002, while loading of total phosphorus was calculated from July through December, 2002.

Parameter	Sampling Site CT-P1	Sampling Site CT-P2	Difference	% Reduction
Average Total Phosphorus Concentration (µg/L) (baseflow and storm samples combined)	138	152	+14	-10
Average Total Suspended Solids (mg/L)	66	79	+13	-20
Loading of Total Phosphorus (pounds)	449	221	-228	49

SUMMARY AND CONCLUSIONS

The transparency in Cherry Creek Reservoir was measured by Secchi depth and percent transmittance. The highest transparency was observed in the reservoir in late July, and the lowest was measured in early May and mid-October. The whole-reservoir mean Secchi depth was 0.9 m during the July to September period, a higher value than that observed in 2001, but slightly lower than 1993-2000 values (Table 14). July to September 1% light transmittance averaged 2.8 m in 2002.

TABLE 14: Water quality and total phosphorus loads data for Cherry Creek Reservoir, July-September 1992-2002. **Bold** indicates value meets the respective standard, goal, or TMAL value.

Year	Chlorophyll *a* (µg/L)	Secchi Depth (m)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	**5,857**	7,474	0.78
1993	**14.4**	1.2	62	826	**4,110**	5,905	0.70
1994	**10.0**	1.1	59	1,144	**4,049**	7,001	0.58
1995	**9.4**	1.6	48	913	**7,972**	11,781	0.68
1996	20.5	1.6	62	944	**4,715**	7,644	0.62
1997	22.3	1.0	96	1,120	**5,761**	10,362	0.56
1998	26.5	1.0	89	880	**13,577**	20,903	0.65
1999	28.9	1.0	81	753	17,471	27,739	0.63
2000	25.2	1.0	81	802	**12,593**	18,610	0.68
2001	26.1	0.75	87	757	**9,837**	17,250	0.57
2002	18.8	0.9	74	858	**4,246**	7,498	0.57
10-Year Mean	19.9	1.1	73	906	8,199	12,924	0.64
Median	20.5	1.0	74	880	5,857	10,362	0.63

* Stream, alluvium, and precipitation.

Periods of thermal stratification were observed in the reservoir in 2002. Dissolved oxygen profiles indicated that anoxic conditions were present through the summer, as oxygen concentrations were frequently reduced in lower depths of the reservoir. The temperature and oxygen profiles observed in the reservoir in 2002 were similar to those recorded in past years.

The 2002 reservoir summer mean total phosphorus concentration of 74 µg/L was lower than that measured in 2001, but still exceeded the goal of 40 µg/L total phosphorus. The summer mean total phosphorus concentration was lower than values recorded in 1997 through 2001 (Table 14). Since 1987, the goal of 40 µg/L total phosphorus as a July - September mean has only been met once, in 1989.

The summer mean chlorophyll *a* concentration in Cherry Creek Reservoir was 18.8 µg/L, a value in excess of the 15 µg/L standard (Table 14). The summer mean concentration of chlorophyll *a* was lower than the mean values reported for 1996 through 2001. The long-term summer mean chlorophyll *a* concentrations since 1996 indicate no significant difference between seasonal mean chlorophyll *a* concentrations over the past seven years. Since 1987, the July - September chlorophyll *a* standard of 15 µg/L has been met in four of 16 years, but only three times in the last 11 years (Table 14).

The total precipitation at Cherry Creek Reservoir during 2002 was 12.9 inches. The mean concentration of total phosphorus collected from rain samples in 2002 was 508 µg/L, an increase of 60% from the 2001 value of 202 µg/L. This increase in rain sample total phosphorus concentration resulted in the highest annual phosphorus load from precipitation into the reservoir for the past 16 years (Table 10). The total inflow from tributary streams was 4,606 AF, which was lower than the 8,332 AF observed in 2001. The total phosphorus loads to the reservoir were estimated to be 1,267 lbs from precipitation, 1,973 lbs from surface flows, and 1,006 lbs from Cherry Creek alluvial flow. The total external load in 2002 of 4,246 lbs met the phased TMAL of 14,270 lbs/year. The total of 4,246 lbs in 2002 represents a 76% decrease in total load over that observed during peak flows in 1999. This 76% drop in TP loads compares to a 35% decrease in July - September chlorophyll *a* over the same period.

Pollution reduction facilities constructed on Cottonwood Creek continued to be effective in reducing the loads of phosphorus to the reservoir. In 2002, the Cottonwood Creek Perimeter Pond reduced the instream load of phosphorus by 11%. The Cottonwood Creek-Peoria Pond reduced phosphorus loading by 49% from July through December.

LITERATURE CITED

Advanced Sciences, Inc. 1994a. *Cherry Creek Basin, Annual Water-Quality Monitoring Report, 1993 Water Year*. Prepared for the Cherry Creek Basin Water Quality Authority, Project No. 8970.

Advanced Sciences, Inc. 1994b. 1993 Cherry Creek Basin Water Quality Authority Contract: Project 8790. Exhibits A through H (amended).

American Public Health Association (APHA). 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. Prepared and published jointly by the Amer. Publ. Health Assoc., American Water Works Association, and Water Pollution Control Federation, Washington, DC.

Carpenter, S.R., J.F. Kitchell, and J.R. Hodgson. 1985. Cascading trophic interactions and lake productivity. *Bioscience* 35:634-639.

Chadwick Ecological Consultants, Inc. 1995. *Cherry Creek Reservoir Annual Aquatic Biological and Nutrient Monitoring Study, 1994*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 1996. *Cherry Creek Reservoir Annual Aquatic Biological and Nutrient Monitoring Study, 1995*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 1997. *Cherry Creek Reservoir Annual Aquatic Biological and Nutrient Monitoring Study, 1996*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 1998a. *Analysis of Phosphorus Loads to Cherry Creek Reservoir*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 1998b. *Cherry Creek Reservoir Annual Aquatic Biological and Nutrient Monitoring Study, 1997*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 1999. *Cherry Creek Reservoir 1998 Annual Aquatic Biological and Nutrient Monitoring Study*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 2000. *Cherry Creek Reservoir 1999 Annual Aquatic Biological and Nutrient Monitoring Study*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 2001. *Cherry Creek Reservoir 2000 Annual Aquatic Biological and Nutrient Monitoring Study*. Prepared for the Cherry Creek Basin Water Quality Authority.

Chadwick Ecological Consultants, Inc. 2002. *Cherry Creek Reservoir 2001 Annual Aquatic Biological and Nutrient Monitoring Study*. Prepared for the Cherry Creek Basin Water Quality Authority.

Cole, G.A. 1979. *Textbook of Limnology*, 2nd Edition. The C.V. Mosby Company, St. Louis, MO.

Colorado Department of Public Health and Environment. 2001. *The Basic Standards and Methodologies for Surface Water* (5 CCR 1002-31). Regulation No. 31. Water Quality Control Division, Denver, CO.

Cooke, D.C., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. *Restoration & Management of Lakes & Reservoirs*, 2nd Edition. Lewis Publishers, Boca Raton, FL.

Denver Regional Council of Governments. 1984. *Cherry Creek Reservoir Clean Lakes Study*. Denver Regional Council of Governments, Denver, CO.

Denver Regional Council of Governments. 1985. *Cherry Creek Basin Water Quality Management Master Plan*. Prepared in Cooperation with Counties, Municipalities, Water and Sanitation Districts in the Cherry Creek Basin and Colorado Department of Health.

Goldman, C.R., and A.J. Horne. 1983. *Limnology*. McGraw-Hill Company, NY.

Halepaska & Associates, Inc. 1999. *1998 Annual Report, Phase I Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin*. Prepared for the Cherry Creek Basin Water Quality Authority, Project No. 5601:6.

Halepaska & Associates, Inc. 2000. *1999 Annual Report, Phase I Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin*. Prepared for the Cherry Creek Basin Water Quality Authority.

Halepaska & Associates, Inc. 2001. *2000 Annual Report, Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin*. Prepared for the Cherry Creek Basin Water Quality Authority.

Halepaska & Associates, Inc. 2002. *2001 Annual Report, Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin*. Prepared for the Cherry Creek Basin Water Quality Authority.

Hintze, J.L. 2001. NCSS and PASS. Number Cruncher Statistical Systems, Kaysville, UT.

In-Situ, Inc. 1986 (as amended). *Cherry Creek Reservoir and Cherry Creek Basin Monitoring Program, Southeastern Denver Metropolitan Area, Colorado: Proposal No. 4405*. Prepared for the Cherry Creek Basin Authority, December 3 (with later modifications).

Jones, J.R. 1994. *Report on Cherry Creek Reservoir, Summer 1993*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 1995. *Report on Cherry Creek Reservoir, Summer 1994*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 1996. *Report on Cherry Creek Reservoir, 1995 Sampling Season*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 1997. *Report on Cherry Creek Reservoir, 1996 Sampling Season*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 1998. *Report on Cherry Creek Reservoir, 1997 Sampling Season*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 1999. *Report on Cherry Creek Reservoir, 1998 Sampling Season*. Report to Cherry Creek Basin Water Quality Authority.

Jones, J.R. 2001. *Report on Cherry Creek Reservoir, 1992-2001 and Historical Data*. Report to Cherry Creek Basin Water Quality Authority.

Knowlton, M.R., and J.R. Jones. 1993. *Limnological Investigations of Cherry Creek Lake*. Final report to Cherry Creek Basin Water Quality Authority.

LaZerte, B.D., and Nürnberg, G. 2000 *Cherry Creek Reservoir Dynamic Model*. Prepared for the Cherry Creek Basin Water Quality Authority.

Nürnberg, G., and LaZerte, B. 2000. *Modeling Future Scenarios for Cherry Creek Reservoir*. Prepared for the Cherry Creek Basin Water Quality Authority.

Vanni, M.J., and C.D. Layne. 1996. Nutrient recycling and herbivory as mechanisms in the "top-down" effect of fish on algae in lakes. *Ecology* 78:21-40.

Vanni, M.J., C.D. Layne, and S.E. Arnott. 1996. "Top-down" trophic interactions in lakes: effects of fish on nutrient dynamics. *Ecology* 78:1-20.

Wetzel, R.G. 2001. *Limnology*, 3rd Edition. Academic Press, San Diego, CA.

Zellweger Analytics. 1999. *QuickChem Methods*. Milwaukee, WI.

APPENDIX A

RESERVOIR WATER QUALITY DATA

CCR-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
01/22/02	CCR-1 Photic	59	11	4	878	543	90	15	32.0
03/26/02	CCR-1 Photic	51	4	3	889	570	<5	20	23.8
04/16/02	CCR-1 Photic	69	9	<3	825	493	<5	14	22.0
05/06/02	CCR-1 Photic	90	15	4	809	441	<5	17	30.7
05/20/02	CCR-1 Photic	66	16	<3	706	444	<5	12	17.1
06/03/02	CCR-1 Photic	48	10	5	628	464	<5	9	9.7
06/18/02	CCR-1 Photic	67	15	<3	1012	677	<5	33	15.2
07/02/02	CCR-1 Photic	91	18	5	1334	899	7	32	18.9
07/16/02	CCR-1 Photic	89	29	12	925	589	<5	21	25.3
07/30/02	CCR-1 Photic	75	10	7	1053	683	<5	21	18.9
08/13/02	CCR-1 Photic	82	16	6	822	459	<5	13	25.4
08/27/02	CCR-1 Photic	49	11	5	815	564	<5	32	15.2
09/10/02	CCR-1 Photic	71	20	7	798	476	<5	14	22.9
09/24/02	CCR-1 Photic	72	11	6	718	441	<5	20	24.2
10/15/02	CCR-1 Photic	86	16	9	1080	622	<5	24	40.2
11/19/02	CCR-1 Photic	63	12	6	1137	688	<5	28	31.7

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
01/22/02	CCR-2 Photic	61	10	3	805	436	<5	8	34.0
01/22/02	CCR-2 4m	ND	ND	ND	ND	ND	ND	ND	ND
01/22/02	CCR-2 5m	ND	ND	ND	ND	ND	ND	ND	ND
01/22/02	CCR-2 6m	ND	ND	ND	ND	ND	ND	ND	ND
01/22/02	CCR-2 7m	ND	ND	ND	ND	ND	ND	ND	ND
03/26/02	CCR-2 Photic	69	4	3	890	549	<5	20	24.8
03/26/02	CCR-2 4m	54	6	3	779	434	<5	12	ND
03/26/02	CCR-2 5m	59	4	3	694	379	<5	7	ND
03/26/02	CCR-2 6m	64	6	3	799	447	<5	14	ND
03/26/02	CCR-2 7m	61	4	3	750	391	<5	10	ND
04/16/02	CCR-2 Photic	63	6	<3	738	396	<5	3	20.3
04/16/02	CCR-2 4m	60	7	<3	708	422	<5	3	ND
04/16/02	CCR-2 5m	52	14	<3	724	419	<5	5	ND
04/16/02	CCR-2 6m	79	7	<3	806	435	<5	8	ND
04/16/02	CCR-2 7m	81	6	<3	837	400	<5	7	ND
05/06/02	CCR-2 Photic	84	14	<3	735	407	<5	8	31.6
05/06/02	CCR-2 4m	88	11	4	744	417	<5	9	ND
05/06/02	CCR-2 5m	101	14	4	796	422	<5	7	ND
05/06/02	CCR-2 6m	90	12	<3	785	404	<5	7	ND
05/06/02	CCR-2 7m	93	12	4	807	424	<5	8	ND
05/20/02	CCR-2 Photic	65	18	<3	727	453	<5	9	15.9
05/20/02	CCR-2 4m	72	32	<3	695	426	<5	8	ND
05/20/02	CCR-2 5m	82	14	<3	731	426	<5	6	ND
05/20/02	CCR-2 6m	89	12	<3	832	430	<5	11	ND
05/20/02	CCR-2 7m	109	13	<3	795	424	<5	7	ND
06/03/02	CCR-2 Photic	49	16	5	655	431	<5	8	11.2
06/03/02	CCR-2 4m	113	15	6	661	459	<5	8	ND
06/03/02	CCR-2 5m	60	21	7	640	442	<5	7	ND
06/03/02	CCR-2 6m	65	19	10	684	440	<5	8	ND
06/03/02	CCR-2 7m	74	18	10	699	441	<5	7	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
06/18/02	CCR-2 Photic	66	22	<3	1360	977	<5	53	16.4
06/18/02	CCR-2 4m	64	17	<3	803	494	<5	24	ND
06/18/02	CCR-2 5m	67	25	13	811	554	<5	36	ND
06/18/02	CCR-2 6m	98	54	38	954	690	<5	62	ND
06/18/02	CCR-2 7m	103	66	53	827	535	<5	61	ND
07/02/02	CCR-2 Photic	80	17	4	1073	678	<5	23	11.4
07/02/02	CCR-2 4m	80	29	18	804	519	<5	69	ND
07/02/02	CCR-2 5m	84	29	17	809	538	<5	78	ND
07/02/02	CCR-2 6m	94	46	37	823	613	5	179	ND
07/02/02	CCR-2 7m	97	48	38	876	615	<5	190	ND
07/16/02	CCR-2 Photic	88	27	12	739	466	<5	10	16.7
07/16/02	CCR-2 4m	83	29	17	768	535	<5	22	ND
07/16/02	CCR-2 5m	93	40	25	710	488	<5	35	ND
07/16/02	CCR-2 6m	104	47	36	733	512	<5	62	ND
07/16/02	CCR-2 7m	113	54	42	741	509	<5	64	ND
07/30/02	CCR-2 Photic	64	22	6	1257	893	<5	34	17.3
07/30/02	CCR-2 4m	75	11	6	972	571	<5	14	ND
07/30/02	CCR-2 5m	80	21	10	846	479	<5	10	ND
07/30/02	CCR-2 6m	95	48	32	775	482	<5	13	ND
07/30/02	CCR-2 7m	113	50	38	833	508	<5	12	ND
08/13/02	CCR-2 Photic	72	17	8	765	468	<5	9	20.5
08/13/02	CCR-2 4m	70	16	8	743	439	<5	9	ND
08/13/02	CCR-2 5m	69	18	7	713	439	<5	9	ND
08/13/02	CCR-2 6m	75	17	9	719	440	<5	11	ND
08/13/02	CCR-2 7m	88	20	12	740	448	<5	13	ND
08/27/02	CCR-2 Photic	57	11	5	861	500	<5	13	17.4
08/27/02	CCR-2 4m	59	12	6	885	538	<5	13	ND
08/27/02	CCR-2 5m	56	11	5	853	493	<5	14	ND
08/27/02	CCR-2 6m	57	11	6	868	512	<5	14	ND
08/27/02	CCR-2 7m	57	12	6	838	502	<5	12	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
09/10/02	CCR-2 Photic	69	21	9	763	448	<5	13	20.3
09/10/02	CCR-2 4m	72	21	10	767	463	<5	16	ND
09/10/02	CCR-2 5m	74	22	10	769	438	<5	13	ND
09/10/02	CCR-2 6m	96	23	11	823	464	<5	37	ND
09/10/02	CCR-2 7m	92	24	12	842	463	<5	37	ND
09/24/02	CCR-2 Photic	73	16	7	662	408	<5	10	22.7
09/24/02	CCR-2 4m	72	12	7	618	409	<5	7	ND
09/24/02	CCR-2 5m	77	16	7	646	426	<5	4	ND
09/24/02	CCR-2 6m	76	15	8	689	392	<5	4	ND
09/24/02	CCR-2 7m	77	14	7	657	365	<5	3	ND
10/15/02	CCR-2 Photic	75	18	10	935	583	<5	19	29.9
10/15/02	CCR-2 4m	70	18	9	837	490	<5	13	ND
10/15/02	CCR-2 5m	78	16	9	829	456	<5	9	ND
10/15/02	CCR-2 6m	77	15	9	804	512	<5	12	ND
10/15/02	CCR-2 7m	73	16	9	797	498	<5	9	ND
11/19/02	CCR-2 Photic	56	14	6	879	564	<5	22	30.1
11/19/02	CCR-2 4m	54	12	6	825	482	<5	17	ND
11/19/02	CCR-2 5m	61	14	6	886	549	<5	17	ND
11/19/02	CCR-2 6m	54	25	5	792	461	<5	12	ND
11/19/02	CCR-2 7m	53	10	6	710	462	<5	11	ND

* "ND" denotes "No Data"

CCR-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
01/22/02	CCR-3 Photic	58	8	4	760	472	8	6	29.1
03/26/02	CCR-3 Photic	52	7	3	742	414	<5	10	23.0
04/16/02	CCR-3 Photic	65	8	<3	749	398	<5	6	22.3
05/06/02	CCR-3 Photic	111	12	<3	868	425	<5	9	39.0
05/20/02	CCR-3 Photic	78	14	<3	730	411	<5	9	17.4
06/03/02	CCR-3 Photic	65	28	6	642	456	<5	7	10.3
06/18/02	CCR-3 Photic	51	19	3	817	492	<5	20	8.7
07/02/02	CCR-3 Photic	94	18	4	913	502	<5	11	17.4
07/16/02	CCR-3 Photic	92	27	13	725	458	<5	10	16.5
07/30/02	CCR-3 Photic	69	17	5	824	468	<5	10	14.9
08/13/02	CCR-3 Photic	67	14	5	737	451	<5	6	18.3
08/27/02	CCR-3 Photic	67	13	7	845	478	<5	10	13.1
09/10/02	CCR-3 Photic	58	18	7	732	436	<5	12	21.4
09/24/02	CCR-3 Photic	73	12	7	665	459	<5	<3	15.9
10/15/02	CCR-3 Photic	68	16	8	831	495	<5	13	27.5
11/19/02	CCR-3 Photic	54	12	6	813	509	<5	18	32.7

CCR University of Colorado Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	NO3+NO2-N ug/L	NH4-N ug/L
Analytical Detection Limits		2	2	3	5	3
06/19/02	CCR-1 Photic	43.8	18.1	1.8	3.3	12.9
07/02/02	CCR-3 Photic	64.5	26.0	5.9	0.0	13.4
07/16/02	CCR-2 6m	83.0	52.8	40.4	1.3	70.7
07/30/02	CCR-2 6m	81.4	49.0	33.8	0.0	27.5
08/13/02	CCR-2 7m	55.5	23.9	12.7	1.3	22.9
08/27/02	CCR-2 5m	51.6	19.6	4.3	0.0	10.3
09/10/02	CCR-2 6m	82.4	28.8	14.8	1.1	42.3
09/24/02	CCR-1 Photic	65.8	21.8	4.6	0.7	10.5
10/15/2002	CCR-2 4m	69.5	25.5	9.6	0.0	12.4
11/19/2002	CCR-1 Photic	51.5	15.7	1.3	0.0	17.7

CCR C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	NO3+NO2-N ug/L	NH4-N ug/L
Analytical Detection Limits		2	2	3	5	3
06/19/02	CCR-1 Photic	67	15	<3	<5	33
07/02/02	CCR-3 Photic	94	18	4	<5	11
07/16/02	CCR-2 6m	104	47	36	<5	62
07/30/02	CCR-2 6m	95	48	32	<5	13
08/13/02	CCR-2 7m	88	20	12	<5	13
08/27/02	CCR-2 5m	56	11	5	<5	14
09/10/02	CCR-2 6m	96	23	11	<5	37
09/24/02	CCR-1 Photic	72	11	6	<5	20
10/15/2002	CCR-2 4m	70	18	9	<5	13
11/19/2002	CCR-1 Photic	63	12	6	<5	28

CHERRY CREEK
D.O. DATA, 2002
Site CCR-1

CCR-1 01/22/02
Secchi: ND
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	2.11	537	14.62	8.48	261.7
1	3.30	559	14.73	8.51	262.0
2	3.36	561	15.09	8.53	263.6
3	3.39	562	15.02	8.56	264.6

CCR-1 03/26/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	5.23	623	12.77	8.37	270.8
1	5.18	622	12.80	8.36	270.3
2	5.03	620	12.63	8.42	269.8
3	5.03	620	12.76	8.50	268.2
4	5.04	621	12.79	8.68	265.6
5	5.06	622	12.76	8.88	264.3

CCR-1 04/16/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	12.55	1313	9.78	8.39	228.0
1	12.52	1310	9.88	7.91	244.0
2	11.81	1287	9.42	7.78	253.0
3	10.86	1256	8.80	7.75	259.0
4	10.51	1246	8.51	7.71	263.0
5	10.40	1245	8.28	7.70	266.0
6	9.90	1229	6.85	7.65	272.0

CCR-1 05/06/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	14.85	1422	9.52	8.26	253.5
1	14.33	1404	9.55	8.25	251.7
2	13.84	1386	8.94	8.22	250.7
3	13.35	1372	7.67	8.18	251.4
4	13.04	1364	6.77	8.15	250.4
5	12.98	1362	6.60	8.13	248.7
6	12.87	1357	6.72	8.16	244.7

