CHERRY CREEK RESERVOIR

2004 ANNUAL AQUATIC BIOLOGICAL-NUTRIENT MONITORING STUDY AND COTTONWOOD CREEK PHOSPHORUS REDUCTION FACILITIES MONITORING

MARCH 2005

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Submitted To:

Cherry Creek Basin Water Quality Authority
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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 mean 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 - 2004). Through 2000, these data were also technically reviewed by Dr. John Jones of the University of Missouri-Columbia and with his latest review 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.

- Assess the effectiveness of pollutant reduction facilities (PRF) to reduce phosphorus loads into the reservoir.

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 as part of last year's report 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 2004 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).

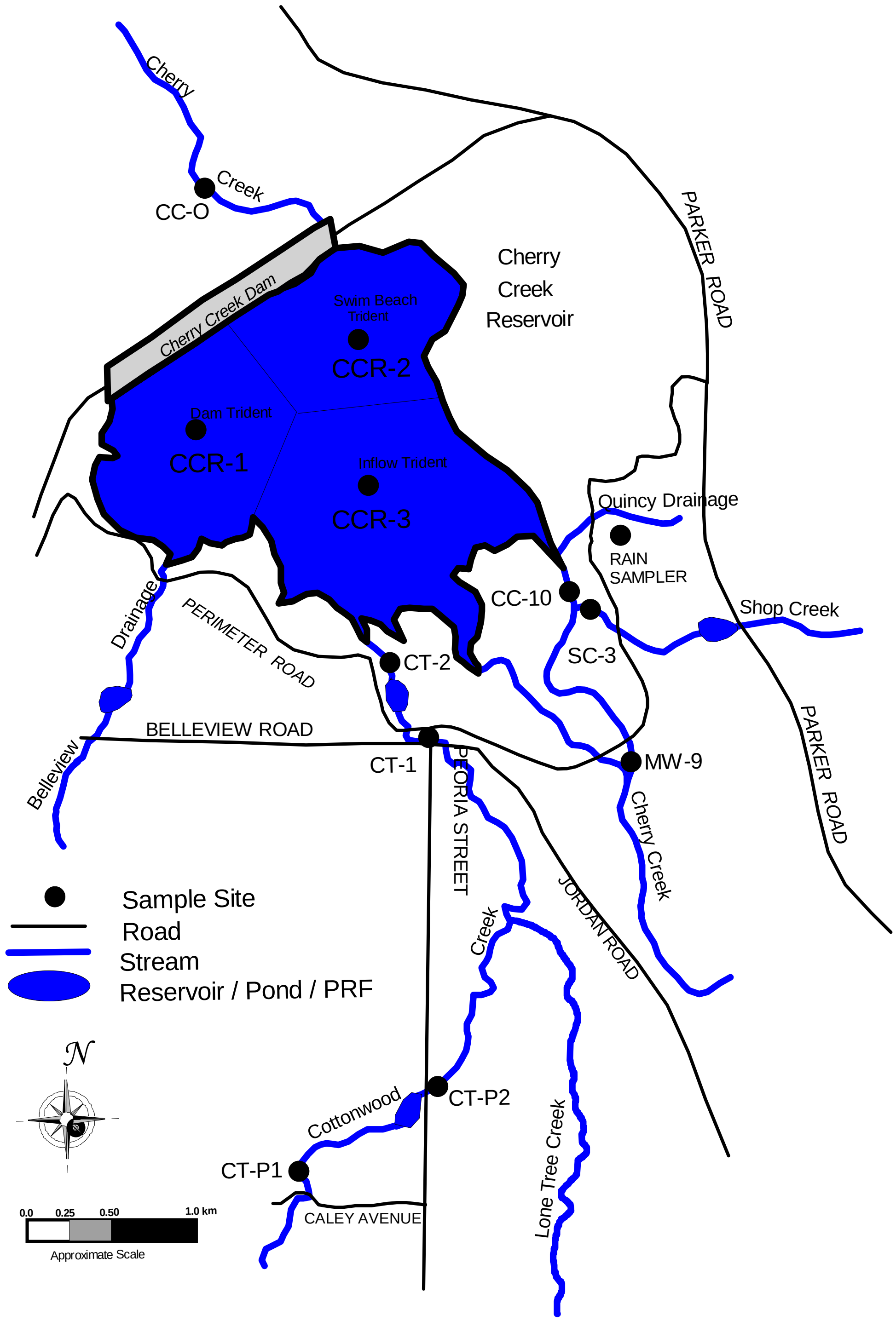

FIGURE 1: Sampling sites on Cherry Creek Reservoir and selected streams, 2004.

Shop Creek

SC-3 This site was established on Shop Creek in 1990 upstream of the Perimeter Road and downstream of the then 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 (i.e., CC-Inflow), but was renamed CC-10 to place it in context with concurrent monitoring in Cherry Creek mainstem upstream of the reservoir (JCHA 1999 - 2005). Monthly surface flow and water quality data have been collected at sites on Cherry Creek upstream of the Perimeter Road (JCHA 1999 - 2005). These sites extend from the Castlewood site in Castlewood Canyon downstream to Site CC-9 at the Perimeter Road.

MW-9 Ground water monitoring well in Cherry Creek State Park near Nature Center.

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 (i.e., CC-Outflow) monitors the water quality of Cherry Creek downstream of the reservoir outlet.

Cottonwood Creek

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 new 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.

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 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.

METHODS

Sampling Methodologies

Field and calculating methods for monitoring the reservoir and study sites follow the Cherry Creek Reservoir Sampling and Analysis Plan (CEC 2003) (Appendix A).

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 January, February and December 2004 due to unsafe ice conditions on the reservoir.

Sampling Trips per Sampling Period

Sampling Period	Frequency	Trips/Period
Oct - Apr	Monthly	4
May - Sept	Bi-Monthly	11
	Total	15

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

Transparency was determined using a Secchi disk and double deck photometer. Detailed methods of both instruments can be found in the Sampling and Analysis Plan located in Appendix A.

Profile Measurements

The second task involved taking dissolved oxygen, temperature, conductivity, and pH 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 at the three lake sites. The Sampling and Analysis Plan in Appendix A outlines the detailed methods used to collect lake water samples, as well as some of the laboratory methods in sample handling and preparation.

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 had been sampling fish populations only every two to three years. No sampling has taken place since 2001.

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

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 2004 sampling season (Table 1). A detailed outline of storm sampling protocols can be found in Appendix A.

TABLE 1: Number of storm samples taken from tributary streams to Cherry Creek Reservoir, 2004.

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

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. Periodic stream discharge measurements were taken using a Marsh McBirney Model 2000 flowmeter. For a complete description of streamflow determination, see Appendix D.

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, University of Colorado, Center of Limnology, for chemical analyses as a quality assurance check. Table 2 lists the parameters analyzed and the methods that were used. Detailed methodologies and laboratory QA/QC procedures 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, 2004.

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 the University of Colorado Center of Limnology. 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. Throughout the year, a randomly selected duplicate sample was taken at one of the reservoir sites, resulting in approximately 14% of the samples each sampling episode having a QA duplicate. Only the one randomly selected reservoir duplicate was shipped to James Saunders for analysis at his laboratory at the University of Colorado (CU). No duplicate samples were taken from stream sites. This resulted in approximately 7% of the total samples collected having a QA duplicate, but still provided a reasonable independent assessment of lake water nutrient 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 2004, with comparison between labs, are located in Appendix F. 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 2004 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 D.

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 2004. 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). If appropriate, 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 0.57 m in late June to a high of 1.12 m in mid-November. The whole-reservoir mean was 0.85 m (standard deviation of 0.14 m) between July and September 2004. This value is virtually the same as in 2003 (Fig. 2). The whole-reservoir mean maximum depth of 1% light transmittance ranged from a high of 4.19 m in early June to a low of 1.03 m in late April. Deepest recorded 1% transmittance values were observed June - November (mean = 2.75 m, median = 2.68 m). 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 in 1997 and have been relative stable since. There is not, however, a statistically significant long-term upward or downward trend ($p > 0.05$, $R^2 = 0.02$) 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 >2°C difference between surface and bottom temperatures (Jones 1998). Differences of approximately 1°C 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).

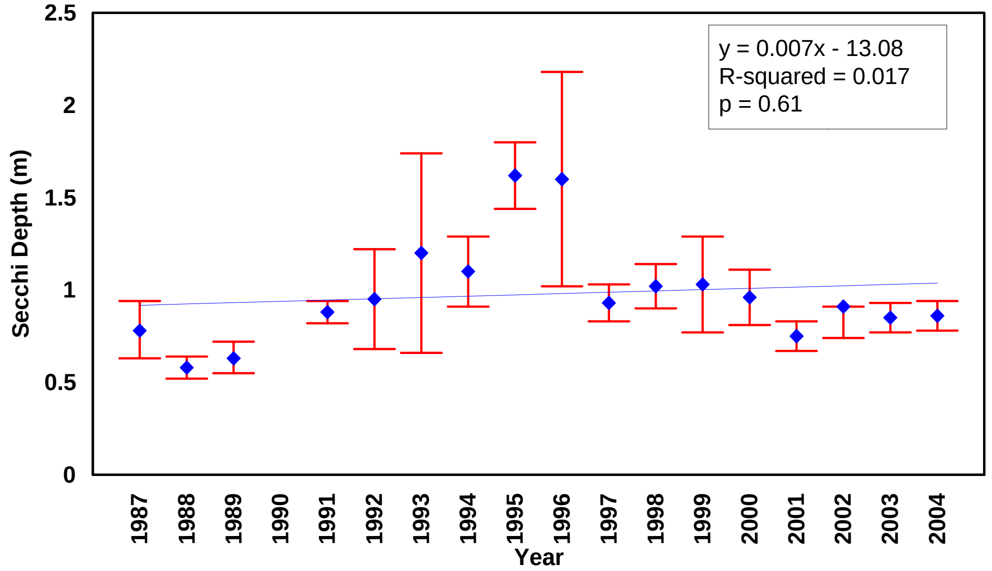

FIGURE 2: Seasonal mean (July to September) Secchi depths (m) measured in Cherry Creek Reservoir (1987 to 2004). Error bars represent a 95% confidence interval around each mean.

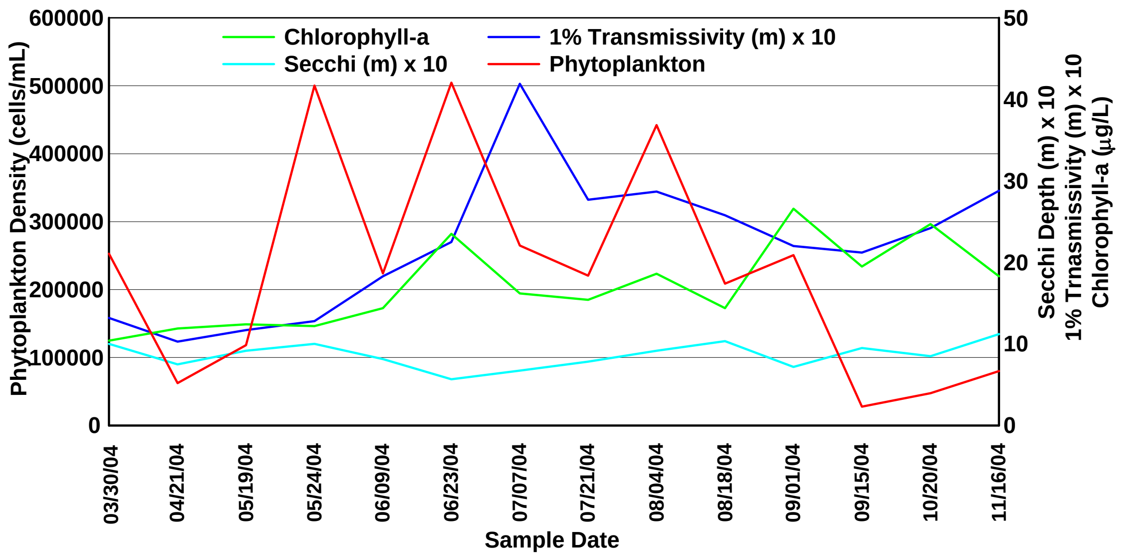

FIGURE 3: Relationship between phytoplankton density, Secchi depth (× 10), 1% transmissivity (× 10), and chlorophyll *a* in Cherry Creek Reservoir, 2004.

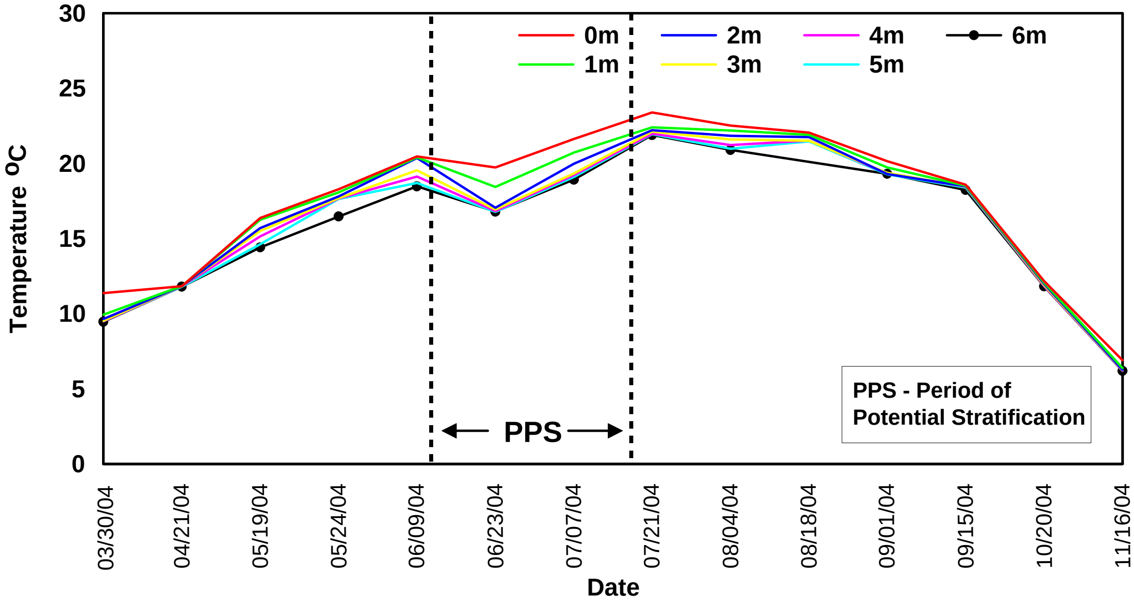

FIGURE 4: Temperature (°C) profiles recorded during routine monitoring at Site CCR-1 in 2004.

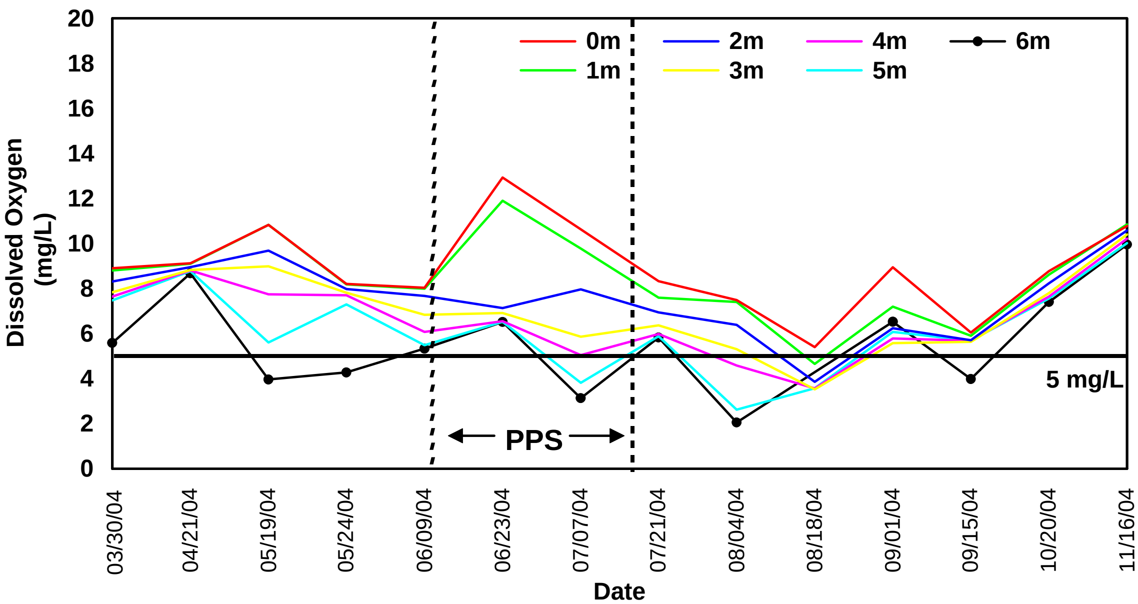

FIGURE 5: Dissolved oxygen (mg/L) profiles recorded during routing monitoring at Site CCR-1 in 2004.

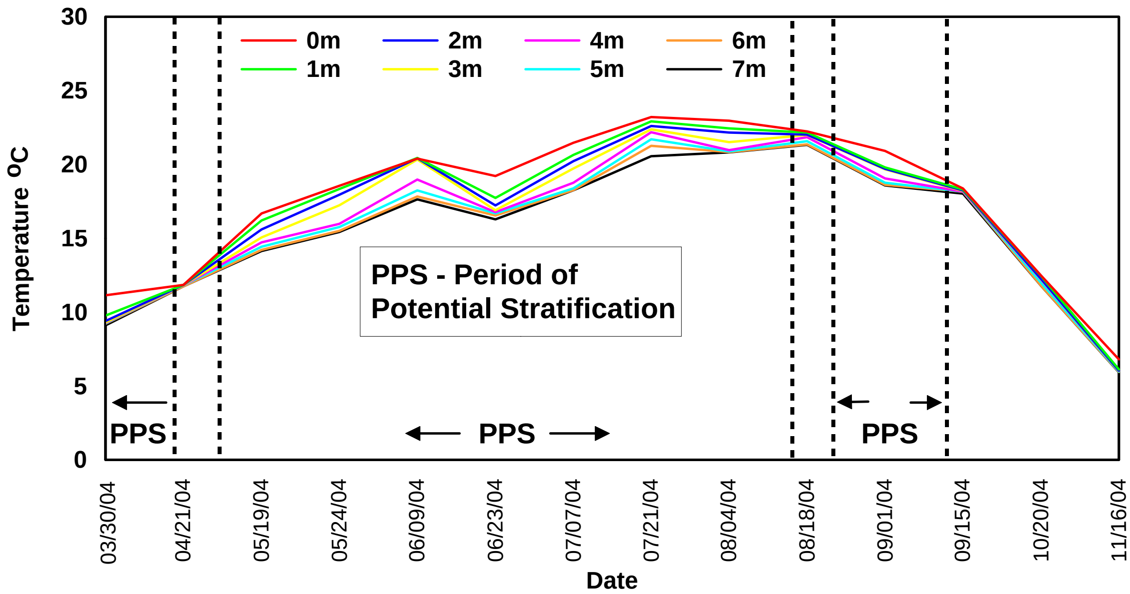

FIGURE 6: Temperature (°C) profiles recorded during routine monitoring at Site CCR-2 in 2004.

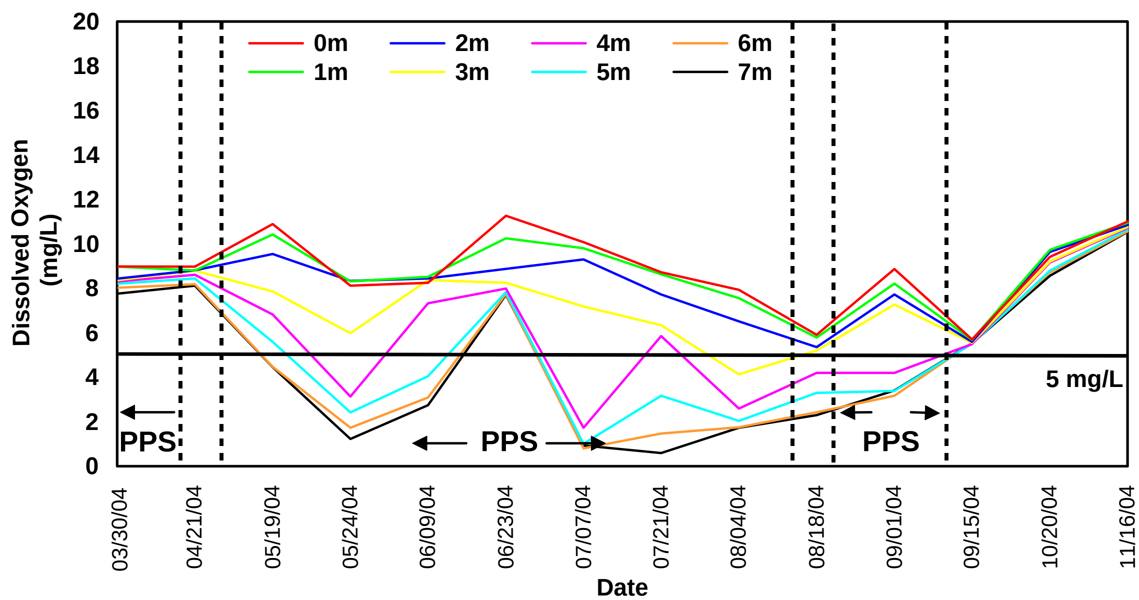

FIGURE 7: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-2 in 2004.

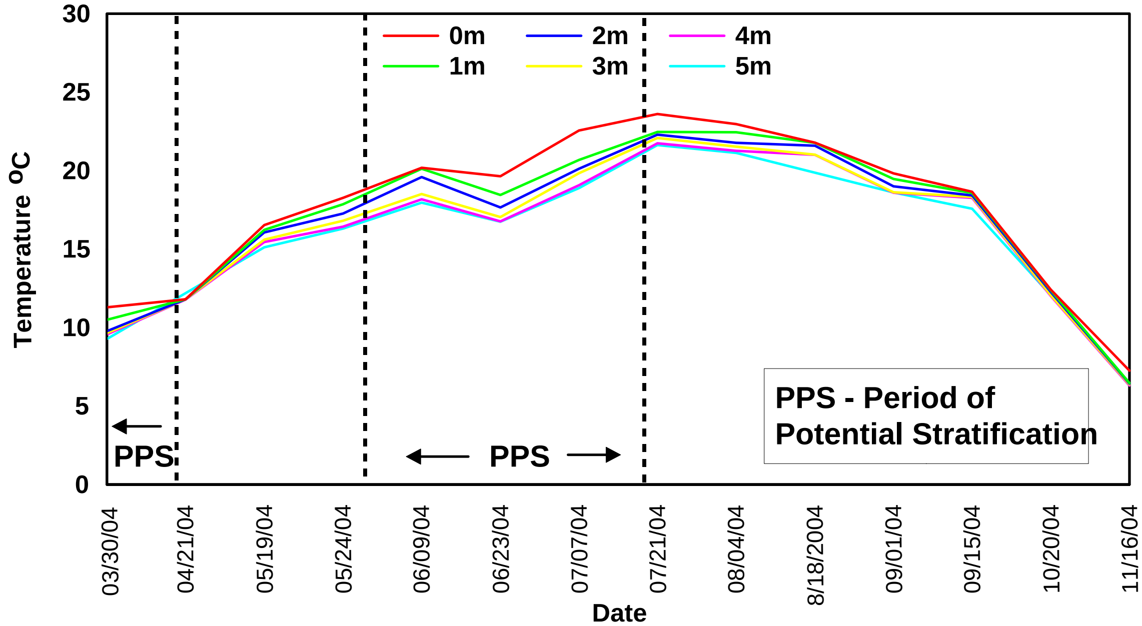

FIGURE 8: Temperature (°C) profiles recorded during routine monitoring at Site CCR-3 in 2004.

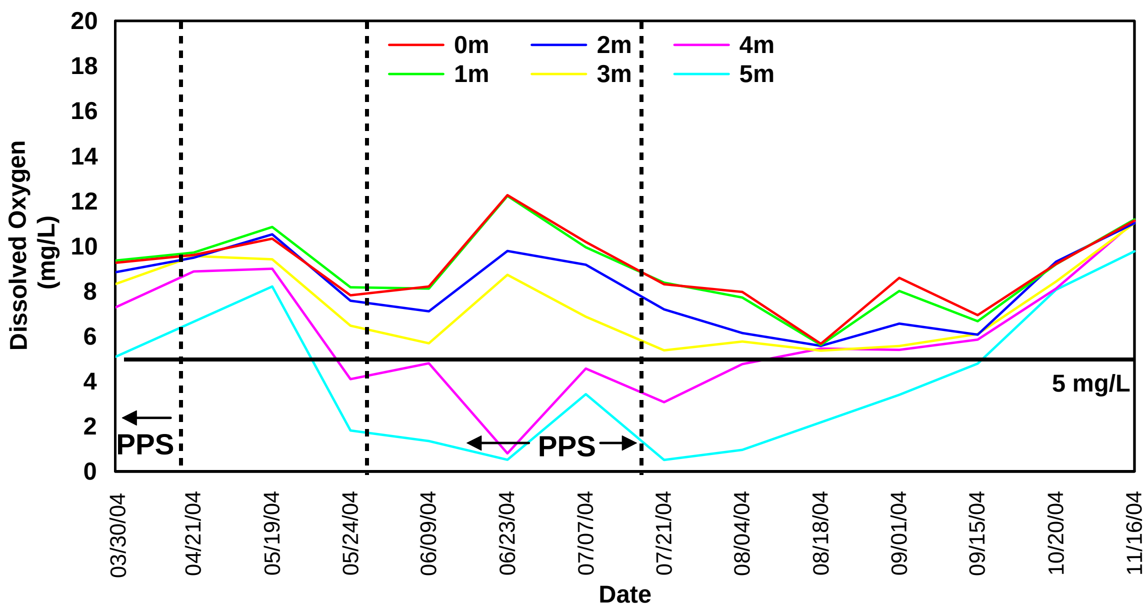

FIGURE 9: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-3 in 2004.

The measured temperature in Cherry Creek Reservoir ranged from a high of 23.61°C in mid-July to a low of 5.93°C in mid-November. As in previous years, periods of thermal stratification were observed in the reservoir. These stratification periods were observed at all lake sites (Figs. 4, 6, and 8). One period of potential stratification occurred at Site CCR-1 in late June though early July. Three periods of potential stratification were observed at Site CCR-2, the first in late March, the second from mid-May through early August, and the third in early September. A short period of potential stratification was seen at Site CCR-3 in late March, followed by a longer period of potential stratification in early June through 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). Significant whole lake mixing events appeared to occur in early July and late July (Figs. 4 - 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 2°C 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.

At Site CCR-1, the DO concentration dropped below 5.0 mg/L at levels at and below 4 m in early July and from early August to late August. This DO depression extended as shallow as 1 m during mid-August at Site CCR-1. Similar concentrations were observed at Site CCR-2 at levels at and below 5 m from late May through early September. During July and August, which had extensive periods with DO <5 mg/L in the deeper waters, 2.3% of the whole-lake volume experienced DO depletion below 5.0 mg/L. No depletion occurred 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 May to mid-September.

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 2004, the whole reservoir mean concentration of total phosphorus in the photic zone ranged from 35 to 131 µg/L with an overall annual mean of 84 µg/L (Fig. 10). Between July and September the concentration of total phosphorus in the photic zone ranged from 82 to 131 µg/L, with a mean of 102 µg/L. These values are comparable to those observed in 1997 through 2003; however, the July - September mean is the highest observed on record (Table 3). Although some peak values appeared related to inflow events (e.g., mid-August), others occurred during periods of no significant inflow (e.g., June - July). Over the year, total phosphorus concentration in the photic zone was not significantly related to inflow ($p > 0.05$, $R^2 = 0.03$).

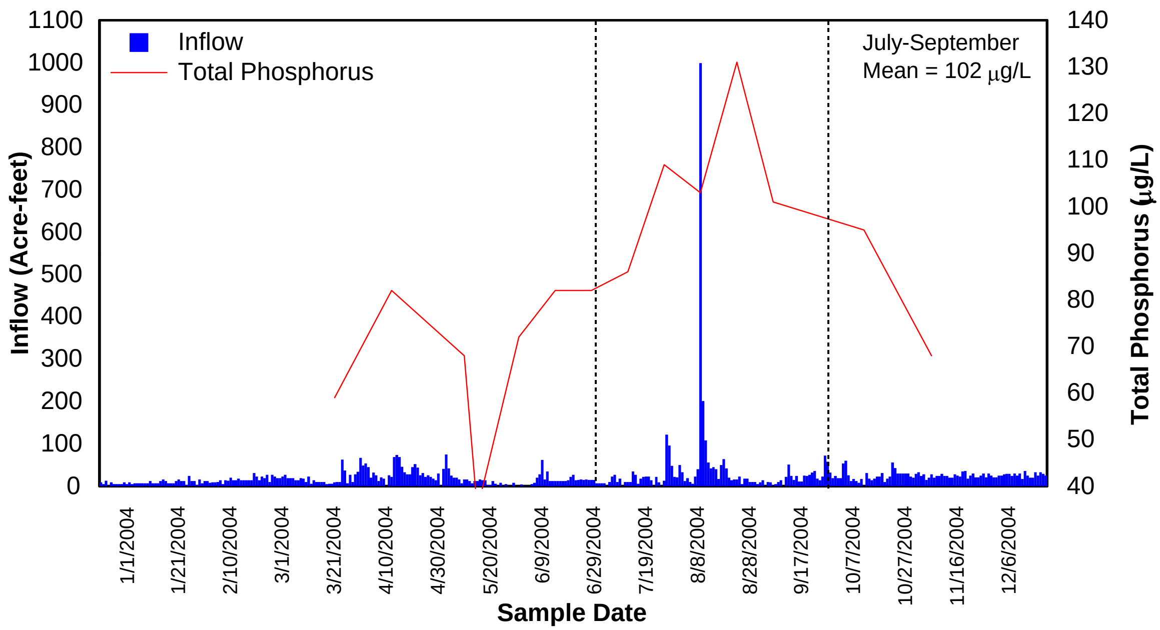

FIGURE 10: Relationship between TP (µg/L) and inflow (AF) in Cherry Creek Reservoir, 2004.