CCR-1 05/20/02
Secchi: 0.70m
1% Trans: 4.00m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	15.49	1433	8.99	8.12	228.5
1	15.42	1431	8.90	8.08	221.7
2	15.36	1429	8.45	7.98	206.1
3	14.72	1412	7.58	7.91	198.1
4	14.00	1389	6.70	7.87	184.1
5	13.39	1375	6.53	7.83	166.3

CCR-1 06/03/02
Secchi: ND
1% Trans: 3.90m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	20.02	1580	8.05	8.28	183.9
1	19.88	1574	8.01	8.24	172.1
2	19.20	1568	7.71	8.17	148.4
3	18.72	1532	7.02	8.09	124.5
4	17.56	1496	5.34	7.94	65.2
5	15.38	1423	2.51	7.80	-28.6
6	15.16	1412	1.50	7.74	-96.1

CCR-1 06/18/02
Secchi: 1.00m
1% Trans: 2.20m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	21.52	1617	9.56	7.91	230.2
1	20.57	1586	9.03	7.86	225.2
2	20.27	1573	8.57	7.82	221.8
3	19.54	1554	5.95	7.70	215.6
4	19.02	1539	4.71	7.70	207.3
5	18.65	1525	2.67	7.61	198.3
6	18.19	1516	2.05	7.67	213.3

CCR-1 07/02/02
Secchi: 0.75m
1% Trans: 3.10m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	23.67	903	10.37	8.13	215.3
1	23.70	902	10.45	8.09	225.7
2	22.55	889	8.28	8.04	244.5
3	22.05	888	5.95	7.96	249.6
4	21.70	882	4.17	7.89	254.3
5	21.22	874	2.53	7.80	259.0
6	20.77	867	1.44	7.75	260.1

* "ND" denotes "No Data"

CCR-1 DO Data Continued

CCR-1 07/16/02
Secchi: 1.00m
1% Trans: 4.00m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	25.01	916	9.11	8.12	100.9
1	24.19	902	8.15	8.02	93.7
2	23.93	898	7.46	7.97	84.0
3	23.47	892	3.60	7.73	53.0
4	23.10	886	1.46	7.50	-10.6
5	22.78	880	0.36	7.50	-59.7
6	22.10	822	0.15	7.12	-195.4

CCR-1 07/30/02
Secchi: 1.00m
1% Trans: 3.50m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	24.29	968	8.67	8.00	164.5
1	24.17	964	8.67	8.05	191.6
2	23.95	961	8.34	8.11	208.2
3	23.46	955	5.28	8.02	217.5
4	23.28	953	3.99	7.94	223.5
5	22.99	949	1.35	7.85	226.0
6	22.77	945	0.30	7.74	-197.1

CCR-1 08/13/02
Secchi: 0.75m
1% Trans: 2.75m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	22.44	916	6.26	8.05	257.0
1	22.33	914	5.69	7.89	259.1
2	22.19	912	5.68	7.89	260.6
3	22.18	911	5.53	7.92	263.3
4	22.11	912	3.88	7.85	267.6
5	22.06	912	2.63	7.79	270.5
6	21.97	911	1.17	7.73	267.6

CCR-1 08/27/02
Secchi: 1.15m
1% Trans: 1.30m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	21.29	901	6.56	7.82	313.6
1	21.29	902	6.50	7.84	312.9
2	21.27	902	6.33	7.86	312.8
3	21.10	899	5.81	7.87	313.4
4	21.05	899	5.52	7.87	313.8
5	21.00	899	5.37	7.88	313.4
6	20.93	898	5.24	7.88	313.4

CCR-1 09/10/02
Secchi: 0.75m
1% Trans: 2.25m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	20.53	882	5.72	7.94	293.5
1	20.52	882	5.71	7.92	293.4
2	20.53	881	5.65	7.91	294.7
3	20.53	881	5.66	7.91	294.2
4	20.53	882	5.73	7.93	295.7
5	20.52	881	5.84	7.93	297.5

CCR-1 09/24/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	17.93	832	7.75	8.03	272.6
1	17.56	824	7.57	8.13	274.1
2	17.49	824	6.82	8.12	276.6
3	17.43	822	6.68	8.11	279.0
4	17.38	821	6.53	8.10	279.0
4.5	17.38	821	6.25	8.09	280.0

CCR-1 10/15/02
Secchi: 0.65m
1% Trans: 2.00m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	13.28	757	9.83	8.16	211.0
1	13.17	754	9.97	8.15	204.0
2	13.14	753	9.99	8.14	197.0
3	13.11	754	9.94	8.12	187.0
4	13.09	777	9.90	8.10	176.0
5	13.07	753	9.76	8.09	160.0
6	13.17	740	6.64	7.93	98.4

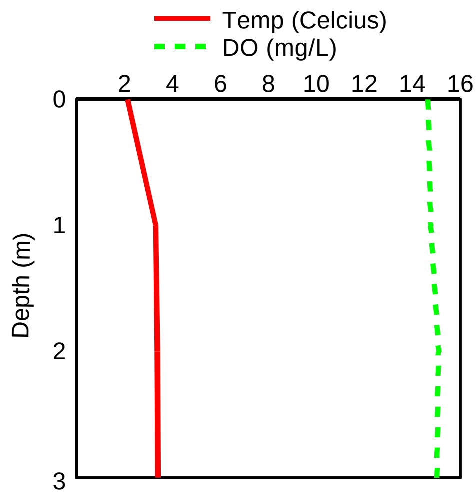
CCR-1 11/19/02
Secchi: 0.80m
1% Trans: 3.25m

Depth (m)	Temp ^oC	Cond.	DO	pH	ORP
0	4.70	594	11.24	8.96	304.0
1	4.67	593	11.41	8.90	304.0
2	4.68	593	11.40	8.85	305.0
3	4.67	580	11.35	8.83	305.0
4	4.52	591	11.27	8.79	306.0
5	4.52	591	11.25	8.77	306.0
6	4.54	591	11.05	8.67	306.0

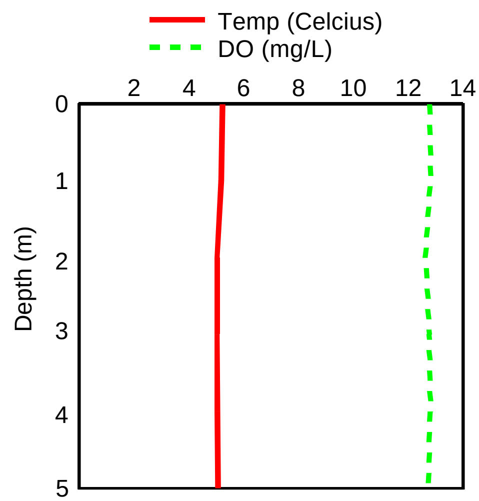
* "ND" denotes "No Data"

CCR-1

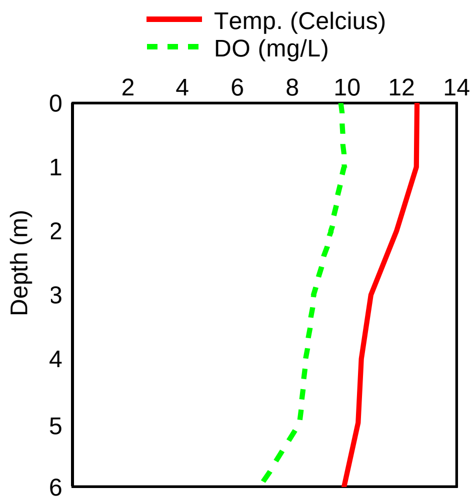
January 22, 2002



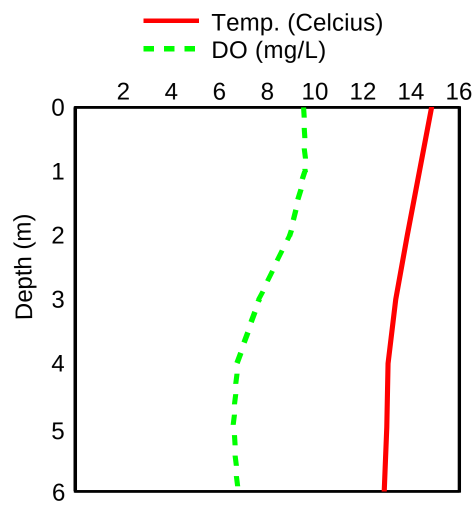
March 26, 2002



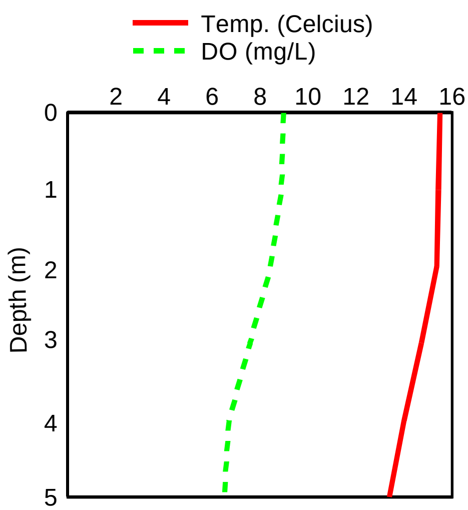
April 16, 2002



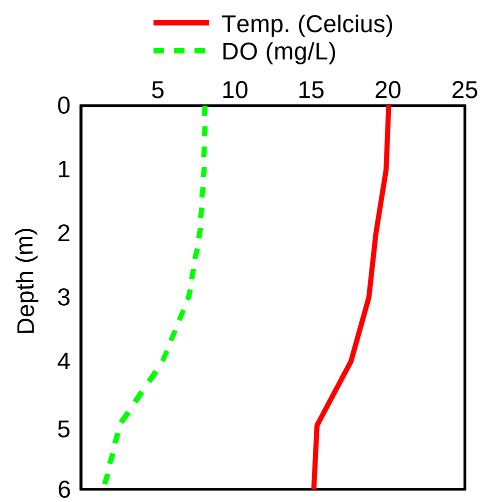
May 6, 2002



May 20, 2002

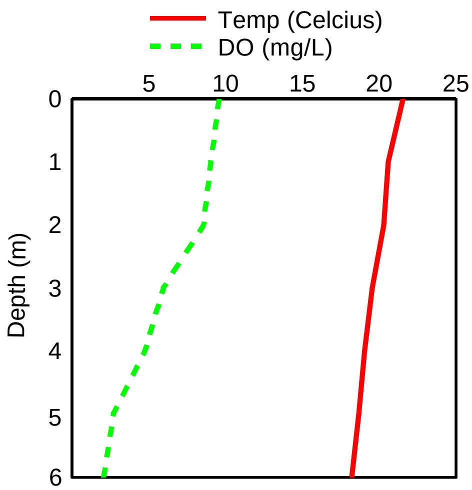


June 3, 2002

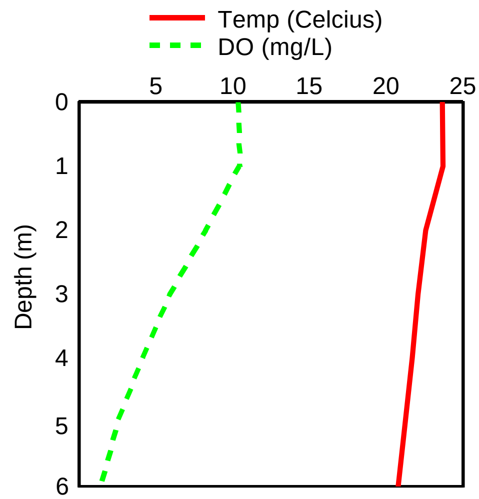


CCR-1

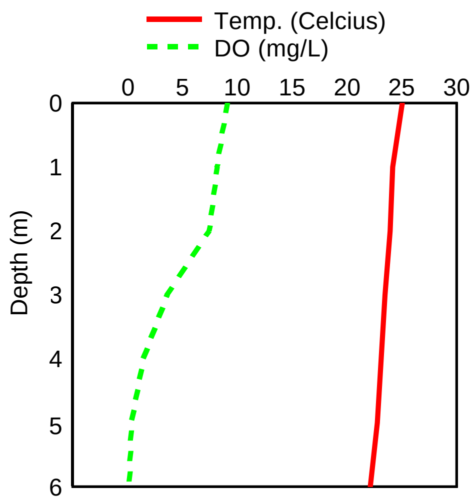
June 18, 2002



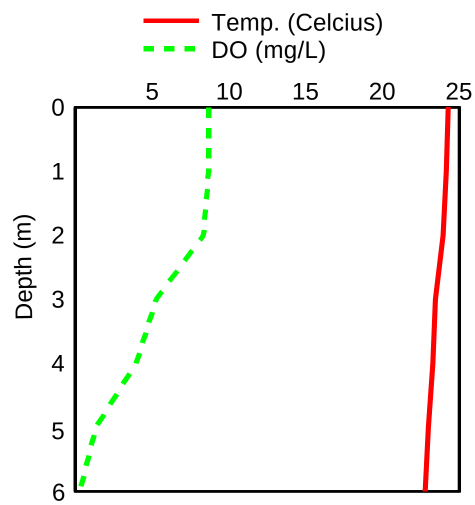
July 2, 2002



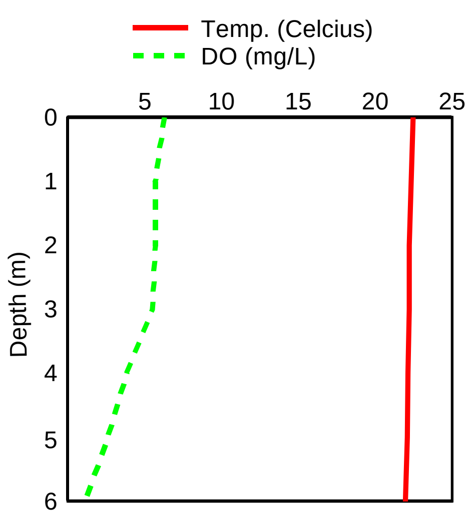
July 16, 2002



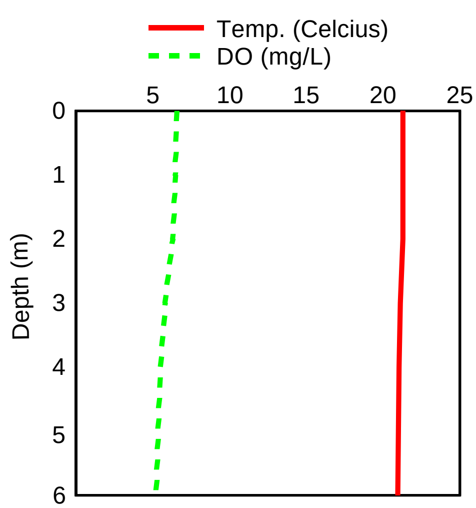
July 30, 2002



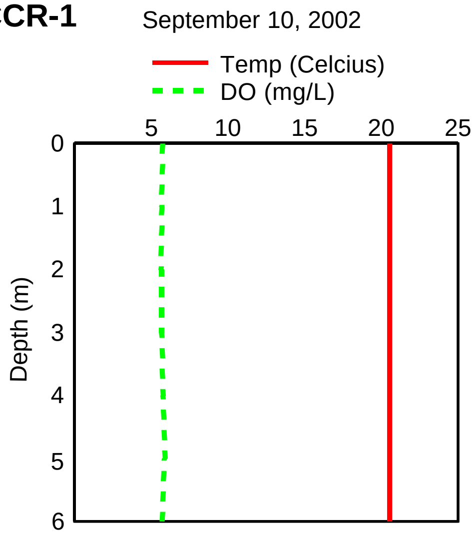
August 13, 2002

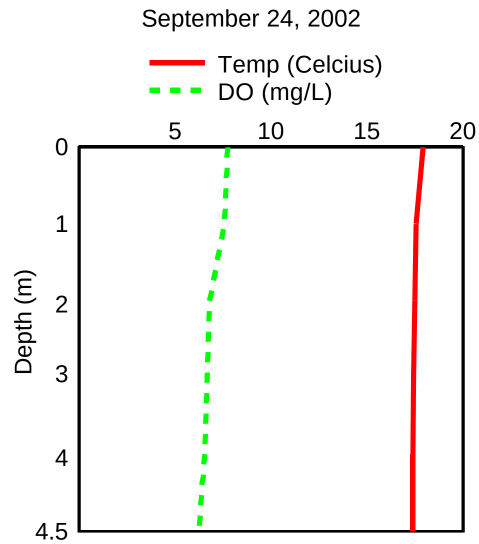


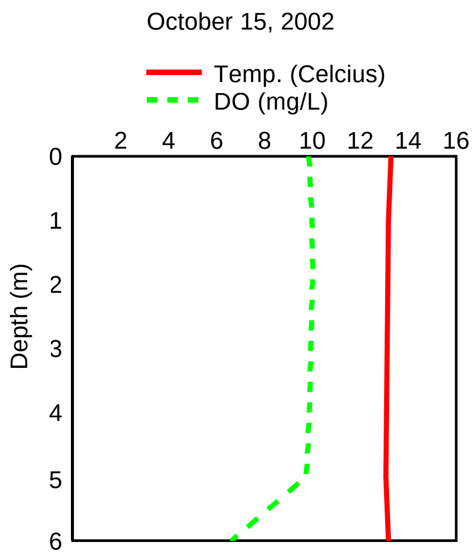
August 27, 2002

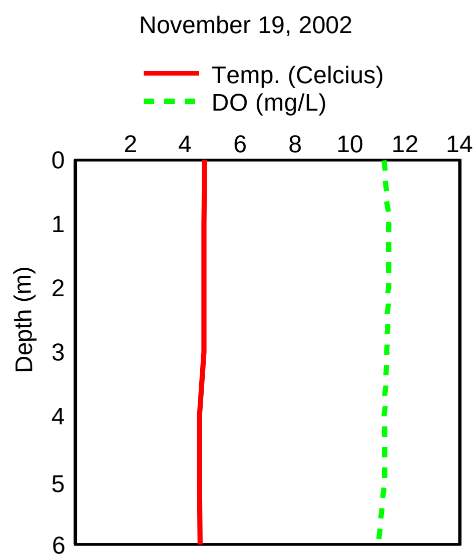


CCR-1


September 10, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5 6


September 24, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20
Depth (m)
0 1 2 3 4 4.5


October 15, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14 16
Depth (m)
0 1 2 3 4 5 6


November 19, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
Depth (m)
0 1 2 3 4 5 6

CHERRY CREEK
D.O. DATA, 2002
Site CCR-2

CCR-2 01/22/02
Secchi: ND
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	3.70	568	11.57	8.87	245.1
1	3.51	565	12.33	8.88	246.3
2	3.39	565	12.32	8.85	248.5
3	3.44	567	12.10	8.86	249.7

CCR-2 03/26/02
Secchi: 0.60m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	5.25	621	12.82	8.42	268.4
1	5.20	620	12.84	8.42	267.5
2	5.19	620	12.58	8.41	267.0
3	4.82	614	12.76	8.42	266.0
4	4.78	613	12.58	8.42	266.2
5	4.75	613	12.58	8.44	265.1
6	4.71	613	12.59	8.43	264.5
7	4.73	613	12.32	8.51	263.3

CCR-2 04/16/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	12.60	1278	9.64	8.05	246.0
1	12.61	1314	9.78	7.95	250.0
2	12.59	1317	9.74	7.93	254.0
3	12.54	1310	9.71	7.91	257.0
4	12.32	1303	9.66	7.90	259.0
5	11.97	1290	9.19	7.88	267.0
6	10.71	1256	8.09	7.88	272.0
7	9.40	1210	5.83	7.82	280.0

CCR-2 05/06/02
Secchi: 0.65m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	14.75	1413	9.48	8.39	259.2
1	14.13	1394	9.46	8.38	258.6
2	13.71	1379	9.11	8.37	257.7
3	13.50	1372	8.85	8.35	256.8
4	13.43	1369	8.83	8.36	254.0
5	13.41	1368	8.80	8.34	252.3
6	13.32	1367	8.29	8.35	249.9
7	13.10	1360	7.75	8.34	248.6

CCR-2 05/20/02
Secchi: 0.75m
1% Trans: 3.50m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	15.22	1421	9.13	8.37	263.4
1	14.98	1412	8.83	8.34	262.5
2	14.78	1411	8.41	8.31	261.2
3	14.61	1406	8.04	8.28	259.1
4	14.25	1397	7.22	8.22	257.3
5	13.55	1375	6.34	8.18	255.6
6	13.32	1368	5.85	8.17	252.7
7	13.24	1365	5.45	8.17	248.9

CCR-2 06/03/02
Secchi: 1.00m
1% Trans: 3.60m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	19.23	1554	8.23	8.27	241.6
1	18.87	1531	7.94	8.20	242.2
2	18.57	1528	7.62	8.15	240.4
3	18.11	1514	6.76	8.08	240.1
4	17.41	1487	6.06	8.01	238.4
5	15.78	1436	4.21	7.93	242.3
6	15.37	1420	3.92	7.94	240.3
7	14.80	1403	1.69	7.89	240.0

CCR-2 06/18/02
Secchi: 0.85m
1% Trans: 2.95m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	21.51	1613	9.59	8.18	250.5
1	20.78	1585	9.72	8.13	247.9
2	20.54	1578	9.12	8.06	246.1
3	20.43	1577	8.54	8.01	244.3
4	20.18	1566	7.26	7.93	242.6
5	18.75	1530	4.08	7.84	246.0
6	18.26	1513	2.75	7.82	243.7
7	17.79	1499	0.36	7.73	244.8

CCR-2 07/02/02
Secchi: 1.00m
1% Trans: 3.30m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	23.41	907	8.87	8.40	236.6
1	23.24	904	8.88	8.36	243.0
2	22.95	900	8.43	8.35	248.2
3	22.32	892	6.77	8.28	254.1
4	21.22	875	3.72	8.13	261.2
5	20.92	869	2.65	8.04	264.5
6	20.75	867	1.97	8.00	265.4
7	20.60	864	1.14	7.91	267.1

* "ND" denotes "No Data"

CCR-2 DO Data Continued

CCR-2 07/16/02
Secchi: 1.00m
1% Trans: 3.75m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	24.29	911	8.26	8.13	147.5
1	23.60	895	7.19	8.06	141.0
2	23.45	892	6.94	8.01	134.9
3	23.11	887	5.54	7.93	125.5
4	22.73	881	3.25	7.85	114.9
5	22.62	879	2.53	7.82	109.7
6	22.52	877	1.75	7.83	106.2
7	22.42	876	1.31	7.86	105.5

CCR-2 07/30/02
Secchi: 1.13m
1% Trans: 3.50m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	24.50	973	8.32	8.27	152.4
1	24.03	964	8.52	8.20	144.6
2	23.73	958	7.72	8.10	138.6
3	23.65	958	7.17	8.04	131.0
4	23.27	954	4.54	7.80	121.1
5	23.09	951	3.49	7.80	108.5
6	22.89	947	1.46	7.70	96.7
7	22.73	945	0.33	7.80	91.8

CCR-2 08/13/02
Secchi: 1.25m
1% Trans: 3.25m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	22.38	917	6.06	8.14	240.1
1	22.11	912	5.61	8.15	244.6
2	21.96	909	5.09	8.13	250.2
3	21.84	907	4.99	8.14	255.0
4	21.71	905	5.19	8.16	258.0
5	21.67	903	5.35	8.18	259.0
6	21.66	904	4.94	8.16	262.0
7	21.65	899	1.49	7.65	-40.0

CCR-2 08/27/02
Secchi: 0.98m
1% Trans: 1.21m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	21.38	904	6.68	8.06	282.1
1	21.42	904	6.66	8.08	283.6
2	21.42	905	6.62	8.11	284.5
3	21.43	905	6.62	8.11	285.6
4	21.42	904	6.65	8.12	286.1
5	21.40	903	6.72	8.14	286.8
6	21.17	901	5.46	8.11	285.1
7	21.07	902	5.93	8.15	285.7

CCR-2 09/10/02
Secchi: 0.55m
1% Trans: 2.35m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	20.27	877	5.04	7.93	270.1
1	20.28	876	4.95	7.94	271.2
2	20.28	876	5.03	7.97	272.1
3	20.28	877	4.94	7.97	273.9
4	20.28	877	4.93	8.00	276.3
5	20.28	876	4.92	8.01	276.8
6	20.28	878	4.79	8.01	278.4
7	20.28	878	4.73	8.02	279.0

CCR-2 09/24/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	17.78	829	7.52	8.23	271.4
1	17.50	823	7.39	8.22	273.1
2	17.33	820	7.16	8.20	274.8
3	17.24	819	6.80	8.10	275.8
4	17.22	819	6.67	8.17	277.4
5	17.21	818	6.62	8.17	278.5
6	17.17	819	6.43	8.14	279.5
7	17.12	819	5.64	8.08	270.0

CCR-2 10/15/02
Secchi: 0.65m
1% Trans: 2.25m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	13.28	756	8.69	8.26	188.0
1	13.00	751	8.95	8.29	197.0
2	12.85	748	8.37	8.27	203.0
3	12.83	747	8.23	8.27	208.0
4	12.77	747	8.11	8.26	212.0
5	12.67	745	8.08	8.27	214.0
6	12.42	741	7.90	8.27	217.0
7	12.40	741	7.69	8.26	218.0

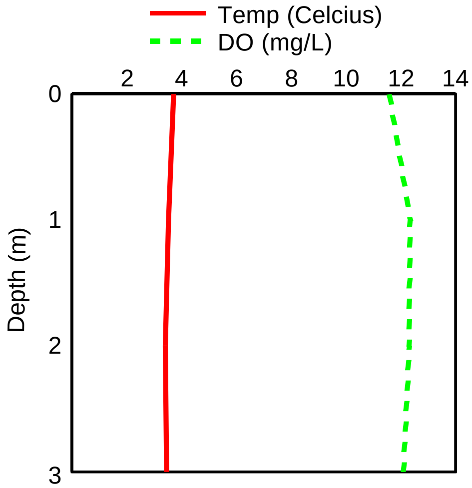
CCR-2 11/19/02
Secchi: 0.75m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	4.78	595	11.27	8.98	289.0
1	4.69	593	11.30	8.94	291.0
2	4.63	593	11.24	8.91	292.0
3	4.58	591	11.09	8.87	293.0
4	4.56	590	11.00	8.86	294.0
5	4.56	591	10.94	8.85	294.0
6	4.57	591	10.77	8.84	295.0
7	4.66	593	10.32	8.72	296.0

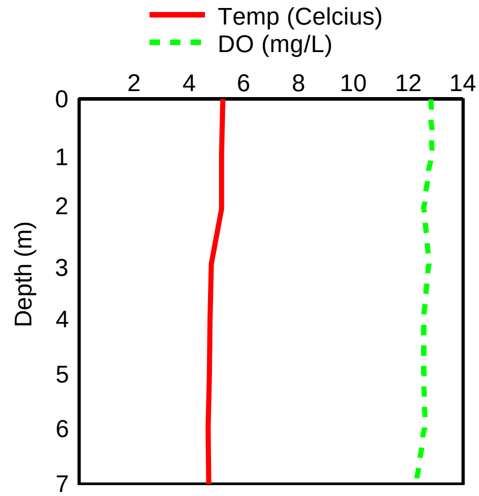
* "ND" denotes "No Data"

CCR-2

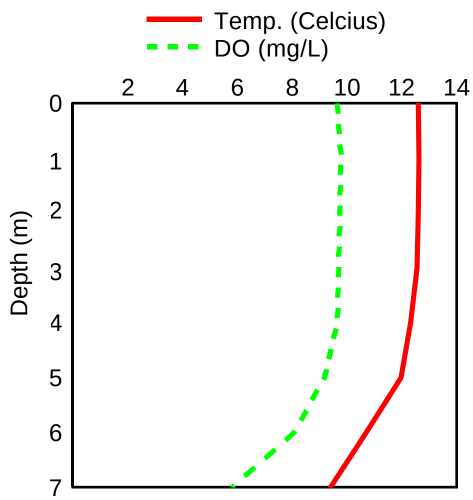
January 22, 2002



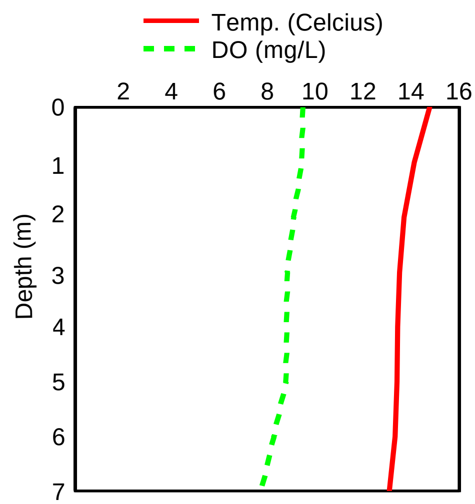
March 26, 2002



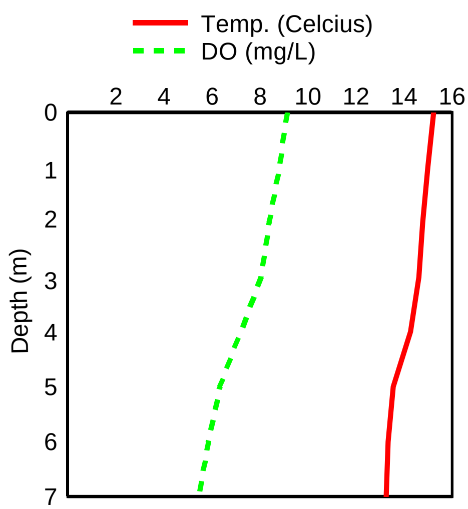
April 16, 2002



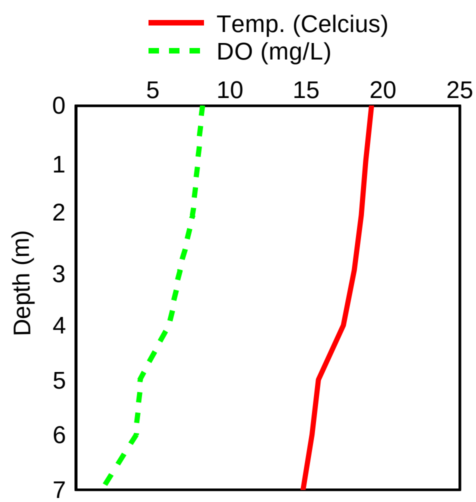
May 6, 2002



May 20, 2002

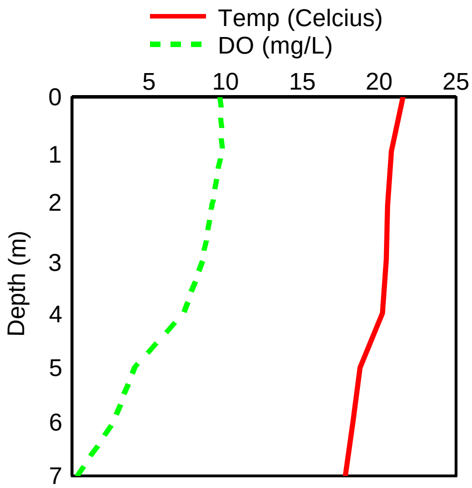


June 3, 2002

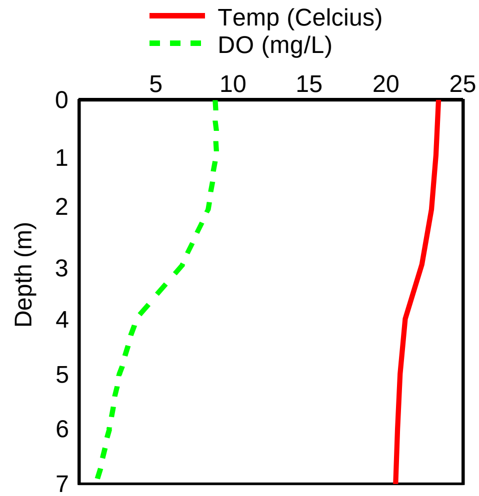


CCR-2

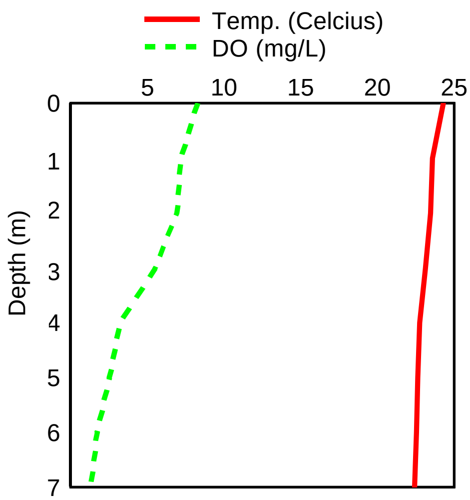
June 18, 2002



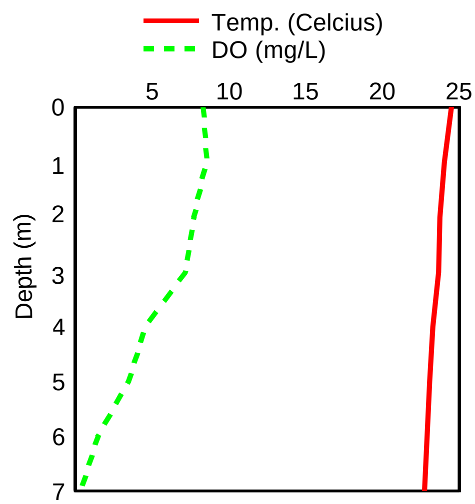
July 2, 2002



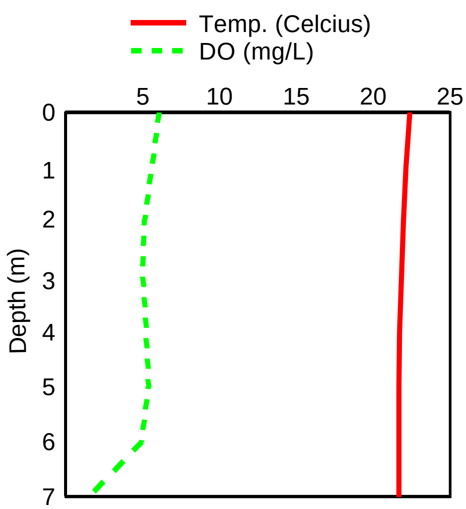
July 16, 2002



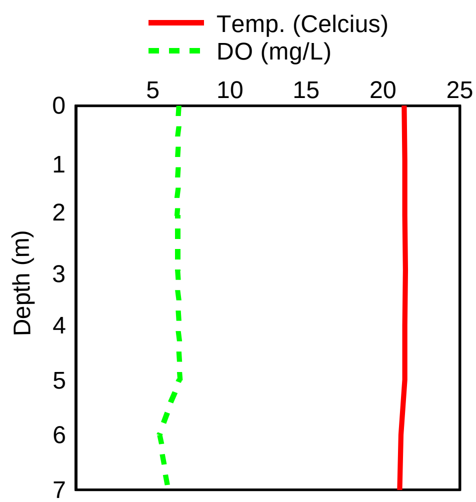
July 30, 2002



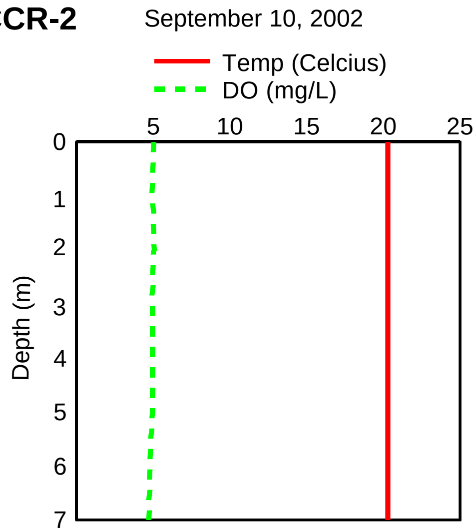
August 13, 2002



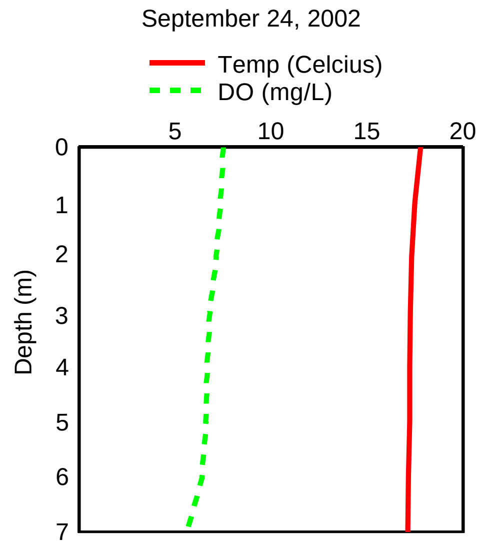
August 27, 2002



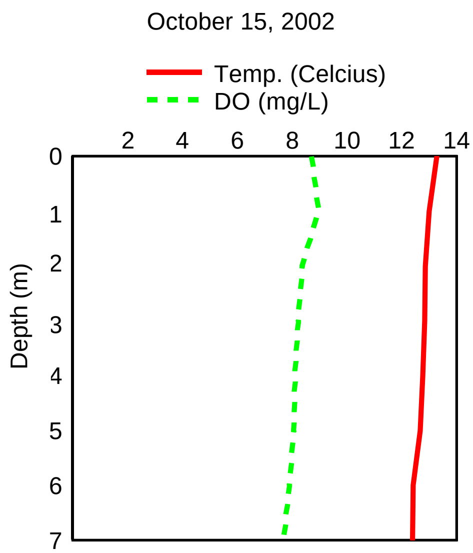
CCR-2



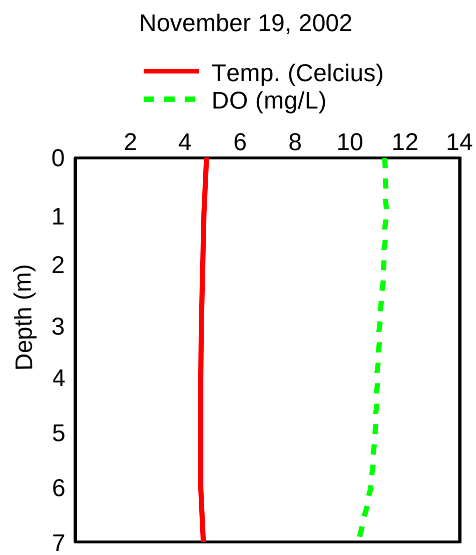
September 10, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6 7
Depth (m)



September 24, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20
0 1 2 3 4 5 6 7
Depth (m)



October 15, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6 7
Depth (m)



November 19, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6 7
Depth (m)

CHERRY CREEK
D.O. DATA, 2002
Site CCR-3

CCR-3 01/22/02
Secchi: ND
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	3.30	557	4.85	8.92	257.5
1	3.71	569	6.28	8.91	256.3
2	3.51	568	5.57	8.90	256.5
3	3.38	568	5.18	8.89	256.8

CCR-3 03/26/02
Secchi: 0.72m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	5.35	623	13.16	8.47	278.5
1	5.19	619	13.00	8.45	278.7
2	4.92	615	12.80	8.41	278.7
3	4.72	612	12.86	8.42	278.2
4	4.72	612	12.58	8.44	277.9
5	4.74	613	12.53	8.43	277.5

CCR-3 04/16/02
Secchi: 0.85m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	11.91	1288	9.62	8.37	224.0
1	11.88	1290	9.64	8.20	233.0
2	11.94	1291	9.66	8.13	241.0
3	11.97	1316	9.64	8.10	245.0
4	11.95	1293	9.63	8.10	247.0
5	10.92	1291	9.47	8.08	249.0

CCR-3 05/06/02
Secchi: 0.45m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	14.60	1451	9.09	8.34	183.8
1	13.87	1401	8.73	8.32	165.1
2	13.61	1382	7.96	8.30	143.2

CCR-3 05/20/02
Secchi: 0.50m
1% Trans: 3.00m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	15.86	1451	9.04	8.43	198.6
1	15.36	1434	8.77	8.39	184.2
2	15.17	1426	8.54	8.37	166.7
3	14.99	1449	8.00	8.32	143.2
4	14.72	1412	6.60	8.26	100.4
5	14.18	1406	5.07	8.22	33.4

CCR-3 06/03/02
Secchi: 0.75m
1% Trans: 2.60m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	19.52	1564	7.70	8.07	218.4
1	19.25	1551	7.67	8.04	214.6
2	18.61	1532	7.52	8.01	213.2
3	18.38	1523	6.74	7.95	209.9
4	17.96	1531	5.35	7.90	211.5
5	17.42	1494	5.44	7.93	209.2

CCR-3 06/18/02
Secchi: 1.00m
1% Trans: 2.90m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	20.27	1579	8.87	8.31	256.0
1	19.88	1562	8.13	8.25	252.7
2	19.67	1557	7.24	8.19	252.0
3	19.25	1546	6.07	8.14	252.4
4	19.10	1543	5.05	8.10	252.0

CCR-3 07/02/02
Secchi: 0.75m
1% Trans: 2.80m

Depth (m)	Temp °C	Cond.	DO	pH	ORP
0	22.57	899	7.52	8.56	226.1
1	22.50	896	7.34	8.50	232.7
2	22.29	893	7.06	8.42	243.1
3	21.97	887	6.65	8.37	248.6
4	21.75	882	5.60	8.28	255.3
5	21.48	878	4.64	8.20	260.9

* "ND" denotes "No Data"

CCR-3 DO Data Continued

CCR-3	07/16/02				
Secchi:	1.25m				
1% Trans:	3.50m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	24.70	908	7.60	8.14	57.0
1	23.30	890	6.88	8.10	42.2
2	23.01	884	6.37	8.06	30.9
3	22.85	882	5.94	8.03	0.0
4	22.33	762	5.74	8.02	10.6
4.5	22.46	868	5.19	8.06	106.2

CCR-3	07/30/02				
Secchi:	1.15m				
1% Trans:	3.50m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	24.68	978	7.35	8.29	80.0
1	23.68	956	8.13	8.35	109.9
2	23.31	952	7.22	8.32	114.2
3	23.08	948	6.31	8.28	120.0
4	22.78	965	5.53	8.24	124.0
5	22.50	938	3.79	8.15	111.0

CCR-3	08/13/02				
Secchi:	1.00m				
1% Trans:	3.25m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	22.70	922	7.17	8.38	177.9
1	22.18	912	7.18	8.40	191.2
2	21.74	904	6.80	8.41	201.0
3	21.68	903	6.71	8.41	207.5
4	21.39	899	6.47	8.40	211.4
5	20.97	890	4.22	8.24	197.0

CCR-3	08/27/02				
Secchi:	0.62m				
1% Trans:	1.18m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	20.97	897	6.07	8.14	102.4
1	20.98	897	6.16	8.14	117.9
2	20.93	896	6.11	8.15	132.7
3	20.93	896	6.09	8.16	140.3
4	20.81	895	5.69	8.15	152.7
5	20.66	885	4.90	8.09	148.1

CCR-3	09/10/02				
Secchi:	0.75m				
1% Trans:	2.65m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	20.24	876	6.39	8.14	260.4
1	20.25	877	6.28	8.18	261.5
2	20.25	877	6.26	8.21	262.6
3	20.25	876	6.23	8.21	263.7
4	20.25	877	6.21	8.23	265.7
5	20.24	876	6.13	8.23	266.9

CCR-3	09/24/02				
Secchi:	0.75m				
1% Trans:	ND				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	17.48	882	7.93	8.28	248.0
1	17.32	818	7.79	8.28	249.6
2	17.02	813	7.32	8.25	251.6
3	16.88	811	6.73	8.22	254.6
3.5	16.90	812	6.48	8.19	257.0

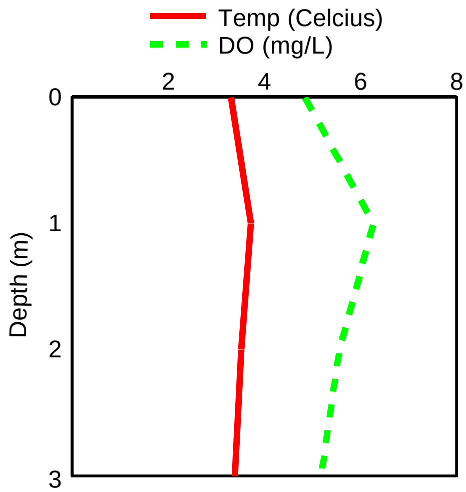
CCR-3	10/15/02				
Secchi:	0.55m				
1% Trans:	2.10m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	13.23	756	8.85	8.31	216.0
1	12.67	746	8.81	8.33	219.0
2	12.41	740	8.62	8.32	221.0
3	12.30	738	8.53	8.32	225.0
4	12.05	734	8.36	8.31	227.0