TABLE 3: Comparison of annual mean (monitoring period) and July-September mean phosphorus, nitrogen, and chlorophyll *a* levels in Cherry Creek Reservoir, 1987 - 2004. Annual means based on January through December sampling.

	Source	Total Nitrogen (µg/L)		Total Phosphorus (µg/L)		Mean Chlorophyll *a* (µg/L)	
Year	of Data	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	4.7	6.2
1995	CEC 1996	910	913	48	48	13.9	15.6
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	CEC 2003	847	858	70	74	21.7	18.8
2003	CEC 2004	990	1,121	87	90	23.2	25.8
2004	Present Study	923	977	84	102	17.0	18.4
Long-term average		905	936	70	72	15.7	18.2
Median		870	913	78	70	16.5	18.6

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 significantly ($p < 0.05$) and positively related to chlorophyll *a* (slope = 0.14, $R^2 = 0.45$), and was not significantly related to water clarity, either as Secchi depth (slope = -0.02, $R^2 = 0.09$), or 1% transmittance (slope = 0.14, $R^2 = 0.14$), or to phytoplankton density (slope = -1,304.2, $R^2 = 0.04$).

Nutrient profile samples collected in 2004 showed a well-mixed reservoir in spring and fall (Fig. 11). It appears there were brief periods of nutrient release from bottom sediments in March and July as evidenced by increasing TP concentrations with increasing depth (Fig. 11), despite little or no surface inflow to the reservoir (Fig. 10.).

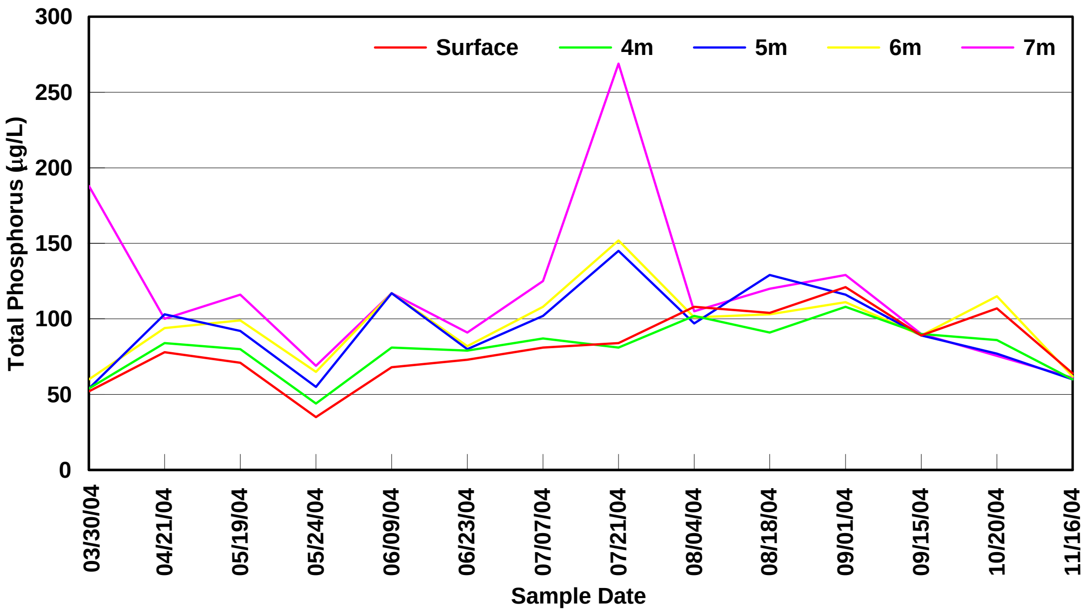

FIGURE 11: Phosphorus concentrations from profile samples at Site CCR-2, Cherry Creek Reservoir, 2004.

The whole reservoir mean concentration of total nitrogen in the photic zone ranged from 782 to 1,119 µg/L, with a mean of 923µg/L in 2004 (Table 3). During the July to September period, the whole reservoir mean total nitrogen concentration ranged from 883 to 1,119 µg/l, with a mean concentration of 977 µg/L (Table 3). Total nitrogen was significantly ($p < 0.05$) related to chlorophyll *a* (slope = 0.04, $R^2 = 0.55$), but not to Secchi depth (slope = -0.01, $R^2 = 0.22$).

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. 11). In 2004, the summer mean concentration of total phosphorus was 102 µg/L. This value is higher than any values observed previously (Table 3). Statistical analyses performed on 1987 - 2004 seasonal mean TP data indicates a significant ($p = <0.01$, slope = 2.24, $R^2 = 0.40$) upward trend. There appeared to be a slight decreasing trend in July - September mean TP over the 1997 - 2002 period (Fig. 12), although this trend stopped in 2003 - 2004. With the exception of a value of 39 µg/L in

1989, seasonal mean TP values in Cherry Creek Reservoir have consistently exceeded the goal of 40 µg/L over the past 18 years of monitoring. One-way analysis of variance test (ANOVA) did not show any significant difference in mean annual TP values from 1997 through 2004.

Chlorophyll *a* Levels

The mean whole reservoir concentration of chlorophyll *a* showed a generally increasing trend through the year (Fig. 13), with their highest annual level in early September (26.6 µg/L). Following the spike, concentrations of chlorophyll *a* decreased through the rest of the year; the lowest concentration of 10.4 µg/L was observed in late March. The annual mean chlorophyll *a* concentration of 17.0 µg/L is lower than the 2003 value (23.2 µg/L). The July to September mean chlorophyll *a* concentration of 18.4 µg/L was comparable to past values (Table 3), but lower than the value of 26.8 µg/L in 2003. The July - September mean in 2004 still exceeded the standard of 15 µg/L chlorophyll *a* for the reservoir.

<u>Long-Term Chlorophyll *a* Trends in Cherry Creek Reservoir</u>

July to September mean chlorophyll *a* concentrations have met the standard of 15 µg/L only five out of the past 18 years (Fig. 14), and not since 1994. Since 1987, there has been a slight, but significant ($p < 0.05$), increasing trend (slope = 0.72, R^2 = 0.239) in the July to September mean concentration of chlorophyll *a* in Cherry Creek Reservoir (Fig. 14). Results of a one-way ANOVA test indicate that there is no statistically significant difference between seasonal mean chlorophyll *a* concentrations, from 1996 through 2004.

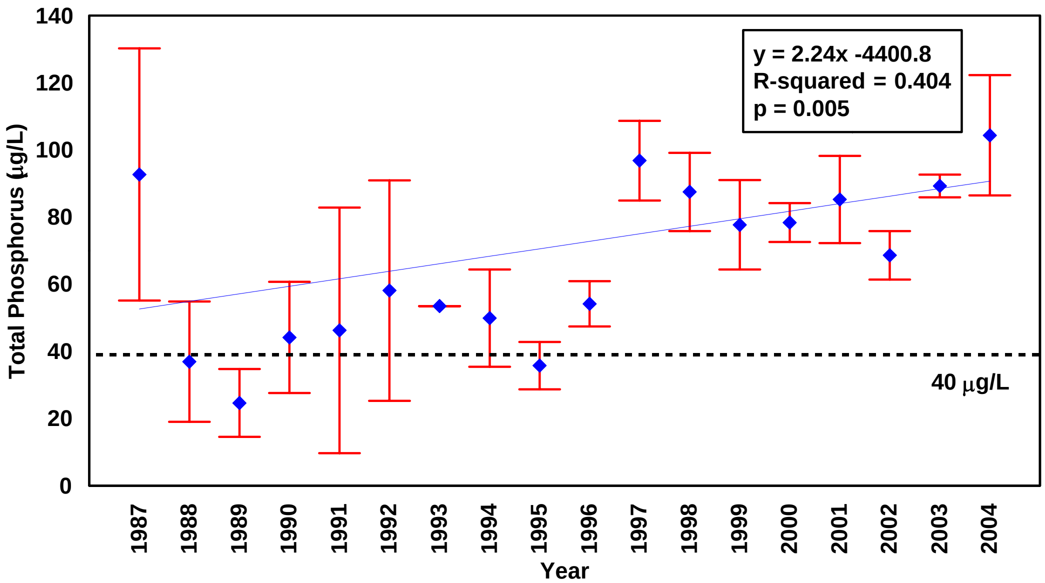

FIGURE 12: Seasonal mean (July to September) total phosphorus concentrations (µg/L) measured in Cherry Creek Reservoir, 1987 - 2004. Error bars represent a 95% confidence interval around each mean.

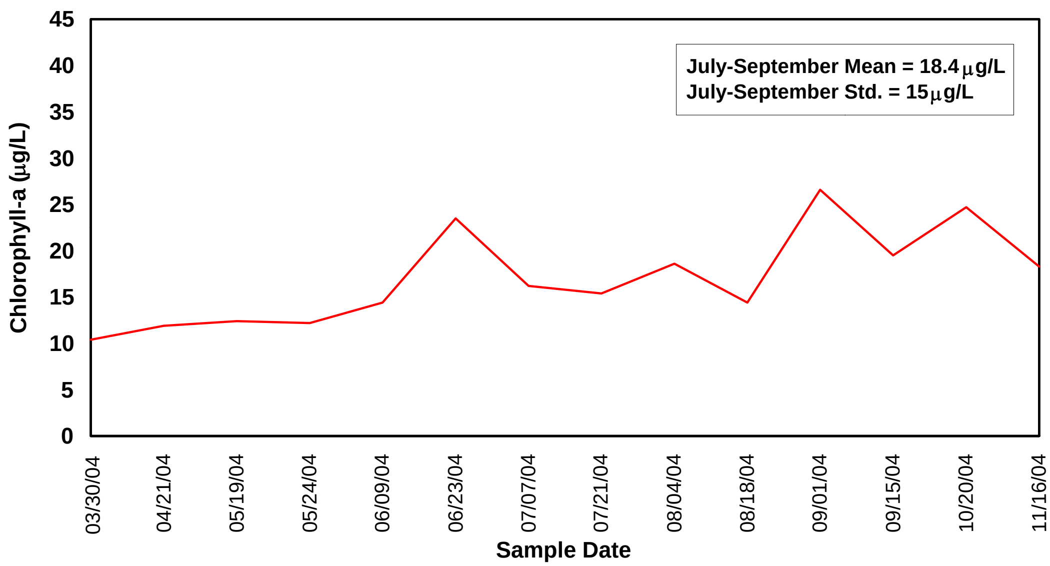

FIGURE 13: Concentration of chlorophyll *a* (µg/L) in Cherry Creek Reservoir, 2004.

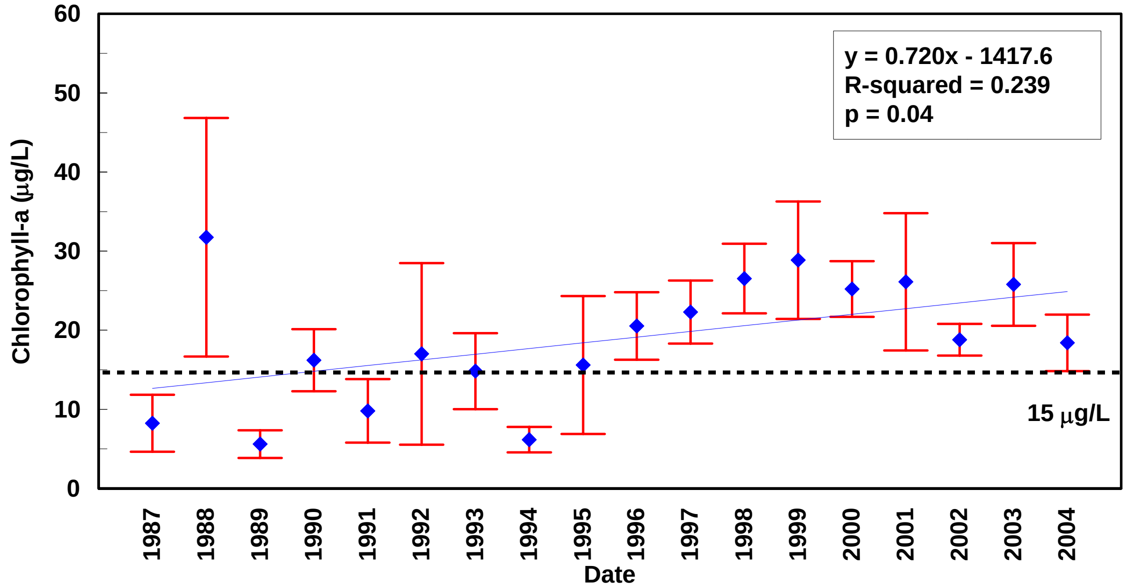

FIGURE 14: Seasonal mean (July to September) chlorophyll *a* concentrations measured in Cherry Creek Reservoir, 1987 to 2004. Error bars represent 95% confidence interval around each mean.

Reservoir Biology

Phytoplankton

Phytoplankton Populations

The photic density of phytoplankton in Cherry Creek Reservoir ranged from 27,794 cells/mL on September 15 to 504,376 cells/mL on June 23 (Table 4). The number of taxa present in the reservoir ranged from a low of 34 on March 30 and May 19, and reached a high of 58 on July 7. Phytoplankton abundances were highest in the spring, summer, and fall months. Annually, the community was dominated by blue-green algae. Green algae was the second most prevalent group. The May and June spikes in phytoplankton densities 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 2004. Additionally, no significant relationship could be determined between phytoplankton density and chlorophyll *a* or total nitrogen concentrations.

TABLE 4: Density (cells/mL) of phytoplankton and total number of taxa collected from all three sites on Cherry Creek Reservoir, 2004.

Taxa	30 Mar	21 Apr	19 May	24 May	9 June	23 June	7 July
Diatoms							
Centrics	10	460	170	285	1,715	1,815	7,850
Pennates	7,386	175	295	175	125	140	140
Green Algae	22,090	16,880	30,880	55,035	141,865	113,255	36,190
Blue-Green Algae	219,980	33,900	85,580	443,520	76,440	384,710	218,770
Golden-Brown Algae	265	0	35	5	55	0	80
Yellow-Green Algae	0	0	0	0	1	0	0
Euglenoids	0	0	0	5	170	11	2
Dinoflagellates	25	0	0	0	15	70	2
Cryptomonads	3,115	10,975	1,270	1,285	3,485	4,360	970
Haptomonads	0	0	0	0	0	0	0
Microflagellates	0	0	0	0	0	15	880
Total Density	**252,871**	**62,390**	**118,230**	**500,310**	**223,871**	**504,376**	**264,885**
Total Taxa	**34**	**35**	**34**	**45**	**52**	**53**	**58**
Taxa	21 July	4 Aug	18 Aug	1 Sept	15 Sept	20 Oct	16 Nov
Diatoms							
Centrics	1,407	1,205	984	3,700	103	789	14,280
Pennates	551	240	40	0	6	160	85
Green Algae	12,585	56,510	137,970	74,208	12,661	23,104	53,975
Blue-Green Algae	202,790	379,280	68,042	165,706	14,210	16,570	9,980
Golden-Brown Algae	321	6	0	0	5	20	0
Yellow-Green Algae	20	0	0	2	0	0	0
Euglenoids	20	30	48	31	13	10	0
Dinoflagellates	6	0	121	80	8	320	155
Cryptomonads	1,655	4,265	1,042	6,180	248	3,950	1,410
Haptomonads	0	0	0	0	60	0	0
Microflagellates	1,015	415	400	680	480	2,720	200
Total Density	**220,369**	**442,051**	**208,647**	**250,587**	**27,794**	**47,643**	**80,085**
Total Taxa	**56**	**57**	**43**	**56**	**47**	**45**	**43**

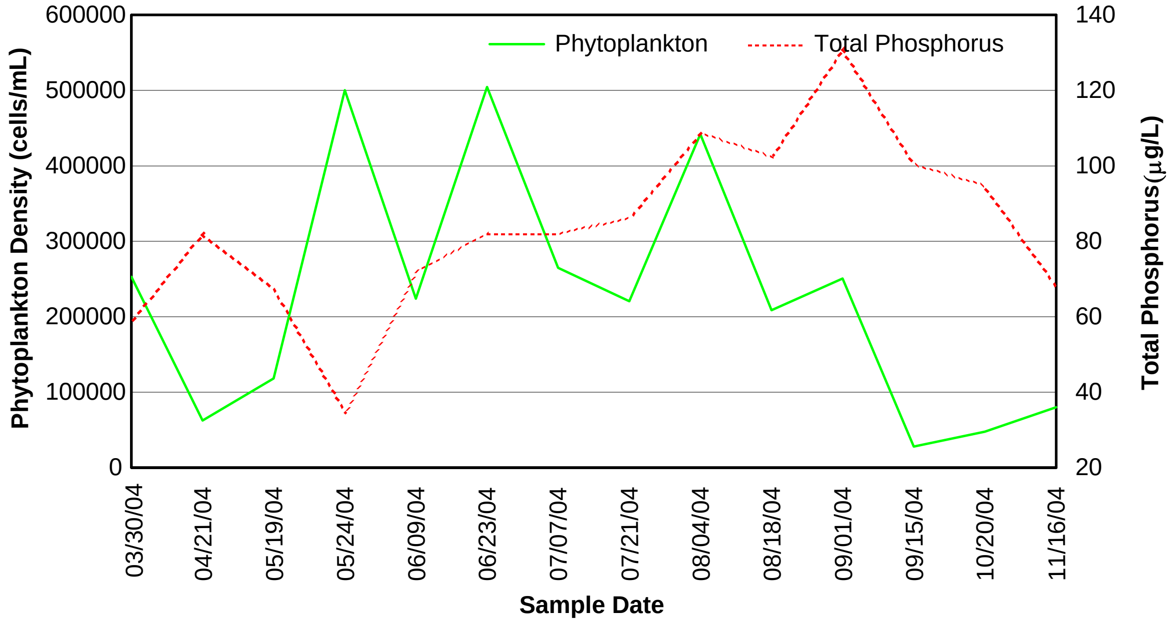

FIGURE 15: Comparison of photic phytoplankton densities from the three reservoir sampling sites to mean total phosphorus concentrations from three sites in Cherry Creek Reservoir, 2004.

Historic Phytoplankton

The phytoplankton community was dominated by blue-green algae in 2004 (Table 5). The proportion of total phytoplankton abundance accounted for by blue-green algae in 2004 (72%) was greater than all values dating back to 1984. This, in part, may be due to different methods used to analyze phytoplankton samples. The new methods and techniques appear to use technologies which are better at identifying smaller species of algae. 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. Although not found in past years, yellow-green algae were present in low numbers in mid-June, mid-July, and early September. Historically, micro blue-green algae have dominated the phytoplankton community in Cherry Creek Reservoir.

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).

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 2004 (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. Only three fish species were stocked in 2004 (Table 6), rainbow trout, walleye, and channel catfish.

TABLE 5: Reservoir mean phytoplankton density (cells/mL) and number of taxa in Cherry Creek Reservoir, 1984 to 2004.

Density, Richness	1984	1985	1986	1987	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Blue-Green Algae																				
Density	71,780	66,496	99316	168,259	155,180	273,175	307,691	77,516	15,708	10,015	18,194	16,599	19716	44951	15263	164290	148691	941	54114	165677
Taxa Richness	7	7	6	18	24	24	14	16	7	3	7	9	10	11	8	19	12	3	21	27
Green Algae																				
Density	5,864	11,760	25,595	11,985	19,177	55,415	18,688	41,899	1,198	314	355	738	2461	1809	898	43881	33217	1973	55190	56236
Taxa Richness	11	10	13	58	76	66	46	48	16	2	11	11	1518	18	18	71	56	27	70	75
Diatoms																				
Density	1,776	3,863	5,428	10,677	12,880	9,311	4,160	1,243	946	194	2,189	2,354	1109	628	838	12019	5256	978	2026	1720
Taxa Richness	6	4	7	34	30	31	21	11	15	2	15	13	8	18	16	34	22	24	22	26
Golden-Brown Algae																				
Density	--	7	125	469	56	505	821	93	158	3	63	249	227	56	--	391	1346	34	44	57
Taxa Richness	--	1	1	6	4	7	5	4	1	1	2	4	2	2	--	14	13	3	5	5
Euglenoids																				
Density	514	135	208	251	276	108	89	23	231	196	304	409	838	698	1252	126	91	22	308	24
Taxa Richness	2	1	1	9	9	6	3	5	2	1	2	3	3	3	1	6	4	3	9	11
Dinoflagellates																				
Density	--	13	19	19	83	28	23	54	--	31	5	21	--	18	45	80	157	193	20	57
Taxa Richness	--	1	1	2	4	3	2	2	--	1	2	4	--	2	2	8	6	5	3	5
Cryptomonads																				
Density	1,513	718	1,113	1,090	2,689	1,689	628	529	332	450	919	1,104	1487	1393	559	2472	2851	355	3282	3158
Taxa Richness	2	3	3	6	4	5	2	3	1	1	1	1	1	1	1	4	6	4	8	8
Miscellaneous																				
Density	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1923	5714	15	1294	164
Taxa Richness	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	1	3	6
Total Density	**81447**	**82,992**	**131,804**	**192750**	**190,341**	**340,231**	**329,773**	**121,357**	**18,573**	**11,203**	**22,029**	**21,474**	**25,838**	**49453**	**18855**	**225182**	**197323**	**4510**	**116278**	**227093**
Total Taxa	**28**	**27**	**32**	**133**	**151**	**142**	**93**	**89**	**42**	**11**	**40**	**45**	**39**	**55**	**46**	**157**	**120**	**70**	**141**	**164**

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 has not conducted any fish population sampling in Cherry Creek Reservoir since 2001.

Phosphorus Concentration in Streams

The mean annual concentration of total phosphorus in streams ranged from a low of 51 µg/L at CT-P1 to a high of 215 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 60 µg/L at Site CT-P2 to a high of 234 µg/L at Site CC-10. 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 195 µg/L at Site SC-3 to a high of 495 µg/L at Site CC-10.

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

Additional analyses were performed on data from the three main tributaries at sites directly upstream of Cherry Creek Reservoir (Sites CC-10, SC-3, and CT-2) to determine trends in phosphorus and orthophosphate concentrations from 1995 to 2004. Over this period, mean phosphorus concentration was highest at Site CC-10 (230 µg/L) and lowest at Site CT-2 (104 µg/L) (Table 8). Mean orthophosphate concentration was also highest at Site CC-10 (178 µg/L) and lowest at Site CT-2 (40 µg/L). Orthophosphate comprised 77% of the total phosphorus concentrations measured at both Site CC-10 and at Site SC-3. At Site CT-2, orthophosphate made up only 39% of total measured phosphorus (Fig. 16).

TABLE 6: Quantity and size of fish stocked in Cherry Creek Reservoir, 1985 to 2004.

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
2003	Rainbow trout	10-11	30,111
	Walleye	0.25	4,136,709
	Channel catfish	2-2.5	33,669
2004	Rainbow trout	10-11	43,553
	Walleye	0.25	2,874,100
	Channel catfish	2.5	13,500

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, 2004.

	Baseflow Samples				Storm Samples	
	Summer		Annual		June - 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	234	36	215	29	495	267
CCO	120	35	88	24	--	--
Cottonwood Creek						
CT-1	65	37	78	30	440	369
CT-2	74	35	91	56	253	124
CT-P1	76	20	51	14	300	212
CT-P2	60	23	80	44	196	66
Shop Creek						
SC-3	229	9	173	25	195	15

TABLE 8: Comparison of annual total phosphorus and orthophosphate concentrations for Sites CC-10, SC-3, and CT-2 from 1995 to 2004.

		Stream Site		
		CC-10	SC-3	CT-2
Total Phosphorus (µg/L)	Minimum	22	0.1	0.1
	Maximum	553	456	415
	Mean	230	126	104
Orthophosphate (µg/L)	Minimum	0.1	0.1	3
	Maximum	362	401	175
	Mean	178	97	40

Concentrations of total phosphorus have exhibited an increasing but insignificant trend over time at Site CC-10 ($p = 0.252$, $R^2 = 0.01$, slope = 0.20) (Fig. 17). Concentrations of orthophosphate at Site CC-10 (Fig. 18) were also not significantly related to time ($p > 0.05$, $R^2 = 0.010$). The relationship between total phosphorus and with orthophosphate concentration with time was significant and indicated a slight upward trend at Site SC-3 (Fig. 20) with an apparent increase in variability in recent years. This may be an indication of potentially reduced effectiveness of the Shop Creek methods over time. Both the total phosphorus and especially orthophosphate show a decreasing trend at Site CT-2 (Figs. 21 and 22), with the trend statistically significant for orthophosphate ($p < 0.01$, $R^2 = 0.42$, slope = -0.64). The observed downward trend and strongly reduced variability in orthophosphate concentrations at Site CT-2 from 1995 - 2004 may be an indication of the increasing effectiveness of the Cottonwood Creek PRF, which was installed in 1996, and the addition of the Peoria wetland in 2002. There appears to be a seasonal pattern in phosphorus concentration at all sites, which is not specifically addressed in the trend analysis.

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

Data for alluvial phosphorus concentrations from Site MW-9 were obtained from Halepaska (2004 unpublished). These data were used to estimate loadings from alluvial flows to the reservoir, as summarized below. Regression analyses were also performed on data from Site MW-9 to determine trends in alluvial total dissolved phosphorus and orthophosphate concentrations from 1994 to 2004 (Figs. 23 and 24). Total dissolved phosphorus was used because total phosphorus is not measured at Site MW-9. Similar to the phosphorus trends observed at Site CC-10, alluvial concentrations of total dissolved phosphorus exhibited a weakly significant increasing trend over time at Site MW-9 ($p = 0.00$, $R^2 = 0.105$, slope = 0.17) (Fig. 23), although this regression explains only 1% of the observed variance. Total dissolved phosphorus concentrations ranged from 210 µg/L to 230 µg/L, with a mean of 220 µg/L. Alluvial concentrations of orthophosphate at Site MW-9 (Fig. 24) were significantly correlated to time ($p < 0.01$, $R^2 = 0.292$, slope = 0.34) and indicated a slight upward trend. Orthophosphate concentrations at Site MW-9 were similar to surface water concentrations, with a mean concentration of 210 µg/L (Fig. 16).

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 weakly significant, and indicated a positive correlation at Site CT-2 ($p < 0.01$, $R^2 = 0.077$, slope = 0.06).

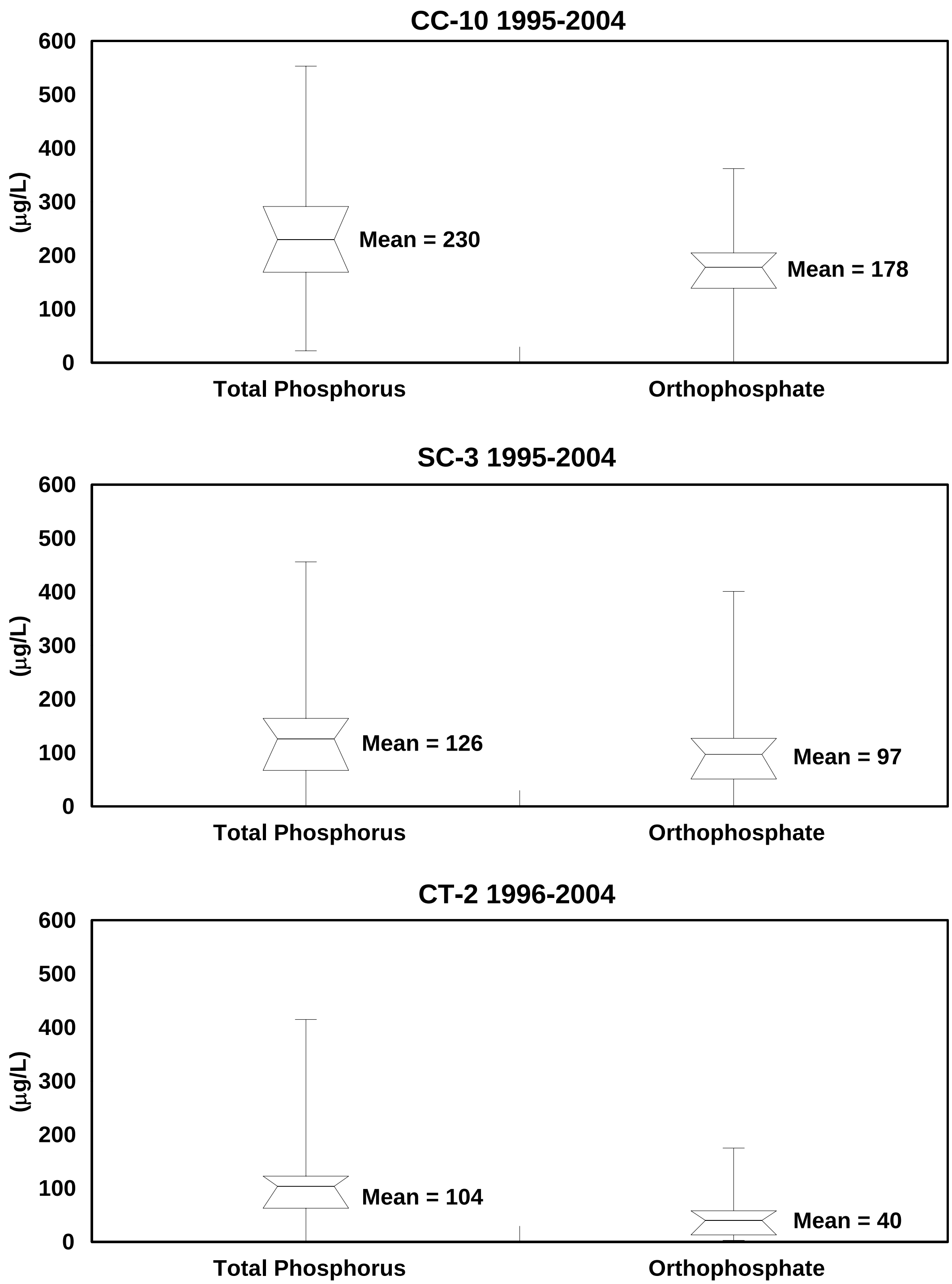

FIGURE 16: Total phosphorus and orthophosphate mean concentrations and box-plots in Cherry Creek Reservoir upstream tributaries (1995 - 2004).