CCR-3	11/19/02				
Secchi:	0.85m				
1% Trans:	3.35m				
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**	**ORP**
0	4.92	597	11.00	8.99	215.0
1	4.65	592	11.29	8.96	223.0
2	4.59	590	11.29	8.92	230.0
3	4.53	590	11.14	8.93	235.0
4	4.51	589	10.97	8.91	239.0
5	4.57	590	10.43	8.78	242.0

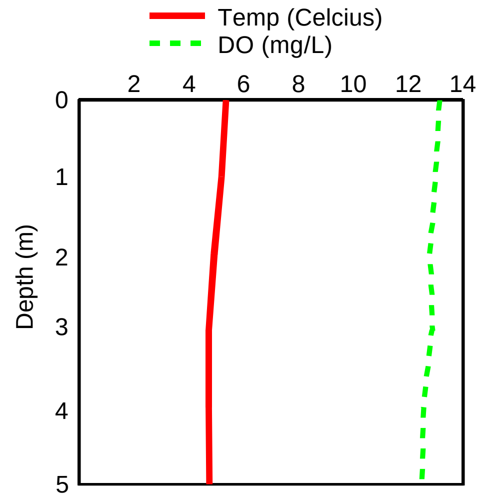
* "ND" denotes "No Data"

CCR-3

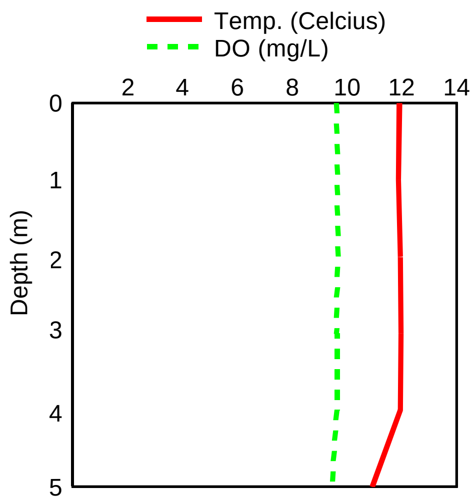
January 22, 2002



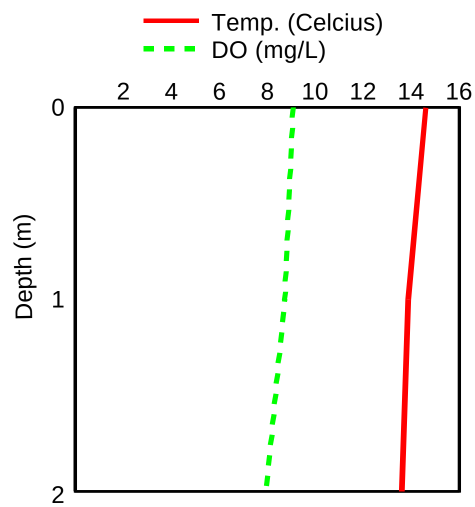
March 26, 2002



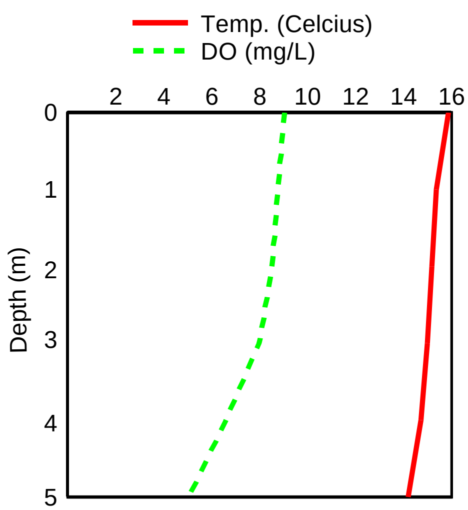
April 16, 2002



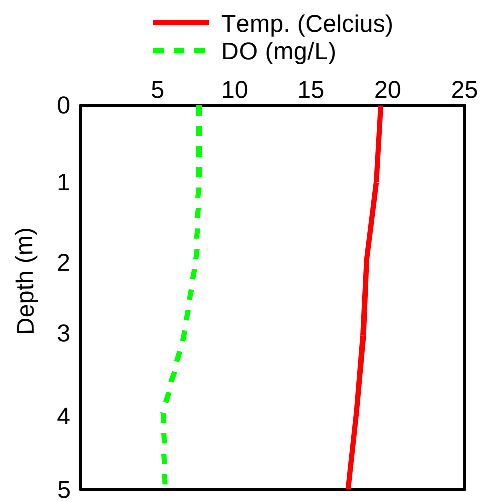
May 6, 2002



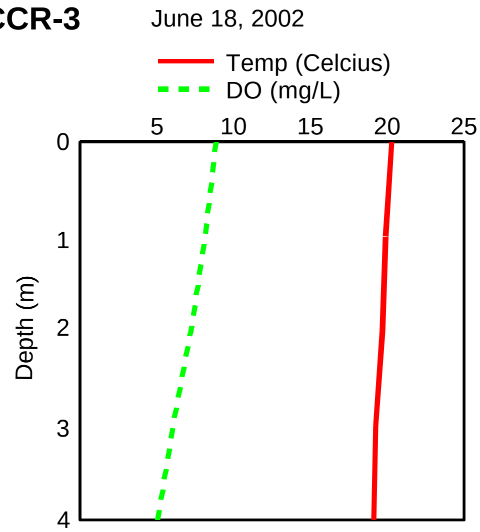
May 20, 2002

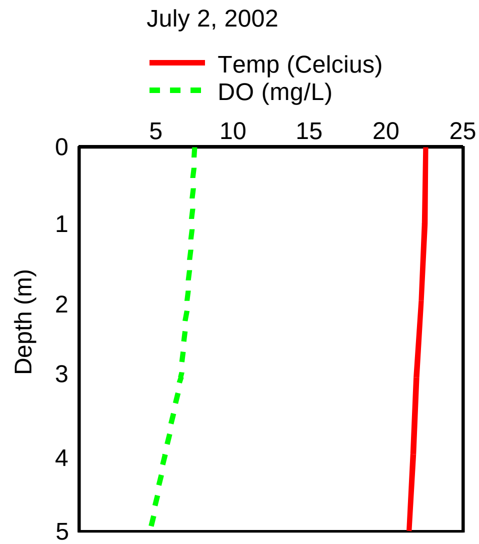


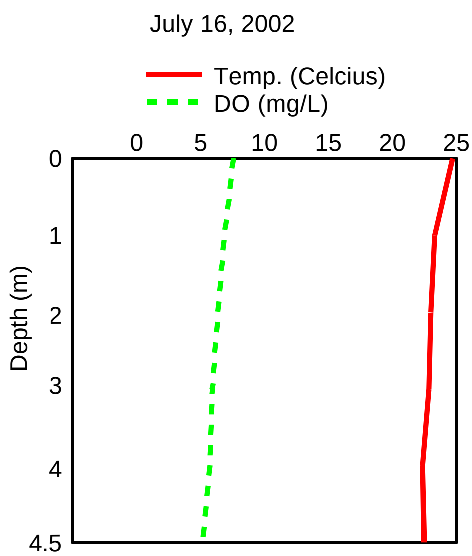
June 3, 2002

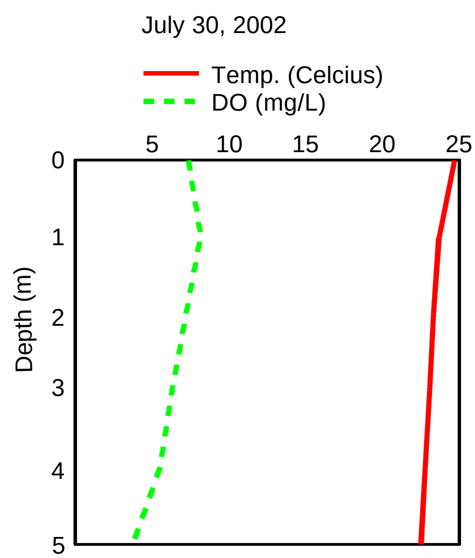


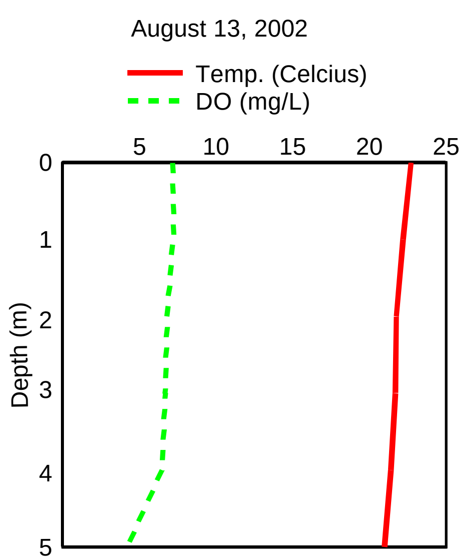
CCR-3

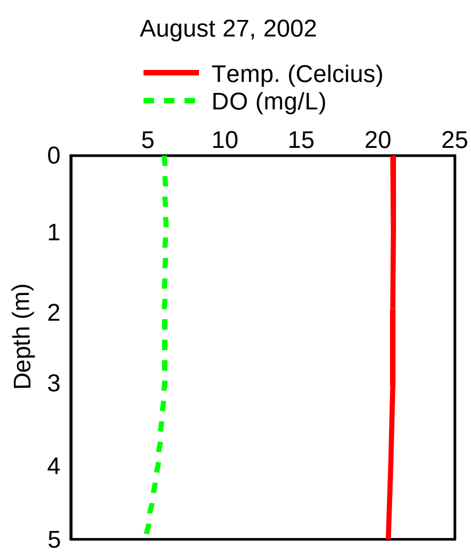

June 18, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4
Depth (m)


July 2, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

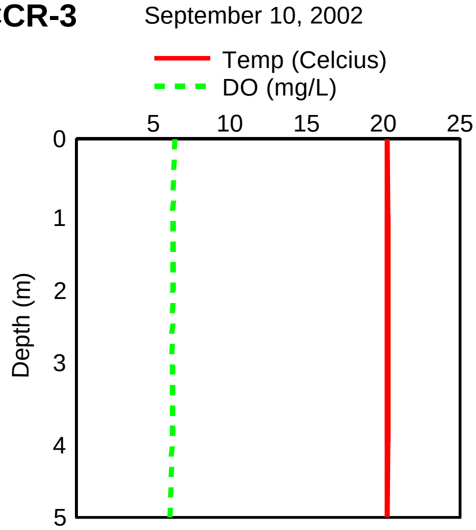

July 16, 2002
Temp. (Celcius)
DO (mg/L)
0 5 10 15 20 25
0 1 2 3 4 4.5
Depth (m)

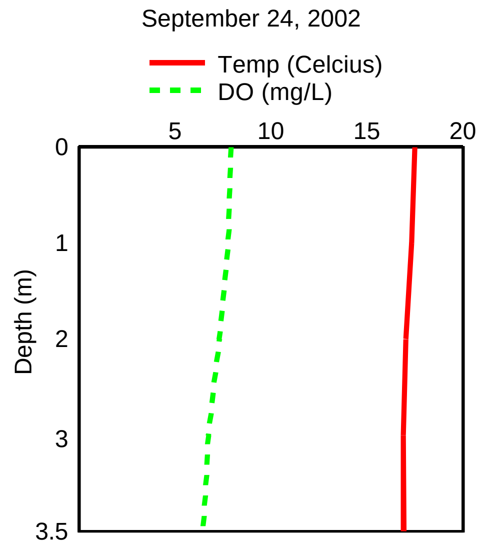

July 30, 2002
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

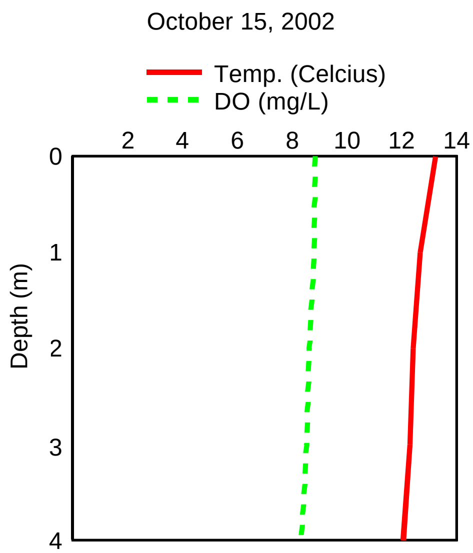

August 13, 2002
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

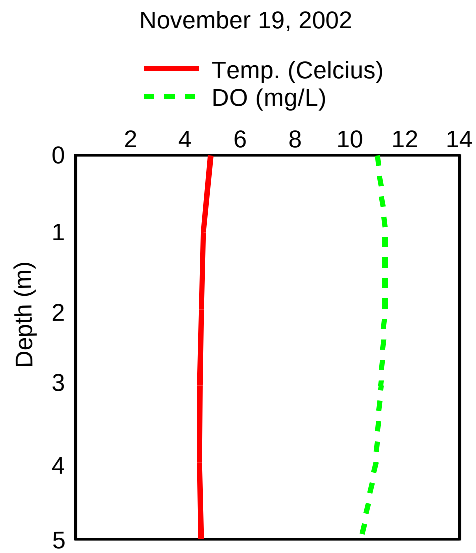

August 27, 2002
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

CCR-3


September 10, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)


September 24, 2002
Temp (Celcius)
DO (mg/L)
5 10 15 20
0 1 2 3 3.5
Depth (m)


October 15, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4
Depth (m)


November 19, 2002
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5
Depth (m)

Cherry Creek Reservoir Secchi and 1% Transmissivity Depths for 2002

CCR-1				CCR-2				CCR-3			
Date	Secchi (m)	1% Trans (m)	Ratio	Date	Secchi (m)	1% Trans (m)	Ratio	Date	Secchi (m)	1% Trans (m)	Ratio
01/22/02	ND	ND	ND	01/22/02	ND	ND	ND	01/22/02	ND	ND	ND
03/26/02	0.75	ND	ND	03/26/02	0.60	ND	ND	03/26/02	0.72	ND	ND
04/16/02	0.75	ND	ND	04/16/02	0.75	ND	ND	04/16/02	0.85	ND	ND
05/06/02	0.75	ND	ND	05/06/02	0.65	ND	ND	05/06/02	0.45	ND	ND
05/20/02	0.70	4.00	5.71	05/20/02	0.75	3.50	4.67	05/20/02	0.50	3.00	6.00
06/03/02	ND	3.90	ND	06/03/02	1.00	3.60	3.60	06/03/02	0.75	2.60	3.47
06/18/02	1.00	2.20	2.20	06/18/02	0.85	2.95	3.47	06/18/02	1.00	2.90	2.90
07/02/02	0.75	3.10	4.13	07/02/02	1.00	3.30	3.30	07/02/02	0.75	2.80	3.73
07/16/02	1.00	4.00	4.00	07/16/02	1.00	3.75	3.75	07/16/02	1.25	3.50	2.80
07/30/02	1.00	3.50	3.50	07/30/02	1.13	3.50	3.10	07/30/02	1.15	3.50	3.04
08/13/02	0.75	2.75	3.67	08/13/02	1.25	3.25	2.60	08/13/02	1.00	3.25	3.25
08/27/02	1.15	1.30	1.13	08/27/02	0.98	1.21	1.23	08/27/02	0.62	1.18	1.90
09/10/02	0.75	2.25	3.00	09/10/02	0.55	2.35	4.27	09/10/02	0.75	2.65	3.53
09/24/02	0.75	ND	ND	09/24/02	0.75	ND	ND	09/24/02	0.75	ND	ND
10/15/02	0.65	2.00	3.08	10/15/02	0.65	2.25	3.46	10/15/02	0.55	2.10	3.82
11/19/02	0.80	3.25	4.06	11/19/02	0.75	ND	ND	11/19/02	0.85	3.35	3.94
Average	0.83	2.93	3.45	Average	0.84	2.97	3.35	Average	0.80	2.80	3.49
Median	0.75	3.10	3.58	Median	0.75	3.28	3.47	Median	0.75	2.90	3.47

* "ND" denotes "No Data"

APPENDIX B

STREAMWATER QUALITY AND PRECIPITATION DATA

CC-10 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/22/02	CC-10	229	152	151	1672	1493	1221	71	51.0	7.4
02/20/02	CC-10	187	141	137	1560	1430	1062	45	37.0	7.2
03/26/02	CC-10	129	97*	99*	858	808	532	19	30.7	10.0
04/16/02	CC-10	187	151	144	842	734	368	36	24.2	7.9
05/06/02	CC-10	274	202	202	1244	1086	777	81	35.2	5.6
06/03/02	CC-10	352	247	235	1331	1095	733	118	48.2	6.4
07/16/02	CC-10	219	158	147	909	752	495	39	47.8	9.4
08/27/02	CC-10	149	105	118	634	500	254	27	30.4	5.0
09/24/02	CC-10	159	129*	131*	573	531	305	28	28.6	7.2
10/15/02	CC-10	152	128*	146*	906	847	622	31	24.6	6.2
11/19/02	CC-10	231	194	191	1280	1133	802	138	19.4	6.2
12/17/2002	CC-10	196	165*	168*	1440	1340	1043	105	25.8	9.4
05/17/02	CC-10 storm	247	178*	180*	1381	1246	818	93	36.2	6.8
05/24/02	CC-10 storm	253	161	148	1584	1340	802	98	56.7	14.3
06/04/02	CC-10 storm	352	191	181	1640	1219	713	75	51.7	14.0
06/20/02	CC-10 storm	257	179	162	1405	1117	532	86	43.0	10.4
09/19/02	CC-10 storm	155	117	120	919	818	589	65	25.8	6.4

* Data within acceptable (10%) difference between parameters.

CC-O C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/22/02	CC-O	84	11	6	904	557	29	20	21.0	6.0
02/20/02	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND
03/26/02	CC-O	135	7	4	853	384	6	8	38.6	9.8
04/16/02	CC-O	140	12	4	983	432	<5	8	43.6	14.8
05/06/02	CC-O	76	17	<3	812	516	<5	10	15.2	5.6
06/03/02	CC-O	56	28	10	948	762	<5	54	12.6	6.4
07/16/02	CC-O	105	62	21	894	633	9	8	24.6	8.8
08/27/02	CC-O	49	18	7	793	572	<5	9	9.8	5.0
09/24/02	CC-O	134	19	11	733	353	<5	<3	57.5	13.9
10/15/02	CC-O	82	15	8	813	444	<5	9	29.2	12.2
11/19/2002	CC-O	96	20	7	1013	546	<5	12	23.8	9.2
12/17/2002	CC-O	43	9	<3	735	512	14	12	22.0	10.4

"ND" denotes "No Data"

CT-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/22/02	CT-1	77	27	19	3973	3826	3416	136	43.0	6.4
02/20/02	CT-1	100	24	15	3907	3633	2958	152	60.2	9.2
03/26/02	CT-1	62	10**	14**	2146	2107	1710	21	50.0	11.2
04/16/02	CT-1	55	10	9	1631	1376	890	52	37.4	9.6
05/06/02	CT-1	89	20	14	2415	2105	892	954	58.4	8.6
06/03/02	CT-1	36	12	8	1944	1780	1338	19	17.2	6.0
07/16/02	CT-1	58	24	21	2968	2824	2217	21	17.6	5.4
08/27/02	CT-1	70	10	6	2632	2203	1787	25	30.8	8.4
09/24/02	CT-1	70	20	16	2214	2027	1710	90	28.6	7.2
10/15/02	CT-1	59	34*	35*	2666*	2704*	2314	13	22.6	9.2
11/19/2002	CT-1	38	12	8	4220	4055	3753	37	22.6	6.4
12/17/2002	CT-1	47	13	7	4246	4051	3282	248	35.8	9.8
05/17/02	CT-1 storm	233	22	12	2686	2122	1070	439	244.0	30.0
05/24/02	CT-1 storm	696	41	37	2534	1687	778	419	598.0	62.0
06/04/02	CT-1 storm	358	32	26	2234	1270	660	127	718.0	63.0
06/20/02	CT-1 storm	193	34	18	2416	1908	1001	153	103.5	18.0
08/28/02	CT-1 storm	154	13	7	2039	1446	963	18	103.0	20.0
08/30/02	CT-1 storm	141	62	56	1468	1422	856	ND	142.7	22.2
09/19/02	CT-1 storm	234	46	42	1446	1169	678	218	142.5	22.5

* Data within acceptable (10%) difference between parameters.
** Data outside acceptable (10%) difference between parameters.

CT-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/22/02	CT-2	65	15**	18**	4328	4212	3800	150	27.0	6.2
02/20/02	CT-2	68	16	14	3742	3593	2639	228	34.2	7.6
03/26/02	CT-2	68	9**	13**	2446	2338	1861	45	48.0	10.8
04/16/02	CT-2	91	7	6	1880	1493	931	102	51.8	11.8
05/06/02	CT-2	288	16	10	2970	2354	955	1331	283.2	31.5
06/03/02	CT-2	78	16	9	1976	1693	1235	80	56.0	13.3
07/16/02	CT-2	134	19	13	2795	2446	1834	80	79.0	13.0
08/27/02	CT-2	104	9	5	2231	1749	1260	34	69.0	14.8
09/24/02	CT-2	72	20	15	2389	2089	1751	105	44.3	10.8
10/15/02	CT-2	104	35*	36*	2932	2793	2242	43	44.4	11.0
11/19/2002	CT-2	50	11	9	4604	4247	3923	82	33.0	6.2
12/17/02	CT-2	52	8	6	4223	3947	3236	249	36.8	10.2
05/17/02	CT-2 Storm	135	18	7	2446	1986	949	423	89.5	16.5
05/24/02	CT-2 Storm	303	33	28	2078	1510	652	380	174.3	34.7
06/04/02	CT-2 Storm	280	30	21	2021	1378	742	130	117.5	19.5
06/20/02	CT-2 Storm	175	33	17	2326	1918	956	227	64.0	14.0
08/28/02	CT-2 Storm	145	13	5	2029	1428	964	13	69.0	14.0
08/30/02	CT-2 Storm	152	90	78	1550	1544	934	ND	90.8	18.0
09/19/02	CT-2 Storm	357	87	67	2847	2353	1414	526	81	17.5

"ND" denotes "No Data"
* Data within acceptable (10%) difference between parameters.
** Data outside acceptable (10%) difference between parameters.

CT-P1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
06/03/02	CT-P1	78	32	23	1197	960	353	75	34.6	9.2
07/16/02	CT-P1	116	45	34	1542	1259	497	146	33.7	12.0
08/27/02	CT-P1	102	14	11	1434	985	620	28	49.8	13.8
09/24/02	CT-P1	64	9	6	950	626	328	20	19.8	8.4
10/15/02	CT-P1	52	35	25	1234	1125	719	52	17.4	7.4
11/19/2002	CT-P1	50	40	34	1159	1083	581	66	10.8	4.4
12/17/02	CT-P1	12	4	3	958	883	514	34	16.8	7.8
05/24/02	CT-P1 storm	251	46	33	1981	1277	548	282	105.0	22.5
06/04/02	CT-P1 storm	323	78	63	1765	1195	562	256	177.0	41.0
06/20/02	CT-P1 storm	177	44	25	1806	1379	481	248	37.0	13.3
06/26/02	CT-P1 storm	143	24	9	2262	1642	781	308	20.6	8.7
08/23/02	CT-P1 storm	93	ND	ND	1530	ND	ND	ND	ND	ND
08/28/02	CT-P1 storm	391	15	6	2671	1445	869	29	285.5	50.0
08/30/02	CT-P1 storm	78	19	10	1337	1117	468	ND	47.0	12.5

"ND" denotes "No Data"

CT-P2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
02/20/02	CT-P2	34	11	8	1924	1725	1084	233	19.8	6.6
03/26/02	CT-P2	31	3**	4**	1121	970	589	15	24.2	8.6
04/16/02	CT-P2	51	7	5	1061	814	373	16	25.0	8.4
05/06/02	CT-P2	54	10	<3	1143	901	361	87	33.2	5.2
06/03/02	CT-P2	53	6	5	1153	869	381	15	25.0	8.2
07/16/02	CT-P2	122	18	8	1263	699	168	32	60.3	16.0
08/27/02	CT-P2	67	10	7	1433	993	576	16	25.2	11.6
09/24/02	CT-P2	61	7	5	1083	771	493	<3	24.4	9.2
10/15/02	CT-P2	27	6	4	1208	1064	666	14	18.8	8.6
11/19/2002	CT-P2	18	7	7	1406	1390	987	21	11.2	4.4
12/17/2002	CT-P2	38	3*	4*	1294	1214	855	19	25.0	9.4
05/17/02	CT-P2 storm	99	25	10	2210	1834	935	192	32.8	8.0
05/24/02	CT-P2 storm	225	45	40	1866	1327	571	314	101.0	23.5
06/04/02	CT-P2 storm	273	55	49	1770	1187	532	200	131.5	14.0
06/20/02	CT-P2 storm	232	78	51	2142	1684	625	281	58.7	16.0
06/26/02	CT-P2 storm	112	22	9	1695	1260	656	39	22.8	7.8
08/23/02	CT-P2 storm	78	ND	ND	1485	ND	ND	ND	ND	ND
08/28/02	CT-P2 storm	109	18	10	1683	1208	722	11	27.7	12.5
08/30/02	CT-P2 storm	706	18	13	1369	1288	642	ND	499.5	70.0

"ND" denotes "No Data"
* Data within acceptable (10%) difference between parameters.
** Data outside acceptable (10%) difference between parameters.

SC-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/22/02	SC-3	190	160	150	3701*	3724*	3327	79	8.6	<4
02/20/02	SC-3	151	99	84	3201	2821	2116	137	13.6	5.8
03/26/02	SC-3	168	149	133	1011	948	504	66	22.8	8.4
04/16/02	SC-3	266	235	210	611	481	18	28	16.4	7.0
05/06/02	SC-3	300	264	242	785	681	80	51	10.6	3.4
06/03/02	SC-3	456	405	401	605	502	44	30	16.2	7.4
07/16/02	SC-3	321	297	288	679	612	206	32	18.4	6.8
08/27/02	SC-3	135	110*	117*	527	432	64	14	20.0	6.6
09/24/02	SC-3	84	70	70	584*	592*	293	<3	21.8	7.6
10/15/02	SC-3	42	38	36	930	850	615	9	13.8	7.0
11/19/2002	SC-3	81	62	59	1110	1027	725	34	5.8	<4.0
12/17/02	SC-3	54	30	30	2638	2617	2300	14	14.8	7.6
05/17/02	SC-3 storm	189	127	110	1611	1458	786	55	14.4	4.4
05/24/02	SC-3 storm	207	115	102	1722	1374	859	120	30.7	13.7
06/04/02	SC-3 storm	279	156	136	1795	1311	720	15	19.7	8.7
06/20/02	SC-3 storm	279	171	144	1468	1164	448	73	25.2	10.0
09/19/02	SC-3 storm	115	91	90	1228	1194	933	84	13	5.0

* Data within acceptable (10%) difference between parameters.

Rain Gauge C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus ug/L	Total Dissolved Phosphorus ug/L	Ortho-Phosphate ug/L	Total Nitrogen ug/L	Total Dissolved Nitrogen ug/L	NO3+NO2-N ug/L	NH4-N ug/L
	Analytical Detection Limits	2	2	3	4	4	5	3
05/24/02	Rain Gauge	463	351	288	4104	3470	1273	1432
06/04/02	Rain Gauge	612	549	506	4839	4531	508	1143
06/20/02	Rain Gauge	648	401	348	5496	4206	709	1469
06/26/02	Rain Gauge	763	590	556	11435	10178	785	8437
08/23/02	Rain Gauge	252	ND	ND	3648	ND	ND	ND
08/28/02	Rain Gauge	310	168	151	3359	2786	1195	1322

"ND" denotes "No Data"

APPENDIX C

STREAMFLOW, RAINFALL, PHOSPHORUS LOADING CALCULATIONS, AND NORMALIZED U.S. ARMY CORPS OF ENGINEERS INFLOW DATA

Streamflow Determination

Stream discharges for Cherry Creek, Cottonwood Creek and Shop Creek were determined by developing a stage discharge relationship for each site (Table C-1). Water levels (stage) were monitored using ISCO Model 4220 and 6700 flowmeters. Flows were monitored daily on Cottonwood Creek, Shop Creek, and Cherry Creek with some dates estimated due to icing or flowmeter malfunctions. Rating curves were developed for each sampling site by measuring stream discharge (ft^3/sec) with a Marsh McBirney Model 2000 flowmeter, and recording the water level at the staff gage (ft) and ISCO flowmeter (ft). Data from 1998, 1999, 2000, 2001, and 2002 were used in calculating rating curves. In 1999, a minimum of three measurements over a range of discharges were taken at the following sampling sites: CC-10, CT-1, CT-2, and SC-3. In 2000, three measurements were taken at each of the following sites: CC-10, CT-1, CT-2, and SC-3. In 2001, one measurement was taken at Site CT-2. In 2002, four measurements were taken at Sites CT-1, CT-2, and SC-3, and three measurements were taken at Sites CC-10, CT-P1, and CT-P2.

TABLE C-1: Stage (H in ft) discharge (Q in cfs) relationships for Sites CC-10, CT-1, CT-2, SC-3, CT-P1, and CT-P2.

Site	Equation	R^2
CC-10	$Q = H^3 \times 3.49 + 1.0$	0.81
CT-1	$Q = H^{3.8} \times 1.01$	0.87
CT-2	$Q = H^{4.83} \times 0.067$	0.89
SC-3	$Q = H^3 \times 9.48 + 0.025$	0.95
CT-P1	$Q = H^{3.41} \times 13.3$	0.99
CT-P2	$Q = H^{2.2} \times 1.25$	0.99

Phosphorus Loading from Tributary Streams

For all streams, water chemistry, including concentration of total phosphorus was measured from stream samples taken at regular intervals and from storms during the months of January through December 2002 (Appendix B). In 1999, 2000, 2001, and 2002, all estimates of loading to Cherry Creek Reservoir were based upon calendar year (January to December). In previous years, loading had been estimated on a water year (October to September), but were later converted to calendar year from 1992 on.

The concentration of total phosphorus in the samples and corresponding flows, measured at sampling time, were paired in regression relationships (Table C-2). Regressions using data from previous reports (ASI 1994a, Chadwick Ecological Consultants, Inc. 1995, 1996, 1997, 1998, 1999, 2000, 2001, and 2002), combined with data from 2002, were developed to predict phosphorus concentrations from flow measurements for 2002 load calculations. Note that for some sites, there is no significant relationship between flow values and phosphorus concentrations (e.g., the Cherry Creek mainstem inflow and reservoir outflow). In those cases, the phosphorus concentrations for load calculations were based on the mean value from the current year.

TABLE C-2: Mean total dissolved phosphorus concentration (P_{con}) from alluvium and regression equations relating streamflow (Q, ft^3/sec) to concentration of total phosphorus (P_{con}) in Cherry Creek, Cottonwood Creek, and Shop Creek for 2002.

Site	Equation	R^2
Alluvium	P_{con} (mg/L) = 0.187	--
CC-10	P_{con} (mg/L) = 0.219	--
CC-O	P_{con} (mg/L) = 0.091	--
CT-1	P_{con} (mg/L) = 0.013 × Q + 0.07	0.79
CT-2	P_{con} (mg/L) = 0.0098 × Q + 0.05	0.65
SC-3	P_{con} (mg/L) = 0.035 × ln Q + 0.22	0.71
CT-P1	P_{con} (mg/L) = 0.074 × Q + 0.008	0.80
CT-P2	P_{con} (mg/L) = 0.07 × $Q^{1.5}$ + 0.028	0.61

Using these relationships, the average daily phosphorus (P_{con}) was calculated from average daily flow for each tributary stream. Daily loadings in pounds/day (L_{day}) into the reservoir were then calculated using the equation below (Eq. 1), with L_{day} then summed over 2002 to obtain total annual phosphorus loading.

EQUATION 1:

$$L_{day} = mg/L \left(Q_{in} \left(\frac{86400\ sec}{day} \left(\frac{28.3169\ L}{cf} \left(\frac{2.205 \times 10^{-6}\ lbs}{mg} \right.\right.\right.\right.$$

where:

L_{day} = pounds per day phosphorus loading,

mg/L = concentration of total phosphorus for a particular daily flow (based on the equation in Table C-2)

Q_{in} = mean daily flow in ft^3/sec.

Phosphorus Loading from Precipitation

Precipitation data are collected at the Cherry Creek dam by the U.S. Army Corps of Engineers (COE). To estimate phosphorus loading into the reservoir due to precipitation, COE data from 2002 were used, based on the assumption that precipitation generally fell evenly across the reservoir (Appendix B), although rain showers in the Cherry Creek Reservoir area can be localized. Calculation of phosphorus loading into Cherry Creek Reservoir from precipitation was based on the mean phosphorus concentration from 2002 and Equation 2.

EQUATION 2:

$$L_{precip} = PR/12 \;(\; A_{res} \;(\; 43650\ ft^2/acre \;(\; mg/L \;(\; \frac{28.31692}{cf} \;(\; \frac{2.206 \times 10^{-6}\ lbs}{mg}$$

where:

L_{precip} = pounds of phosphorus from precipitation,

PR = rainfall precipitation in inches,

A_{res} = surface area of the reservoir (852 ac), and

mg/L = median concentration of phosphorus.

Cherry Creek Reservoir Outflow

Streamflow out of Cherry Creek Reservoir is monitored by a COE flow station throughout the year. Water samples were taken once a month in Cherry Creek downstream at the dam during 2002. These samples were assessed for water quality, and a regression relationship between the concentration of total phosphorus and the measured flow in the stream was attempted. However, this regression was not significant. In the relationship in Equation 1, loads leaving the reservoir were calculated based on a mean total phosphorus concentration of 0.091 mg/L in 2002 (Table C-2).

Phosphorus Loading from Alluvium

The COE monitors inflow to Cherry Creek Reservoir as a function of change in storage, based on changes in reservoir level, measured outflow, precipitation, and evaporation, to provide daily and monthly inflow (AF). CEC monitors inflow to the reservoir using gaging stations on Cherry Creek, Cottonwood Creek, and Shop Creek (the three main surface inflows). Estimates of direct precipitation were provided by the COE, and estimates of alluvial phosphorus concentrations were provided by JCHA. From these data, CEC calculates an estimated total inflow (AF) and phosphorus loading (lbs) to the reservoir.

Given differences in the two methods for determining inflow, combined with the potential for unmonitored multiple Cherry Creek channels in the wetlands adjacent to the reservoir and the potential for the COE calculations to underestimate dam leakage (Lewis and Saunders 2002), an exact match between COE and CEC calculated inflows is not expected. In 2002, COE inflows were calculated at 7,498 AF, while CEC calculated inflows at 5,521 AF (see following summary data tables). In past years, CEC adjusted (normalized) inflow values from the stream sites to account for this difference. Those normalization procedures can be found in CEC (1998b, 1999, 2000, 2001, and 2002). In 2002, CEC did not "normalize" inflow data by adding flow to the surface stream site data. Instead, we based our adjustments on conclusions reached by Lewis and Saunders (2002). They believe the COE method results in a systematic underestimate of inflow to the reservoir from the alluvium. When estimating inflow, the COE does not specifically quantify alluvial inflows or outflows although, functionally, those flows must account for a portion of the variations in reservoir storage. Based on these findings, CEC believes the difference in inflow values between the COE calculations and CEC streamflows could be attributed wholly to alluvial inflow. Using this approach, total alluvial inflow was estimated to be 1,977 AF in 2002. Calculation of alluvial phosphorus loading into Cherry Creek Reservoir was based on the mean alluvial phosphorus concentration for 2002 (0.187 mg/L) and Equation 3.

EQUATION 3:

$$L_{alluvium} = mg/L \;(\; Q_{alluvium} \;(\; \frac{2.205 \times 10^{-6}\ lbs}{mg} \;(\; \frac{325{,}851\ gal}{Ac\text{-}ft} \;(\; \frac{L}{0.2642\ gal}$$

where:

$L_{alluvium}$ = alluvial phosphorus loading in pounds per year

mg/L = mean alluvial phosphorus concentration for the year

$Q_{alluvium}$ = total alluvial flow in Ac-ft per year

To ensure comparability over time, alluvial flows and loads for 1994 to 2001 were then recalculated in 2002, using the same approach outlined above. For 1993, annual alluvial loads were based on the mean of 1994 through 1997 values.

Note also that in the past, CEC used provisional (preliminary) inflow estimates from the COE in preparation of this monitoring report. When addressing the alluvial flow issue in 2002, we became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, we revised inflow and load estimates for 1992 - 2001 to match the more accurate, and finalized, inflow values from the COE.

2002	Total In Af CEC	Total In Af COE
January	381.81	1063.26
February	494.29	1100.88
March	793.63	1694.88
April	334.93	790.02
May	256.59	512.82
June	290.01	641.52
July	164.83	152.46
August	170.48	134.64
September	253.05	273.24
October	416.62	506.88
November	511.84	326.7
December	538.36	300.96
Total	4606.43	7498.26

CC-10

	Af CEC	P lbs CEC
January	228.57	136.38
February	365.04	217.82
March	643.47	383.95
April	241.25	143.95
May	67.40	40.22
June	68.12	40.65
July	61.56	36.73
August	61.55	36.73
September	59.89	35.74
October	62.62	37.36
November	61.64	36.78
December	63.50	37.89
	1984.61	1184.19

CT-2

	Af CEC	P lbs CEC
January	153.24	31.19
February	129.24	26.18
March	150.16	30.79
April	93.68	17.05
May	189.18	67.68
June	221.89	91.98
July	103.27	20.92
August	108.93	31.77
September	193.16	50.91
October	354.00	105.10
November	450.20	152.69
December	474.86	162.86
	2621.82	789.13

SC-3

	Af CEC	P lbs CEC
January	21.54	11.23
February	6.59	2.63
March	14.37	6.67
April	11.59	5.15
May	21.17	11.73
June	32.95	19.06
July	11.09	5.64
August	12.33	6.80
September	0.03	4.78
October	5.24	2.36
November	4.80	1.79
December	3.18	1.01
	144.88	78.85

	Precip (af)	Outflow (af)
January	36.92	1053.36
February	13.49	960.30
March	195.25	1702.80
April	0.00	805.86
May	188.86	0.00
June	110.05	461.34
July	56.80	0.00
August	118.57	0.00
September	105.79	514.80
October	71.00	554.40
November	17.75	0.00
December	0.00	0.00
	914.48	6052.86

	Precip (lbs)	Outflow (lbs)
January	51.14	261.17
February	18.69	238.10
March	270.45	422.19
April	0.00	199.80
May	261.60	0.00
June	152.44	114.38
July	78.68	0.00
August	164.24	0.00
September	146.54	127.64
October	98.35	137.46
November	24.59	0.00
December	0.00	0.00
	1266.70	1500.74

	Alluvium (af)	Alluvium (lbs)
2002 Total	1977.35	1005.59

* "ND" denotes "No Data"

CT-1

	Af CEC	P lbs CEC
January	161.08	47.00
February	121.35	33.03
March	193.16	59.91
April	113.80	29.49
May	235.11	145.52
June	314.00	299.27
July	119.58	39.47
August	132.79	57.31
September	149.77	58.84
October	147.19	52.55
November	114.59	29.78
December	127.50	34.23
	1929.93	886.39

CT-P1

	Af CEC	P lbs CEC
January	ND	ND
February	ND	ND
March	ND	ND
April	ND	ND
May	ND	ND
June	ND	ND
July	55.46	38.09
August	90.93	241.64
September	88.01	66.70
October	101.03	84.36
November	54.85	11.67
December	41.91	6.71
	432.19	449.16

CT-P2

	Af CEC	P lbs CEC
January	ND	ND
February	ND	ND
March	ND	ND
April	ND	ND
May	ND	ND
June	ND	ND
July	58.54	42.85
August	31.85	19.35
September	60.35	35.35
October	85.05	41.07
November	93.98	43.31
December	91.77	39.05
	421.54	220.97

* "ND" denotes "No Data"

2002
Cherry Creek 10
Average Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	4.09	4.85	7.72	8.08	1.16	1.01	1.01	1.00	1.00	1.00	1.03	1.03
2	3.90	4.85	9.78	8.42	1.12	1.01	1.00	1.00	1.00	1.13	1.03	1.03
3	2.92	4.73	9.25	10.27	1.10	1.06	1.00	1.00	1.00	1.02	1.03	1.03
4	1.87	5.20	11.79	8.88	1.10	3.10	1.00	1.00	1.00	1.01	1.03	1.03
5	1.72	5.24	14.82	7.88	1.08	1.82	1.01	1.00	1.00	1.01	1.03	1.03
6	1.79	5.52	12.76	8.10	1.07	1.22	1.01	1.01	1.00	1.01	1.03	1.03
7	1.75	5.35	12.22	8.08	1.06	1.14	1.00	1.00	1.00	1.01	1.07	1.03
8	2.81	5.45	11.95	7.67	1.06	1.10	1.00	1.00	1.00	1.01	1.08	1.03
9	3.11	4.74	12.25	6.02	1.06	1.07	1.00	1.00	1.00	1.01	1.03	1.03
10	3.54	5.73	11.10	5.70	1.06	1.08	1.01	1.00	1.01	1.01	1.03	1.03
11	3.54	5.70	11.04	5.09	1.06	1.06	1.04	1.00	1.00	1.01	1.03	1.03
12	3.28	6.20	11.51	4.53	1.09	1.05	1.01	1.00	1.00	1.01	1.03	1.03
13	3.60	6.18	12.02	4.03	1.05	1.05	1.00	1.00	1.06	1.01	1.03	1.03
14	3.17	6.68	14.71	3.58	1.06	1.03	1.00	1.00	1.07	1.01	1.04	1.03
15	3.04	6.20	13.60	3.17	1.05	1.03	1.00	1.00	1.00	1.01	1.04	1.03
16	3.11	5.85	12.38	2.82	1.09	1.03	1.00	1.00	1.00	1.01	1.04	1.03
17	3.05	6.69	11.62	2.25	1.08	1.02	1.00	1.00	1.00	1.01	1.04	1.03
18	2.72	7.54	11.79	1.85	1.05	1.02	1.00	1.00	1.00	1.01	1.03	1.03
19	2.37	14.33	10.99	1.64	1.05	1.03	1.00	1.00	1.05	1.02	1.03	1.03
20	2.72	9.42	9.30	1.56	1.05	1.17	1.00	1.00	1.00	1.02	1.03	1.04
21	2.78	6.21	8.60	1.55	1.04	1.04	1.00	1.00	1.00	1.02	1.03	1.03
22	3.98	6.46	7.67	1.30	1.04	1.09	1.00	1.00	1.00	1.02	1.03	1.03
23	4.43	7.23	9.36	1.14	1.12	1.04	1.00	1.00	1.00	1.02	1.03	1.03
24	5.31	7.51	9.06	1.18	1.94	1.01	1.00	1.00	1.00	1.03	1.04	1.04
25	5.16	7.11	9.19	1.23	1.17	1.05	1.00	1.00	1.00	1.03	1.05	1.04
26	5.84	7.61	8.27	1.22	1.08	1.01	1.00	1.00	1.02	1.03	1.05	1.08
27	6.38	8.08	8.46	1.20	1.05	1.01	1.00	1.00	1.02	1.03	1.04	1.03
28	5.94	7.73	8.58	1.15	1.04	1.03	1.00	1.00	1.01	1.03	1.04	1.04
29	6.00		8.25	1.13	1.03	1.01	1.00	1.01	1.00	1.04	1.04	1.04
30	5.79		7.78	1.13	1.02	1.00	1.00	1.06	1.00	1.04	1.03	1.04
31	5.75		7.17		1.02		1.00	1.00		1.03		1.04
Total	115.44	184.37	324.98	121.84	34.04	34.40	31.09	31.09	30.25	31.63	31.13	32.07
Max	6.38	14.33	14.82	10.27	1.94	3.10	1.04	1.06	1.07	1.13	1.08	1.08
Min	1.72	4.73	7.17	1.13	1.02	1.00	1.00	1.00	1.00	1.00	1.03	1.03
Ac-ft	228.57	365.04	643.47	241.25	67.40	68.12	61.56	61.55	59.89	62.62	61.64	63.50