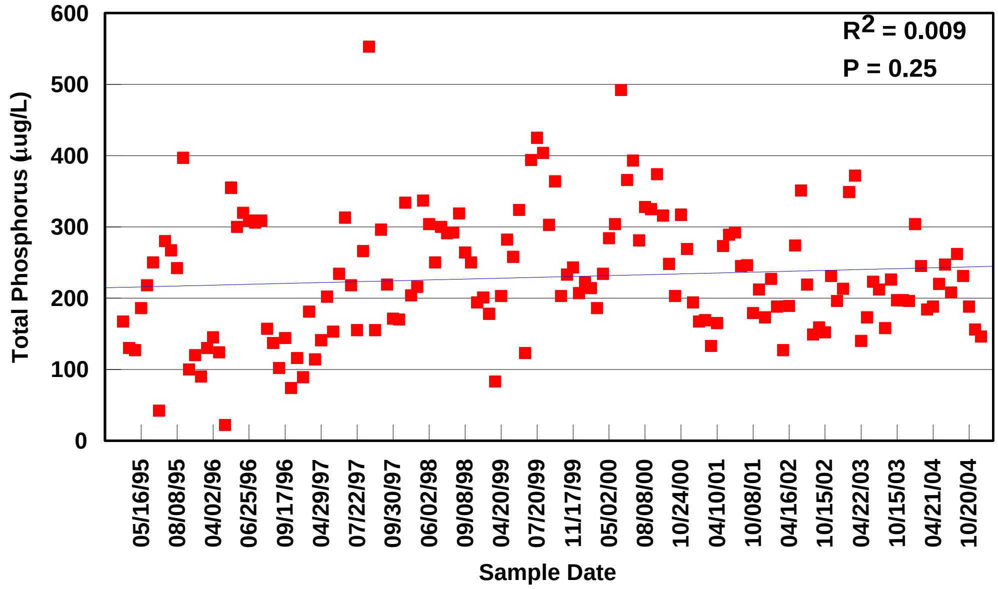

FIGURE 17: Mean total phosphorus concentrations measured in Site CC-10 (1995 - 2004).

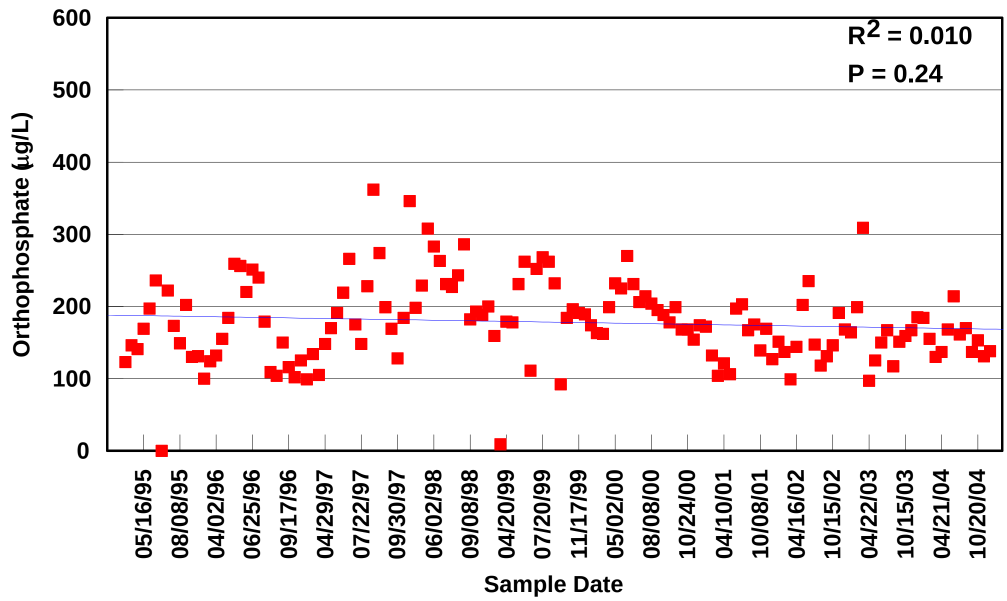

FIGURE 18: Mean orthophosphate concentrations measured in Site CC-10 (1995 - 2004).

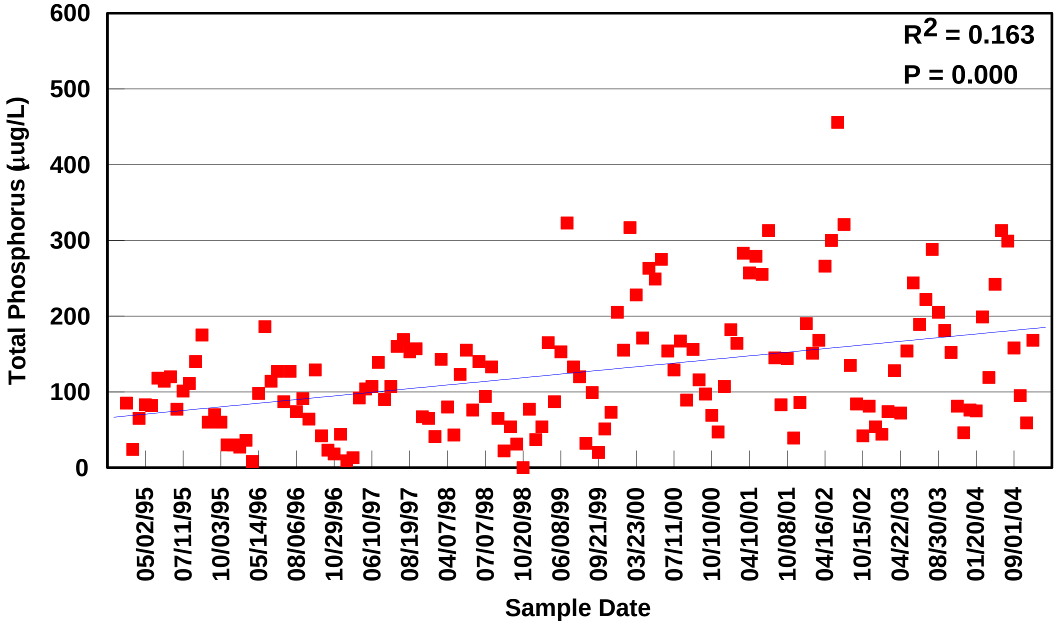

FIGURE 19: Mean total phosphorus concentrations measured in Site SC-3 (1995 - 2004).

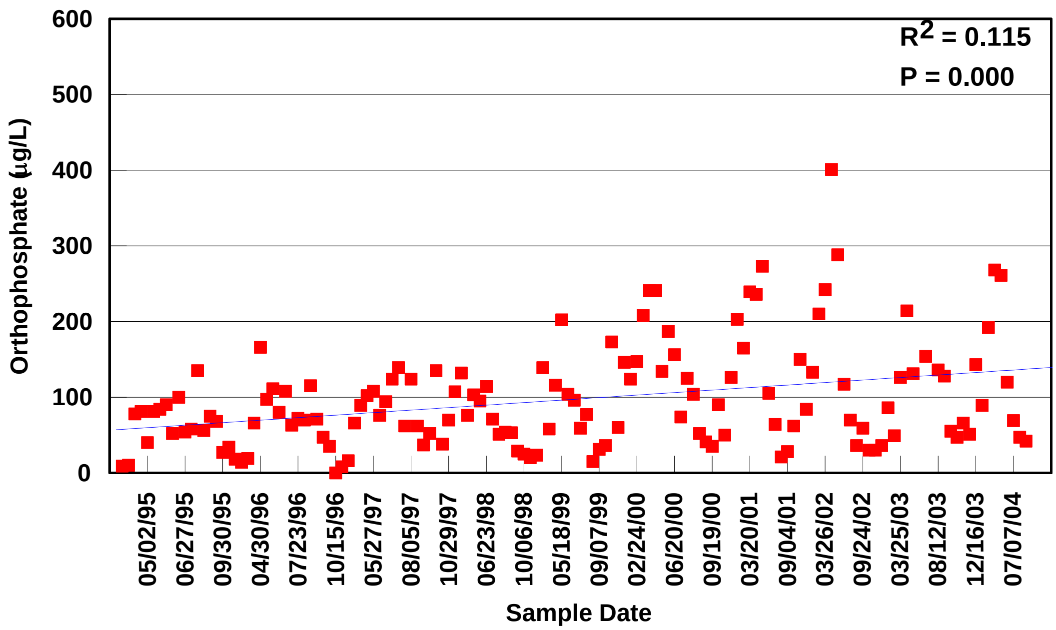

FIGURE 20: Mean orthophosphate concentrations measured in Site SC-3 (1995 - 2004).

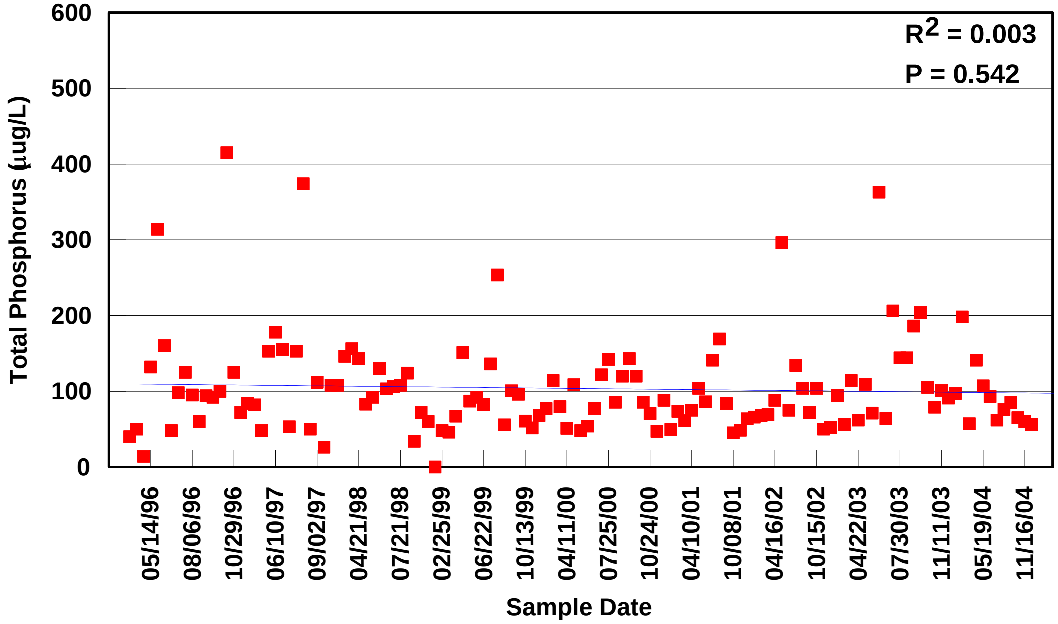

FIGURE 21: Mean total phosphorus concentrations measured in Site CT-2 (1995 - 2004).

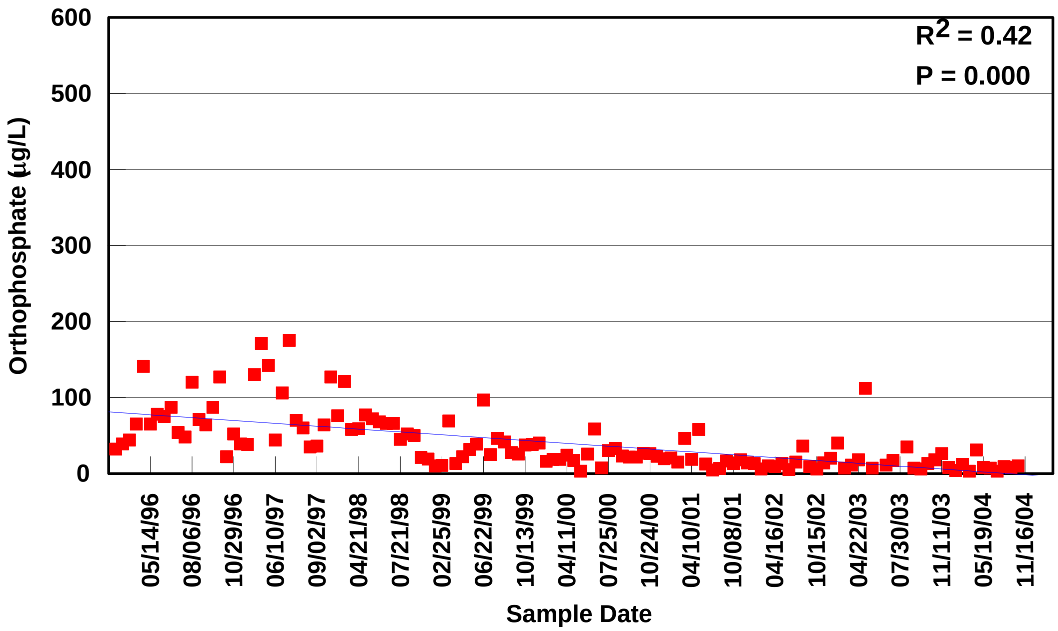

FIGURE 22: Mean orthophosphate concentrations measured in Site CT-2 (1995 - 2004).

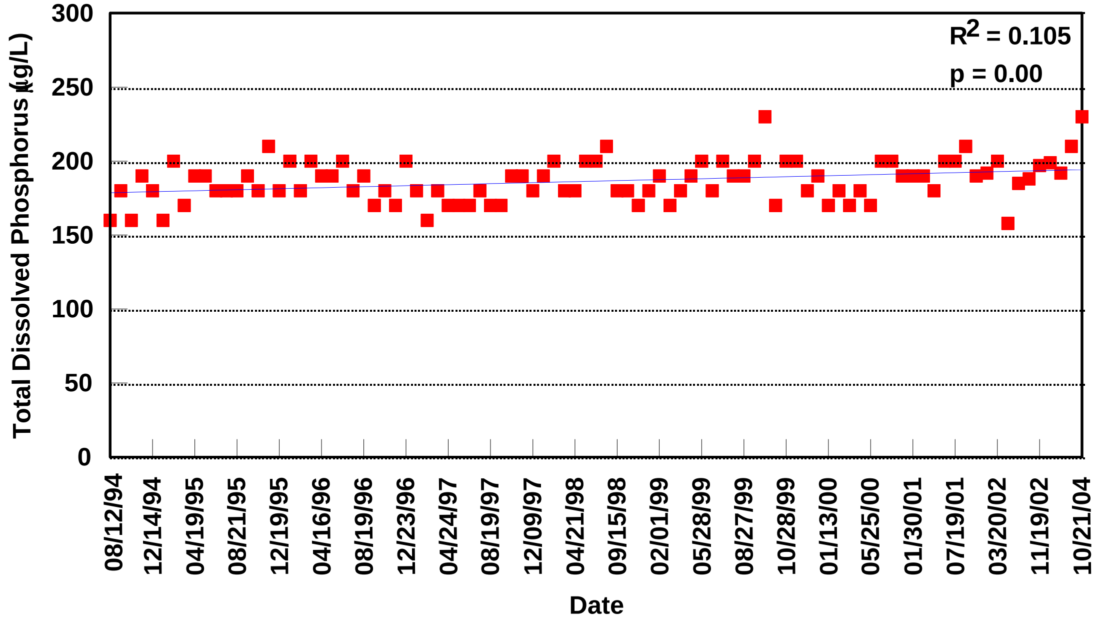

FIGURE 23: Mean total dissolved phosphorus concentrations measured at Site MW-9 (1994 - 2004).

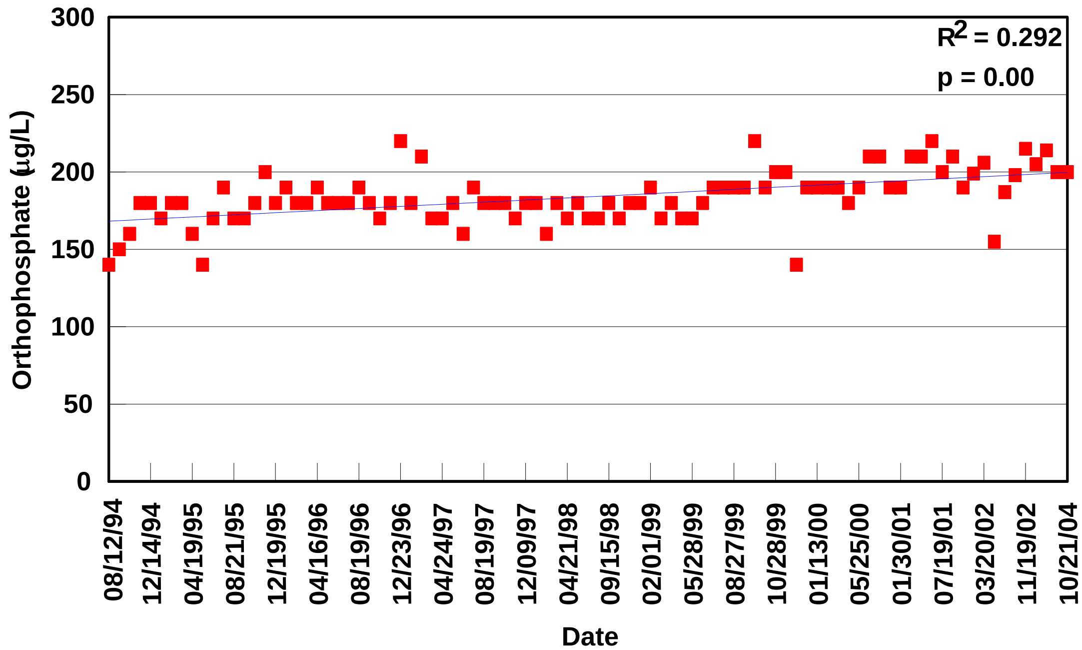

FIGURE 24: Mean orthophosphate concentrations measured at Site MW-9 (1994 - 2004).

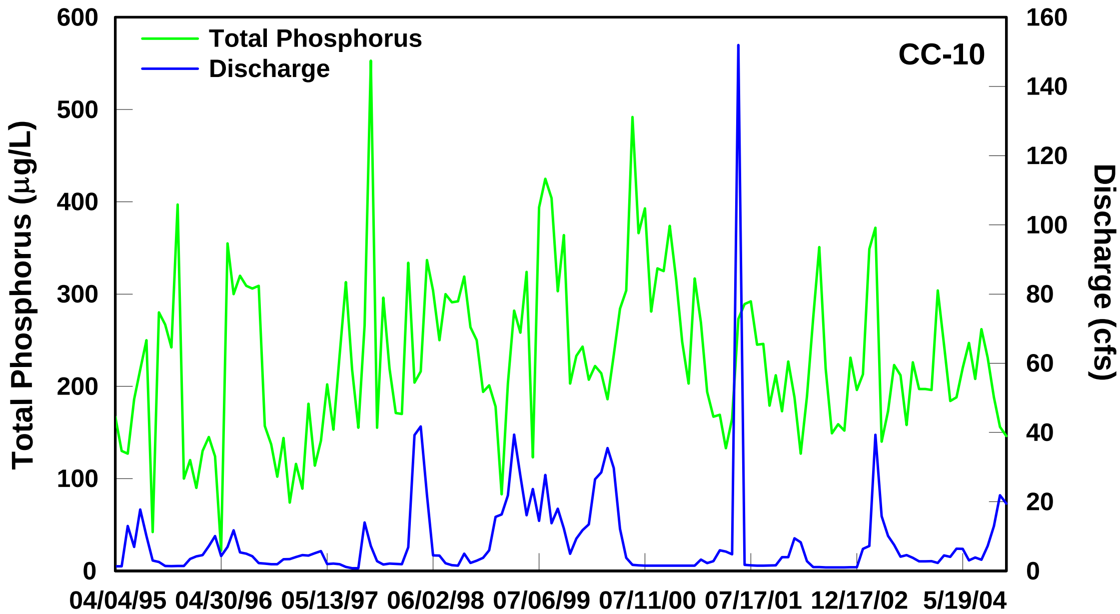

FIGURE 25: Relationship between total phosphorus concentrations and discharge measurements in Site CC-10, 2004.

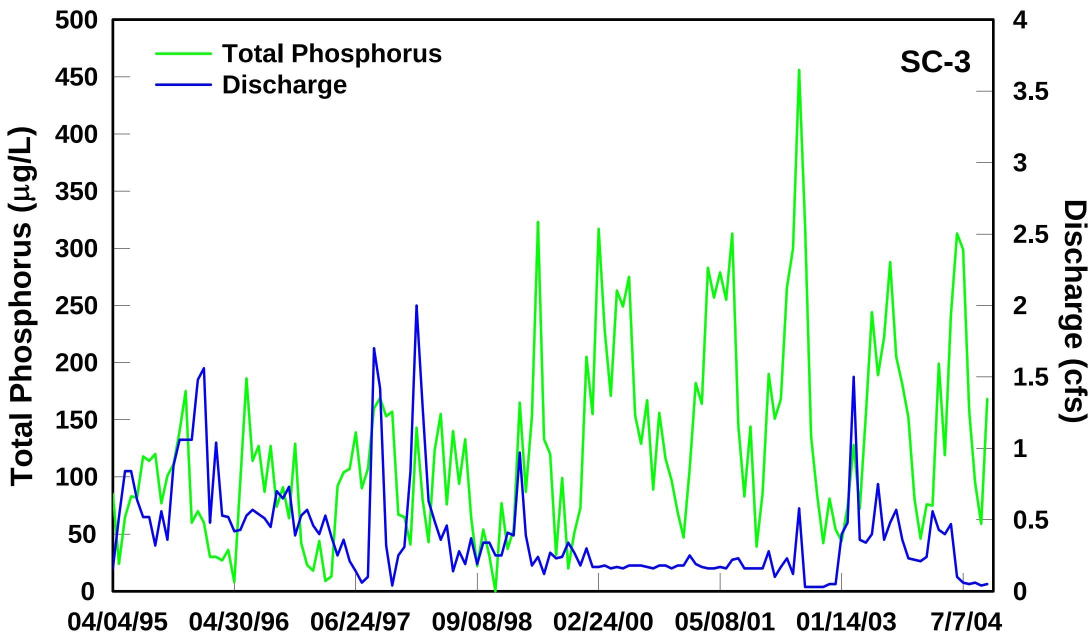

FIGURE 26: Relationship between total phosphorus concentrations and discharge measurements in Site SC-3, 2004.

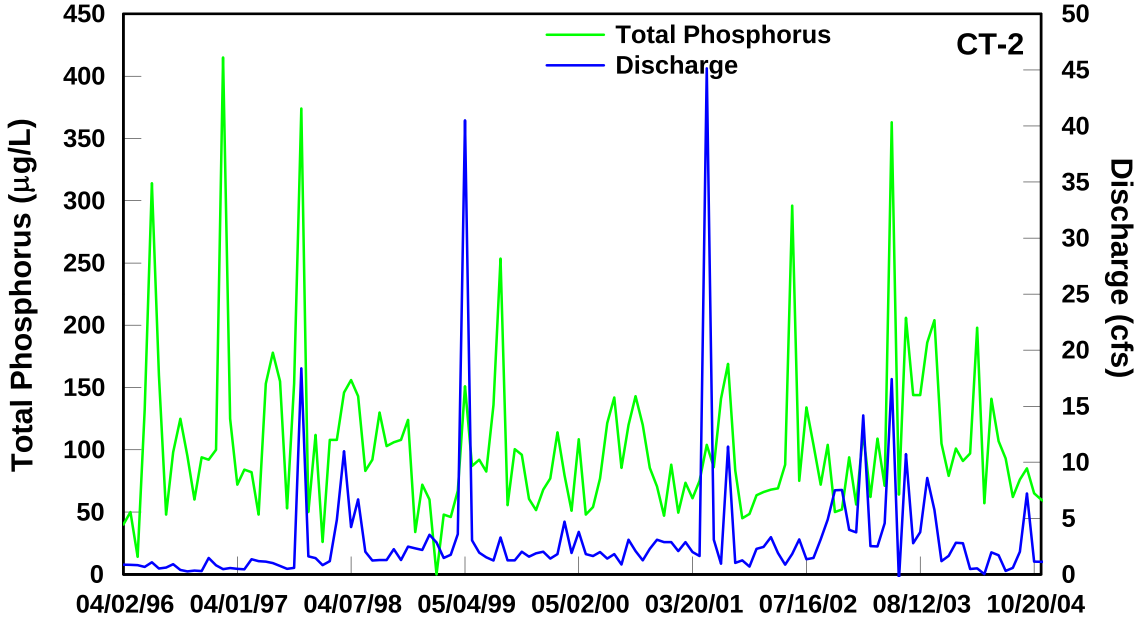

FIGURE 27: Relationship between total phosphorus concentrations and discharge measurements in Site CT-2, 2004.

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 previously 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 any internal loads.

External source of nutrients include inflow from streams and precipitation, which carry nutrients from soil erosion, agricultural and residual runoff, treated wastewater, 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). However, a nutrient enrichment study by Lewis *et al.* (2004) indicated that nitrogen was often the primary limiting nutrient in Cherry Creek Reservoir during the growing season.

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 2004, including the tributary streams Cottonwood Creek, Cherry Creek, and Shop Creek, as well as from precipitation and alluvium, as summarized below.

Phosphorus Loads from Tributary Streams

The greatest proportion of the phosphorus load to the reservoir was from surface flows in the Cherry Creek mainstem (7,379 lbs). Because Cherry Creek is monitored downstream of Shop Creek, the 210 lbs contributed by Shop Creek has been subtracted from the total load calculated from the site. Additional phosphorus was contributed by Cottonwood Creek (2,592 lbs). The total phosphorus load to Cherry Creek Reservoir from tributary streams in 2004 was calculated at 10,181 lbs (Table 9).

Phosphorus Loads in Reservoir Outflow

The total outflow from Cherry Creek Reservoir as measured by the COE was 14,513 AF (Appendix D). The calculated phosphorus load leaving the reservoir in 2004 was determined to be 4,812 lbs (Table 9).

Phosphorus Loading from Precipitation

The mean concentration of total phosphorus in the rain samples collected in 2004 was 40 µg/L. This value is considerably (37%) lower than the 2003 value and may reflect a reduction in the inclusion of “dry fall” in past samples as a result of more consistent cleansing of the sampler (See Appendix A). As a result, a year with above average annual precipitation, 20.3 inches, still leads to a lower than average total phosphorus load of 150 lbs per year (Table 9, and Appendix D). The long-term mean estimated total phosphorus loading from rain samples collected at the reservoir between 1987 and 2004 is 784 lbs (Table 10).

TABLE 9: Estimated net phosphorus loading (lbs/year) into Cherry Creek Reservoir, 1992 to 2004.

Source of Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	13-yr. Mean	% of Total Load
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	103	210	115	1
Cherry Creek	2894	1727	2142	2795	2347	2041	7666	8745	8306	3412	1105	4637	7379	4235	50
Cottonwood Creek	1081	177	321	2184	553	646	1143	1822	1087	1292	789	1130	2592	1140	13
Subtotal for Streamflows	**4106**	**1987**	**2598**	**5094**	**3007**	**2804**	**8936**	**10663**	**9475**	**4807**	**1973**	**5870**	**10181**	**5500**	
Cherry Creek Alluvium	874	1387*	967	1676	968	1937	3787	5912	2341	4444	1006	2307	2181	2291	27
Direct Precipitation	877	736	484	1202	740	1020	854	896	777	586	1267	391	150	768	9
Total Load	**5857**	**4110**	**4049**	**7972**	**4715**	**5761**	**13577**	**17471**	**12593**	**9837**	**4246**	**8568**	**12512**	**8559**	
Cherry Creek Outflow	1314	711	993	2049	992	996	4207	9650	3688	4842	1501	4978	4812	3126	
Net Load	**4543**	**399**	**3056**	**5923**	**3723**	**4765**	**9370**	**7821**	**8905**	**4995**	**2745**	**3590**	**7700**	**5195**	
Standard TP Load to Reservoir (lb/ac-ft)	**0.78**	**0.7**	**0.58**	**0.68**	**0.62**	**0.56**	**0.65**	**0.63**	**0.68**	**0.57**	**0.57**	**0.51**	**0.73**	**0.64**	

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

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 3,646 AF based on the analysis summarized below and in Appendix D. The total alluvial addition to the reservoir was estimated to be 2,181 lbs total phosphorus in 2004 (Table 9).