2002
Cherry Creek 10
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	4.83	5.73	9.12	9.55	1.37	1.20	1.19	1.18	1.18	1.18	1.22	1.22
2	4.61	5.73	11.55	9.95	1.33	1.19	1.19	1.18	1.18	1.33	1.22	1.22
3	3.45	5.58	10.93	12.14	1.30	1.25	1.19	1.18	1.18	1.20	1.22	1.22
4	2.21	6.15	13.93	10.49	1.30	3.66	1.18	1.18	1.18	1.19	1.22	1.22
5	2.03	6.19	17.51	9.31	1.28	2.15	1.19	1.18	1.18	1.19	1.22	1.22
6	2.12	6.52	15.07	9.57	1.26	1.44	1.19	1.19	1.18	1.19	1.22	1.22
7	2.07	6.32	14.44	9.55	1.25	1.35	1.18	1.18	1.18	1.19	1.26	1.22
8	3.32	6.43	14.12	9.06	1.26	1.30	1.18	1.18	1.18	1.19	1.28	1.22
9	3.68	5.60	14.47	7.12	1.25	1.27	1.18	1.18	1.18	1.19	1.22	1.22
10	4.19	6.77	13.11	6.73	1.25	1.27	1.19	1.18	1.19	1.19	1.22	1.22
11	4.18	6.73	13.04	6.01	1.25	1.25	1.23	1.18	1.19	1.19	1.22	1.22
12	3.88	7.32	13.60	5.35	1.29	1.24	1.19	1.18	1.19	1.19	1.22	1.22
13	4.25	7.31	14.20	4.76	1.25	1.24	1.18	1.18	1.25	1.19	1.22	1.22
14	3.74	7.89	17.38	4.23	1.25	1.21	1.18	1.18	1.26	1.20	1.23	1.22
15	3.59	7.32	16.07	3.75	1.24	1.22	1.18	1.18	1.18	1.20	1.23	1.22
16	3.67	6.91	14.63	3.33	1.29	1.21	1.18	1.18	1.18	1.20	1.23	1.22
17	3.60	7.90	13.73	2.66	1.27	1.21	1.18	1.18	1.18	1.20	1.23	1.22
18	3.21	8.91	13.93	2.19	1.24	1.21	1.18	1.18	1.18	1.20	1.22	1.22
19	2.80	16.93	12.99	1.94	1.23	1.21	1.18	1.18	1.24	1.20	1.22	1.22
20	3.21	11.12	10.99	1.84	1.24	1.38	1.18	1.18	1.18	1.20	1.22	1.23
21	3.28	7.34	10.16	1.83	1.23	1.23	1.18	1.18	1.18	1.20	1.22	1.22
22	4.71	7.63	9.06	1.53	1.23	1.29	1.19	1.18	1.18	1.21	1.22	1.22
23	5.23	8.54	11.06	1.34	1.33	1.23	1.18	1.18	1.18	1.21	1.22	1.22
24	6.28	8.87	10.71	1.39	2.29	1.20	1.18	1.18	1.18	1.21	1.23	1.22
25	6.09	8.40	10.86	1.45	1.38	1.24	1.18	1.18	1.18	1.21	1.24	1.23
26	6.90	8.99	9.77	1.44	1.28	1.20	1.18	1.18	1.20	1.22	1.24	1.27
27	7.53	9.55	9.99	1.41	1.24	1.20	1.18	1.18	1.20	1.22	1.22	1.21
28	7.02	9.14	10.14	1.36	1.22	1.22	1.18	1.18	1.19	1.22	1.22	1.22
29	7.08	0.00	9.75	1.34	1.22	1.19	1.18	1.20	1.19	1.23	1.22	1.23
30	6.84	0.00	9.20	1.33	1.21	1.18	1.18	1.25	1.18	1.22	1.22	1.23
31	6.79	0.00	8.47	0.00	1.20	0.00	1.18	1.18	0.00	1.22	0.00	1.23
Total	136.38	217.82	383.95	143.95	40.22	40.65	36.73	36.73	35.74	37.36	36.78	37.89
Mean	4.40	7.03	12.39	4.64	1.30	1.31	1.18	1.18	1.15	1.21	1.19	1.22
Max	7.53	16.93	17.51	12.14	2.29	3.66	1.23	1.25	1.26	1.33	1.28	1.27
Min	2.03	0.00	8.47	0.00	1.20	0.00	1.18	1.18	0.00	1.18	0.00	1.21

2002
Cherry Creek Outflow
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	18	17	20	25	0	0	0	0	0	25	0	0
2	18	17	20	25	0	0	0	0	0	25	0	0
3	18	17	20	25	0	0	0	0	0	25	0	0
4	17	7	20	25	0	0	0	0	4	24	0	0
5	17	0	20	25	0	0	0	0	10	24	0	0
6	17	0	20	25	0	18	0	0	6	24	0	0
7	17	8	20	25	0	18	0	0	0	13	0	0
8	17	20	20	25	0	18	0	0	0	1	0	0
9	17	20	20	25	0	17	0	0	0	4	0	0
10	17	20	20	25	0	17	0	0	0	5	0	0
11	17	20	20	25	0	17	0	0	2	5	0	0
12	18	20	27	20	0	17	0	0	3	5	0	0
13	18	20	35	17	0	17	0	0	7	5	0	0
14	17	20	35	17	0	17	0	0	14	5	0	0
15	17	19	35	17	0	17	0	0	14	5	0	0
16	17	20	35	17	0	17	0	0	11	5	0	0
17	17	20	35	17	0	17	0	0	5	5	0	0
18	17	20	35	17	0	17	0	0	7	5	0	0
19	17	20	34	10	0	9	0	0	11	5	0	0
20	17	20	34	0	0	0	0	0	11	5	0	0
21	17	20	34	0	0	0	0	0	11	5	0	0
22	17	20	34	0	0	0	0	0	11	5	0	0
23	17	20	34	0	0	0	0	0	11	5	0	0
24	17	20	34	0	0	0	0	0	11	5	0	0
25	17	20	34	0	0	0	0	0	10	5	0	0
26	17	20	34	0	0	0	0	0	10	5	0	0
27	17	20	31	0	0	0	0	0	16	5	0	0
28	17	20	25	0	0	0	0	0	25	8	0	0
29	17		25	0	0	0	0	0	25	12	0	0
30	17		25	0	0	0	0	0	25	5	0	0
31	17		25		0		0	0		0		0
Total	532	485	860	407	0	233	0	0	260	280	0	0
Mean	17.16	17.32	27.74	13.57	0.00	7.77	0.00	0.00	8.67	9.03	0.00	0.00
Max	18	20	35	25	0	18	0	0	25	25	0	0
Min	17	0	20	0	0	0	0	0	0	0	0	0
Ac-ft	1053.36	960.30	1702.80	805.86	0.00	461.34	0.00	0.00	514.80	554.40	0.00	0.00

2002
Cherry Creek Outflow
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.84	8.35	9.82	12.27	0.00	0.00	0.00	0.00	0.00	12.27	0.00	0.00
2	8.84	8.35	9.82	12.27	0.00	0.00	0.00	0.00	0.00	12.27	0.00	0.00
3	8.84	8.35	9.82	12.27	0.00	0.00	0.00	0.00	0.00	12.27	0.00	0.00
4	8.35	3.44	9.82	12.27	0.00	0.00	0.00	0.00	1.96	11.78	0.00	0.00
5	8.35	0.00	9.82	12.27	0.00	0.00	0.00	0.00	4.91	11.78	0.00	0.00
6	8.35	0.00	9.82	12.27	0.00	8.84	0.00	0.00	2.95	11.78	0.00	0.00
7	8.35	3.93	9.82	12.27	0.00	8.84	0.00	0.00	0.00	6.38	0.00	0.00
8	8.35	9.82	9.82	12.27	0.00	8.84	0.00	0.00	0.00	0.49	0.00	0.00
9	8.35	9.82	9.82	12.27	0.00	8.35	0.00	0.00	0.00	1.96	0.00	0.00
10	8.35	9.82	9.82	12.27	0.00	8.35	0.00	0.00	0.00	2.45	0.00	0.00
11	8.35	9.82	9.82	12.27	0.00	8.35	0.00	0.00	0.98	2.45	0.00	0.00
12	8.84	9.82	13.25	9.82	0.00	8.35	0.00	0.00	1.47	2.45	0.00	0.00
13	8.84	9.82	17.18	8.35	0.00	8.35	0.00	0.00	3.44	2.45	0.00	0.00
14	8.35	9.82	17.18	8.35	0.00	8.35	0.00	0.00	6.87	2.45	0.00	0.00
15	8.35	9.33	17.18	8.35	0.00	8.35	0.00	0.00	6.87	2.45	0.00	0.00
16	8.35	9.82	17.18	8.35	0.00	8.35	0.00	0.00	5.40	2.45	0.00	0.00
17	8.35	9.82	17.18	8.35	0.00	8.35	0.00	0.00	2.45	2.45	0.00	0.00
18	8.35	9.82	17.18	8.35	0.00	8.35	0.00	0.00	3.44	2.45	0.00	0.00
19	8.35	9.82	16.69	4.91	0.00	4.42	0.00	0.00	5.40	2.45	0.00	0.00
20	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	5.40	2.45	0.00	0.00
21	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	5.40	2.45	0.00	0.00
22	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	5.40	2.45	0.00	0.00
23	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	5.40	2.45	0.00	0.00
24	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	5.40	2.45	0.00	0.00
25	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	4.91	2.45	0.00	0.00
26	8.35	9.82	16.69	0.00	0.00	0.00	0.00	0.00	4.91	2.45	0.00	0.00
27	8.35	9.82	15.22	0.00	0.00	0.00	0.00	0.00	7.85	2.45	0.00	0.00
28	8.35	9.82	12.27	0.00	0.00	0.00	0.00	0.00	12.27	3.93	0.00	0.00
29	8.35	0.00	12.27	0.00	0.00	0.00	0.00	0.00	12.27	5.89	0.00	0.00
30	8.35	0.00	12.27	0.00	0.00	0.00	0.00	0.00	12.27	2.45	0.00	0.00
31	8.35	0.00	12.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	261.17	238.10	422.19	199.80	0.00	114.38	0.00	0.00	127.64	137.46	0.00	0.00
Mean	8.42	7.68	13.62	6.45	0.00	3.69	0.00	0.00	4.12	4.43	0.00	0.00
Max	8.84	9.82	17.18	12.27	0.00	8.84	0.00	0.00	12.27	12.27	0.00	0.00
Min	8.35	0.00	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2002
Cottonwood Creek 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.63	1.78	4.32	2.36	2.14	2.15	2.03	1.05	1.70	1.59	1.97	1.75
2	3.63	1.71	6.30	2.29	2.12	2.07	2.29	0.96	1.44	14.94	2.00	1.77
3	3.63	1.76	3.27	2.22	2.09	1.23	0.70	0.80	1.59	3.37	1.99	1.79
4	3.43	1.86	3.92	2.15	1.99	31.28	1.31	0.86	1.44	2.22	2.03	1.80
5	3.53	1.79	3.88	2.08	1.99	2.79	1.49	1.16	1.49	1.86	2.04	1.87
6	3.34	1.88	3.29	2.02	2.01	0.69	11.74	1.61	1.44	1.72	2.04	1.87
7	3.53	1.89	2.85	1.96	2.04	0.51	5.10	1.38	1.43	1.63	1.98	1.86
8	3.63	1.85	3.36	1.89	2.10	0.39	2.08	1.12	1.36	1.54	1.94	1.82
9	2.20	3.07	3.93	1.83	2.07	0.47	1.65	1.13	1.46	1.49	1.86	1.86
10	3.18	1.99	2.57	1.78	2.09	1.23	1.86	1.03	2.71	1.55	1.83	1.86
11	2.60	1.96	2.37	1.72	2.20	2.51	3.64	0.91	1.87	1.67	1.85	1.89
12	2.30	1.87	2.30	1.68	3.80	2.48	2.00	0.88	1.73	1.66	1.66	1.92
13	2.04	2.03	2.34	1.91	2.42	2.34	1.70	1.16	5.90	1.65	1.66	1.94
14	1.99	2.00	4.13	1.96	2.01	2.03	1.48	1.15	5.15	1.63	2.79	1.92
15	1.99	1.88	3.96	1.83	1.83	1.82	1.39	1.13	1.70	1.67	2.28	1.96
16	2.08	1.90	2.99	1.89	5.61	1.78	1.62	1.20	1.55	1.67	2.03	1.99
17	2.09	1.87	2.51	1.83	3.45	1.79	1.47	1.09	1.39	1.81	1.87	1.97
18	3.80	3.52	2.66	1.79	2.50	1.78	1.47	1.15	3.12	1.69	1.90	1.88
19	1.87	2.96	2.70	1.88	2.29	3.22	1.37	1.24	16.72	1.69	1.83	1.87
20	1.96	2.18	3.41	1.85	2.25	5.62	1.21	1.24	3.01	1.72	1.78	2.99
21	1.92	1.99	3.48	1.80	2.11	2.98	1.13	1.26	1.95	1.78	1.72	1.89
22	1.96	1.99	3.31	1.59	1.99	2.83	1.18	1.52	1.78	1.83	1.69	2.74
23	4.40	2.36	2.74	1.77	12.12	4.48	1.17	1.96	1.78	1.89	1.74	1.94
24	2.11	3.16	2.36	1.72	32.85	19.52	1.14	1.54	1.70	1.96	1.79	2.79
25	2.67	3.05	2.02	1.78	4.81	42.96	1.16	1.61	1.63	2.02	2.04	3.24
26	2.21	2.20	3.22	1.98	3.49	5.69	1.24	2.16	2.29	2.22	2.18	3.90
27	2.10	2.26	3.16	2.03	2.94	2.34	1.15	1.56	1.95	2.74	1.86	1.87
28	1.97	2.54	2.74	1.94	2.57	2.26	1.11	3.07	1.55	2.29	1.86	1.85
29	1.84		2.74	2.01	2.39	5.06	1.08	16.27	1.44	3.35	1.84	1.84
30	1.98		2.36	1.96	2.24	2.29	1.27	11.44	1.39	3.20	1.83	1.83
31	1.76		2.36		2.22		1.22	2.44		2.30		1.93
Total	81.36	61.29	97.55	57.47	118.74	158.59	60.39	67.06	75.64	74.34	57.87	64.39
Max	4.40	3.52	6.30	2.36	32.85	42.96	11.74	16.27	16.72	14.94	2.79	3.90
Min	1.76	1.71	2.02	1.59	1.83	0.39	0.70	0.80	1.36	1.49	1.66	1.75
Ac-ft	161.08	121.35	193.16	113.80	235.11	314.00	119.58	132.79	149.77	147.19	114.59	127.50

2002
Cottonwood Creek 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	2.29	0.89	2.94	1.28	1.13	1.14	1.05	0.47	0.85	0.78	1.02	0.88
2	2.29	0.85	5.16	1.23	1.12	1.08	1.24	0.43	0.69	21.30	1.04	0.89
3	2.29	0.88	1.98	1.18	1.10	0.57	0.30	0.34	0.78	2.07	1.03	0.90
4	2.12	0.95	2.56	1.14	1.03	80.42	0.61	0.38	0.69	1.18	1.06	0.91
5	2.21	0.90	2.52	1.09	1.03	1.60	0.72	0.53	0.72	0.95	1.06	0.95
6	2.04	0.96	2.01	1.05	1.04	0.29	14.10	0.79	0.69	0.86	1.06	0.95
7	2.21	0.97	1.65	1.01	1.06	0.21	3.75	0.66	0.68	0.80	1.02	0.94
8	2.29	0.94	2.06	0.97	1.10	0.16	1.09	0.51	0.64	0.75	1.00	0.92
9	1.17	1.82	2.57	0.93	1.08	0.19	0.81	0.51	0.70	0.72	0.94	0.94
10	1.91	1.03	1.43	0.89	1.10	0.57	0.95	0.46	1.54	0.75	0.92	0.95
11	1.45	1.01	1.29	0.86	1.17	1.39	2.30	0.40	0.95	0.83	0.94	0.97
12	1.24	0.95	1.24	0.83	2.45	1.37	1.04	0.39	0.87	0.82	0.82	0.98
13	1.06	1.05	1.27	0.98	1.32	1.27	0.84	0.53	4.67	0.81	0.82	0.99
14	1.03	1.04	2.76	1.01	1.04	1.06	0.71	0.53	3.80	0.80	1.60	0.98
15	1.03	0.96	2.60	0.92	0.93	0.92	0.66	0.51	0.85	0.83	1.23	1.01
16	1.09	0.97	1.76	0.96	4.32	0.89	0.80	0.55	0.75	0.83	1.05	1.03
17	1.10	0.95	1.39	0.93	2.14	0.90	0.70	0.49	0.66	0.91	0.95	1.02
18	2.45	2.20	1.50	0.90	1.38	0.90	0.70	0.53	1.86	0.84	0.97	0.96
19	0.95	1.73	1.53	0.96	1.23	1.94	0.65	0.58	25.92	0.84	0.92	0.95
20	1.01	1.15	2.10	0.94	1.21	4.34	0.56	0.58	1.77	0.86	0.89	1.75
21	0.98	1.03	2.17	0.91	1.11	1.75	0.51	0.59	1.00	0.89	0.86	0.96
22	1.01	1.03	2.02	0.78	1.03	1.63	0.54	0.74	0.90	0.93	0.84	1.56
23	3.02	1.28	1.56	0.89	14.88	3.10	0.54	1.01	0.89	0.97	0.87	1.00
24	1.11	1.89	1.28	0.86	88.07	34.09	0.52	0.75	0.84	1.01	0.90	1.60
25	1.51	1.81	1.05	0.89	3.44	145.66	0.53	0.79	0.80	1.05	1.06	1.96
26	1.18	1.17	1.94	1.02	2.17	4.42	0.58	1.15	1.23	1.18	1.16	2.54
27	1.10	1.21	1.89	1.06	1.72	1.27	0.53	0.76	1.00	1.56	0.94	0.95
28	1.02	1.41	1.56	0.99	1.43	1.21	0.50	1.82	0.76	1.23	0.95	0.94
29	0.93		1.56	1.04	1.31	3.70	0.49	24.71	0.69	2.05	0.93	0.93
30	1.02		1.28	1.01	1.20	1.23	0.59	13.50	0.66	1.92	0.93	0.92
31	0.88		1.28		1.18		0.56	1.34		1.24		0.99
Total	47.00	33.03	59.91	29.49	145.52	299.27	39.47	57.31	58.84	52.55	29.78	34.23
Mean	1.52	1.18	1.93	0.98	4.69	9.98	1.27	1.85	1.96	1.70	0.99	1.10
Max	3.02	2.20	5.16	1.28	88.07	145.66	14.10	24.71	25.92	21.30	1.60	2.54
Min	0.88	0.85	1.05	0.78	0.93	0.16	0.30	0.34	0.64	0.72	0.82	0.88

2002
Cottonwood Creek 2
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.20	2.24	2.41	1.69	0.77	1.67	2.30	0.87	2.38	3.59	7.34	7.65
2	2.20	2.30	2.35	1.86	1.15	1.55	1.68	0.81	1.55	8.12	7.00	7.53
3	2.20	2.19	2.50	1.96	3.13	3.11	1.44	0.76	1.45	5.60	6.96	7.68
4	2.36	2.31	3.09	2.04	1.56	25.26	1.34	0.78	1.38	5.49	6.84	7.69
5	2.25	2.34	3.64	1.98	1.58	17.90	1.18	0.90	1.31	5.39	6.89	8.11
6	2.25	2.34	3.25	2.04	1.82	6.27	3.34	1.20	1.28	5.28	7.02	8.19
7	2.25	2.32	2.84	2.07	1.44	3.19	6.96	1.20	1.26	5.28	7.15	8.02
8	2.41	2.35	2.77	2.13	1.85	2.52	2.83	0.88	1.26	5.18	7.28	8.05
9	2.51	2.38	3.03	1.90	1.75	2.12	1.85	0.89	1.27	5.18	7.42	8.02
10	2.83	2.07	2.70	1.82	1.66	1.77	1.65	0.86	2.15	5.08	7.56	7.98
11	3.40	1.89	2.34	1.95	1.76	1.85	2.99	0.80	3.02	5.08	7.69	7.90
12	2.82	1.21	2.23	1.99	2.60	1.77	2.70	0.77	3.74	4.98	7.83	7.83
13	2.74	1.15	2.23	1.81	2.32	1.77	1.93	0.88	4.08	4.98	7.90	7.76
14	2.54	1.18	3.44	1.64	1.98	1.58	1.37	0.90	7.00	4.88	7.96	7.69
15	2.50	2.97	3.56	1.49	1.70	1.39	1.21	0.90	3.59	4.88	7.92	7.62
16	2.46	3.67	3.10	0.87	2.51	1.25	1.36	0.91	2.51	4.83	7.88	7.56
17	2.46	2.36	2.57	0.82	3.67	1.20	1.39	0.87	2.00	4.81	7.58	7.53
18	2.35	2.22	2.43	0.84	2.34	1.18	1.28	0.90	2.23	5.02	7.49	7.60
19	2.26	3.74	2.50	0.86	1.82	1.11	1.23	0.98	12.45	5.00	7.50	7.75
20	2.41	3.32	2.31	0.84	1.84	3.58	1.12	1.08	6.73	5.37	7.56	7.82
21	2.40	2.41	2.29	0.83	1.87	3.73	1.12	1.09	3.95	5.45	7.53	7.92
22	2.44	2.89	2.01	0.86	1.90	3.02	1.03	1.15	3.52	5.58	7.43	7.83
23	2.64	2.06	1.98	1.86	3.96	2.46	0.98	1.70	3.13	6.00	7.54	7.85
24	2.64	2.08	1.95	1.90	23.55	1.77	0.96	1.32	3.11	5.87	7.88	7.85
25	2.67	2.20	1.92	1.78	9.17	1.84	0.99	1.27	3.15	6.06	8.27	7.67
26	2.87	2.38	1.90	1.75	4.22	4.84	1.00	1.73	3.65	6.07	8.43	7.51
27	2.54	2.32	1.79	1.75	2.99	3.25	0.99	1.47	4.24	8.15	8.13	7.51
28	2.61	2.36	1.75	1.62	2.55	2.17	0.97	2.19	3.57	7.15	7.93	7.42
29	2.50		1.72	1.56	2.36	4.03	0.96	4.40	3.29	7.56	7.75	7.41
30	2.35		1.66	0.78	1.93	2.93	1.05	15.48	3.29	8.97	7.71	7.37
31	2.36		1.57		1.78		0.96	5.07		7.92		7.51
Total	77.40	65.27	75.84	47.32	95.55	112.07	52.16	55.02	97.55	178.79	227.38	239.83
Max	3.40	3.74	3.64	2.13	23.55	25.26	6.96	15.48	12.45	8.97	8.43	8.19
Min	2.20	1.15	1.57	0.78	0.77	1.11	0.96	0.76	1.26	3.59	6.84	7.37
Ac-ft	153.24	129.24	150.16	93.68	189.18	221.89	103.27	108.93	193.16	354.00	450.20	474.86