The COE monitors inflow to Cherry Creek Reservoir as a function of change in storage (i.e., reservoir volume) based on 1) changes in reservoir level, 2) measured outflow, 3) precipitation, and 4) evaporation, to calculate daily and monthly inflow (AF). This method for calculating reservoir volume does not account for groundwater inflow via alluvium. CEC monitors surface water inflow to the reservoir using gaging stations on Cherry Creek, Cottonwood Creek, and Shop Creek (the three main surface inflows).

TABLE 10: Phosphorus loading into Cherry Creek Reservoir from precipitation, 1987 to 2004. 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
CEC 2003	2002	12.9	1,267
CEC 2004	2003	18.8	391
Present Study	2004	20.3	150
Mean		**17.6**	**784**

Given differences in the two methods for determining inflow (COE back-calculated based on change in stage vs. streamflows), 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 should not be expected. In 2004, COE inflows were calculated at 17,177 AF, while CEC calculated inflows from streams at 12,092 AF and from precipitation at 1,439 AF (see Appendix D). Lewis and Saunders (2002) concluded that 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, net alluvial inflow was estimated to be 3,646 AF in 2004. This flow and the mean phosphorus concentration of 220 µg/L were then used to calculate net alluvial load the reservoir of 2,181 lbs of phosphorus. Past estimates of alluvial load have been calculated 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 2004, the three tributary streams contributing phosphorus loads to the reservoir included Cherry Creek (7,379 lbs without Shop Creek), Cottonwood Creek (2,592 lbs), and Shop Creek (210 lbs). The net load of phosphorus to the reservoir from the Cherry Creek alluvium was estimated at 2,181 lbs. The estimated phosphorus load to the reservoir from precipitation was 150 lbs. The estimated total load of phosphorus entering the reservoir in 2004 was determined to be 12,512 lbs (Fig. 28), which meets the TMAL of 14,270 lbs per year. The estimated phosphorus load leaving the reservoir in 2004 was determined to be 4,812 lbs. Consistent with the TMAL, these values do not include any estimates of internal phosphorus loads. Standardized phosphorus loads (lb/ac-ft) was 0.73 lbs/ac-ft in 2004, considerably higher than values recorded the previous ten years (Table 9). The increase in 2004 is probably related, in part, to the construction action on Cotton Creek and the August flood event (see discussion below).

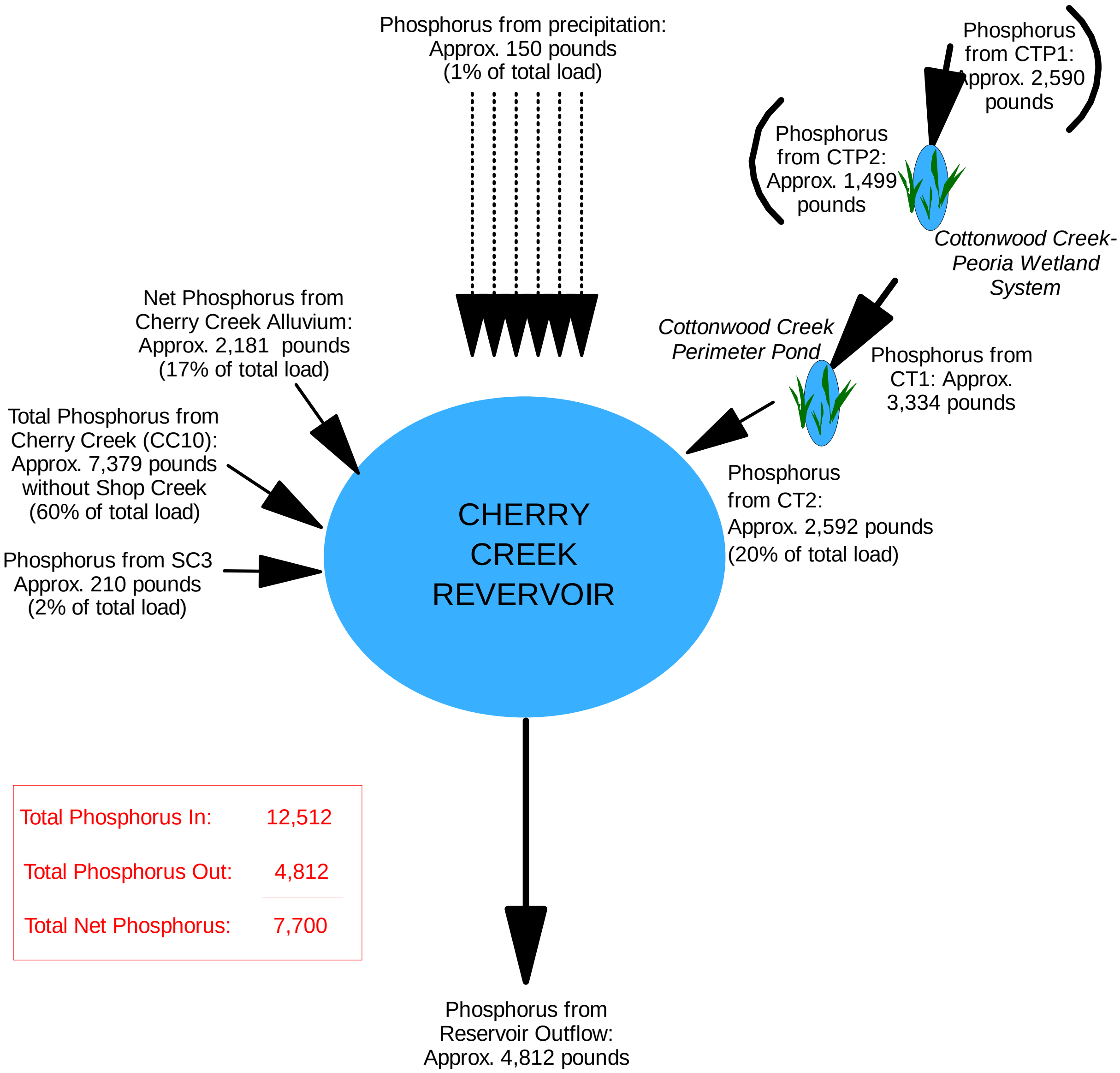

FIGURE 28: Mass balance diagram of phosphorus loading in Cherry Creek Reservoir, 2004.

Effectiveness of Cottonwood Creek Pollutant Reduction Facilities

Cottonwood Creek - Peoria 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, the values from 2002 represent less than a full calendar year (i.e., only July - December 2002). The mean concentration of total phosphorus in 2004 was reduced from 142 µg/L at Site CT-P1 to 123 µg/L at Site CT-P2 (Table 11). The mean concentration of TSS decreased from 87 µg/L upstream of the pond/wetland system to 53 µg/L downstream of the pond/wetland system (Table 11). The estimated load of phosphorus below the pond/wetland system decreased 42%, from 2,590 lbs at Site CT-P1 to 1,499 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. These data indicate that the new PRF has been effective in reducing the phosphorus loads in 2003 and 2004 (Table 11).

TABLE 11: Annual historical (2003 - 2004) total phosphorus and total suspended solids concentrations through the Cottonwood Creek - Peoria wetlands system.

Parameter	Year	Data Source	Sampling Sites CT-P1	Sampling Sites CT-P2	Difference	% Reduction
Average Total Phosphorus Concentration (µg/L) (baseflow and storm samples combined)	2003	CEC	101	92	- 9	9
	2004	CEC	142	123	- 19	13
	Mean		**122**	**108**	**- 14**	**11**
Average Total Suspended Solids (mg/L)	2003	CEC	31	34	+ 3	-10
	2004	CEC	87	53	- 34	39
	Mean		**59**	**44**	**- 16**	**15**
Loading of Total Phosphorus (pounds)	2003	CEC	771	574	- 197	26
	2004	CEC	2,590	1,499	-1,091	42
	Mean		**1,681**	**1,037**	**- 644**	**34**

Cottonwood Creek Perimeter Pond

The effectiveness of the existing Cottonwood Creek stormwater "Perimeter Pond" in reducing phosphorus loads to the reservoir can be gaged by comparing concentration of total phosphorus and TSS and the loads of total phosphorus at the sites immediately upstream and downstream of the pond (Table 12). During 2004, the mean concentration of total phosphorus decreased from 212 to 151 μg/L after passing through the pond (Table 12). This represents a 29% reduction in phosphorus concentration, the third lowest percent reduction since the pond's inception (Table 12). The load of total phosphorus was reduced from 3,334 lbs upstream of the pond to 2,592 lbs downstream of the pond, representing a 22% reduction in load (Table 12). This value is about average for the pond (Table 12). The concentration of TSS was decreased by 48% from 155 mg/L upstream to 81 mg/L downstream of the pond (Table 12). 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.

In past years, higher phosphorus and TSS concentrations observed at the Cottonwood Creek perimeter pond, when compared to the Cottonwood Creek - Peoria wetland system, indicate potential loading from stream channel erosion. In an effort to reduce phosphorus loading in the reservoir from the stream itself, channel reconstruction was conducted on Cottonwood Creek downstream of the Cottonwood Creek - Peoria wetland system in 2004. This reconstruction may have accounted for the increased loads observed between these two existing PRFs, e.g., 1,499 lbs TP at Site CT-P2 and 3,334 lbs TP at Site CT-1 (Fig. 28). This increase was also greatly influenced by a flood event in early August (see Fig. 10).

TABLE 12: Annual historical (1997 to 2004) 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	1997	CEC	200	133	- 67	34
Concentration (µg/L)	1998	CEC	289	210	- 79	27
(baseflow, storm samples	1999	CEC	158	157	- 1	0
combined)	2000	CEC	187	149	- 38	20
	2001	CEC	165	114	- 51	31
	2002	CEC	146	143	- 3	2
	2003	CEC	144	129	- 15	10
	2004	CEC	212	151	- 61	29
	Mean		188	148	- 39	19
Annual Average Total Suspended	1997	CEC	207	87	- 120	58
Solids (mg/L)	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
	2003	CEC	84	62	- 22	26
	2004	CEC	155	81	- 74	48
	Mean		166	81	- 90	48
Annual Loading of Total	1997	CEC	3,351	1,103	-2,248	67
Phosphorus (pounds)	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
	2003	CEC	1,777	1,130	- 647	36
	2004	CEC	3,334	2,592	- 742	22
	Mean		3,186	2,009	-1,270	37

Shop Creek and Quincy Drainage Pond

Historical sampling of the PRFs on Shop Creek and Quincy Drainage indicate efficient phosphorus removal in these streams. Shop Creek was monitored for ten years from 1990 to 2000 at sites upstream and downstream of PRF stations (detection pond and wetlands). The Shop Creek PRF had an average phosphorus load reduction of 173 lbs, with an average of 63% reduction in load. Quincy Drainage was even more efficient with 99% reduction in loads over the period of 1996-1999. The average phosphorus load reduction was 138 lbs. This increase was also greatly influenced by a flood event in early August (see Fig. 10).

SUMMARY AND CONCLUSIONS

Transparency

The highest transparency in Cherry Creek Reservoir was observed in the reservoir in mid-November, and the lowest was measured in late June. The whole-reservoir mean Secchi depth was 0.85 m during the July to September period, a similar value to that observed in 2003, but slightly lower than the long-term average (Table 13).

TABLE 13: Water quality and total phosphorus loads data for Cherry Creek Reservoir, July-September 1992 - 2004. **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 Precipitation (inches)	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17	0.9	66	970	**5,857**	18.5	7,474	0.78
1993	**14.4**	1.2	62	826	**4,110**	15.6	5,905	0.7
1994	**10**	1.1	59	1,144	**4,049**	10.2	7,001	0.58
1995	**9.4**	1.6	48	913	**7,972**	25.3	11,781	0.68
1996	20.5	1.6	62	944	**4,715**	15.5	7,644	0.62
1997	22.3	1	96	1,120	**5,761**	21.8	10,362	0.56
1998	26.5	1	89	880	**13,577**	20.0	20,903	0.65
1999	28.9	1	81	753	17,471	21.5	27,739	0.63
2000	25.2	1	81	802	**12,593**	17.8	18,610	0.68
2001	26.1	0.75	87	757	**9,837**	16.0	17,250	0.57
2002	18.8	0.9	74	858	**4,246**	12.9	7,498	0.57
2003	25.8	0.86	90	1,121	**8,568**	18.8	14,929	0.57
2004	18.4	0.85	102	977	**12,512**	20.3	17,177	0.73
13-Year Mean	20.3	1	77	928	8,559	18.0	13,406	0.64
Median	21.5	1	81	913	7,972	18.5	11,781	0.63

* Stream, alluvium, and precipitation.

Temperature and Dissolved Oxygen

Periods of thermal stratification were observed in the reservoir in 2004. Dissolved oxygen profiles indicated that anoxic conditions were present in lower depths of the reservoir through the summer. The temperature and oxygen profiles observed in the reservoir in 2004 were similar to those recorded in past years.

Total Phosphorus

The 2004 reservoir summer mean total phosphorus concentration of 102 µg/L was the highest observed in the period of record (Table 13), and exceeded the goal of 40 µg/L total phosphorus. Since 1987, the goal of 40 µg/L total phosphorus as a July - September mean has only been met once, in 1989.

Chlorophyll *a*

The summer mean chlorophyll *a* concentration in Cherry Creek Reservoir was 18.4 µg/L, a value in excess of the 15 µg/L standard (Table 13). The summer mean concentration of chlorophyll *a* in 2004 was lower than the mean value reported for 2003 despite the increase in total phosphorus. The long-term summer mean chlorophyll *a* concentrations since 1996 indicate no significant difference between seasonal mean chlorophyll *a* concentrations over the past eight years. Since 1987, the July - September chlorophyll *a* standard of 15 µg/L has not been met since 1995 (Table 13).

Phosphorus Loading

The total precipitation at Cherry Creek Reservoir during 2004 was 20.3 inches. The mean concentration of total phosphorus collected from rain samples in 2004 was 40 µg/L, a decrease of 37% from the 2003 value of 152 µg/L. The total inflow from tributary streams was 12,092 AF, which was higher than the 9,239 AF observed in 2003. The total phosphorus loads to the reservoir were estimated to be 150 lbs from precipitation, 10,181 lbs from surface flows, and 2,181 lbs from Cherry Creek alluvial flow. The total external load in 2004 of 12,512 lbs met the phased TMAL of 14,270 lbs/year. The total of 12,512 lbs in 2004 represents a 28% decrease in total load over that observed during peak flows in 1999.

PRF Effectiveness

Pollution reduction facilities constructed on Cottonwood Creek continued to be effective in reducing the loads of phosphorus to the reservoir. The Cottonwood Creek - Peoria Pond reduced phosphorus loading by 42% in 2004. In 2004, the Cottonwood Creek Perimeter Pond reduced the instream load of phosphorus by 22%. The channel on Cottonwood Creek, below Cottonwood Creek - Peoria Pond, was reconstructed in 2004 in an effort to reduce future phosphorus loading to the reservoir from streambank erosion. In the past, the PRFs on Shop Creek and Quincy Drainage were also monitored. These established wetland ponds proved to be very efficient in reducing the phosphorus load. Shop Creek averaged 63% reduction in phosphorus load, while Quincy Drainage averaged 99% load reduction.

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APPENDIX A

Cherry Creek Reservoir
Sampling and Analysis Plan

CHERRY CREEK RESERVOIR

AQUATIC BIOLOGICAL AND NUTRIENT SAMPLING AND LABORATORY ANALYSES

SAMPLING, ANALYSIS, AND QUALITY ASSURANCE WORK PLAN

MAY 2003

Submitted to:

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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 (Authority). The Authority initially created by an intergovernmental agreement, was specially authorized by legislation adopted in 1988. The Authority develops and implements the means to protect the water quality of Cherry Creek Basin and Reservoir. Following recent legislation, the Board was reconstituted in 2001 and now includes Arapahoe and Douglas Counties, seven municipalities (Aurora, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, and Parker), one member representing the seven special districts (Arapahoe, Cottonwood, Inverness, Meridian, Parker, Pinery, and Stonegate Village), and seven citizens appointed by the governor. This Authority was created for the purpose of coordinating and implementing the investigations necessary to protect and to preserve the quality of water resources of the Cherry Creek basin while allowing for further economic development.

The Cherry Creek Basin Master Plan (DRCOG 1985), approved by the Colorado Water Quality Control Commission (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 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 stormwater, 2) nutrient levels in precipitation, and 3) chlorophyll *a* levels within the reservoir. This monitoring program has been modified over the years in response to changes in the Control Regulation, various research goals, and suggestions from outside reviewers, including input from the Water Quality Control Division (WQCD).

PROJECT DESCRIPTION

The Authority has prepared this Sampling, Analysis, and Quality Assurance Work Plan (Sampling and Analysis Plan) for aquatic biological nutrient analyses to be conducted on Cherry Creek Reservoir and selected off-lake sampling sites in 2003. This Sampling and Analysis Plan sets out field and laboratory protocols necessary to achieve quality data designed to help characterize the potential relationships between nutrient loading (both in-lake and external) and reservoir productivity. The specific objectives of the Sampling and Analysis Plan study are:

1. Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus species, in Cherry Creek Reservoir as well as in various streams flowing into the reservoir and measure nutrients in the reservoir outflow.

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

3. Determine biological productivity in Cherry Creek Reservoir, as measured by chlorophyll *a* concentrations and algal densities.

4. Provide data on the effectiveness of pollutant removal from Pollutant Removal Facilities (PRF) constructed by the Authority.

This Sampling and Analysis Plan presents the proposed 2003 sampling and analyses requirements for Cherry Creek Reservoir and includes discussions of: 1) project organization and responsibilities; 2) quality assurance objectives for the measurement of data in terms of accuracy, representativeness, comparability, and completeness; 3) field sampling and sample preservation procedures; 4) laboratory processing and analytical procedures; and 5) guidelines for data verification and reporting, quality control checks, corrective actions, and quality assurance reporting.

PROJECT ORGANIZATION AND RESPONSIBILITIES

All personnel involved in the investigation and in the generation of data are implicitly a part of the overall project and quality assurance program. Certain individuals have specifically delegated responsibilities, as described below.

Project Manager

The Project Manager for the aquatic biological and field sampling portions of the study is responsible for fiscal oversight and technical management of the project and for ensuring that all work is conducted in accordance with Scope of Service, Sampling and Analysis Plan, and approved procedures. Tasks include:

- Maintain routine contact with the project's progress, regularly review the project schedule, and review all work products.

- Evaluate impacts on project objectives and the need for corrective actions based on quality control checks, and whenever the data quality objective of 100% completeness is not met.

- Maintain a central file, which contains or indicates the location of all documents relating to this project.

- Review and update of this Sampling and Analysis Plan, as needed.

- Coordinate with the Authority, the WQCD, and the Authority's other consultants to ensure compliance with the Cherry Creek Reservoir Control Regulation No. 72.

Quality Assurance Manager

Quality Assurance oversight will be provided by a qualified individual with specific education and experience in water quality sampling and analysis. The Quality Assurance Manager shall be responsible for evaluation and review of all data reports relevant to the project and perform data verification. The Quality Assurance Manager shall work with the Project Manager to determine the need for corrective actions and, together, will make recommendations for any needed changes to either sampling methodologies or laboratory analytical procedures.

Analytical and Biological Laboratory Managers

The Analytical Laboratory Manager shall ensure that all water quality samples are analyzed in a technically sound and timely manner. The Analytical Laboratory Manager shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory. The Analytical Laboratory Manager will be responsible for all data reduction and verification and ensure that the data is provided in a format agreed upon between the Project Manager, the Analytical Laboratory Manager, and the Authority.

The Biological Laboratory Manager shall ensure that all biological samples are analyzed in a technically sound and timely manner. The Biological Laboratory Manager shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory. The Biological Laboratory Manager will be responsible for all data reduction and verification, and ensure that the data is provided in a format agreed upon between the Project Manager, the Analytical Laboratory Manager, and the Authority.

Sampling Crew

The field sampling efforts shall be conducted by individuals qualified in the collection of chemical, physical, and biological surface water samples. Field tasks and sampling oversight will be provided by the Project Manager. The Sampling Crew shall be responsible for following all procedures for sample collection, including complete and accurate documentation.

AQUATIC BIOLOGICAL AND NUTRIENT SAMPLING

Reservoir Monitoring Sites

Sampling would be conducted at sites established during past sampling efforts, as modified herein (see Figure 1 for location of all sites).

Cherry Creek Reservoir

CCR-1 This site is also called the Dam site and corresponds to the northwest trident when partitioning the lake by estimations of volume.

CCR-2 This site is also called the Swim Beach site and corresponds to the northeast trident when partitioning the lake by estimations of volume.

CCR-3 This site is also called the Inlet site and corresponds to the south trident when partitioning the lake by estimations of volume.

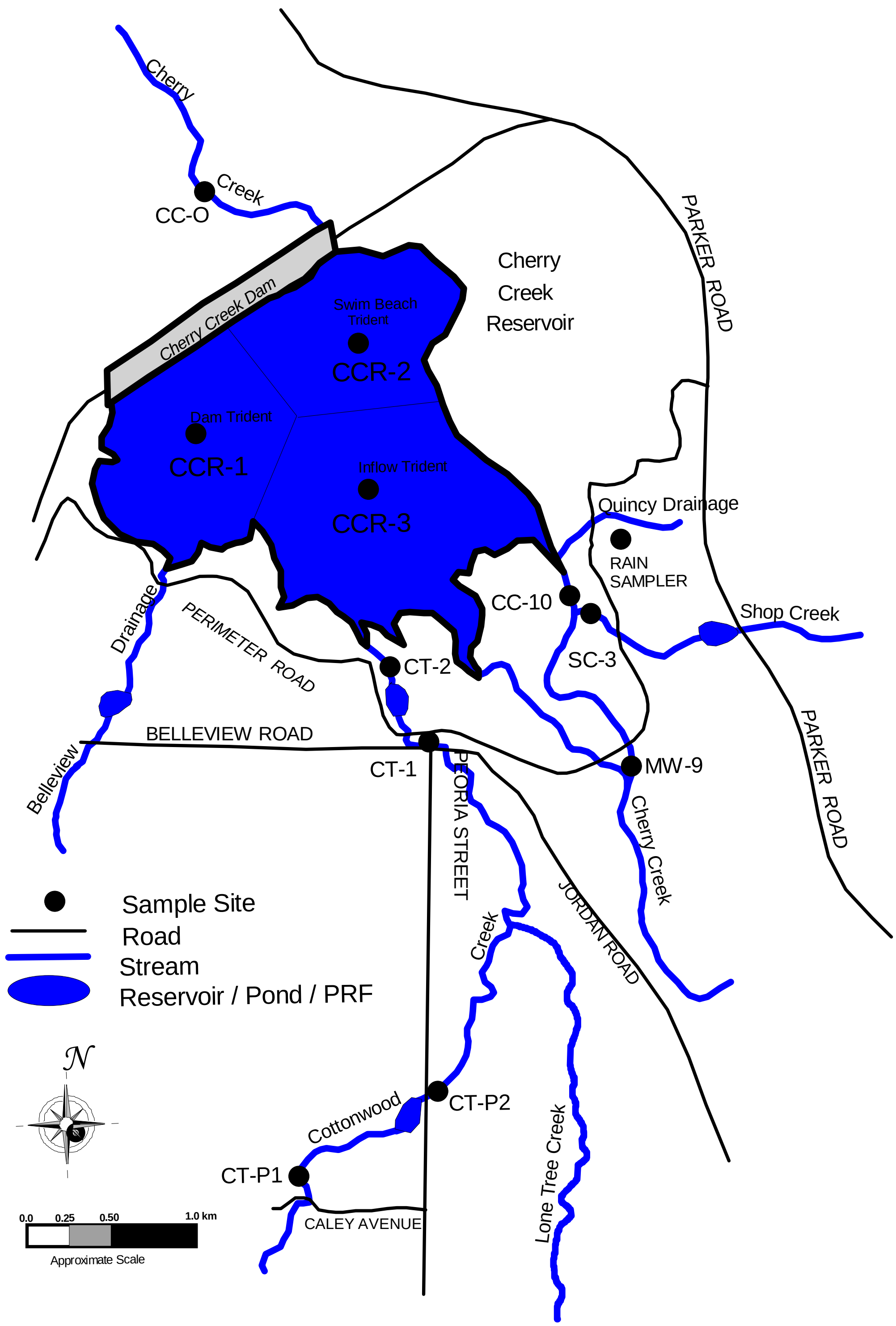

Figure 1: Sampling sites on Cherry Creek Reservoir and selected streams.

Stream Monitoring Sites

Cherry Creek

CC-10 This site is on Cherry Creek immediately downstream of the Shop Creek confluence, approximately 0.5 km upstream of Cherry Creek Reservoir. This site measures loads from Cherry Creek and Shop Creek that enter the reservoir.

CC-O This site is on Cherry Creek downstream of Cherry Creek Reservoir near the USGS gaging station within the Kennedy Golf Course.

Cottonwood Creek

CT-2 This site is immediately downstream of the phosphorus control facility (PRF), upstream of Cherry Creek Reservoir (i.e., Perimeter Road Pond). Although this site also measures the performance of the Perimeter Road Pond PRF, it is included in the reservoir portion of the effort since it is needed to measure loads to the reservoir from Cottonwood Creek.

PRF Monitoring Sites

Shop Creek

SC-3 This site is downstream of the Shop Creek detention pond and wetland complex above the confluence with Cherry Creek mainstem, and downstream of the Perimeter Road.

Cottonwood Creek

CT-P1 This site is located on Cottonwood Creek upstream of the new detention pond PRF at Peoria Street.

CT-P2 This site is located on Cottonwood Creek just downstream of Peoria Street Pond PRF and in the upper end of the streambank stabilization reach.

CT-1 This site is on Cottonwood Creek just downstream of Belleview Avenue, upstream of the Cherry Creek Park Perimeter Road. Note that Site CT-2 is included in the reservoir monitoring requirements.

Precipitation Sampling Site

This site is located near the Quincy Drainage, upstream of the Perimeter Road. The sampler consists of a clean, inverted plastic trash can lid used to funnel rain into a one-gallon container.

Analyte List

The sampling and analyses shall be conducted in accordance with the methods and detection limits provided in Table 1.

TABLE 1: Standard methods for analysis.

Analyte	Standard Methods*	Other Method Designations	Recommended Hold Times	Detection Limit
Manual Analyses				
pH		Denver Instrument pH/ATC Ag/AgCl combination electrode	24 hrs.	
Alkalinity	2320 B		24 hrs.	2 mg/$CaCO_3$/L
Hardness	2340 C (modified)	HACH Method 8266, ManVer 2 Buret Titration	24 hrs.	2 mg/$CaCO_3$/L
Total Suspended Solids	2540 D		7 days	4 mg/L
Total Volatile Suspended Solids	2540 E		7 days	4 mg/L
Chlorophyll	10200 H (modified)	Hot Ethanol Extraction	-24 hrs. before filtration	0.1 mg/m^3
Nutrient Analyses				
Orthophosphate	4500-P G	QuickChem 10-115-01-1-T	48 hrs.	3 µg/L
Total Phosphorus	4500-P G	QuickChem 10-115-01-1-U, with manual digestion	-24 hrs. before digestion	2 µg/L
Nitrate + Nitrite	4500-NO3 I	QuickChem 10-107-04-1-B	48 hrs.	5 µg/L
Total Nitrogen	4500-N B (modified)		-24 hrs. before digestion; -7 days after digestion	4 µg/L
Ammonia	none	QuickChem 10-107-06-3-D	24 hrs.	3 µg/L
Biological Analyses				
Phytoplankton	Analyzed by Dr. Jim Sanders, Associate Director Center for Limnology, University of Colorado			

* From *Standard Methods for Examination of Water and Waste Water* (20th Edition).

Sampling Schedule

Reservoir Sampling

The general sampling schedule includes regular sampling trips to the reservoir at varying frequency over the annual sampling period, as outlined below. Sampling in our winter months (November - February) will depend on ice conditions and safety concerns.

TABLE 2: Reservoir Sampling Schedule

Sampling Period	Frequency	Trips/Period
January to April (not February)	Monthly	3
May to September	Every 2 Weeks	11
October to November (not December)	Monthly	2
	Total	16

Stream Sampling

Standard sampling is conducted monthly concurrent with the regular reservoir sampling trips when possible to generally provide information during non-storm event periods, corresponding to the low-flow ambient samples collected in earlier studies.

TABLE 3: Stream Sampling Schedule

Sampling Period	Frequency	Trips/Period
January to December	Monthly	12
	Total	12

Representative Storm Event Sampling

There are six stream sites for storm event sampling(i.e., S-3, CC-10, CT-1, CT-2, CT-P1, and CT-P2). Storm samples are not collected at Site CC-O downstream of the reservoir, unless the Army Corps of Engineers (Corps) alerts the Consultant to an outflow event that could be tied to a storm-related inflow. Up to five storm events shall be collected over the summer for Cherry Creek (Site CC-10) and on Shop Creek (Site S-3). Up to seven storm events shall be collected at the four sites on Cottonwood Creek (CT-1, CT-2, CT-P1, and CT-P2). The actual number of storm events for which samples are obtained will be subject to weather patterns.