2002
Cottonwood Creek 2
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.85	0.87	0.96	0.61	0.24	0.60	0.90	0.27	0.94	1.65	4.83	5.16
2	0.85	0.90	0.92	0.68	0.38	0.54	0.60	0.25	0.54	5.68	4.47	5.03
3	0.85	0.85	1.00	0.73	1.36	1.35	0.50	0.24	0.50	3.17	4.44	5.19
4	0.93	0.90	1.34	0.77	0.55	40.53	0.45	0.24	0.47	3.08	4.32	5.20
5	0.87	0.92	1.68	0.74	0.56	21.76	0.39	0.29	0.44	2.99	4.37	5.66
6	0.87	0.92	1.44	0.77	0.67	3.77	1.49	0.40	0.43	2.90	4.50	5.76
7	0.87	0.91	1.20	0.78	0.50	1.40	4.44	0.40	0.43	2.90	4.63	5.56
8	0.96	0.93	1.15	0.81	0.68	1.02	1.19	0.28	0.43	2.82	4.77	5.59
9	1.01	0.94	1.30	0.70	0.63	0.81	0.68	0.28	0.43	2.82	4.91	5.56
10	1.18	0.78	1.11	0.67	0.59	0.64	0.59	0.27	0.82	2.73	5.06	5.51
11	1.53	0.70	0.92	0.73	0.64	0.68	1.28	0.25	1.30	2.73	5.20	5.44
12	1.18	0.40	0.87	0.74	1.06	0.64	1.12	0.24	1.75	2.65	5.36	5.36
13	1.14	0.38	0.87	0.66	0.91	0.64	0.72	0.28	1.98	2.65	5.44	5.28
14	1.03	0.39	1.55	0.58	0.74	0.56	0.47	0.28	4.47	2.58	5.50	5.20
15	1.00	1.27	1.63	0.52	0.61	0.48	0.40	0.28	1.65	2.58	5.45	5.13
16	0.98	1.70	1.34	0.28	1.01	0.42	0.46	0.29	1.01	2.54	5.40	5.06
17	0.98	0.93	1.04	0.26	1.70	0.40	0.48	0.28	0.75	2.52	5.09	5.03
18	0.92	0.86	0.97	0.27	0.92	0.39	0.43	0.29	0.86	2.69	4.98	5.10
19	0.88	1.75	1.00	0.27	0.66	0.37	0.41	0.32	11.56	2.67	5.00	5.27
20	0.96	1.48	0.91	0.27	0.68	1.64	0.37	0.35	4.21	2.97	5.06	5.34
21	0.95	0.96	0.89	0.26	0.69	1.74	0.37	0.36	1.89	3.04	5.03	5.45
22	0.97	1.22	0.76	0.27	0.70	1.30	0.33	0.38	1.60	3.15	4.93	5.36
23	1.08	0.78	0.74	0.69	1.90	0.98	0.31	0.61	1.36	3.52	5.04	5.37
24	1.08	0.79	0.73	0.70	35.68	0.64	0.31	0.45	1.35	3.41	5.40	5.37
25	1.10	0.85	0.71	0.65	6.92	0.68	0.32	0.43	1.38	3.57	5.84	5.17
26	1.21	0.94	0.70	0.64	2.08	2.55	0.32	0.62	1.69	3.58	6.03	5.01
27	1.03	0.91	0.65	0.63	1.28	1.44	0.32	0.51	2.09	5.71	5.69	5.01
28	1.06	0.93	0.63	0.58	1.03	0.84	0.31	0.84	1.63	4.63	5.47	4.91
29	1.00		0.62	0.55	0.93	1.94	0.31	2.21	1.46	5.06	5.27	4.90
30	0.93		0.59	0.24	0.72	1.24	0.34	16.85	1.46	6.67	5.22	4.85
31	0.93		0.55		0.65		0.31	2.73		5.45		5.01
Total	31.19	26.18	30.79	17.05	67.68	91.98	20.92	31.77	50.91	105.10	152.69	162.86
Mean	1.01	0.93	0.99	0.57	2.18	3.07	0.67	1.02	1.70	3.39	5.09	5.25
Max	1.53	1.75	1.68	0.81	35.68	40.53	4.44	16.85	11.56	6.67	6.03	5.76
Min	0.85	0.38	0.55	0.24	0.24	0.37	0.31	0.24	0.43	1.65	4.32	4.85

2002
Cottonwood Creek Peoria 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	ND	ND	ND	ND	ND	ND	0.67	0.25	0.72	2.30	1.09	0.78
2	ND	ND	ND	ND	ND	ND	0.66	0.24	0.54	11.57	1.05	0.79
3	ND	ND	ND	ND	ND	ND	0.61	0.29	0.44	2.53	1.01	0.71
4	ND	ND	ND	ND	ND	ND	0.49	0.42	0.45	1.53	0.98	0.71
5	ND	ND	ND	ND	ND	ND	7.67	0.97	0.45	1.07	0.94	0.72
6	ND	ND	ND	ND	ND	ND	4.36	1.07	0.44	0.90	0.98	0.71
7	ND	ND	ND	ND	ND	ND	1.34	0.46	0.46	0.86	0.94	0.73
8	ND	ND	ND	ND	ND	ND	0.68	0.51	0.43	0.82	0.87	0.65
9	ND	ND	ND	ND	ND	ND	0.55	0.44	0.57	0.81	0.87	0.63
10	ND	ND	ND	ND	ND	ND	1.81	0.32	2.28	0.78	0.87	0.62
11	ND	ND	ND	ND	ND	ND	1.81	0.25	0.95	0.77	0.87	0.66
12	ND	ND	ND	ND	ND	ND	1.23	0.27	1.23	0.77	0.87	0.70
13	ND	ND	ND	ND	ND	ND	0.85	0.26	5.17	0.78	0.87	0.71
14	ND	ND	ND	ND	ND	ND	0.57	0.25	1.55	0.78	1.40	0.69
15	ND	ND	ND	ND	ND	ND	0.37	0.24	0.89	0.78	1.31	0.72
16	ND	ND	ND	ND	ND	ND	0.44	0.23	0.71	0.78	0.95	0.71
17	ND	ND	ND	ND	ND	ND	0.33	0.23	0.51	0.78	0.90	0.73
18	ND	ND	ND	ND	ND	ND	0.31	0.22	6.57	0.81	0.84	0.69
19	ND	ND	ND	ND	ND	ND	0.28	0.22	7.95	0.84	0.78	0.66
20	ND	ND	ND	ND	ND	ND	0.26	0.23	2.15	0.87	0.74	0.68
21	ND	ND	ND	ND	ND	ND	0.28	0.35	1.28	0.91	0.74	0.71
22	ND	ND	ND	ND	ND	1.01	0.33	1.39	1.02	0.94	0.76	0.69
23	ND	ND	ND	ND	ND	0.70	0.26	0.60	0.91	0.94	0.80	0.68
24	ND	ND	ND	ND	ND	0.64	0.25	0.58	0.81	0.94	0.89	0.65
25	ND	ND	ND	ND	ND	7.37	0.25	1.75	0.75	0.98	1.09	0.65
26	ND	ND	ND	ND	ND	1.21	0.24	0.78	1.57	2.33	0.81	0.60
27	ND	ND	ND	ND	ND	0.77	0.23	2.03	1.25	3.22	0.85	0.62
28	ND	ND	ND	ND	ND	0.74	0.23	4.72	0.89	1.73	0.87	0.65
29	ND		ND	ND	ND	0.72	0.22	23.66	0.80	3.94	0.96	0.64
30	ND		ND	ND	ND	0.70	0.22	1.78	0.72	2.33	0.78	0.64
31	ND		ND		ND		0.21	0.91		1.63		0.64
Total	ND	ND	ND	ND	ND	13.85	28.01	45.92	44.45	51.02	27.70	21.17
Max	ND	ND	ND	ND	ND	7.37	7.67	23.66	7.95	11.57	1.40	0.79
Min	ND	ND	ND	ND	ND	0.64	0.21	0.22	0.43	0.77	0.74	0.60
Ac-ft	ND	ND	ND	ND	ND	27.43	55.46	90.93	88.01	101.03	54.85	41.91

* "ND" denotes "No Data"

2002
Cottonwood Creek Peoria 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	ND	ND	ND	ND	ND	ND	0.21	0.04	0.24	2.22	0.52	0.28
2	ND	ND	ND	ND	ND	ND	0.20	0.03	0.14	53.95	0.49	0.28
3	ND	ND	ND	ND	ND	ND	0.17	0.05	0.10	2.67	0.45	0.23
4	ND	ND	ND	ND	ND	ND	0.12	0.09	0.10	1.00	0.42	0.23
5	ND	ND	ND	ND	ND	ND	23.83	0.42	0.10	0.50	0.39	0.24
6	ND	ND	ND	ND	ND	ND	7.77	0.50	0.09	0.36	0.42	0.23
7	ND	ND	ND	ND	ND	ND	0.77	0.10	0.10	0.33	0.39	0.24
8	ND	ND	ND	ND	ND	ND	0.21	0.13	0.09	0.30	0.34	0.20
9	ND	ND	ND	ND	ND	ND	0.14	0.09	0.16	0.30	0.34	0.18
10	ND	ND	ND	ND	ND	ND	1.38	0.06	2.17	0.28	0.34	0.18
11	ND	ND	ND	ND	ND	ND	1.38	0.04	0.40	0.27	0.34	0.20
12	ND	ND	ND	ND	ND	ND	0.65	0.04	0.66	0.27	0.34	0.23
13	ND	ND	ND	ND	ND	ND	0.33	0.04	10.90	0.28	0.34	0.23
14	ND	ND	ND	ND	ND	ND	0.15	0.04	1.02	0.28	0.85	0.22
15	ND	ND	ND	ND	ND	ND	0.07	0.03	0.35	0.28	0.74	0.24
16	ND	ND	ND	ND	ND	ND	0.09	0.03	0.23	0.28	0.40	0.23
17	ND	ND	ND	ND	ND	ND	0.06	0.03	0.13	0.28	0.36	0.24
18	ND	ND	ND	ND	ND	ND	0.05	0.03	17.49	0.30	0.32	0.22
19	ND	ND	ND	ND	ND	ND	0.04	0.03	25.59	0.32	0.28	0.20
20	ND	ND	ND	ND	ND	ND	0.04	0.03	1.94	0.34	0.25	0.21
21	ND	ND	ND	ND	ND	ND	0.04	0.06	0.71	0.37	0.25	0.23
22	ND	ND	ND	ND	ND	0.45	0.06	0.83	0.46	0.39	0.26	0.22
23	ND	ND	ND	ND	ND	0.23	0.04	0.17	0.37	0.39	0.29	0.21
24	ND	ND	ND	ND	ND	0.19	0.04	0.16	0.30	0.39	0.35	0.20
25	ND	ND	ND	ND	ND	22.00	0.03	1.30	0.26	0.42	0.52	0.19
26	ND	ND	ND	ND	ND	0.64	0.03	0.28	1.05	2.27	0.30	0.17
27	ND	ND	ND	ND	ND	0.27	0.03	1.73	0.68	4.29	0.33	0.18
28	ND	ND	ND	ND	ND	0.25	0.03	9.10	0.36	1.27	0.34	0.20
29	ND		ND	ND	ND	0.24	0.03	224.46	0.29	6.37	0.41	0.19
30	ND		ND	ND	ND	0.22	0.03	1.33	0.24	2.27	0.28	0.19
31	ND		ND		ND		0.03	0.37		1.13		0.19
Total	ND	ND	ND	ND	ND	24.48	38.09	241.64	66.70	84.36	11.67	6.71
Mean	ND	ND	ND	ND	ND	2.72	1.23	7.79	2.22	2.72	0.39	0.22
Max	ND	ND	ND	ND	ND	22.00	23.83	224.46	25.59	53.95	0.85	0.28
Min	ND	ND	ND	ND	ND	0.19	0.03	0.03	0.09	0.27	0.25	0.17

* "ND" denotes "No Data"

2002
Cottonwood Creek Peoria 2
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	ND	ND	ND	ND	ND	ND	1.23	0.13	0.72	1.25	1.71	1.46
2	ND	ND	ND	ND	ND	ND	0.96	0.13	0.59	3.05	1.66	1.48
3	ND	ND	ND	ND	ND	ND	0.91	0.12	0.53	1.54	1.67	1.48
4	ND	ND	ND	ND	ND	ND	0.83	0.14	0.48	1.25	1.58	1.52
5	ND	ND	ND	ND	ND	ND	1.81	0.34	0.48	1.14	1.61	1.53
6	ND	ND	ND	ND	ND	ND	5.28	0.50	0.48	1.09	1.64	1.53
7	ND	ND	ND	ND	ND	ND	2.00	0.28	0.48	1.04	1.60	1.58
8	ND	ND	ND	ND	ND	ND	1.34	0.21	0.54	1.02	1.52	1.56
9	ND	ND	ND	ND	ND	ND	0.97	0.21	0.57	0.99	1.49	1.47
10	ND	ND	ND	ND	ND	ND	1.97	0.20	0.77	0.99	1.50	1.47
11	ND	ND	ND	ND	ND	ND	2.15	0.19	0.66	0.99	1.50	1.50
12	ND	ND	ND	ND	ND	ND	1.61	0.19	0.99	0.99	1.51	1.54
13	ND	ND	ND	ND	ND	ND	1.21	0.19	2.88	0.99	1.53	1.54
14	ND	ND	ND	ND	ND	ND	0.91	0.19	4.25	0.99	2.14	1.54
15	ND	ND	ND	ND	ND	ND	0.66	0.19	0.99	0.99	1.79	1.54
16	ND	ND	ND	ND	ND	ND	1.04	0.18	0.87	0.99	1.65	1.54
17	ND	ND	ND	ND	ND	ND	0.58	0.18	0.77	1.02	1.57	1.54
18	ND	ND	ND	ND	ND	ND	0.55	0.18	2.04	1.05	1.55	1.47
19	ND	ND	ND	ND	ND	ND	0.46	0.19	2.60	1.07	1.53	1.46
20	ND	ND	ND	ND	ND	ND	0.39	0.19	1.38	1.10	1.49	1.46
21	ND	ND	ND	ND	ND	ND	0.39	0.27	0.91	1.18	1.48	1.50
22	ND	ND	ND	ND	ND	ND	0.32	0.48	0.73	1.28	1.43	1.47
23	ND	ND	ND	ND	ND	ND	0.24	0.39	0.68	1.30	1.49	1.48
24	ND	ND	ND	ND	ND	ND	0.21	0.37	0.64	1.42	1.50	1.45
25	ND	ND	ND	ND	ND	3.35	0.23	0.44	0.61	1.44	1.63	1.44
26	ND	ND	ND	ND	ND	1.79	0.25	0.66	0.97	2.13	1.57	1.39
27	ND	ND	ND	ND	ND	1.15	0.25	0.40	0.87	2.35	1.51	1.45
28	ND	ND	ND	ND	ND	2.93	0.25	1.20	0.70	1.76	1.54	1.48
29	ND		ND	ND	ND	2.06	0.22	3.61	0.66	2.68	1.55	1.50
30	ND		ND	ND	ND	1.76	0.19	2.99	0.64	2.07	1.49	1.47
31	ND		ND		ND		0.15	1.17		1.79		1.50
Total	ND	ND	ND	ND	ND	13.03	29.57	16.09	30.48	42.95	47.46	46.35
Max	ND	ND	ND	ND	ND	3.35	5.28	3.61	4.25	3.05	2.14	1.58
Min	ND	ND	ND	ND	ND	1.15	0.15	0.12	0.48	0.99	1.43	1.39
Ac-ft	ND	ND	ND	ND	ND	25.81	58.54	31.85	60.35	85.05	93.98	91.77

* "ND" denotes "No Data"

2002
Cottonwood Creek Peoria 2
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	ND	ND	ND	ND	ND	ND	0.82	0.02	0.27	0.85	1.70	1.20
2	ND	ND	ND	ND	ND	ND	0.49	0.02	0.19	6.60	1.59	1.24
3	ND	ND	ND	ND	ND	ND	0.43	0.02	0.16	1.35	1.62	1.23
4	ND	ND	ND	ND	ND	ND	0.37	0.02	0.13	0.85	1.43	1.31
5	ND	ND	ND	ND	ND	ND	1.94	0.08	0.13	0.70	1.49	1.32
6	ND	ND	ND	ND	ND	ND	24.99	0.14	0.13	0.63	1.55	1.33
7	ND	ND	ND	ND	ND	ND	2.44	0.06	0.13	0.57	1.47	1.42
8	ND	ND	ND	ND	ND	ND	0.99	0.04	0.16	0.55	1.31	1.39
9	ND	ND	ND	ND	ND	ND	0.50	0.04	0.18	0.52	1.25	1.20
10	ND	ND	ND	ND	ND	ND	2.37	0.04	0.31	0.52	1.27	1.22
11	ND	ND	ND	ND	ND	ND	2.88	0.03	0.24	0.52	1.26	1.28
12	ND	ND	ND	ND	ND	ND	1.49	0.03	0.52	0.52	1.29	1.34
13	ND	ND	ND	ND	ND	ND	0.79	0.03	5.76	0.52	1.33	1.34
14	ND	ND	ND	ND	ND	ND	0.44	0.03	14.70	0.52	2.85	1.34
15	ND	ND	ND	ND	ND	ND	0.23	0.03	0.52	0.52	1.89	1.35
16	ND	ND	ND	ND	ND	ND	0.57	0.03	0.40	0.52	1.57	1.35
17	ND	ND	ND	ND	ND	ND	0.19	0.03	0.31	0.55	1.40	1.35
18	ND	ND	ND	ND	ND	ND	0.17	0.03	2.56	0.59	1.37	1.22
19	ND	ND	ND	ND	ND	ND	0.12	0.03	4.49	0.61	1.32	1.19
20	ND	ND	ND	ND	ND	ND	0.09	0.03	1.05	0.65	1.24	1.19
21	ND	ND	ND	ND	ND	ND	0.10	0.06	0.44	0.75	1.23	1.28
22	ND	ND	ND	ND	ND	ND	0.07	0.13	0.28	0.89	1.13	1.21
23	ND	ND	ND	ND	ND	ND	0.05	0.09	0.25	0.93	1.25	1.23
24	ND	ND	ND	ND	ND	ND	0.04	0.09	0.22	1.11	1.26	1.17
25	ND	ND	ND	ND	ND	8.28	0.04	0.11	0.20	1.15	1.53	1.16
26	ND	ND	ND	ND	ND	1.88	0.05	0.23	0.49	2.83	1.41	1.06
27	ND	ND	ND	ND	ND	0.71	0.05	0.10	0.40	3.55	1.29	1.18
28	ND	ND	ND	ND	ND	6.02	0.05	0.77	0.26	1.82	1.35	1.23
29	ND		ND	ND	ND	2.60	0.04	9.91	0.23	4.86	1.37	1.26
30	ND		ND	ND	ND	1.81	0.04	6.30	0.22	2.65	1.25	1.22
31	ND		ND		ND		0.03	0.74		1.89		1.26
Total	ND	ND	ND	ND	ND	21.29	42.85	19.35	35.35	41.07	43.31	39.05
Mean	ND	ND	ND	ND	ND	3.55	1.38	0.62	1.18	1.32	1.44	1.26
Max	ND	ND	ND	ND	ND	8.28	24.99	9.91	14.70	6.60	2.85	1.42
Min	ND	ND	ND	ND	ND	0.71	0.03	0.02	0.13	0.52	1.13	1.06

* "ND" denotes "No Data"

2002
Shop Creek 3
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.28	0.17	0.17	0.17	0.14	0.47	0.28	0.03	0.17	0.03	0.06	0.06
2	0.28	0.17	0.43	0.24	0.14	0.49	0.21	0.03	0.03	0.93	0.05	0.06
3	0.28	0.17	0.28	0.20	0.13	0.58	0.22	0.03	0.03	0.05	0.07	0.05
4	0.28	0.17	0.17	0.18	0.13	3.06	0.17	0.05	0.05	0.03	0.07	0.05
5	0.28	0.17	0.17	0.17	0.13	0.50	0.16	0.18	0.03	0.03	0.08	0.05
6	0.28	0.17	0.17	0.19	0.12	0.23	0.75	0.91	0.03	0.03	0.07	0.05
7	0.28	0.17	0.17	0.19	0.11	0.23	0.31	0.31	0.03	0.03	0.23	0.05
8	0.28	0.10	0.17	0.18	0.15	0.23	0.12	0.12	0.03	0.03	0.27	0.06
9	0.28	0.10	0.28	0.16	0.09	0.22	0.11	0.14	0.03	0.03	0.10	0.06
10	0.28	0.10	0.28	0.18	0.12	0.25	0.37	0.05	0.08	0.03	0.10	0.06
11	0.28	0.10	0.28	0.24	0.16	0.25	1.38	0.03	0.03	0.03	0.09	0.05
12	0.28	0.10	0.28	0.21	0.38	0.24	0.16	0.03	0.03	0.03	0.08	0.05
13	0.28	0.10	0.28	0.19	0.16	0.24	0.06	0.04	1.74	0.03	0.07	0.05
14	0.28	0.10	0.28	0.19	0.18	0.24	0.04	0.06	1.06	0.03	0.07	0.05
15	0.28	0.10	0.28	0.21	0.13	0.26	0.03	0.04	0.04	0.03	0.07	0.05
16	0.28	0.10	0.28	0.23	0.39	0.30	0.03	0.03	0.04	0.03	0.07	0.05
17	0.28	0.10	0.28	0.23	0.18	0.29	0.03	0.03	0.04	0.03	0.05	0.05
18	0.28	0.10	0.28	0.24	0.09	0.29	0.03	0.03	0.03	0.03	0.05	0.05
19	0.28	0.10	0.28	0.27	0.10	0.31	0.03	0.03	0.49	0.03	0.05	0.05
20	0.28	0.10	0.28	0.26	0.09	1.53	0.04	0.03	0.03	0.03	0.05	0.05
21	0.28	0.10	0.28	0.21	0.08	1.04	0.03	0.03	0.03	0.03	0.05	0.05
22	0.28	0.10	0.28	0.20	0.08	1.22	0.68	0.12	0.03	0.03	0.05	0.05
23	0.63	0.10	0.17	0.17	0.90	0.79	0.11	0.08	0.03	0.04	0.05	0.05
24	2.07	0.10	0.17	0.20	3.01	0.23	0.04	0.04	0.03	0.06	0.06	0.05
25	0.63	0.10	0.16	0.17	0.55	0.43	0.03	0.03	0.03	0.06	0.12	0.05
26	0.28	0.10	0.17	0.17	0.51	0.95	0.03	0.03	0.08	0.05	0.10	0.05
27	0.28	0.10	0.17	0.16	0.50	0.16	0.03	0.03	0.14	0.44	0.07	0.05
28	0.28	0.10	0.17	0.16	0.51	0.22	0.03	0.46	0.03	0.11	0.07	0.05
29	0.17		0.19	0.15	0.50	1.11	0.04	0.56	0.03	0.17	0.06	0.05
30	0.17		0.19	0.15	0.47	0.26	0.03	2.26	0.03	0.11	0.06	0.05
31	0.17		0.17		0.47		0.03	0.43		0.07		0.05
Total	10.88	3.33	7.26	5.85	10.69	16.64	5.60	6.23	0.05	2.65	2.42	1.61
Max	2.07	0.17	0.43	0.27	3.01	3.06	1.38	2.26	0.03	0.93	0.27	0.06
Min	0.17	0.10	0.16	0.15	0.08	0.16	0.03	0.03	0.03	0.03	0.05	0.05
Ac-ft	21.54	6.59	14.37	11.59	21.17	32.95	11.09	12.33	0.03	5.24	4.80	3.18

2002
Shop Creek 3
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.27	0.15	0.15	0.15	0.12	0.49	0.26	0.01	0.15	0.01	0.04	0.04
2	0.27	0.15	0.44	0.22	0.11	0.51	0.19	0.01	0.02	1.09	0.03	0.04
3	0.27	0.15	0.27	0.17	0.11	0.63	0.20	0.01	0.01	0.03	0.05	0.03
4	0.27	0.15	0.15	0.16	0.10	4.28	0.14	0.03	0.03	0.02	0.05	0.03
5	0.27	0.15	0.15	0.14	0.10	0.53	0.14	0.16	0.01	0.01	0.05	0.03
6	0.27	0.15	0.15	0.16	0.10	0.21	0.85	1.07	0.01	0.01	0.05	0.03
7	0.27	0.15	0.15	0.16	0.08	0.21	0.30	0.30	0.01	0.01	0.21	0.03
8	0.27	0.08	0.15	0.16	0.12	0.21	0.10	0.09	0.01	0.01	0.25	0.04
9	0.27	0.08	0.27	0.13	0.07	0.20	0.09	0.11	0.01	0.01	0.08	0.04
10	0.27	0.08	0.27	0.16	0.09	0.24	0.37	0.03	0.06	0.01	0.07	0.04
11	0.27	0.08	0.27	0.22	0.14	0.23	1.72	0.02	0.02	0.01	0.07	0.03
12	0.27	0.08	0.27	0.19	0.38	0.22	0.14	0.02	0.01	0.01	0.06	0.03
13	0.27	0.08	0.27	0.17	0.14	0.22	0.04	0.02	2.25	0.01	0.05	0.03
14	0.27	0.08	0.27	0.17	0.16	0.23	0.02	0.04	1.27	0.01	0.05	0.03
15	0.27	0.08	0.27	0.18	0.11	0.25	0.02	0.02	0.02	0.01	0.05	0.03
16	0.27	0.08	0.27	0.21	0.40	0.29	0.02	0.01	0.02	0.02	0.05	0.03
17	0.27	0.08	0.27	0.21	0.16	0.28	0.02	0.01	0.03	0.02	0.03	0.03
18	0.27	0.08	0.27	0.23	0.07	0.28	0.02	0.01	0.02	0.02	0.03	0.03
19	0.27	0.08	0.27	0.25	0.07	0.30	0.02	0.01	0.52	0.02	0.03	0.03
20	0.27	0.08	0.27	0.24	0.07	1.95	0.02	0.01	0.02	0.01	0.03	0.03
21	0.27	0.08	0.27	0.18	0.06	1.24	0.02	0.02	0.01	0.02	0.03	0.03
22	0.27	0.08	0.27	0.17	0.05	1.49	0.76	0.10	0.01	0.02	0.03	0.03
23	0.69	0.08	0.15	0.14	1.05	0.91	0.09	0.06	0.01	0.02	0.03	0.03
24	2.75	0.08	0.15	0.18	4.19	0.21	0.02	0.02	0.01	0.04	0.04	0.03
25	0.69	0.08	0.13	0.15	0.58	0.44	0.01	0.01	0.01	0.04	0.09	0.03
26	0.27	0.08	0.15	0.14	0.53	1.12	0.01	0.01	0.06	0.03	0.07	0.03
27	0.27	0.08	0.14	0.14	0.53	0.13	0.01	0.01	0.12	0.45	0.05	0.03
28	0.27	0.08	0.15	0.13	0.54	0.20	0.01	0.48	0.02	0.09	0.05	0.03
29	0.15		0.16	0.13	0.53	1.34	0.02	0.61	0.01	0.14	0.04	0.03
30	0.15		0.17	0.12	0.49	0.24	0.01	3.03	0.01	0.08	0.04	0.03
31	0.15		0.15		0.49		0.02	0.44		0.05		0.03
Total	11.23	2.63	6.67	5.15	11.73	19.06	5.64	6.80	4.78	2.36	1.79	1.01
Mean	0.36	0.09	0.22	0.17	0.38	0.64	0.18	0.22	0.16	0.08	0.06	0.03
Max	2.75	0.15	0.44	0.25	4.19	4.28	1.72	3.03	2.25	1.09	0.25	0.04
Min	0.15	0.08	0.13	0.12	0.05	0.13	0.01	0.01	0.01	0.01	0.03	0.03

2002
Cherry Creek Precipitation (in.)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0.40	0	0	0	0	0	0	0	0.02	0
2	0.02	0	0.01	0	0.01	0	0	0	0	0.38	0	0
3	0	0	0	0	0	0	0	0	0	0.02	0.01	0
4	0	0	0	0	0	0.82	0	0	0	0	0	0
5	0	0	0	0	0	0.02	0	0.07	0	0	0	0
6	0	0	0	0	0	0	0.31	0.41	0	0	0	0
7	0	0	0	0	0	0	0	0.14	0	0	0	0
8	0	0	0	0	0	0	0	0.15	0	0	0	0
9	0	0	1.50	0	0	0	0	0.02	0	0	0	0
10	0.12	0	0	0	0	0	0	0	0.25	0	0	0
11	0	0	0	0	0	0	0.31	0	0.02	0	0	0
12	0	0	0	0	0.08	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0.65	0	0	0
14	0	0	0.15	0	0	0	0	0	0	0	0.03	0
15	0	0	0.09	0	0	0	0	0	0	0	0.03	0
16	0	0	0	0	0	0	0	0	0	0	0.02	0
17	0	0	0	0	1.70	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0.60	0	0	0	0	0	0.35	0	0	0
20	0	0	0	0	0	0.35	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0.24	0.17	0.18	0	0	0	0
23	0.38	0	0	0	0	0	0.01	0	0	0	0	0
24	0	0	0	0	0.62	0	0	0	0	0	0.04	0
25	0	0.17	0	0	0.25	0.12	0	0	0	0	0.10	0
26	0	0.02	0	0	0	0	0	0	0.02	0	0	0
27	0	0	0	0	0	0	0	0	0.20	0.29	0	0
28	0	0	0	0	0	0	0	0.15	0	0	0	0
29	0		0	0	0	0	0	0	0	0.13	0	0
30	0		0	0	0	0	0	0.55	0	0.15	0	0
31	0		0		0		0	0		0.03		0
Total	0.52	0.19	2.75	0.00	2.66	1.55	0.80	1.67	1.49	1.00	0.25	0.00
Mean	0.02	0.01	0.09	0.00	0.09	0.05	0.03	0.05	0.05	0.03	0.01	0.00
Max	0.38	0.17	1.50	0.00	1.70	0.82	0.31	0.55	0.65	0.38	0.10	0.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ac-ft	36.92	13.49	195.25	0.00	188.86	110.05	56.80	118.57	105.79	71.00	17.75	0.00

2002
Cherry Creek Precipitation
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.00	39.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00
2	1.97	0.00	0.98	0.00	0.98	0.00	0.00	0.00	0.00	37.37	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.98	0.00
4	0.00	0.00	0.00	0.00	0.00	80.64	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	1.97	0.00	6.88	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	30.49	40.32	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.77	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.75	0.00	0.00	0.00	0.00
9	0.00	0.00	147.52	0.00	0.00	0.00	0.00	1.97	0.00	0.00	0.00	0.00
10	11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.59	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	30.49	0.00	1.97	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	7.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.93	0.00	0.00	0.00
14	0.00	0.00	14.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.95	0.00
15	0.00	0.00	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.95	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00
17	0.00	0.00	0.00	0.00	167.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	59.01	0.00	0.00	0.00	0.00	0.00	34.42	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	34.42	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	23.60	16.72	17.70	0.00	0.00	0.00	0.00
23	37.37	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	60.97	0.00	0.00	0.00	0.00	0.00	3.93	0.00
25	0.00	16.72	0.00	0.00	24.59	11.80	0.00	0.00	0.00	0.00	9.83	0.00
26	0.00	1.97	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.67	28.52	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.75	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.79	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	54.09	0.00	14.75	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		2.95		0.00
Total	51.14	18.69	270.45	0.00	261.60	152.44	78.68	164.24	146.54	98.35	24.59	0.00
Mean	1.65	0.67	8.72	0.00	8.44	5.08	2.54	5.30	4.88	3.17	0.82	0.00
Max	37.37	16.72	147.52	0.00	167.19	80.64	30.49	54.09	63.93	37.37	9.83	0.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX D

BIOLOGICAL DATA

2002 CHERRY CREEK PHYTOPLANKTON
COMPOSITE

GENUS/SPECIES	01/22/02	03/26/02	04/16/02	05/06/02	05/20/02	06/03/02	06/18/02	07/02/02	07/16/02	07/30/02	08/13/02	08/27/02	09/10/02	09/24/02	10/15/02	11/19/02
BACILLARIOPHYTA																
Order Centrales																
Cyclotella atomus		11							93						158	251
Cyclotella meneghiniana					7	9		14		39	89		84	60	79	
Cyclotella ocellata					7		27	55	56	39			56		40	
Cyclotella stelligera											30		84		40	84
Melosira distans alpigena		22	85	121	41	17	109			39		104	111	120		
Melosira granulata angustissima																418
Stephanodiscus astraea minutula			11	9	7					137	89	21	28		198	167
Stephanodiscus hantzschii				9		9				59	119	104	418	241		84
Order Pennales																
Asterionella formosa	17	87														
Caloneis ventricosa minuta								14								
Fragilaria construens				9									56			
Fragilaria construens venter									19		30					
Fragilaria crotonensis						9			371	489		42				
Navicula cryptocephala				9			27									
Navicula decussis												21				
Navicula graciloides				19												
Navicula viridula			11													
Nitzschia acicularis					20			14		137			56	90	40	
Nitzschia microcephala														30		
Nitzschia paleacea										157	178		139		79	334
Nitzschia tryblionella									19							
Rhoicosphenia curvata			21					14								
Synedra radians	17	22	21	19	14		27					21		120	119	7,350
Synedra ulna										137	59	21			158	668
CHLOROPHYTA																
Ankistrodesmus falcatus	555	54	32	19	20	26	82		56		178	125	167	60	40	
Chlamydomonas sp.	156	119	11				82	495	519	313	1,128	626	278	90	237	84
Chodatella wratislawiensis	35	32				17							56			
Closteriopsis longissima					7											
Coelastrum microporum													223			
Crucigenia crucifera						35							56			
Crucigenia quadrata														60	40	
Crucigenia tetrapedia			11							78		42	111		79	919
Dictyosphaerium ehrenbergianum															1,266	
Eudorina elegans								220	297	235						
Gloeocystis ampla						35			371							
Oocystis parva															633	334
Oocystis pusilla				37	27	87	219	83		78				90	158	
Pediastrum boryanum															316	
Pediastrum duplex				75												

GENUS/SPECIES	01/22/02	03/26/02	04/16/02	05/06/02	05/20/02	06/03/02	06/18/02	07/02/02	07/16/02	07/30/02	08/13/02	08/27/02	09/10/02	09/24/02	10/15/02	11/19/02
CHLOROPHYTA (cont.)																
Pediastrum tetras															158	
Scenedesmus abundans				19				55			119	167		120	79	
Scenedesmus acuminatus	347	43	85	75	27	174	109		148	137	59	334	1,114	962	316	1,002
Scenedesmus bijuga									223							
Scenedesmus quadricauda	69	141	403	559	327	87	328	468	742	313	593	710	1,058	1,864	949	1,002
Selenastrum minutum	364	541	159	130	75	70		83	111	20	30	42	111		40	
Sphaerocystis schroeteri	139							55	223							
Staurastrum gracile								28						30		
Staurastrum sp.											30				40	
Tetraedron minimum		11		9	14	52	55	55				63	334	90	316	
Tetraedron regulare			11	56	75	43				20	89	42	56	30		
Tetrastrum staurogeniaeforme		43		19	14	9	27			20	89	84			40	84
CYANOPHYTA																
Anabaena flos-aquae						487	7,927	83		3,739		84	28	60		
Anabaena planctonica									297	509	1,484					
Aphanothece sp.													56	30	277	
CHRYSOPHYTA																
Chromulina sp.		11										42	28	60	119	167
Chrysococcus rufescens											30			30		
Pseudopedinella sp.						9				20				30		
EUGLENOPHYTA																
Trachelomonas granulosa	52	11		9												
Trachelomonas hispida	35								19							
Trachelomonas volvocina										20	59	21	56	30	40	
PYRRHOPHYTA																
Ceratium hirundinella								14	37							
Dinobryon sertularia						96	1,421		408	59	30					
Dinobryon sp.												21				
Glenodinium sp.	52	11			20		27	248	130	98	59	42			40	251
Hemidinium sp.											30					
CRYPTOPHYTA																
Chroomonas sp.				9							30					
Cryptomonas erosa	226	65	21	84	102	122	137	83	204	78	356	146	167	210	237	167
Cryptomonas sp.		11														
Rhodomonas minuta	191	195	605	186	143	235	55	69	148		148	146	56	842	198	
MISCELLANEOUS																
Unid. flagellate	52	11		19				14			59				79	
Total Density (Cells/ml)	2,307	1,441	1,487	1,500	947	1,628	10,659	2,164	4,491	6,970	5,194	3,071	4,987	5,349	6,608	13,366
Total # of Taxa	15	19	14	22	18	20	16	20	21	25	26	24	26	24	32	17

APPENDIX E

QUALITY ASSURANCE/QUALITY CONTROL

QA/QC Analysis

A number of steps are taken to assure the quality of water chemistry and chlorophyll *a* data being collected. First, field blanks are taken into the field during water quality sampling. Secondly, Chadwick & Associates, Inc. (C&A) laboratory performs internal QA/QC for each set of samples for each sampling period, including duplicate analysis of all samples, frequent checks against known standards, and frequent calibration of equipment. Lastly, duplicate aliquots are sent to an independent laboratory (University of Colorado [CU]) for analysis. Chlorophyll *a* analysis is conducted by C&A aquatic biological laboratory.

Data quality for total phosphorus (TP), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP, measured as orthophosphate), nitrate-nitrite, and ammonia for C&A and CU laboratories were compared using a simple, least squares regression analysis. To determine if the laboratories are in agreement on the data, the regression must meet the following criteria:

1. The linear regression must represent a significant relationship ($p \leq 0.05$),
2. The regressions should have a slope at or near 1, and
3. The regression should explain the majority of the observed variance (i.e., $R^2 \geq 0.50$).

When these three criteria are met, the values reported by C&A and CU are averaged. In cases when one or more of the criteria are not met, the data do not meet the independent QA/QC and only the CU data would be used.

2002

Comparison of data collected during the 2002 field season shows good agreement between C&A and CU for TP, TDP, SRP, nitrate-nitrite, and ammonia (Table E-1). Regression slopes were all significantly different ($p \leq 0.05$) from zero, with slope values ranging from 0.70 to 1.07. Values for R^2 ranged from 0.60 to 0.98. Because of the close correlation between the results from the two labs, values from both labs were averaged. C&A and CU found all values for nitrate-nitrite to be below the analytical detection limit (5 µg/L). This demonstrates agreement between labs, but prevented the development of a statistical regression.

TABLE E-1: Summary statistics from comparison between Chadwick & Associates, Inc. laboratories and University of Colorado laboratories for phosphorus and nitrogen species for 2002. ND = no difference; all values were below analytical detection limits.

	p	Slope	R^2	QA/QC Criteria Met
Total Phosphorus	0.01	0.91	0.60	Yes
Total Dissolved Phosphorus	0.00	1.07	0.96	Yes
Soluble Reactive Phosphorus (Orthophosphate)	0.00	0.87	0.98	Yes
Nitrate-Nitrite	ND	ND	ND	Yes
Ammonia	0.00	0.70	0.69	Yes

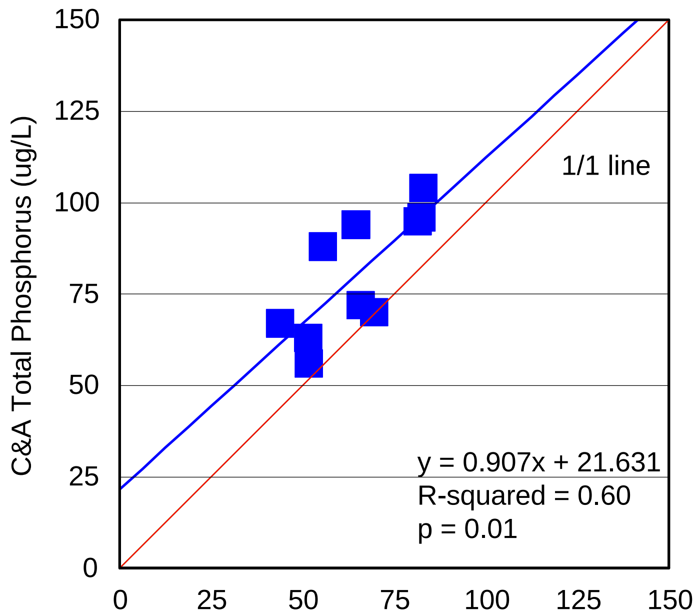


FIGURE E-1: Relationship between Chadwick & Associates, Inc. laboratory total phosphorus and University of Colorado total phosphorus for 2002.

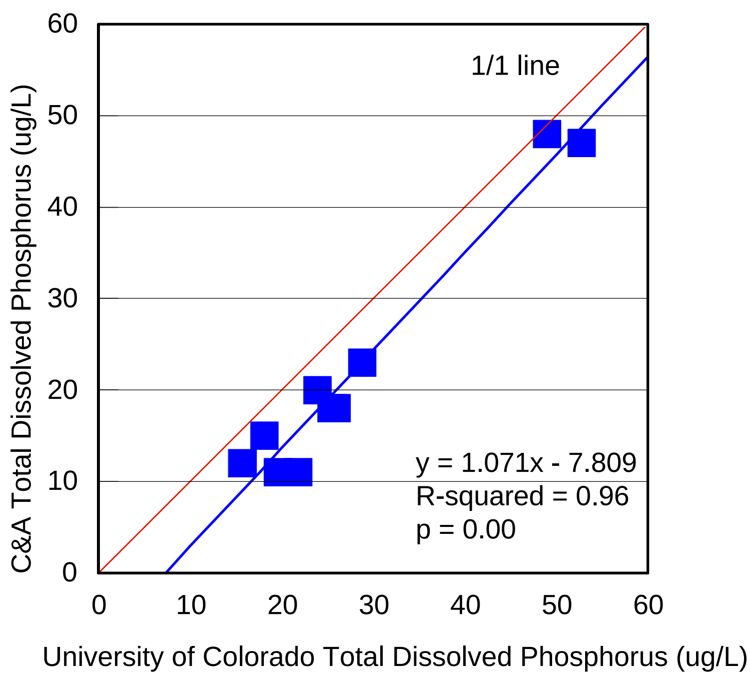


FIGURE E-2: Relationship between Chadwick & Associates, Inc. laboratory total dissolved phosphorus and University of Colorado total dissolved phosphorus for 2002.

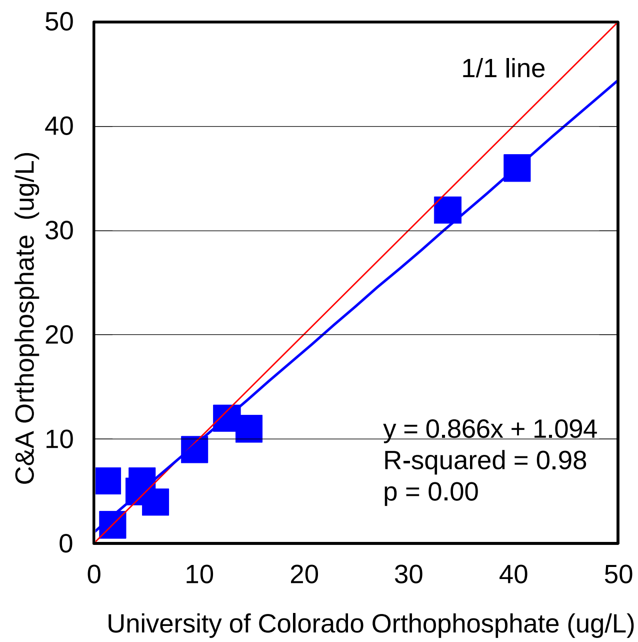


FIGURE E-3: Relationship between Chadwick & Associates, Inc. laboratory orthophosphate and University of Colorado orthophosphate for 2002.

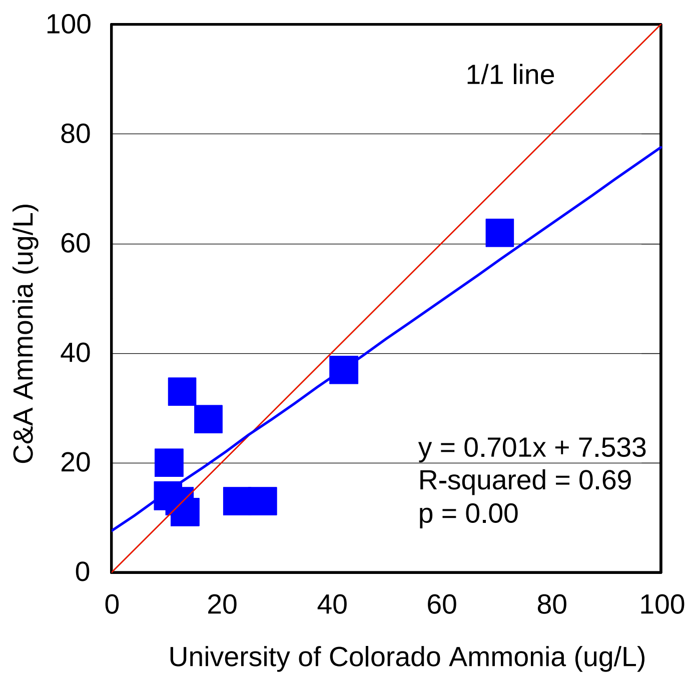


FIGURE E-4: Relationship between Chadwick & Associates, Inc. laboratory ammonia and University of Colorado ammonia for 2002.