The recommended storm sampling period is April through September to attempt to capture some of the late spring snowmelt events as well as the summer "monsoon" season..

Precipitation Sampling

Precipitation samples are to be collected after "significant" rainfall events, defined as 0.5 inches or more. The sampler shall be inspected weekly and emptied of any accumulations of insignificant precipitation and the collector (inverted trash can lid) cleaned. This procedure is required to minimize insignificant amounts of precipitation contaminating the sample by allowing "dry-fall" to be washed into the sampler between significant events.

Field Methodologies

Reservoir Sampling

Transparency

Transparency shall be determined using a Secchi disk and a combined-deck photometer. The Secchi reading would be taken from the shady side of the boat. If this is not possible, sunglasses or other shading will be used to reduce glare. The disk is lowered slowly until the white quadrants disappear, at which point the depth is recorded to the nearest tenth of a meter. The disk is then lowered roughly 1 m further and slowly brought back up until the white quadrants reappear and again the depth is recorded. The Secchi disk depth is recorded as the average of these two readings.

A second method to measure the depth of the euphotic zone is to determine 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 is accomplished by using a double-deck photometer. One photocell remains on the surface, and the other is lowered into the water on the sunny side of the boat. Both photocells are 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.

Depth Profile Measurements

Measurements for dissolved oxygen, temperature, conductivity, and pH shall be taken at 1 m intervals using a YSI meter, Model # 600XL multi-probe meter. This meter shall be calibrated at the C&A Laboratory prior to each sampling episode to ensure accurate readings. To determine maximum depth, a Secchi disk will be lowered until it reaches the bottom. This reading will be taken on the opposite side of the boat from where water samples are being taken to minimize chances of sample contamination from the sediment. Profile measurements are taken no deeper than 0.5 m off the bottom to minimize potential contamination of the probes.

Water Samples

A primary task is sampling of water for nutrient and biology analyses. An upper-reservoir composite sample shall be taken at each of the three reservoir sites, kept separate for each site, and analyzed individually for nutrients and chlorophyll. A composite comprised of equal contributed aliquots collected with a vertical Van Dorn water sampler (approximately 3 L) at 1 m increments beginning at the surface and continuing to the 3 m depth (the upper 3 m of the reservoir represents 71% of the lake volume).

Samples are collected using a vertical Van Dorn sampler (3 L volume) by lowering to the appropriate depth (as outlined above). A "messenger" is sent to trip the sampler, and the water is brought to the boat and transferred to a clean plastic bucket for splitting into aliquots, as described above. The sampler is rinsed thoroughly with lake water between samples and between sites. Aliquots are taken from the photic composite for chemical analyses consisting of three 4-L just (two for chlorophyll and one for nutrients).

Water sample depth profile sampling is also conducted at Site CCR-2 in the deepest area in the reservoir. At this site, additional water samples shall be obtained at the 4, 5, 6, and 7 m depths. The last sample (7 m) would be collected roughly 1 m off the bottom, to minimize disturbance of bottom sediments during sampling. With variation in reservoir elevation throughout the year, it may not be possible to actually collect a sample at the 7 m depth every sampling episode. Samples are collected using a vertical Van Dorn sampler (3 L volume). The sampler is lowered to the appropriate depth (as outlined above). A "messenger" is sent to trip the sampler, and the water is brought to the boat and transferred to a clean bucket for splitting into aliquots, as described above. The sampler is rinsed thoroughly with lake water between samples and between sites.

Based on this sampling scheme, the number of samples taken at each site is as below:

TABLE 4: Samples per Station/Sampling Episode

Location		Photic Composite	1-m Increment Depth Samples
Dam	(CCR-1)	1	0
Swim Beach	(CCR-2)	1	4
Inflow	(CCR-3)	1	0
Total Samples/Sample Episode		3	4
Grand Total		7	

Water Quality Analyses

1. Nutrients, alkalinity, hardness, and pH analyses conducted in all reservoir water samples.

2. Chlorophyll would be analyzed in the 3 m photic depth profile samples only from June - September, one set per month.

3. Phytoplankton would be sampled twice monthly from April - October, and monthly from November - March from the 0-3 m water composite samples.

See Table 1 for the list of analytes, laboratory methods, and detection limits.

Stream Sampling

One sample shall be collected from each of the stream sampling sites during the sampling period, when there is sufficient flow. Samples shall be taken as mid-stream mid-depth grab samples with a polyethylene scoop and composited in a 5-gallon plastic bucket. Aliquots shall be taken from the composite for chemical analyses consisting of two 4-L jugs for analysis of parameters, as listed in Table 5.

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 and suspended solids. No samples were collected at Site CC-O during January, February, October, and December due to lack of water. With the exception of Site SC-3 in July, flows were sufficient at each tributary 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.

Stream Sampling

One sample shall be collected from each of the stream sampling sites during the sampling period, when there is sufficient flow. Samples shall be taken as mid-stream mid-depth grab samples with a polyethylene scoop and composited in a 5-gallon plastic bucket. Aliquots shall be taken from the composite for chemical analyses consisting of two 4-L jugs for analysis of parameters, as listed below in Table 5.

Automatic Sampler

Each stream sampling station upstream of the reservoir also contains an Authority-owned ISCO flow meter and sampling device, which is powered by a 12-volt battery. The flow meter is a pressure transducer that measures stream water level. 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). Discharge is measured using methods outlined in Harrelson *et al* 1994. To determine flow rate, the level must be translated into flow rate using a "stage-discharge" relationship. The Authority has developed such a relationship for each site over the years. Since stage-discharge relationships can change over the years, the relationship is calibrated annually using a flow meter to take stream flow measurements three to four times per year at a range of flows. These data shall be combined with previous data to validate and modify the stage-discharge relationship for that site.

Water level data are stored in the ISCO sampler and must be downloaded to calibrate the station. Downloading of the data shall occur at least monthly to minimize the risk of a bad battery or other power failure resulting in a loss of data. The flow data and stage-discharge rating curves shall be checked throughout the year by comparing calculated flow estimates to actual flow measurements taken in the field with a flowmeter. Flow at time of sampling shall be calculated using stage-discharge relationships and is used to develop the flow-to-phosphorus relationship necessary to calculate daily loads (which are totaled for monthly and annual loads). The Corps is also contacted and daily precipitation and inflows/outflows from the reservoir obtained.

Storm Event Sampling

Samples from stormwater flow events are collected with ISCO automatic samplers, which collects samples when the water reaches a pre-set level. The level is determined by analyzing annual hydrographs from each stream and determining storm levels. When the pre-set level is reached, the ISCO collects a sample every 15 minutes for approximately 2.5 hours (i.e., a timed composite) or until the water recedes below the pre-set level. This sampling procedure occurs at Sites S-3, CC-10, CT-1, CT-2, CT-P1, and CT-P2. Following the storm event, water collected by the automatic samplers shall be composited (timed composite) and transferred to water jugs for analysis. Approximately 4 L would be collected from the 24 bottles, with each bottle contributing a sample amount representative of the flow at which it was taken. During the seasons in which no storm samples are taken, the storm samplers are disabled.

Precipitation Sampling

After each significant storm, the sample bottle shall be removed and taken to a qualified laboratory for analysis of total phosphorus, total nitrogen, and nitrite-nitrate. If sufficient volume remains, samples shall be tested for alkalinity, water hardness, pH, and suspended solids. The sampler shall be inspected and cleaned of any accumulations of insignificant precipitation on a weekly basis. This will prevent extraneous "dry fall" from being washed into the sampler between significant storm events.

Field-Related Quality Assurance/Quality Control

To ensure data quality, a number of quality assurance checks will be used. During each standard sampling episode, 1-split from the reservoir and 1-split from the stream (i.e., 28 total samples) shall be shipped to CU laboratory for analysis.

Field sampling quality control will consist of the use of a field blank. This field blank shall contain laboratory-grade deionized water that will be carried through the entire sampling episode. The cap of this jug will be removed at a particular site and left open during the regular sampling effort, after which time the cap will be replaced. One field blank will be used for every sampling trip. The field blanks and trip duplicates will be analyzed for the same parameters as a routine sample and later compared to samples analyzed by a qualified laboratory to provide QA/QC checks. Chain of custody procedures will be observed during the field sampling and delivery of samples to a qualified laboratory and to the CU laboratory.

LABORATORY PROCEDURES

Chemical Laboratory Analysis

Chemical analyses for the water collected in the study (Table 1) will be conducted by a qualified laboratory. Water samples will be analyzed for the parameters listed below.

TABLE 5: List of Analytes by Sample Depth

3-m Photic Composite Samples	1-m Increment Depth Samples	Stream Samples Precipitation Samples
pH, Conductivity, and Temperature	TP, TDP, SRP	TD, TDP, SRP
Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), and Soluble Reactive Phosphorus (SRP)	TN, TDN, NO_3+NO_2, Ammonia	TN, TDN, NO_3+NO_2, Ammonia
Total Nitrogen (TN, Total Dissolved Nitrogen (TDN), NO_3+NO_2, and Ammonia		Total Suspended Solids (TSS)/ Total Volatile Suspended Solids (TVSS) (not on precipitation)
Chlorophyll		
Phytoplankton (sampled on reservoir sampling dates: twice monthly from April - October, and monthly from November - March from the 0-3 m water composite samples)		

Biological Laboratory Analysis

Biological analyses for the samples collected in the study, as described above, will be conducted at a qualified laboratory and analyzed for chlorophyll *a*. The methods of these analyses, with appropriate QA/QC procedures shall be in accordance with the methods provided in Table 1. Phytoplankton samples will be sent to the Colorado University Center for Limnology to be analyzed by Dr. Jim Saunders.

DATA VERIFICATION, REDUCTION, AND REPORTING

Data verification shall be conducted to insure that raw data are not altered. All field data, such as those generated during any field measurements and observations, will be entered directly into a bound Field Book. Sampling Crew members will be responsible for proof reading all data transfers, if necessary. At least ten percent of all data transfers will be checked for accuracy.

The Quality Assurance Project Manager will conduct data verification activities to assess laboratory performance in meeting quality assurance requirements. Such reviews include a verification that: 1) the correct samples were analyzed and reported in the correct units; 2) the samples were properly preserved and not held beyond applicable holding times; 3) instruments are regularly calibrated and meeting performance criteria; and 4) laboratory QA objectives for precision and accuracy are being met.

Data reduction for laboratory analyses is conducted by Consultant's personnel in accordance with EPA procedures, as available, for each method. Analytical results and appropriate field measurements are input into a computer spreadsheet. No results will be changed in the spreadsheet unless the cause of the error is identified and documented.

A data control program will be followed to insure that all documents generated during the project are accounted for upon their completion. Accountable documents include: Field Books, Sample Chain of Custody, Sample Log, analytical reports, quality assurance reports, and interpretive reports.

Data shall be summarized and provided to the Authority's Technical Advisory Committee on a monthly basis and presented in an annual report.

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American Public Health Association. 1998. *Standard Methods for Examination of Water and Wastewater*, 20th Edition. American Public Health Association, Washington, DC.

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APPENDIX B

Reservoir Water Quality Data

CCR-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
3/30/04	CCR-1 Photic	66	13	5	945	607	<5	16	11.8
4/21/04	CCR-1 Photic	85	22	9	886	530	<5	25	11.7
5/19/04	CCR-1 Photic	66	16	4	846	539	<5	14	11.9
5/24/04	CCR-1 Photic	32	6	4	810	535	<5	12	10.9
6/9/04	CCR-1 Photic	80	19	3	898	506	<5	11	16.5
6/23/04	CCR-1 Photic	84	13	5	1123	697	<5	26	24.3
7/7/04	CCR-1 Photic	90	21	5	912	490	<5	6	16.5
7/21/04	CCR-1 Photic	82	28	8	1081	604	<5	16	15.5
8/4/04	CCR-1 Photic	104	22	6	1052	608	<5	14	18.0
8/18/04	CCR-1 Photic	100	27	16	1020	695	<5	41	11.0
9/1/04	CCR-1 Photic	124	16	7	1231	638	<5	23	35.4
9/15/04	CCR-1 Photic	111	15	9	913	501	<5	11	22.9
10/20/04	CCR-1 Photic	85	21	10	1022	687	<5	22	21.0
11/16/04	CCR-1 Photic	63	17	7	762	479	<5	13	18.4

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
3/30/04	CCR-2 Photic	52	12	3	775	509	<5	8	10.0
3/30/04	CCR-2 4m	54	12	3	812	479	<5	5	ND
3/30/04	CCR-2 5m	54	11	4	757	485	<5	6	ND
3/30/04	CCR-2 6m	60	12	4	763	493	<5	7	ND
3/30/04	CCR-2 7m	188	13	3	1158	526	<5	16	ND
04/21/04	CCR-2 Photic	78	18	6	849	493	<5	13	9.3
04/21/04	CCR-2 4m	84	20	8	885	544	<5	21	ND
04/21/04	CCR-2 5m	103	20	8	947	551	<5	24	ND
04/21/04	CCR-2 6m	94	20	8	894	573	<5	26	ND
04/21/04	CCR-2 7m	100	24	11	1098	700	<5	42	ND
05/19/04	CCR-2 Photic	71	17	4	759	469	<5	8	14.3
05/19/04	CCR-2 4m	80	17	6	823	513	<5	12	ND
05/19/04	CCR-2 5m	92	20	7	813	475	<5	8	ND
05/19/04	CCR-2 6m	99	26	13	879	506	<5	18	ND
05/19/04	CCR-2 7m	116	30	17	878	528	<5	15	ND
05/24/04	CCR-2 Photic	35	6	4	874	536	<5	11	12.2
05/24/04	CCR-2 4m	44	8	8	717	500	<5	12	ND
05/24/04	CCR-2 5m	55	14	15	805	452	<5	12	ND
05/24/04	CCR-2 6m	65	15	17	826	520	<5	12	ND
05/24/04	CCR-2 7m	69	15	19	905	468	<5	12	ND
06/09/04	CCR-2 Photic	68	21	3	846	506	<5	9	13.5
06/09/04	CCR-2 4m	81	23	3	830	444	<5	5	ND
06/09/04	CCR-2 5m	117	26	20	903	558	5	90	ND
06/09/04	CCR-2 6m	117	34	27	922	601	6	122	ND
06/09/04	CCR-2 7m	117	39	34	1041	638	10	148	ND
06/23/04	CCR-2 Photic	73	11	4	881	493	<5	11	21.0
06/23/04	CCR-2 4m	79	11	5	905	504	<5	12	ND
06/23/04	CCR-2 5m	80	11	4	896	499	<5	9	ND
06/23/04	CCR-2 6m	82	13	6	842	471	<5	9	ND
06/23/04	CCR-2 7m	91	13	6	824	444	<5	11	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
07/07/04	CCR-2 Photic	81	17	3	893	551	<5	12	15.2
07/07/04	CCR-2 4m	87	18	7	747	455	<5	6	ND
07/07/04	CCR-2 5m	102	37	27	802	519	<5	54	ND
07/07/04	CCR-2 6m	108	37	26	757	485	<5	68	ND
07/07/04	CCR-2 7m	125	42	32	758	514	<5	73	ND
07/21/04	CCR-2 Photic	84	20	5	956	589	<5	13	15.0
07/21/04	CCR-2 4m	81	27	18	900	585	<5	39	ND
07/21/04	CCR-2 5m	145	83	73	960	600	<5	123	ND
07/21/04	CCR-2 6m	152	88	77	941	785	<5	129	ND
07/21/04	CCR-2 7m	269	157	143	1229	736	<5	233	ND
08/04/04	CCR-2 Photic	108	20	6	1048	604	<5	12	18.6
08/04/04	CCR-2 4m	102	31	22	804	522	<5	42	ND
08/04/04	CCR-2 5m	97	24	13	876	518	<5	18	ND
08/04/04	CCR-2 6m	101	34	22	793	527	<5	54	ND
08/04/04	CCR-2 7m	105	33	24	848	623	<5	67	ND
08/18/04	CCR-2 Photic	104	18	10	950	555	<5	14	15.9
08/18/04	CCR-2 4m	91	19	9	851	535	<5	20	ND
08/18/04	CCR-2 5m	129	28	20	840	533	<5	50	ND
08/18/04	CCR-2 6m	103	31	24	849	534	<5	68	ND
08/18/04	CCR-2 7m	120	36	26	912	567	<5	98	ND
09/01/04	CCR-2 Photic	121	15	7	1081	549	<5	14	27.5
09/01/04	CCR-2 4m	108	22	16	939	541	5	31	ND
09/01/04	CCR-2 5m	116	40	30	964	612	13	115	ND
09/01/04	CCR-2 6m	111	34	28	1033	685	13	117	ND
09/01/04	CCR-2 7m	129	47	36	1100	780	19	184	ND
09/15/04	CCR-2 Photic	89	17	12	817	511	<5	26	10.7
09/15/04	CCR-2 4m	90	18	12	817	496	<5	28	ND
09/15/04	CCR-2 5m	89	18	12	791	489	<5	29	ND
09/15/04	CCR-2 6m	89	18	13	764	487	<5	28	ND
09/15/04	CCR-2 7m	90	19	13	775	475	<5	30	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Analytical Detection Limits		2	2	3	4	4	5	3	
Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
10/20/04	CCR-2 Photic	107	15	6	1199	603	<5	7	31.6
10/20/04	CCR-2 4m	86	15	6	810	575	<5	7	ND
10/20/04	CCR-2 5m	77	15	7	1000	608	<5	8	ND
10/20/04	CCR-2 6m	115	18	9	861	624	<5	13	ND
10/20/04	CCR-2 7m	ND	ND	ND	ND	ND	ND	ND	ND
11/16/04	CCR-2 Photic	64	19	7	798	518	8	18	18.3
11/16/04	CCR-2 4m	60	17	7	744	471	8	15	ND
11/16/04	CCR-2 5m	60	19	7	727	471	8	15	ND
11/16/04	CCR-2 6m	62	18	6	715	452	7	13	ND
11/16/04	CCR-2 7m	61	17	8	723	463	8	14	ND

* "ND" denotes "No Data"

CCR-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
3/30/04	CCR-3 Photic	58	12	<3	844	542	<5	10	9.4
4/21/04	CCR-3 Photic	82	22	7	885	483	<5	7	14.8
5/19/04	CCR-3 Photic	68	15	3	741	480	<5	9	11.1
5/24/04	CCR-3 Photic	39	<2	4	822	496	<5	8	13.4
6/9/04	CCR-3 Photic	68	11	4	839	522	<5	11	13.3
6/23/04	CCR-3 Photic	88	12	4	1000	555	<5	17	25.1
7/7/04	CCR-3 Photic	75	16	4	849	488	<5	7	16.8
7/21/04	CCR-3 Photic	92	21	7	936	521	<5	13	15.8
8/4/04	CCR-3 Photic	114	20	5	950	503	<5	7	19.2
8/18/04	CCR-3 Photic	105	16	8	938	620	<5	14	16.2
9/1/04	CCR-3 Photic	147	22	14	1046	549	<5	18	17.0
9/15/04	CCR-3 Photic	103	15	6	919	481	<5	10	24.8
10/20/04	CCR-3 Photic	94	15	7	979	607	<5	10	21.5
11/16/04	CCR-3 Photic	76	16	5	785	463	<5	12	18.3

CCR University of Colorado Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	NO3+NO2-N µg/L	NH4-N µg/L
Analytical Detection Limits		2	2	3	5	3
03/30/04	CCR-2 6m	54.2	17.5	1.3	0.0	12.9
04/21/04	CCR-1 phtoic	65.6	28.1	6.5	0.0	30.3
05/19/04	CCR-2 4m	59.1	21.0	4.3	0.0	16.2
05/24/04	CCR-1 photic	60.9	23.8	2.7	0.0	14.1
06/09/04	CCR-2 7m	119.5	53.1	35.4	0.0	144.5
06/23/04	CCR-2 photic	67.9	22.2	3.6	0.0	9.4
07/07/04	CCR-3 photic	68.9	23.5	2.1	0.0	4.6
07/21/04	CCR-2 4m	78.8	36.4	17.9	0.0	40.2
08/04/04	CCR-2 photic	77.7	26.1	5.0	0.0	17.5
08/18/04	CCR-2 photic	81.2	33.4	8.7	0.0	15.6
09/01/04	CCR-2 photic	82.4	29.7	8.4	0.0	10.3
09/15/04	CCR-3 photic	91.8	24.5	7.4	0.0	8.7
10/20/04	CCR-2 6m	59.2	20.3	5.9	7.2	22.9
11/16/04	CCR-2 7m	60.1	21.7	4.1	5.6	17.4

CCR C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	NO3+NO2-N µg/L	NH4-N µg/L
Analytical Detection Limits		2	2	3	5	3
03/30/04	CCR-2 6m	60	12	4	<5	7
04/21/04	CCR-1 phtoic	85	22	9	<5	25
05/19/04	CCR-2 4m	80	17	6	<5	12
05/24/04	CCR-1 photic	32	6	4	<5	12
06/09/04	CCR-2 7m	117	39	34	10	148
06/23/04	CCR-2 photic	73	11	4	<5	11
07/07/04	CCR-3 photic	75	16	4	<5	7
07/21/04	CCR-2 4m	81	27	18	<5	39
08/04/04	CCR-2 photic	108	20	6	<5	12
08/18/04	CCR-2 photic	104	18	10	<5	14
09/01/04	CCR-2 photic	121	15	7	<5	14
09/15/04	CCR-3 photic	103	15	6	<5	10

CCR C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	NO_3+NO_2-N µg/L	NH_4-N µg/L
Analytical Detection Limits		2	2	3	5	3
10/20/04	CCR-2 6m	115	18	9	<5	13
11/16/04	CCR-2 7m	61	17	8	8	14

CHERRY CREEK
D.O. DATA, 2004
Site CCR-1

Date 03/30/04
Secchi 1.00 m
1% 1.30 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.37	752	8.90	8.51
1	9.93	724	8.80	8.46
2	9.65	719	8.31	8.39
3	9.53	717	7.83	8.33
4	9.50	716	7.64	8.30
5	9.50	713	7.47	8.23
6	9.46	714	5.58	8.13

Date 04/21/04
Secchi 0.75 m
1% 1.10 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.83	739	9.12	8.58
1	11.84	738	9.10	8.58
2	11.84	738	8.95	8.57
3	11.84	738	8.82	8.58
4	11.83	738	8.80	8.59
5	11.80	737	8.77	8.59
6	11.80	737	8.67	8.60

Date 05/19/04
Secchi 1.00 m
1% 1.25 m

Depth (m)	Temp °C	Cond.	DO	pH
0	16.38	848	10.83	8.55
1	16.27	844	10.83	8.59
2	15.71	836	9.68	8.55
3	15.51	832	8.98	8.52
4	15.16	826	7.74	8.45
5	14.62	817	5.60	8.32
6	14.41	812	3.96	8.24

Date 05/24/04
Secchi 1.00 m
1% 1.25 m

Depth (m)	Temp °C	Cond.	DO	pH
0	18.29	891	8.2	8.65
1	18.09	886	8.18	8.63
2	17.82	881	7.97	8.60
3	17.70	879	7.81	8.55
4	17.68	879	7.7	8.50
5	17.64	878	7.29	8.45
6	16.48	861	4.27	8.30

Date 06/09/04
Secchi 0.85 m
1% 1.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	20.47	906	8.03	8.63
1	20.41	907	7.99	8.63
2	20.37	902	7.67	8.54
3	19.55	890	6.83	8.48
4	19.13	882	6.07	8.44
5	18.71	874	5.48	8.42
6	18.48	868	5.33	8.46

Date 06/23/04
Secchi 0.60 m
1% 1.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	19.74	886	12.93	8.20
1	18.44	859	11.9	8.07
2	17.06	840	7.13	7.92
3	16.94	837	6.91	7.89
4	16.83	835	6.55	7.85
5	16.78	834	6.52	7.82
6	16.80	834	6.51	7.77

Date 07/07/04
Secchi 0.66 m
1% 4.40 m

Depth (m)	Temp °C	Cond.	DO	pH
0	21.64	849	10.63	8.21
1	20.73	834	9.77	8.05
2	19.99	821	7.96	7.91
3	19.33	810	5.86	7.84
4	19.23	807	5.04	7.81
5	19.11	805	3.81	7.77
6	18.93	804	3.13	7.80

Date 07/21/04
Secchi 0.75 m
1% 2.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	23.40	900	8.32	8.24
1	22.41	881	7.59	8.19
2	22.22	877	6.94	8.16
3	22.12	876	6.36	8.13
4	21.99	875	5.98	8.11
5	21.95	874	5.88	8.12
6	21.90	871	5.82	8.06

CCR-1 DO Data Continued

Date	08/04/04			
Secchi	0.85 m	m		
1%	3.25 m	m		
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	22.53	933	7.49	8.54
1	22.20	925	7.4	8.44
2	21.85	920	6.38	8.35
3	21.60	913	5.3	8.26
4	21.23	905	4.58	8.25
5	20.98	903	2.62	8.08
6	20.91	902	2.05	8.10

Date	08/18/04			
Secchi	1.00 m			
1%	2.75 m			
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	22.06	907	5.39	8.05
1	21.91	905	4.65	8.05
2	21.76	899	3.85	8.06
3	21.52	897	3.52	8.03
4	21.53	895	3.56	8.00
5	21.48	895	3.57	8.05

Date	09/01/04			
Secchi	0.75 m			
1%	2.10 m			
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	20.16	804	8.94	8.59
1	19.74	797	7.19	8.53
2	19.31	793	6.23	8.45
3	19.38	793	5.57	8.37
4	19.33	789	5.78	8.37
5	19.28	793	6.07	8.38
6	19.32	794	6.52	8.40

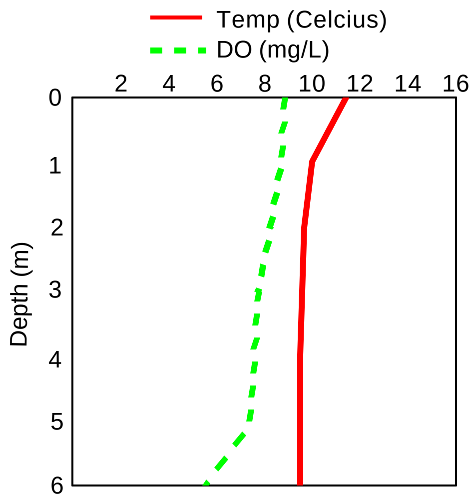
Date	09/15/04			
Secchi	1.65 m			
1%	1.85 m			
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	18.59	815	6.04	8.26
1	18.52	814	5.90	8.24
2	18.48	813	5.70	8.24
3	18.47	812	5.63	8.23
4	18.45	813	5.68	8.23
5	18.40	811	5.69	8.20
6	18.24	809	3.98	8.17

Date	10/20/04			
Secchi	0.90 m			
1%	2.50 m			
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	12.17	697	8.77	8.43
1	12.07	695	8.61	8.40
2	11.99	693	8.23	8.35
3	11.90	693	7.80	8.35
4	11.85	692	7.64	8.33
5	11.85	692	7.55	8.31
6	11.82	692	7.40	8.24

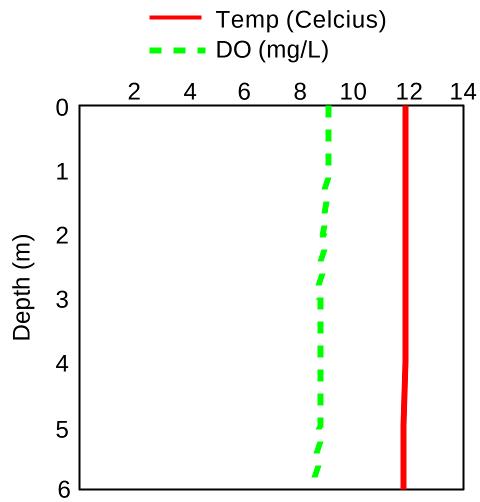
Date	11/16/04			
Secchi	1.10 m			
1%	3.10 m			
Depth (m)	**Temp ^oC**	**Cond.**	**DO**	**pH**
0	6.90	618	10.78	8.45
1	6.38	609	10.85	8.42
2	6.26	607	10.58	8.36
3	6.24	607	10.40	8.34
4	6.21	607	10.22	8.28
5	6.20	608	10.02	8.21
6	6.19	608	9.95	8.14

CCR-1

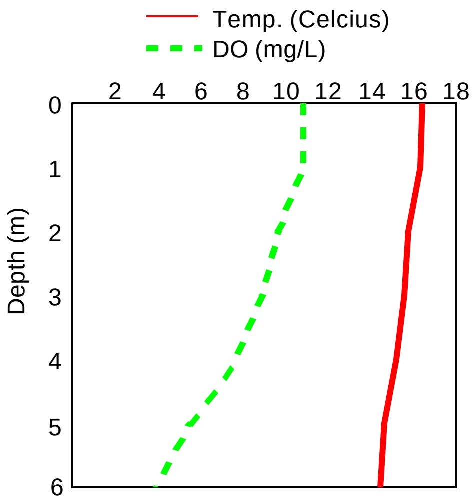
March 30, 2004



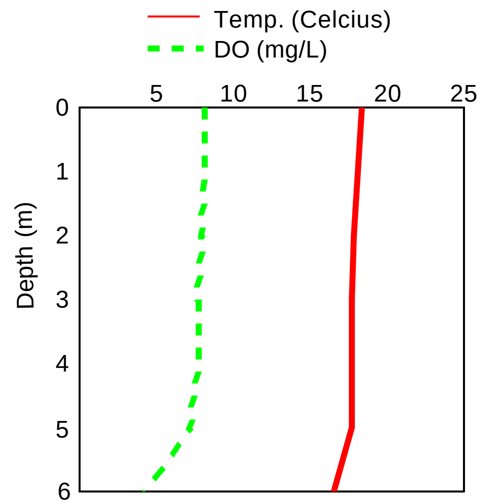
April 21, 2004



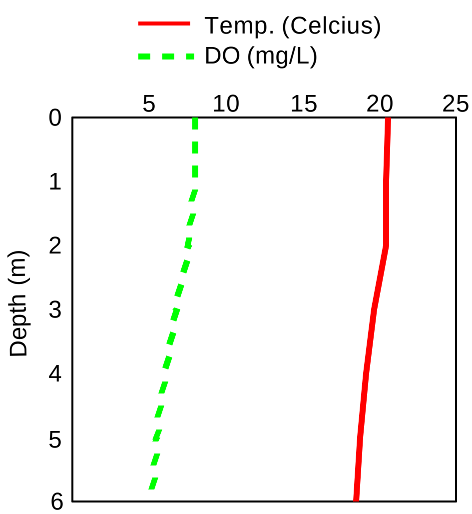
May 19, 2004



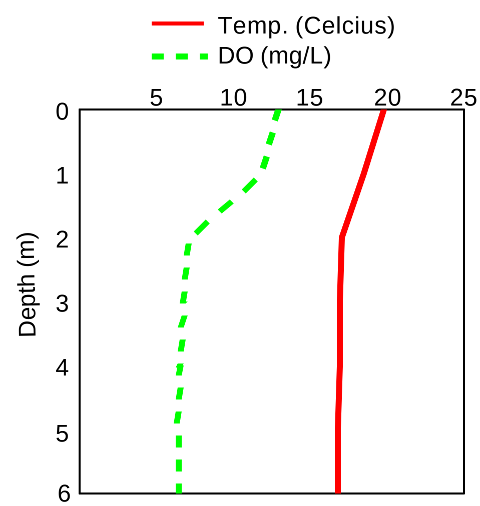
May 24, 2004



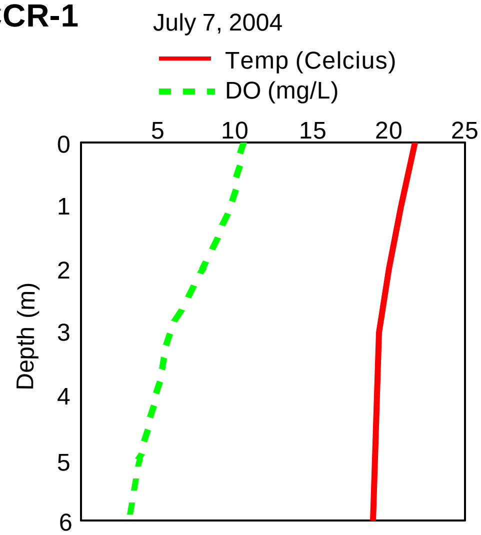
June 9, 2004

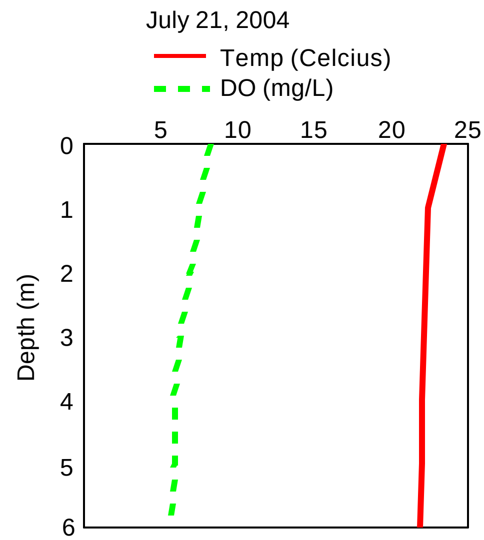


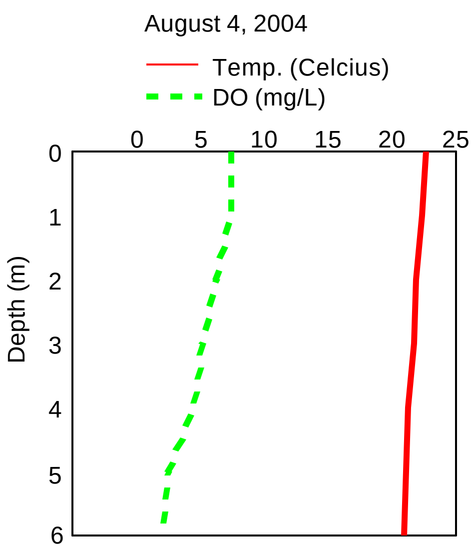
June 23, 2004

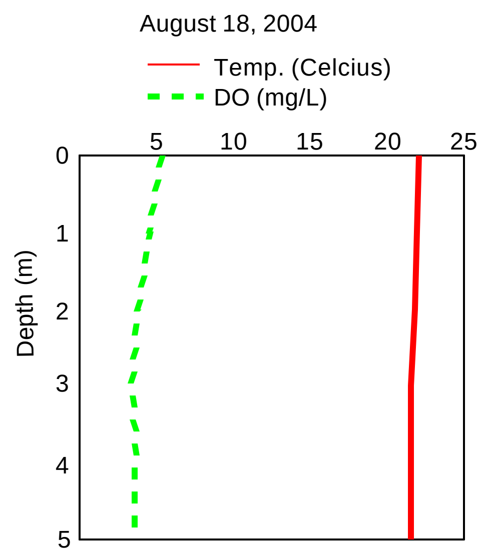


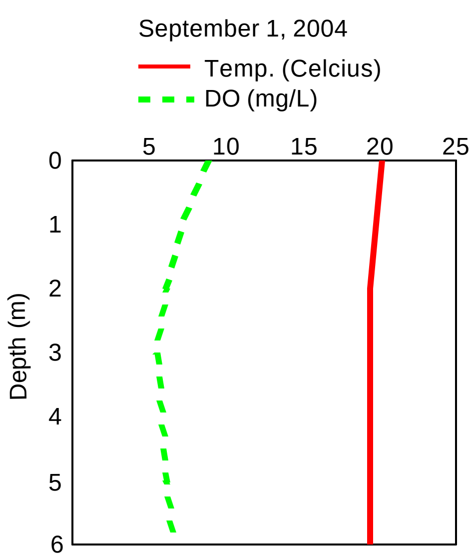
CCR-1

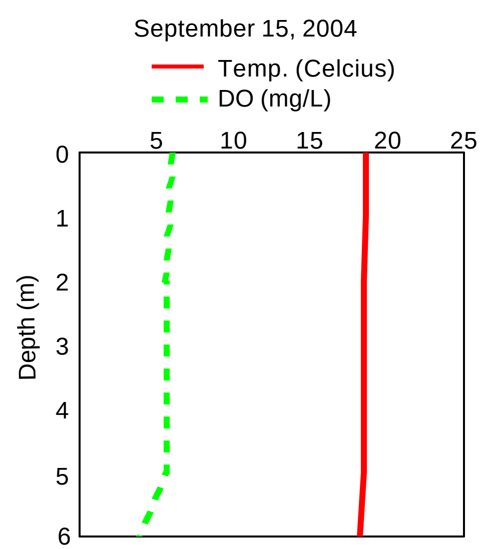

July 7, 2004
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)


July 21, 2004
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)

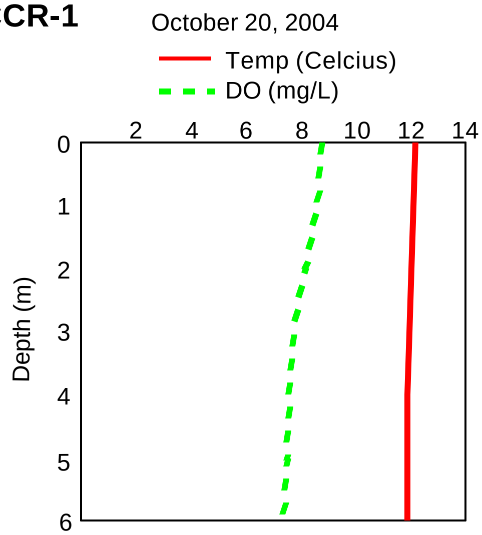

August 4, 2004
Temp. (Celcius)
DO (mg/L)
0 5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)

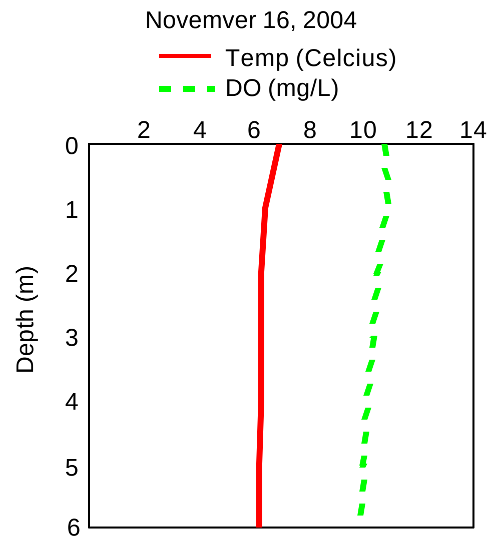

August 18, 2004
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)


September 1, 2004
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)


September 15, 2004
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)

CCR-1


October 20, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6
Depth (m)


Novemver 16, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6
Depth (m)

CHERRY CREEK
D.O. DATA, 2004
Site CCR-2

Date 03/30/04
Secchi 1.00 m
1% 1.35 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.14	747	8.98	8.59
1	9.76	721	8.97	8.56
2	9.39	714	8.43	8.51
3	9.30	711	8.36	8.49
4	9.27	710	8.30	8.48
5	9.24	710	8.20	8.44
6	9.21	709	8.02	8.44
7	9.10	709	7.76	8.44

Date 04/21/04
Secchi 0.75 m
1% 1.00 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.84	737	8.97	8.56
1	11.84	738	8.80	8.56
2	11.84	737	8.81	8.56
3	11.83	737	8.79	8.55
4	11.82	737	8.61	8.55
5	11.81	737	8.44	8.54
6	11.74	736	8.18	8.52
7	11.74	736	8.12	8.52

Date 05/19/04
Secchi 0.75 m
1% 1.00 m

Depth (m)	Temp °C	Cond.	DO	pH
0	16.68	853	10.89	8.62
1	16.21	844	10.42	8.61
2	15.60	833	9.54	8.59
3	15.07	825	7.86	8.51
4	14.72	819	6.82	8.43
5	14.43	813	5.59	8.36
6	14.21	807	4.47	8.26
7	14.14	805	4.45	8.18

Date 05/24/04
Secchi 1.00 m
1% 1.35m

Depth (m)	Temp °C	Cond.	DO	pH
0	18.56	897	8.12	8.74
1	18.34	892	8.31	8.73
2	17.95	884	8.33	8.69
3	17.24	872	5.98	8.57
4	15.98	849	3.13	8.42
5	15.77	844	2.42	8.34
6	15.51	839	1.73	8.27
7	15.43	837	1.23	8.17

Date 06/09/04
Secchi 0.85 m
1% 2.00 m

Depth (m)	Temp °C	Cond.	DO	pH
0	20.40	905	8.25	8.70
1	20.44	906	8.51	8.74
2	20.42	904	8.44	8.77
3	20.33	903	8.37	8.74
4	18.98	874	7.32	8.67
5	18.25	868	4.05	8.45
6	17.83	857	3.09	8.31
7	17.64	854	2.74	8.24

Date 06/23/04
Secchi 0.60 m
1% 2.50 m

Depth (m)	Temp °C	Cond.	DO	pH
0	19.22	882	11.26	8.30
1	17.73	848	10.25	8.23
2	17.23	841	8.87	8.20
3	16.91	833	8.24	8.19
4	16.77	831	7.99	8.19
5	16.68	831	7.83	8.18
6	16.55	824	7.74	8.19
7	16.29	816	7.71	8.21

Date 07/07/04
Secchi 0.66 m
1% 4.05 m

Depth (m)	Temp °C	Cond.	DO	pH
0	21.47	849	10.08	8.27
1	20.65	831	9.80	8.21
2	20.23	823	9.30	8.13
3	19.73	818	7.18	7.98
4	18.77	805	1.73	7.94
5	18.39	795	1.01	7.94
6	18.27	793	0.80	7.98
7	18.26	792	0.93	8.03

Date 07/21/04
Secchi 0.75 m
1% 2.50 m

Depth (m)	Temp °C	Cond.	DO	pH
0	23.22	897	8.72	8.36
1	22.92	890	8.63	8.32
2	22.61	884	7.72	8.19
3	22.38	881	6.34	8.10
4	22.18	878	5.85	8.08
5	21.71	871	3.17	7.99
6	21.26	863	1.47	8.02
7	20.56	849	0.59	8.13

CCR-2 DO Data Continued

Date 08/04/04
Secchi 0.90 m
1% 2.85 m

Depth (m)	Temp °C	Cond.	DO	pH
0	22.97	939	7.93	8.58
1	22.44	928	7.56	8.46
2	22.17	924	6.51	8.27
3	21.51	913	4.13	8.12
4	20.97	903	2.59	8.10
5	20.89	901	2.04	8.11
6	20.84	901	1.75	8.14
7	20.82	901	1.73	8.19

Date 08/18/04
Secchi 1.25 m
1% 2.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	22.24	910	5.91	8.26
1	22.16	908	5.79	8.26
2	22.02	907	5.35	8.30
3	22.00	906	5.20	8.27
4	21.85	904	4.20	8.22
5	21.58	900	3.30	8.18
6	21.36	897	2.43	8.14
7	21.33	894	2.30	8.06

Date 09/01/04
Secchi 0.65 m
1% 2.50 m

Depth (m)	Temp °C	Cond.	DO	pH
0	20.92	819	8.86	8.68
1	19.81	799	8.21	8.62
2	19.71	797	7.72	8.56
3	19.67	797	7.27	8.48
4	19.06	791	4.20	8.38
5	18.77	787	3.38	8.47
6	18.62	785	3.17	8.62
7	18.58	786	3.40	8.64

Date 09/15/04
Secchi 0.50 m
1% 2.00 m

Depth (m)	Temp °C	Cond.	DO	pH
0	18.37	811	5.70	8.34
1	18.31	810	5.68	8.34
2	18.24	808	5.59	8.34
3	18.20	807	5.55	8.34
4	18.16	807	5.49	8.24
5	18.16	807	5.51	8.30
6	18.16	807	5.55	8.32
7	18.03	805	5.53	8.33

Date 10/20/04
Secchi 0.90 m
1% 2.50 m

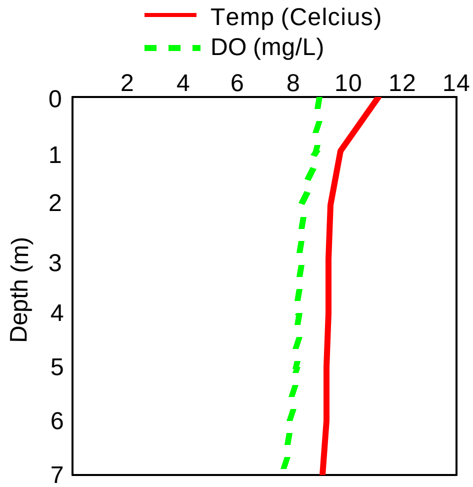
Depth (m)	Temp °C	Cond.	DO	pH
0	12.47	702	9.41	8.52
1	12.44	701	9.73	8.47
2	12.24	699	9.63	8.55
3	12.23	698	9.20	8.56
4	12.20	698	9.16	8.57
5	11.98	697	8.79	8.57
6	11.79	692	8.71	8.56
7	11.77	692	8.56	8.56

Date 11/16/04
Secchi 1.20 m
1% 3.05 m

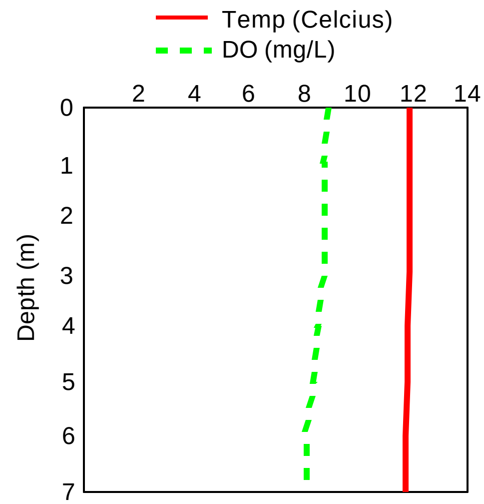
Depth (m)	Temp °C	Cond.	DO	pH
0	6.80	617	11.01	8.62
1	6.12	606	10.95	8.61
2	6.03	604	10.85	8.59
3	6.01	605	10.76	8.60
4	6.01	605	10.72	5.58
5	5.97	603	10.65	8.54
6	5.94	603	10.56	8.49
7	5.93	603	10.54	8.45

CCR-2

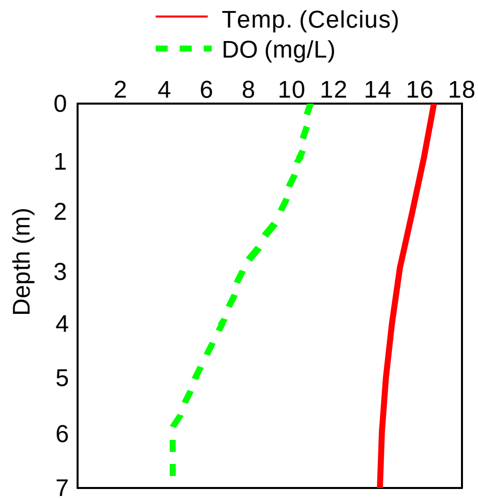
March 30, 2004



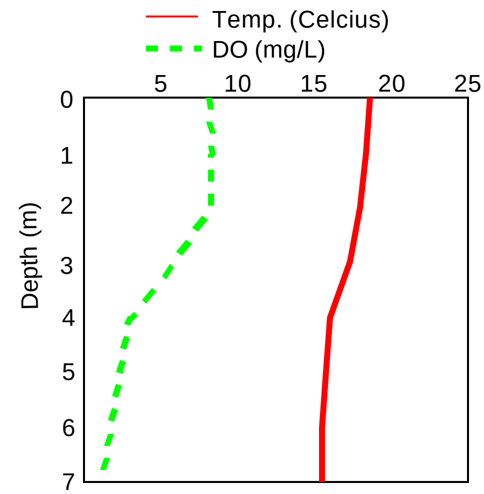
April 21, 2004



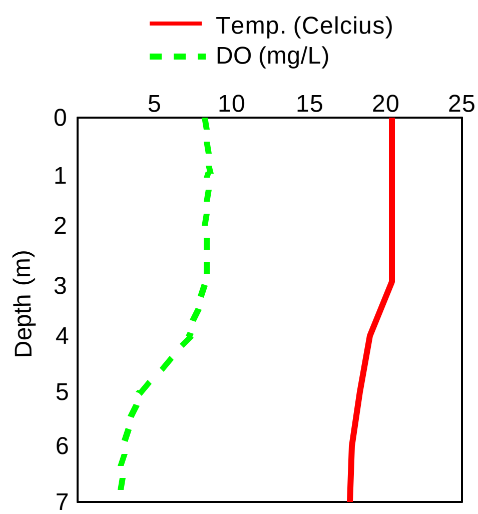
May 19, 2004



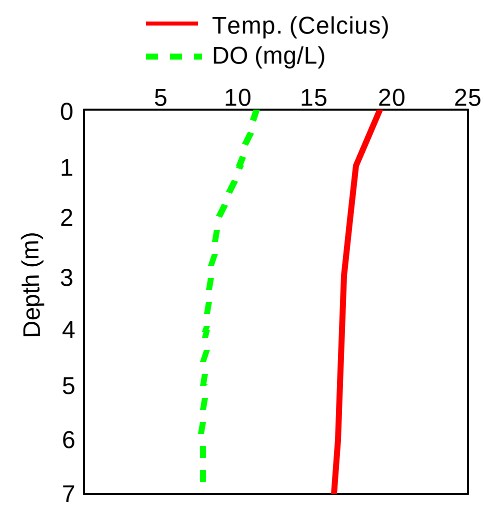
May 24, 2004



June 9, 2004

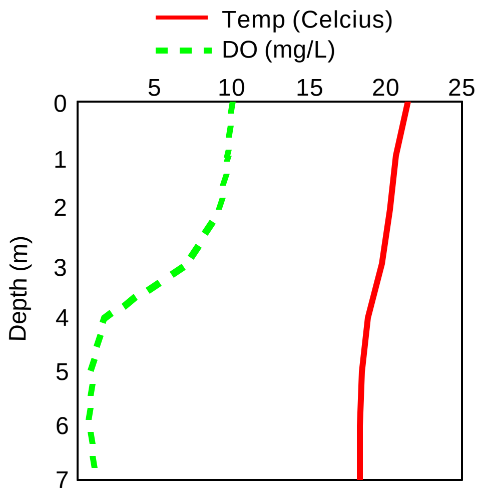


June 23, 2004

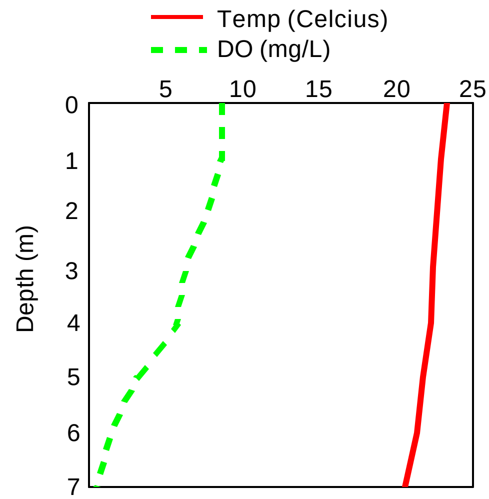


CCR-2

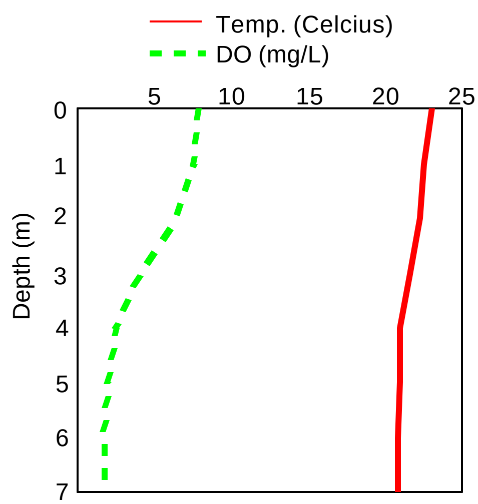
July 7, 2004



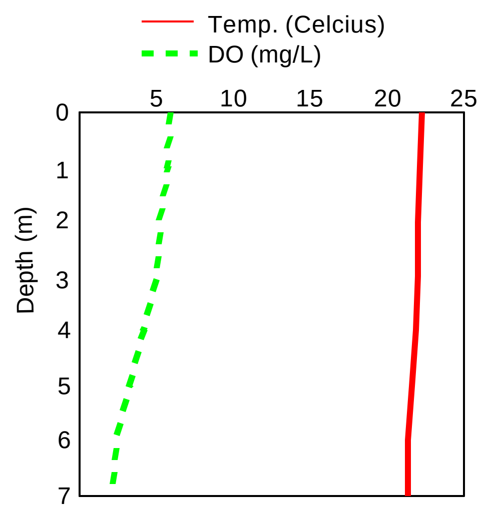
July 21, 2004



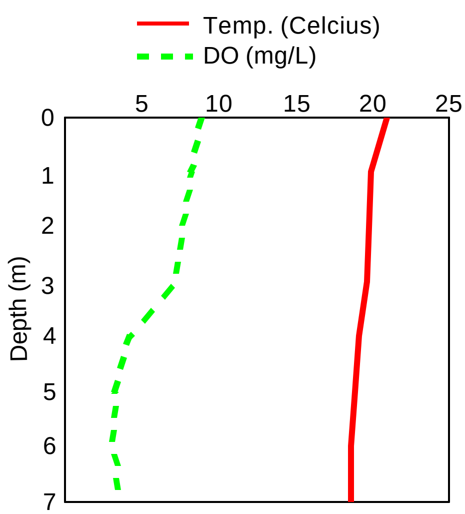
August 4, 2004



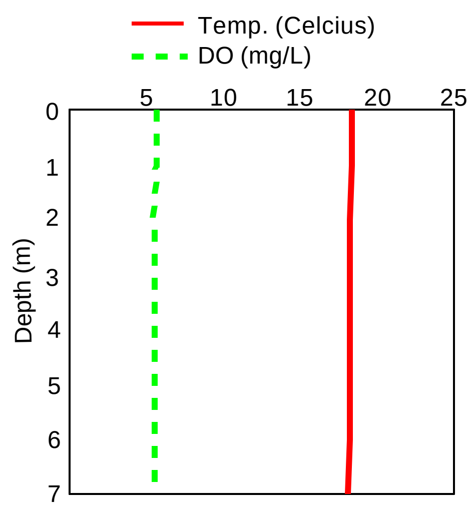
August 18, 2004



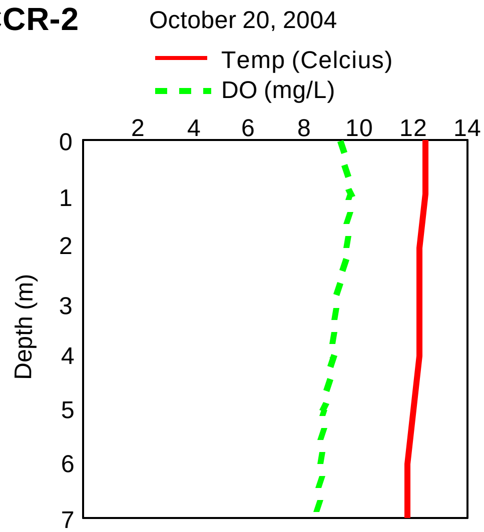
September 1, 2004



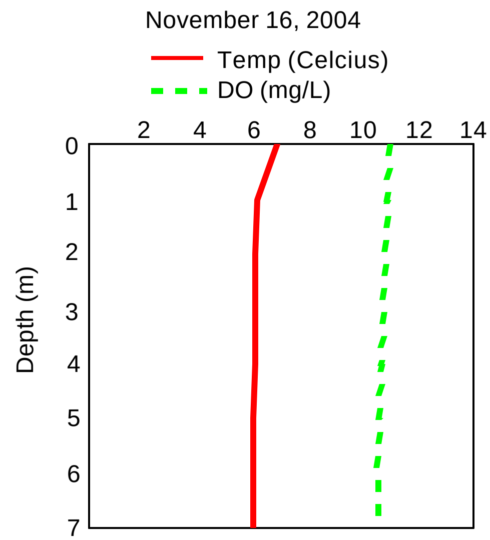
September 15, 2004



CCR-2



October 20, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6 7
Depth (m)



November 16, 2004
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, 2004
Site CCR-3

Date	03/30/04
Secchi	1.00 m
1%	1.30 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	11.30	750	9.26	8.68
1	10.50	734	9.36	8.66
2	9.78	720	8.84	8.59
3	9.65	719	8.32	8.55
4	9.57	717	7.28	8.54
5	9.28	712	5.09	8.50

Date	04/21/04
Secchi	0.75 m
1%	1.00 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	11.80	738	9.61	8.52
1	11.80	738	9.72	8.49
2	11.81	738	9.49	8.41
3	11.80	738	9.56	8.35
4	11.78	738	8.88	8.20

Date	05/19/04
Secchi	1.00 m
1%	1.25 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	16.54	852	10.34	8.54
1	16.23	845	10.86	8.59
2	16.07	842	10.53	8.60
3	15.61	833	9.42	8.59
4	15.46	833	9.00	8.56
5	15.12	827	8.21	8.51

Date	05/24/04
Secchi	1.00 m
1%	1.25 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	18.27	891	7.82	8.62
1	17.86	883	8.17	8.60
2	17.27	871	7.58	8.62
3	16.81	865	6.47	8.58
4	16.43	858	4.10	8.46
5	16.31	855	1.82	8.35

Date	06/09/04
Secchi	0.75 m
1%	1.75 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	20.19	902	8.21	8.57
1	20.12	901	8.12	8.60
2	19.60	893	7.11	8.58
3	18.52	872	5.69	8.51
4	18.18	867	4.80	8.49
5	17.97	862	1.35	8.36

Date	06/23/04
Secchi	0.50 m
1%	2.50 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	19.65	886	12.27	8.07
1	18.45	858	12.23	7.87
2	17.66	847	9.79	7.80
3	17.05	830	8.73	7.81
4	16.77	825	0.80	7.84
5	16.75	810	0.52	8.01

Date	07/07/04
Secchi	0.70 m
1%	4.12 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	22.56	867	10.19	8.36
1	20.69	834	9.95	8.30
2	20.12	823	9.18	8.20
3	19.84	820	6.87	8.12
4	19.07	807	4.57	8.09
5	18.89	804	3.43	8.10

Date	07/21/04
Secchi	0.85 m
1%	3.05 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	23.61	898	8.31	8.19
1	22.47	881	8.38	8.24
2	22.30	878	7.19	8.26
3	22.08	875	5.38	8.24
4	21.75	870	3.08	8.15
5	21.63	826	0.51	8.05

CCR-3 DO Data Continued

Date 08/04/04
Secchi 1.00 m
1% 2.50 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	22.97	941	7.97	8.48
1	22.45	924	7.72	8.40
2	21.77	919	6.15	8.29
3	21.53	913	5.77	8.20
4	21.27	911	4.77	8.15
5	21.13	893	0.96	8.08

Date 08/18/04
Secchi 0.85 m
1% 2.25 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	21.79	904	5.67	8.40
1	21.78	903	5.62	8.39
2	21.59	903	5.58	8.40
3	21.02	891	5.36	8.38
4	21.01	891	5.46	8.36

Date 09/01/04
Secchi 0.75 m
1% 2.00 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	19.83	803	8.59	8.59
1	19.48	796	8.01	8.67
2	19.01	790	6.56	8.61
3	18.63	785	5.57	8.56
4	18.60	785	5.40	8.53
5	18.62	783	3.40	8.45

Date 09/15/04
Secchi 0.70 m
1% 2.50 m

Depth (m)	Temp ^oC	Cond.	DO	pH
0	18.66	817	6.94	8.40
1	18.58	816	6.67	8.37
2	18.42	813	6.07	8.34
3	18.33	812	6.10	8.30
4	18.27	812	5.85	8.26
5	17.58	807	4.79	8.26

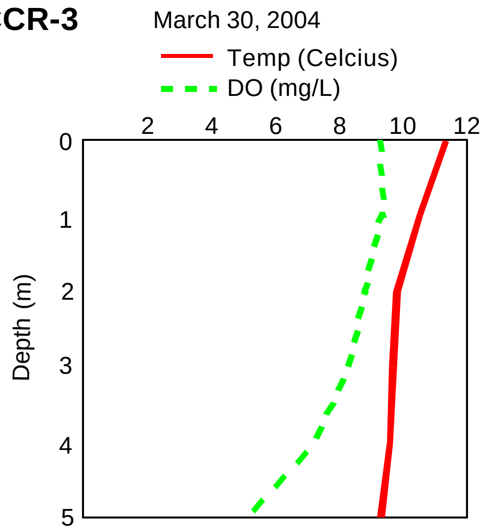
Date 10/20/04
Secchi 0.75 m
1% 2.25 m

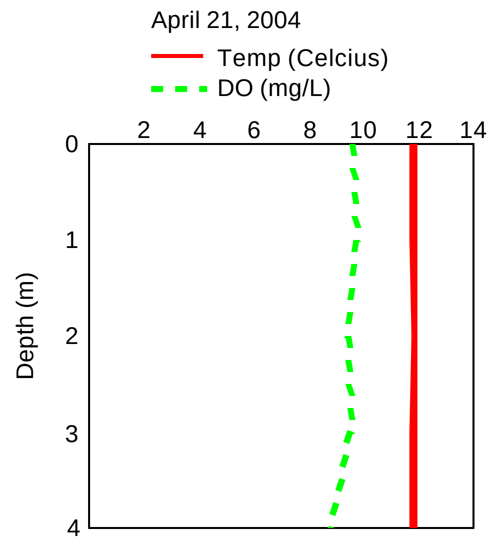
Depth (m)	Temp ^oC	Cond.	DO	pH
0	12.41	701	9.21	8.56
1	12.37	701	9.20	8.53
2	12.26	699	9.31	8.46
3	12.06	696	8.43	8.41
4	12.01	696	8.12	8.41
5	12.06	665	8.07	8.25

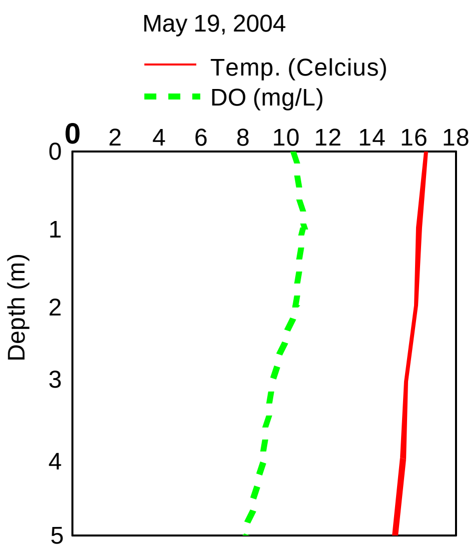
Date 11/16/04
Secchi 1.05 m
1% 2.50 m

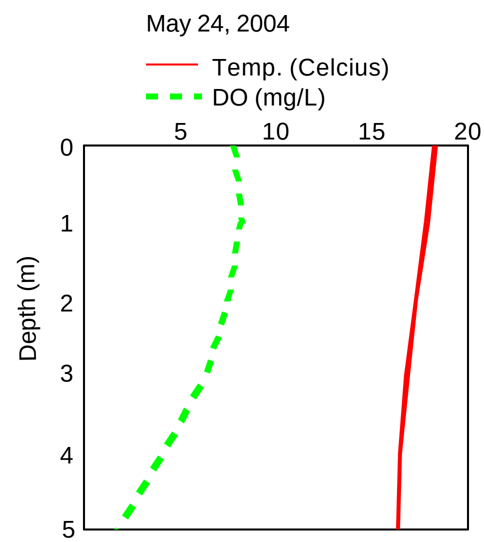
Depth (m)	Temp ^oC	Cond.	DO	pH
0	7.26	626	11.14	8.58
1	6.47	611	11.19	8.56
2	6.43	609	11.03	8.56
3	6.37	609	11.03	8.58
4	6.31	609	11.09	8.58
5	6.32	609	9.77	8.53

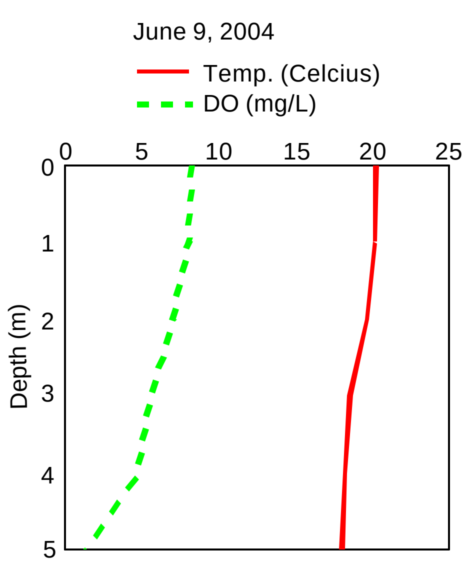
CCR-3

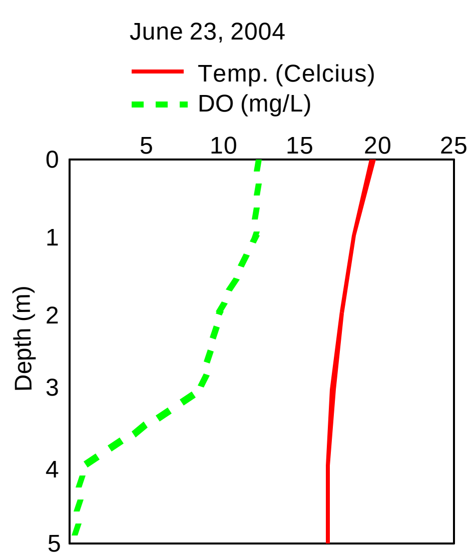

March 30, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12
0 1 2 3 4 5
Depth (m)


April 21, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4
Depth (m)


May 19, 2004
Temp. (Celcius)
DO (mg/L)
0 2 4 6 8 10 12 14 16 18
0 1 2 3 4 5
Depth (m)

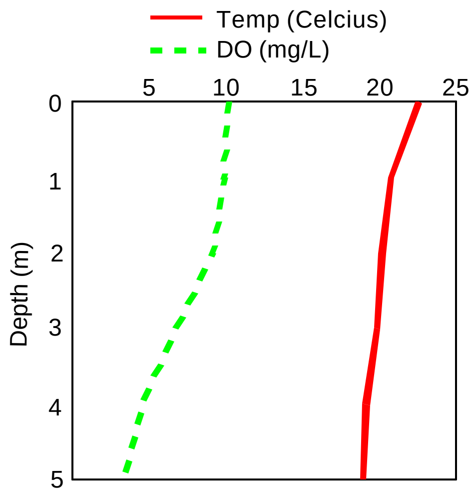

May 24, 2004
Temp. (Celcius)
DO (mg/L)
5 10 15 20
0 1 2 3 4 5
Depth (m)


June 9, 2004
Temp. (Celcius)
DO (mg/L)
0 5 10 15 20 25
0 1 2 3 4 5
Depth (m)

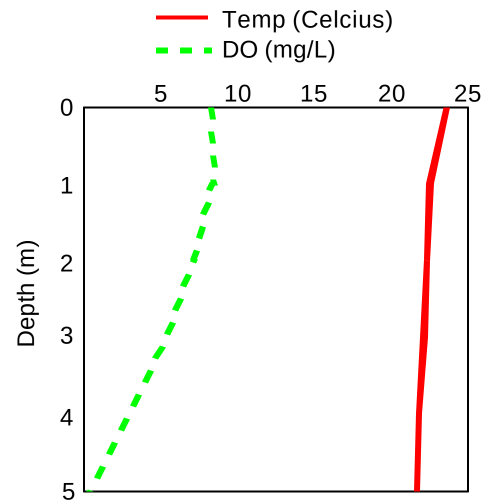

June 23, 2004
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

CCR-3

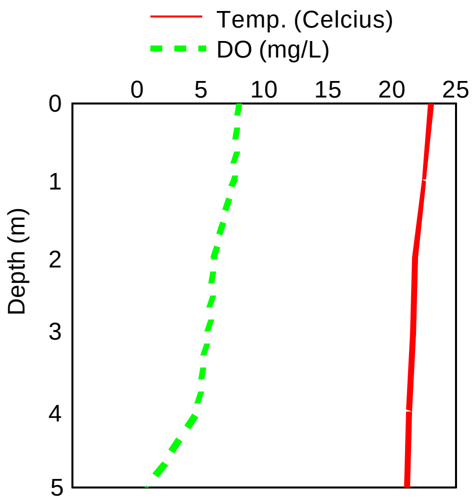
July 7, 2004



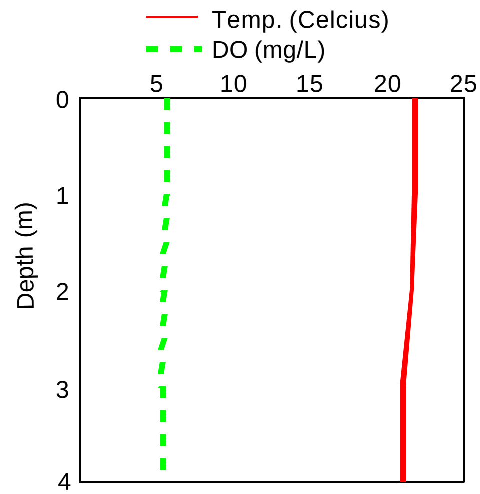
July 21, 2004



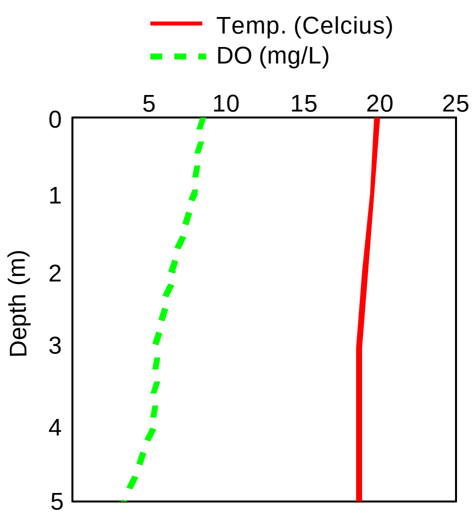
August 4, 2004



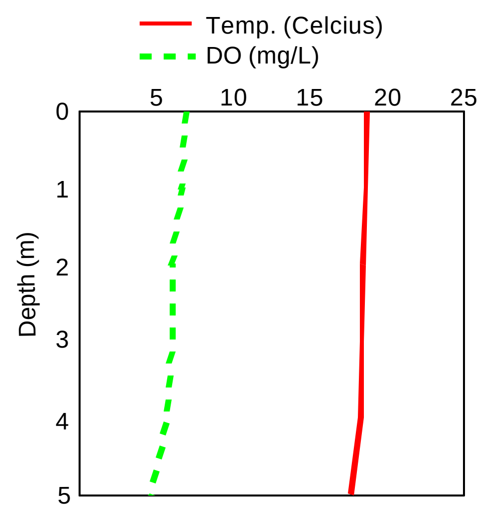
August 18, 2004



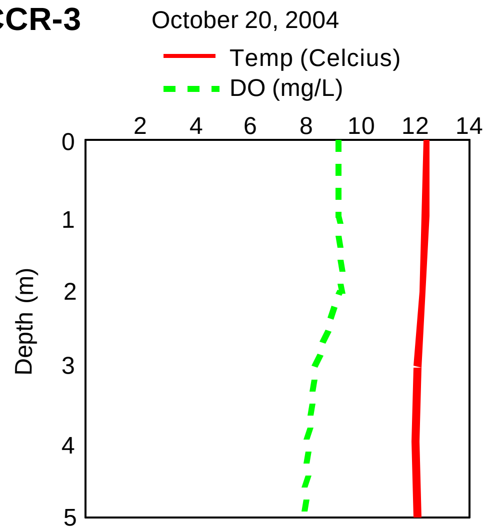
September 1, 2004



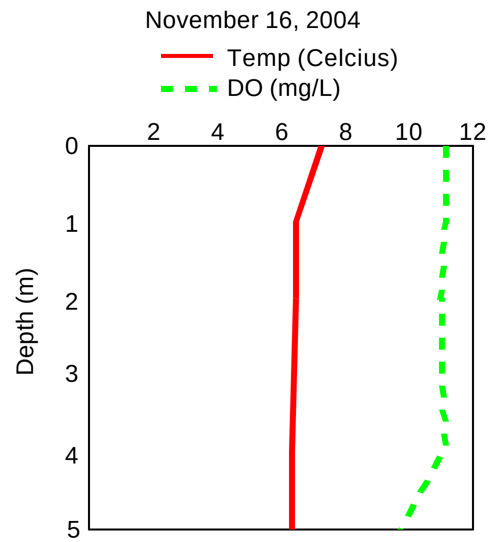
September 15, 2004



CCR-3



October 20, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5
Depth (m)



November 16, 2004
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12
0 1 2 3 4 5
Depth (m)

Cherry Creek Reservoir Secchi and 1% Transmissivity Depths for 2004

	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
03/30/04	1.00	1.30	1.30	03/30/04	1.00	1.35	1.35	03/30/04	1.00	1.30	1.30
04/21/04	0.75	1.10	1.47	04/21/04	0.75	1.00	1.33	04/21/04	0.75	1.00	1.33
05/19/04	1.00	1.25	1.25	05/19/04	0.75	1.00	1.33	05/19/04	1.00	1.25	1.25
05/24/04	1.00	1.25	1.25	05/24/04	1.00	1.35	1.35	05/24/04	1.00	1.25	1.25
06/09/04	0.85	1.75	2.06	06/09/04	0.85	2.00	2.35	06/09/04	0.75	1.75	2.33
06/23/04	0.60	1.75	2.92	06/23/04	0.60	2.50	4.17	06/23/04	0.50	2.50	5.00
07/07/04	0.66	4.40	6.67	07/07/04	0.66	4.05	6.14	07/07/04	0.70	4.12	5.89
07/21/04	0.75	2.75	3.67	07/21/04	0.75	2.50	3.33	07/21/04	0.85	3.05	3.59
08/04/04	0.85	3.25	3.82	08/04/04	0.90	2.85	3.17	08/04/04	1.00	2.50	2.50
08/18/04	1.00	2.75	2.75	08/18/04	1.25	2.75	2.20	08/18/04	0.85	2.25	2.65
09/01/04	0.75	2.10	2.80	09/01/04	0.65	2.10	3.23	09/01/04	0.75	2.00	2.67
09/15/04	1.65	1.85	1.12	09/15/04	0.50	2.00	4.00	09/15/04	0.70	2.50	3.57
10/20/04	0.90	2.50	2.78	10/20/04	0.90	2.50	2.78	10/20/04	0.75	2.25	3.00
11/16/04	1.10	3.10	2.82	11/16/04	1.20	3.05	2.54	11/16/04	1.05	2.50	2.38
Average	0.92	2.22	2.62	Average	0.84	2.21	2.81	Average	0.83	2.16	2.76
Median	0.88	1.98	2.76	Median	0.80	2.30	2.66	Median	0.80	2.25	2.57

APPENDIX C

Streamwater Quality and Precipitation Data

CC-10 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CC-10	304	183*	184*	2125	1181	903	126	49.2	7.6
2/24/04	CC-10	245	147*	155*	1551	1464	1123	92	59.5	13.6
3/30/04	CC-10	184	128*	130*	864	764	506	39	29.8	6.2
4/21/04	CC-10	188	140	137	835	746	477	29	16.8	<4.0
5/19/04	CC-10	220	161*	168*	803	735	463	36	20.0	4.2
6/9/04	CC-10	247	211*	214*	723	615	379	40	20.0	6.0
7/7/04	CC-10	208	167	161	768	649	370	45	30.0	7.2
8/4/04	CC-10	262	169*	170*	974	795	443	42	47.2	7.8
9/1/04	CC-10	231	168	137	1046	954	635	40	30.2	5.4
10/20/04	CC-10	188	153	153	1044	952	512	27	19.8	4.4
11/16/04	CC-10	156	132	131	1099	1098	800	17	13.3	<4.0
12/15/04	CC-10	146	127*	138*	880	849	694	24	9.2	<4.0
6/17/04	CC-10 storm	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/18/04	CC-10 storm	242	ND	ND	1345	ND	ND	126	17.2	6.8
6/21/04	CC-10 storm	237	ND	ND	936	ND	ND	ND	32.6	7.2
6/30/04	CC-10 storm	286	154	152	953	677	330	23	61.0	12.2
8/6/04	CC-10 storm	1056	305	289	2504	1214	540	14	793.3	90.0
8/11/04	CC-10 storm	284	188	184	883	717	271	39	64.8	8.8
8/19/04	CC-10 storm	864	337	309	1889	1021	372	28	630.8	71.7

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

CC-O C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CC-O	62	13	6	1407	535	17	33	12.8	5.6
2/24/04	CC-O	53	11	5	860	607	42	80	16.4	9.1
3/30/04	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/21/04	CC-O	77	18	6	771	485	<5	10	23.4	6.8
5/19/04	CC-O	110	32	12	897	493	<5	8	24.2	7.6
6/9/04	CC-O	105	10	4	1011	549	69	<3	40.0	14.6
7/7/04	CC-O	110	37	28	763	490	15	55	28.8	8.0
8/4/04	CC-O	110	36	27	843	544	14	57	32.0	8.4
9/10/04	CC-O	141	44	35	972	656	51	155	45.3	7.9
10/20/04	CC-O	83	26	15	1221	923	8	49	17.8	5.0
11/16/04	CC-O	59	19	7	694	450	6	13	10.8	4.4
12/15/04	CC-O	52	16	3	684	426	<5	<3	11.6	4.4

"ND" denotes "No Data"

CT-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CT-1	89*	96*	32	4247	3973	2913	931	24.4	4.2
2/24/04	CT-1	106	20	16	5961	5754	1636	4208	48.1	10.8
3/30/04	CT-1	73	33	27	4508	4452	2464	1861	35.2	4.8
4/21/04	CT-1	76	34	29	4365	4165	3575	152	28.8	6.8
5/19/04	CT-1	81	30	25	3952	3822	3449	20	33.6	5.6
6/9/04	CT-1	125	97*	99*	2787	2554	2140	11	14.0	5.8
7/7/04	CT-1	66	21	9	3441	3124	2570	9	59.0	7.2
8/4/04	CT-1	58	20	10	4498	4239	3506	11	26.8	7.2
9/1/04	CT-1	70	7	3	2798	2444	2021	7	25.6	6.2
10/20/04	CT-1	72	19	15	3956	3724	3376	126	34.2	4.6
11/16/04	CT-1	77	14	11	3531	3270	2915	12	17.1	<4.0
12/15/04	CT-1	47	21	14	4704	4608	3389	106	18.4	<4.0
6/17/04	CT-1 storm	231	ND	ND	2492	ND	ND	94	196.5	22.0
6/18/04	CT-1 storm	312	ND	ND	2248	ND	ND	118	296.0	44.0
6/21/04	CT-1 storm	123	ND	ND	1723	ND	ND	ND	74.8	11.5
6/30/04	CT-1 storm	170	17	4	2535	2114	1812	13	87.7	14.7
8/6/04	CT-1 storm	832	54	43	2433	1486	868	43	728.3	80.0
8/11/04	CT-1 storm	584	33	24	2610	1634	1086	88	546.0	54.0
8/19/04	CT-1 storm	826	184	164	948*	1004*	396	84	651.0	58.0

"ND" denotes "No Data"

CT-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CT-2	97	37	26	4394	3836	2753	906	41.2	6.6
2/24/04	CT-2	198	9	8	5442	4788	1519	3234	139.8	20.1
3/30/04	CT-2	57	16	4	4931	4645	2315	2234	34.0	6.2
4/21/04	CT-2	141	18	12	3295	3162	2589	93	84.5	16.0
5/19/04	CT-2	107	9	3	3055	2622	2213	19	55.2	9.0
6/9/04	CT-2	93	37	31	2428	2139	1509	145	110.0	15.7
7/7/04	CT-2	62	17	8	3239	2881	2342	43	31.8	6.6
8/4/04	CT-2	76	15	7	4686	4191	3403	45	38.2	9.2
9/1/04	CT-2	85	6	<3	2566	2114	1670	16	35.8	8.2
10/20/04	CT-2	65	13	9	4037	3647	3306	148	33.4	6.0
11/16/04	CT-2	60	13	8	3929	3578	3204	44	36.8	6.4
12/15/04	CT-2	56	18	10	4920	4704	3337	122	28.8	5.2
6/17/04	CT-2 storm	170	ND	ND	2570	ND	ND	151	88.7	17.7
6/18/04	CT-2 storm	247	ND	ND	1997	ND	ND	127	26.0	9.0
6/21/04	CT-2 storm	106	ND	ND	1589	ND	ND	ND	34.3	11.8
6/30/04	CT-2 storm	125	12	3	2565	2047	1777	6	79.8	18.3
8/6/04	CT-2 storm	248	51	39	2155	1579	1032	73	288.5	35.0
8/11/04	CT-2 storm	208	43	31	2169	1666	1125	78	47.2	11.2
8/19/04	CT-2 storm	670	208	187	1856	1036	421	78	918.3	95.0

"ND" denotes "No Data"

CT-P1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CT-P1	25	7	7	1552	1090	754	73	13.2	4.6
2/24/04	CT-P1	55	8	4	1393	1178	623	63	260.0	43.0
3/30/04	CT-P1	39	10	4	876	731	241	42	21.8	5.8
4/21/04	CT-P1	48	5	<3	879	661	279	51	31.8	7.8
5/19/04	CT-P1	52	11	7	1000	817	403	109	20.2	6.4
6/9/04	CT-P1	56	12	10	927	763	263	64	18.0	7.0
7/7/04	CT-P1	74	29	15	985	751	265	48	15.2	5.8
8/4/04	CT-P1	91	41	29	1106	860	286	54	28.8	10.6
9/1/04	CT-P1	64	11	6	1370	1116	651	95	25.2	6.2
10/20/04	CT-P1	43	10	3	871	704	256	7	22.4	4.8
11/16/04	CT-P1	24	12	5	887	757	440	20	22.0	4.0
12/15/04	CT-P1	36	17	15	802	695	476	12	54.2	8.4
6/17/04	CT-P1 storm	187	ND	ND	1707	ND	ND	111	88.7	17.7
6/18/04	CT-P1 storm	119	ND	ND	1384	ND	ND	138	26.0	9.0
6/21/04	CT-P1 storm	125	ND	ND	1489	ND	ND	ND	34.3	11.8
6/30/04	CT-P1 storm	205	14	3	1392	688	314	9	79.8	18.3
8/6/04	CT-P1 storm	368	23	9	2107	1077	601	15	288.5	35.0
8/11/04	CT-P1 storm	167	44	29	1512	1006	383	75	47.2	11.2
8/19/04	CT-P1 storm	927	55	36	1665	998	462	33	918.3	95.0

"ND" denotes "No Data"

CT-P2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	CT-P2	37	20	16	1555	1431	1206	18	13.2	4.6
2/24/04	CT-P2	356	8	4	2176	1319	762	138	260.0	43.0
3/30/04	CT-P2	41	6	<3	1079	935	491	21	21.8	5.8
4/21/04	CT-P2	89	6	<3	1631	1252	871	30	31.8	7.8
5/19/04	CT-P2	61	9	3	1299	1037	642	16	20.2	6.4
6/9/04	CT-P2	45	15	3	1135	909	430	38	18.0	7.0
7/7/04	CT-P2	42	20	8	1132	998	466	49	15.2	5.8
8/4/04	CT-P2	70	26	16	1348	1140	554	48	28.8	10.6
9/1/04	CT-P2	68	10	5	1469	1151	759	52	25.2	6.2
10/20/04	CT-P2	46	8	5	1247	1210	694	13	22.4	4.8
11/16/04	CT-P2	36	8	6	1221	1098	793	29	22.0	4.0
12/15/04	CT-P2	71	10	7	1110	966	759	26	54.2	8.4
6/17/04	CT-P2 storm	171	ND	ND	2035	ND	ND	229	45.3	13.1
6/18/04	CT-P2 storm	107	ND	ND	1579	ND	ND	89	24.6	8.2
6/21/04	CT-P2 storm	103	ND	ND	1308	ND	ND	ND	40.2	9.0
6/30/04	CT-P2 storm	158	19	5	1193	736	330	7	44.8	12.2
8/6/04	CT-P2 storm	178	53	42	1540	1065	543	57	43.6	8.6
8/11/04	CT-P2 storm	167	45	32	1437	1012	461	110	52.2	11.1
8/19/04	CT-P2 storm	487	157	139	2298	1041	411	97	214.0	30.0

"ND" denotes "No Data"

SC-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
1/20/04	SC-3	75	60	51	2358	2289	2200	22	23.0	4.6
2/24/04	SC-3	199	152	143	1909	1745	460	737	6.7	4.7
3/30/04	SC-3	119	99	89	565	490	79	45	11.8	<4.0
4/21/04	SC-3	242	205	192	564	484	201	26	19.8	<4.0
5/19/04	SC-3	313	286	268	459	400	30	22	14.0	<4.0
6/9/04	SC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/7/04	SC-3	299	264	261	770	689	59	55	10.6	5.2
8/4/04	SC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/1/04	SC-3	158	145	120	372	345	77	8	7.4	<4.0
10/20/04	SC-3	95	74	69	419	345	92	6	7.8	<4.0
11/16/04	SC-3	59	51	47	922	867	649	20	<4.0	<4.0
12/15/04	SC-4	168	41*	42*	1935	1511	1412	9	125.3	12.2
6/17/04	SC-3 storm	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/18/04	SC-3 storm	241	ND	ND	1659	ND	ND	142	13.2	6.6
6/21/04	SC-3 storm	212	ND	ND	625	ND	ND	ND	13.2	<4.0
6/30/04	SC-3 storm	225	118	97	1029	722	372	3	13.8	5.6
8/6/04	SC-3 storm	143	114	103	1044	907	552	9	16.4	4.8
8/11/04	SC-3 storm	203	129	115	877	768	337	13	16.2	6.2
8/19/04	SC-3 storm	147	116	90	811	598	317	14	17.2	<4.0

"ND" denotes "No Data"

Rain Gauge C&A Water Chemisty Data

	Analytical Detection Limits	2	2	3	4	4	5	3
Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L
6/18/04	Rain Gauge	26	ND	ND	1584	ND	ND	1241
6/21/04	Rain Gauge	31	ND	ND	1012	ND	ND	ND
8/6/04	Rain Gauge	ND	ND	ND	ND	ND	ND	ND
8/11/04	Rain Gauge	74	24	13	2102	1916	519	1278
8/19/04	Rain Gauge	28	9	5	1695	291	112	150

"ND" denotes "No Data"

APPENDIX D

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 D-1). Water levels (stage) were monitored using ISCO Model 4220 and 6700 flowmeters. 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). In 2004, six measurements over a range of discharges were taken at Sites CC-10, CT-1, and CT-P1. Five measurements were taken at Site CT-P2, four measurements were taken at Site SC-3, and one measurement was taken at Site CT-2.

Flows were monitored daily on Cottonwood Creek, Shop Creek, and Cherry Creek with some dates estimated due to icing, flooding, or flowmeter malfunctions. Stage relationships were developed with nearby sites to derive flow estimates. Additionally, precipitation events and average flow of recorded data were considered in determining flow estimates.

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 2004 (Appendix C). Since 1999, 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 D-2). Regressions using data from previous reports (ASI 1994a, Chadwick Ecological Consultants, Inc. 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003), combined with data from 2004, were developed to predict phosphorus concentrations from flow measurements for 2004 load calculations. Stage discharge equations obtained from Jim Wulliman with Muller Engineering were used to calculate flows at Site CT-P2 and Site CT-2 (unpublished data, 2004). Note that for some sites, there is no significant relationship between flow values and phosphorus concentrations (e.g., the Cherry Creek mainstem inflow, reservoir outflow, and Site SC-3). In those cases, the phosphorus concentrations for load calculations were based on the mean value from the current year.

TABLE D-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 = $H^{2.25}$ 3.+0.5	0.78
SC-3	Q = $H^{2.66}$×0.79+0.16	0.70
CT-P1	Q = $H^{3.77}$×8.15	0.69
CT-P2	Q = ((3.3)*(1)*(Avg. Level)^(1.5)) (stage 00.0-0.59)	
	Q = ((0.60)*(0.50)*((2*32.2*(Height to Centroid))^(0.5)) (stage 0.61-1.09)	
	Q = ((0.60)*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+(3.3)(1)(Avg. Level)^(1.5)*(Avg. Level-1.0) (stage 1.10-1.99)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((3.33)*(1)*(Avg. Level-2.0)^(1.5)) (stage 2.00-2.59)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(Height to Centroid-2.0)^(1.5)) (stage 2.60-2.99)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(Height to Centroid-2.0)^(0.5))+((3.3)*(1)*(Avg. Level-3.0)^(1.5)) (stage 3.0-3.59)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(Height to Centroid-2.0)^(0.5))+((0.60)*(0.50)*(2*32.2*(Height to Centroid-3.0^(0.5)) (stage 3.6-3.99)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(Height to Centroid-2.0)^(0.5))+((0.60)*(0.50)*(2*32.2*(Height to Centroid-3.0^(0.5))+((3.3)(1)(Avg. Level-4.0))^1.5)) (stage 4.00-4.49)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(Height to Centroid-2.0)^(0.5))+((0.60)*(0.50)*(2*32.2*(Height to Centroid-3.0^(0.5)) (stage 4.5-5.19)	
	((0.60*(0.50)*((2*32.2*(Height to Centroid))^(0.5))+((0.60)*((2*32.2*(Height to Centroid-1.0))^(0.5))+((0.60)*(0.50)*(2*32.2*Height to Centroid-4.0)^(0.5))+((0.60)*(0.50)*(2*32.2*(2*32.2*Height to Centroid-4.0^(0.5))+((3.3)(1)(Avg. Level-5.2)^(1.5)) (stage 5.20-6.80)	
CT-1	Q = $H^{3.5}$×0.55-0.62	0.71
CT-2	Q = $H^{2.37}$×0.94-4.6 (prior to 8/10)	0.99
	3.3×2×$H^{1.5}$ (stage 0.950-1.349 after 8/9)	
	(7.2+3.3×2×$H^{1.5}$)+(3.3×2×(H - 1.0)$^{1.5}$+(3.3×2×(H-0.50)$^{1.5}$ (stage 1.350 and up after 8/9)	

TABLE D-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 2004.

Site	Equation	R^2
CC-O	P_{con} (mg/L) = 0.120	--
CC-10	P_{con} (mg/L) = 0.308	--
SC-3	P_{con} (mg/L) = 0.181	--
CT-P1	P_{con} (mg/L) = 0.0188 × Q + 0.0348	0.75
CT-P2	P_{con} (mg/L) = 0.0082 × Q + 0.0517	0.53
CT-1	P_{con} (mg/L) = 0.0025 × Q + 0.1208	0.68
CT-2	P_{con} (mg/L) = 0.0104 × Q + 0.661	0.72
Alluvium	P_{con} (mg/L) = 0.215	--

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 2004 to obtain total annual phosphorus loading.

EQUATION 1:

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

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 D-2)

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

Phosphorus Loading from Precipitation

Precipitation data collected at the Cherry Creek dam by the U.S. Army Corps of Engineers (COE) were used in the past to estimate phosphorus loading into the reservoir due to precipitation; however, COE reported invalid values for June and July 2004. Precipitation data collected at Denver/Centennial Airport (KAPA) was used to estimate phosphorus loading due to precipitation in 2004, based on the assumption that precipitation generally fell evenly across the reservoir (Appendix D), 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 2004 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 2004. 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 0.120 mg/L in 2004 (Table D-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 2004, COE inflows were calculated at 17,777 AF, while CEC calculated inflows at 12,092 AF from streams and 1,439 AF from precipitation (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). Beginning 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 3,646 AF in 2004. Calculation of alluvial phosphorus loading into Cherry Creek Reservoir was based on the mean alluvial phosphorus concentration for 2004 (0.220 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.

2004

	Total In Af CEC	Total In Af COE
January	332.28	493.00
February	343.33	741.00
March	613.48	980.00
April	1142.26	2000.00
May	767.65	1323.00
June	540.15	651.00
July	483.47	917.00
August	2858.42	4447.00
September	663.13	867.00
October	1251.96	1546.00
November	1584.53	1622.00
December	1511.36	1590.00
Total	12092.01	17177.00

CC-10

	Af CEC	P lbs CEC
January	142.34	119.45
February	182.22	152.92
March	465.31	390.48
April	768.52	644.92
May	536.27	450.03
June	301.70	253.18
July	318.77	267.51
August	1686.19	2014.77
September	431.18	361.83
October	966.79	811.31
November	1264.79	1061.38
December	1264.01	1060.73
	8328.10	7588.50

CT-2

	Af CEC	P lbs CEC
January	189.94	51.50
February	161.11	40.65
March	148.16	37.63
April	373.74	162.24
May	231.38	79.98
June	238.44	89.58
July	164.70	44.15
August	1172.22	1720.61
September	231.95	74.58
October	285.17	100.96
November	319.74	117.00
December	247.35	72.85
	3763.91	2591.73

SC-3

	Af CEC	P lbs CEC
January	25.70	12.67
February	28.89	14.25
March	28.82	14.21
April	58.22	28.71
May	28.77	14.19
June	24.31	11.99
July	13.10	6.46
August	219.27	92.45
September	4.19	2.07
October	10.13	4.99
November	6.10	3.01
December	9.41	4.64
	456.91	209.64

	Precip (af)	Outflow (af)
January	20.59	397.98
February	93.01	910.8
March	18.46	633.6
April	217.97	1677.06
May	99.40	1168.2
June	149.81	241.56
July	87.33	669.24
August	379.14	4205.52
September	85.20	304.92
October	157.62	1441.44
November	85.20	1548.36
December	45.44	1314.72
	1439.17	14513.40

	Precip (lbs)	Outflow (lbs)
January	2.25	130.12
February	10.14	297.79
March	2.01	207.16
April	23.77	548.32
May	10.84	381.95
June	16.34	78.98
July	9.52	218.81
August	33.92	1441.64
September	9.29	99.69
October	17.19	471.28
November	9.29	506.24
December	4.96	429.85
	149.53	4811.82

	Alluvium (af)	Alluvium (lbs)
2004 Total	3645.82	2181.29

CT-1	Af CEC	P lbs CEC	**CT-P1**	Af CEC	P lbs CEC	**CT-P2**	Af CEC	P lbs CEC
January	136.72	47.22	January	37.29	4.50	January	32.32	4.78
February	118.86	40.88	February	72.31	10.78	February	29.93	4.49
March	114.83	39.29	March	63.39	9.50	March	18.67	2.80
April	387.43	154.82	April	478.27	672.00	April	487.56	228.98
May	258.57	97.62	May	96.92	32.93	May	114.43	35.11
June	299.54	121.95	June	208.67	210.80	June	160.46	52.21
July	177.14	62.13	July	70.94	12.14	July	78.33	14.38
August	1348.32	2384.90	August	642.73	1258.90	August	995.80	998.91
September	225.77	81.14	September	108.18	34.15	September	153.87	49.04
October	353.08	144.61	October	244.86	326.08	October	212.33	85.10
November	227.27	81.68	November	64.26	10.40	November	88.20	16.01
December	219.94	77.83	December	57.77	8.26	December	73.56	7.29
	3867.46	3334.07		2145.58	2590.44		2445.46	1499.10

2004
Cherry Creek 10
Average Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.32	2.27	8.16	3.94	25.43	3.70	12.61	3.56	7.17	13.86	25.59	20.41
2	2.32	2.28	7.44	3.96	17.90	3.52	5.84	3.17	6.57	12.68	24.03	19.85
3	2.32	2.23	7.34	15.32	14.06	3.39	4.99	2.94	6.17	10.70	21.99	19.95
4	2.32	2.27	7.64	8.64	12.43	3.31	4.67	3.20	7.33	10.06	21.35	20.74
5	2.32	2.30	8.92	6.03	11.07	3.23	4.39	5.64	13.64	10.33	20.24	22.43
6	2.32	2.27	8.99	4.99	10.14	3.09	4.15	115.39	8.21	32.76	19.61	21.59
7	2.32	2.28	8.55	4.71	8.46	2.97	3.88	51.02	6.31	22.86	19.29	20.43
8	2.32	2.35	8.71	9.06	6.94	2.96	3.71	22.64	5.39	15.04	19.46	20.54
9	2.32	2.28	8.97	16.31	6.05	3.04	3.62	14.14	5.24	13.69	19.64	20.82
10	2.35	2.24	9.51	20.64	5.25	2.96	3.75	10.80	5.53	12.99	22.09	19.18
11	2.37	2.26	9.14	17.27	4.71	2.90	3.42	14.56	5.51	12.53	24.83	20.37
12	2.37	2.26	9.11	17.54	7.13	2.91	3.21	10.26	5.47	12.78	22.25	19.99
13	2.38	2.23	9.79	13.56	24.35	2.85	3.08	7.88	5.51	30.27	21.39	19.25
14	2.35	2.21	9.71	12.07	11.52	2.75	3.06	6.74	5.77	24.70	21.01	19.23
15	2.35	2.21	9.66	10.37	7.84	2.77	3.11	5.56	5.18	18.82	21.15	19.46
16	2.34	2.19	9.73	8.88	6.57	3.25	3.95	4.53	5.07	16.65	21.85	19.72
17	2.32	2.18	10.09	7.85	5.76	4.11	4.75	3.96	4.88	15.75	21.65	20.76
18	2.30	2.25	9.72	7.21	5.35	6.12	4.33	10.85	4.38	15.01	20.90	20.56
19	2.28	2.40	8.79	6.48	6.39	11.41	3.72	199.95	4.39	14.14	20.91	20.60
20	2.30	2.84	7.62	6.14	6.90	5.09	3.51	97.56	4.26	12.90	21.95	21.19
21	2.32	3.67	6.97	6.42	7.42	9.21	3.28	55.13	8.34	13.26	22.27	21.63
22	2.28	3.51	6.68	8.34	7.42	20.78	3.24	38.42	17.10	13.98	21.69	20.45
23	2.27	3.78	6.32	26.50	6.90	7.80	3.41	29.64	11.55	13.78	21.47	17.99
24	2.26	4.50	5.70	38.75	7.77	5.59	16.58	23.30	8.48	14.09	21.01	18.44
25	2.28	5.13	5.29	27.11	7.96	5.14	7.90	19.03	7.97	14.47	20.99	21.87
26	2.30	5.39	4.90	20.31	7.71	5.10	4.20	15.77	7.66	14.58	20.56	22.09
27	2.26	5.75	4.79	16.51	5.41	4.92	3.67	18.37	7.28	14.66	19.93	22.31
28	2.34	6.35	4.50	14.29	4.00	4.85	4.00	23.89	8.67	15.06	21.15	22.11
29	2.41	8.16	4.16	12.84	4.03	4.52	14.25	14.44	8.03	15.13	20.02	21.87
30	2.32		4.05	16.07	4.13	8.13	8.15	10.49	10.72	14.87	18.53	21.79
31	2.32		4.07		3.83		4.57	8.78		15.87		20.80
Total	71.89	92.03	235.01	388.14	270.84	152.38	161.00	851.61	217.77	488.28	638.78	638.39
Max	2.41	8.16	10.09	38.75	25.43	20.78	16.58	199.95	17.10	32.76	25.59	22.43
Min	2.26	2.18	4.05	3.94	3.83	2.75	3.06	2.94	4.26	10.06	18.53	17.99
Ac-ft	142.34	182.22	465.31	768.52	536.27	301.70	318.77	1686.19	431.18	966.79	1264.79	1264.01

2004
Cherry Creek 10
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	3.85	3.77	13.56	6.55	42.26	6.15	20.95	5.92	11.91	23.02	42.52	33.91
2	3.85	3.78	12.37	6.57	29.73	5.85	9.70	5.27	10.92	21.07	39.93	32.99
3	3.85	3.71	12.19	25.46	23.36	5.64	8.29	4.89	10.25	17.79	36.53	33.15
4	3.85	3.77	12.69	14.35	20.65	5.50	7.75	5.31	12.17	16.72	35.47	34.46
5	3.85	3.82	14.82	10.01	18.39	5.37	7.30	9.37	22.66	17.17	33.62	37.27
6	3.85	3.77	14.94	8.29	16.85	5.13	6.89	191.74	13.64	54.44	32.58	35.87
7	3.85	3.78	14.21	7.83	14.06	4.94	6.45	84.78	10.48	37.99	32.05	33.94
8	3.85	3.90	14.47	15.06	11.53	4.92	6.16	37.61	8.96	25.00	32.33	34.14
9	3.85	3.78	14.90	27.10	10.05	5.04	6.02	23.49	8.71	22.74	32.64	34.59
10	3.91	3.72	15.80	34.30	8.73	4.91	6.23	17.94	9.19	21.58	36.70	31.86
11	3.94	3.75	15.18	28.70	7.82	4.81	5.68	24.20	9.16	20.82	41.25	33.85
12	3.93	3.75	15.14	29.14	11.86	4.84	5.34	17.04	9.08	21.24	36.97	33.21
13	3.95	3.71	16.27	22.54	40.47	4.73	5.12	13.09	9.16	50.29	35.54	31.99
14	3.90	3.66	16.13	20.06	19.14	4.57	5.09	11.20	9.59	41.04	34.91	31.95
15	3.90	3.67	16.04	17.24	13.02	4.61	5.17	9.25	8.60	31.28	35.14	32.33
16	3.88	3.63	16.17	14.76	10.92	5.40	6.56	7.52	8.43	27.66	36.30	32.77
17	3.86	3.62	16.76	13.04	9.58	6.83	7.90	6.57	8.11	26.17	35.97	34.49
18	3.82	3.74	16.15	11.98	8.89	10.17	7.20	18.03	7.28	24.94	34.72	34.17
19	3.79	3.99	14.60	10.77	10.62	18.96	6.18	931.99	7.29	23.49	34.75	34.23
20	3.81	4.71	12.66	10.20	11.46	8.46	5.83	162.11	7.07	21.44	36.47	35.21
21	3.86	6.10	11.58	10.67	12.33	15.30	5.45	91.61	13.87	22.03	37.00	35.93
22	3.79	5.84	11.10	13.87	12.33	34.52	5.38	63.84	28.41	23.23	36.03	33.98
23	3.77	6.29	10.51	44.03	11.46	12.97	5.66	49.26	19.19	22.89	35.67	29.88
24	3.76	7.49	9.47	64.39	12.91	9.29	27.55	38.71	14.10	23.41	34.91	30.64
25	3.79	8.53	8.79	45.04	13.22	8.54	13.13	31.61	13.24	24.04	34.88	36.33
26	3.82	8.96	8.13	33.75	12.82	8.47	6.98	26.20	12.73	24.22	34.17	36.70
27	3.75	9.55	7.95	27.44	8.99	8.18	6.10	30.51	12.10	24.36	33.11	37.07
28	3.88	10.56	7.47	23.75	6.65	8.06	6.65	39.69	14.41	25.03	35.14	36.74
29	4.00	13.56	6.91	21.34	6.70	7.51	23.67	23.99	13.34	25.13	33.27	36.33
30	3.86	0.00	6.73	26.70	6.87	13.51	13.54	17.43	17.81	24.70	30.79	36.20
31	3.85	0.00	6.77	0.00	6.37	0.00	7.59	14.58	0.00	26.37	0.00	34.56
Total	119.45	152.92	390.48	644.92	450.03	253.18	267.51	2014.77	361.83	811.31	1061.38	1060.73
Mean	3.85	4.93	12.60	20.80	14.52	8.17	8.63	64.99	11.67	26.17	34.24	34.22
Max	4.00	13.56	16.76	64.39	42.26	34.52	27.55	931.99	28.41	54.44	42.52	37.27
Min	3.75	0.00	6.73	0.00	6.37	0.00	5.09	4.89	0.00	16.72	0.00	29.88

2004
Cherry Creek Outflow
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	11	22	20	35	19	11	11	11	15	19	20
2	0	11	22	20	35	90	11	11	11	15	19	20
3	0	11	22	34	35	0	11	11	9	15	19	20
4	0	11	22	34	35	0	11	11	0	15	19	20
5	0	11	22	34	34	0	11	11	0	15	19	20
6	0	11	22	20	34	0	11	11	0	16	19	20
7	0	11	22	16	34	0	11	11	0	24	19	20
8	0	11	22	0	34	0	11	11	0	24	21	20
9	0	11	22	6	34	0	11	11	0	24	31	20
10	0	11	22	60	34	0	11	22	0	24	31	20
11	0	11	21	60	26	0	11	34	0	24	31	20
12	0	7	21	60	11	0	11	34	0	24	31	20
13	4	4	21	60	11	0	11	40	0	24	31	20
14	11	22	21	56	11	0	11	51	0	26	31	20
15	11	22	13	34	11	0	11	51	0	35	31	20
16	11	22	0	32	11	0	11	51	0	35	31	21
17	11	22	0	27	11	0	11	51	0	35	31	21
18	11	22	0	27	11	0	11	50	0	35	31	21
19	11	17	0	24	11	0	11	52	0	35	31	21
20	11	7	0	11	11	0	11	84	0	35	30	21
21	11	22	0	11	11	0	11	151	0	35	30	21
22	11	22	0	11	11	0	11	151	0	27	30	22
23	11	22	0	11	11	0	10	150	6	19	30	24
24	11	22	0	11	11	0	10	149	27	19	30	24
25	11	22	0	11	11	0	11	149	15	19	30	24
26	11	21	0	17	11	0	11	149	15	19	27	24
27	11	21	0	35	11	0	11	148	15	19	20	24
28	11	21	0	35	11	0	10	148	15	19	20	24
29	11	21	0	35	11	2	11	148	15	19	20	24
30	10		0	35	11	11	11	121	15	19	20	24
31	11		3		11		11	41		19		24
Total	201	460	320	847	590	122	338	2124	154	728	782	664
Mean	6.48	15.86	10.32	28.23	19.03	4.07	10.90	68.52	5.13	23.48	26.07	21.42
Max	11	22	22	60	35	90	11	151	27	35	31	24
Min	0	4	0	0	11	0	10	11	0	15	19	20
Ac-ft	397.98	910.80	633.60	1677.06	1168.20	241.56	669.24	4205.52	304.92	1441.44	1548.36	1314.72

2004
Cherry Creek Outflow
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	7.12	14.24	12.95	22.66	12.30	7.12	7.12	7.12	9.71	12.30	12.95
2	0.00	7.12	14.24	12.95	22.66	58.26	7.12	7.12	7.12	9.71	12.30	12.95
3	0.00	7.12	14.24	22.01	22.66	0.00	7.12	7.12	5.83	9.71	12.30	12.95
4	0.00	7.12	14.24	22.01	22.66	0.00	7.12	7.12	0.00	9.71	12.30	12.95
5	0.00	7.12	14.24	22.01	22.01	0.00	7.12	7.12	0.00	9.71	12.30	12.95
6	0.00	7.12	14.24	12.95	22.01	0.00	7.12	7.12	0.00	10.36	12.30	12.95
7	0.00	7.12	14.24	10.36	22.01	0.00	7.12	7.12	0.00	15.54	12.30	12.95
8	0.00	7.12	14.24	0.00	22.01	0.00	7.12	7.12	0.00	15.54	13.59	12.95
9	0.00	7.12	14.24	3.88	22.01	0.00	7.12	7.12	0.00	15.54	20.07	12.95
10	0.00	7.12	14.24	38.84	22.01	0.00	7.12	14.24	0.00	15.54	20.07	12.95
11	0.00	7.12	13.59	38.84	16.83	0.00	7.12	22.01	0.00	15.54	20.07	12.95
12	0.00	4.53	13.59	38.84	7.12	0.00	7.12	22.01	0.00	15.54	20.07	12.95
13	2.59	2.59	13.59	38.84	7.12	0.00	7.12	25.89	0.00	15.54	20.07	12.95
14	7.12	14.24	13.59	36.25	7.12	0.00	7.12	33.02	0.00	16.83	20.07	12.95
15	7.12	14.24	8.42	22.01	7.12	0.00	7.12	33.02	0.00	22.66	20.07	12.95
16	7.12	14.24	0.00	20.72	7.12	0.00	7.12	33.02	0.00	22.66	20.07	13.59
17	7.12	14.24	0.00	17.48	7.12	0.00	7.12	33.02	0.00	22.66	20.07	13.59
18	7.12	14.24	0.00	17.48	7.12	0.00	7.12	32.37	0.00	22.66	20.07	13.59
19	7.12	11.01	0.00	15.54	7.12	0.00	7.12	69.29	0.00	22.66	20.07	13.59
20	7.12	4.53	0.00	7.12	7.12	0.00	7.12	111.93	0.00	22.66	19.42	13.59
21	7.12	14.24	0.00	7.12	7.12	0.00	7.12	97.75	0.00	22.66	19.42	13.59
22	7.12	14.24	0.00	7.12	7.12	0.00	7.12	97.75	0.00	17.48	19.42	14.24
23	7.12	14.24	0.00	7.12	7.12	0.00	6.47	97.10	3.88	12.30	19.42	15.54
24	7.12	14.24	0.00	7.12	7.12	0.00	6.47	96.46	17.48	12.30	19.42	15.54
25	7.12	14.24	0.00	7.12	7.12	0.00	7.12	96.46	9.71	12.30	19.42	15.54
26	7.12	13.59	0.00	11.01	7.12	0.00	7.12	96.46	9.71	12.30	17.48	15.54
27	7.12	13.59	0.00	22.66	7.12	0.00	7.12	95.81	9.71	12.30	12.95	15.54
28	7.12	13.59	0.00	22.66	7.12	0.00	6.47	95.81	9.71	12.30	12.95	15.54
29	7.12	13.59	0.00	22.66	7.12	1.29	7.12	95.81	9.71	12.30	12.95	15.54
30	6.47	0.00	0.00	22.66	7.12	7.12	7.12	78.33	9.71	12.30	12.95	15.54
31	7.12	0.00	1.94	0.00	7.12	0.00	7.12	0.00	0.00	12.30	0.00	15.54
Total	130.12	297.79	207.16	548.32	381.95	78.98	218.81	1441.64	99.69	471.28	506.24	429.85
Mean	4.20	9.61	6.68	17.69	12.32	2.55	7.06	46.50	3.22	15.20	16.33	13.87
Max	7.12	14.24	14.24	38.84	22.66	58.26	7.12	111.93	17.48	22.66	20.07	15.54
Min	0.00	0.00	0.00	0.00	7.12	0.00	6.47	0.00	0.00	9.71	0.00	12.95

2004
Cottonwood Creek 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.53	1.98	2.54	1.80	14.97	2.47	4.64	2.20	4.77	5.95	10.94	3.63
2	2.53	2.03	2.22	1.85	6.16	2.47	2.99	2.22	2.92	4.31	6.76	3.24
3	2.53	1.52	2.04	14.47	4.77	2.43	2.66	2.24	2.64	2.49	4.34	3.16
4	2.53	1.53	1.98	5.56	3.68	2.25	2.44	3.21	2.49	2.93	4.11	3.22
5	3.81	1.47	2.55	3.95	3.28	2.17	2.37	13.90	2.92	3.53	3.85	3.39
6	4.17	1.44	2.34	3.59	3.05	2.08	2.47	12.82	3.06	30.33	3.35	3.41
7	2.59	1.48	1.97	3.01	2.90	2.02	2.41	5.21	3.16	10.35	3.09	3.28
8	2.59	1.54	1.98	5.13	2.55	1.96	2.25	3.25	3.30	5.62	3.07	3.26
9	2.44	1.64	2.00	5.77	2.90	1.92	2.39	3.05	3.56	4.79	3.04	3.26
10	2.24	1.80	1.96	15.07	3.01	1.83	3.36	3.64	3.61	4.53	3.93	3.36
11	2.24	2.04	1.99	7.32	3.85	1.70	2.17	18.13	3.56	4.55	5.09	3.35
12	2.19	2.53	1.94	11.70	4.30	1.66	2.03	4.75	4.03	4.49	3.33	3.29
13	1.55	1.95	1.92	6.12	18.35	1.61	2.06	3.32	4.45	23.86	2.92	3.32
14	1.87	1.86	1.83	5.79	7.39	1.65	1.87	2.97	4.66	8.87	2.73	3.39
15	1.79	1.86	1.76	4.73	4.77	1.71	1.99	2.69	4.05	5.29	2.75	3.38
16	1.51	1.94	1.74	3.01	3.05	2.36	2.53	2.68	3.53	4.77	2.89	3.89
17	1.64	2.16	1.71	3.33	4.03	10.22	4.51	2.72	3.47	4.57	2.99	3.84
18	1.69	2.20	1.72	2.29	4.12	26.04	5.42	16.73	3.10	4.48	3.19	3.41
19	1.74	2.54	1.74	2.96	2.95	17.54	2.80	290.38	3.37	4.41	3.37	3.22
20	1.76	3.57	1.61	2.48	2.96	4.83	2.63	213.98	3.50	3.76	4.14	3.18
21	2.44	2.77	1.60	2.40	2.55	15.84	2.55	12.97	7.24	3.03	4.34	3.33
22	2.43	2.41	1.69	3.39	2.29	12.59	2.24	6.76	9.42	3.07	3.63	3.73
23	1.88	2.61	1.70	21.98	2.17	4.33	2.58	6.16	3.41	3.08	3.72	4.25
24	1.86	2.34	1.72	19.13	2.55	3.34	4.63	5.60	2.44	3.01	3.63	5.23
25	1.81	2.01	1.66	9.19	2.36	3.09	2.82	5.18	2.39	3.19	3.27	3.79
26	1.87	2.10	1.63	6.97	2.22	4.29	2.38	4.53	2.56	3.21	3.11	3.97
27	1.72	2.05	1.61	5.35	2.49	3.19	2.80	7.92	2.34	3.23	3.07	4.14
28	1.90	2.01	1.60	5.19	2.36	3.39	3.18	10.21	7.27	3.22	3.21	4.07
29	2.61	2.66	1.71	5.39	3.20	2.93	4.84	4.13	2.90	3.16	3.37	3.80
30	2.37		1.70	6.76	2.76	7.36	2.91	3.65	3.91	3.01	3.55	3.72
31	2.22		1.81		2.56		2.54	3.76		3.19		3.58
Total	69.05	60.03	58.00	195.67	130.59	151.28	89.47	680.97	114.02	178.32	114.78	111.08
Max	4.17	3.57	2.55	21.98	18.35	26.04	5.42	290.38	9.42	30.33	10.94	5.23
Min	1.51	1.44	1.60	1.80	2.17	1.61	1.87	2.20	2.34	2.49	2.73	3.16
Ac-ft	136.72	118.86	114.83	387.43	258.57	299.54	177.14	1348.32	225.77	353.08	227.27	219.94

2004
Cottonwood Creek 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	1.74	1.34	1.74	1.22	12.78	1.69	3.31	1.50	3.42	4.35	8.74	2.55
2	1.74	1.38	1.52	1.25	4.53	1.69	2.07	1.51	2.02	3.06	5.02	2.25
3	1.73	1.02	1.38	12.25	3.42	1.66	1.83	1.53	1.82	1.70	3.09	2.19
4	1.73	1.03	1.34	4.04	2.58	1.54	1.67	2.23	1.70	2.03	2.90	2.24
5	2.68	0.99	1.75	2.78	2.28	1.48	1.62	11.67	2.02	2.47	2.71	2.36
6	2.95	0.97	1.60	2.51	2.11	1.41	1.69	10.57	2.12	32.18	2.33	2.38
7	1.78	0.99	1.34	2.09	2.01	1.37	1.65	3.76	2.20	8.19	2.14	2.28
8	1.78	1.04	1.34	3.70	1.75	1.33	1.54	2.26	2.29	4.09	2.12	2.26
9	1.67	1.10	1.36	4.21	2.01	1.30	1.64	2.11	2.49	3.43	2.10	2.26
10	1.52	1.22	1.33	12.89	2.09	1.24	2.34	2.55	2.53	3.23	2.77	2.34
11	1.52	1.38	1.35	5.49	2.71	1.15	1.48	16.25	2.49	3.25	3.66	2.33
12	1.49	1.73	1.32	9.47	3.05	1.12	1.38	3.40	2.84	3.20	2.32	2.29
13	1.05	1.32	1.30	4.49	16.50	1.08	1.40	2.31	3.16	23.23	2.02	2.31
14	1.27	1.26	1.24	4.23	5.56	1.11	1.27	2.05	3.33	6.84	1.88	2.36
15	1.21	1.26	1.19	3.39	3.42	1.16	1.35	1.85	2.86	3.83	1.89	2.36
16	1.01	1.32	1.18	2.08	2.11	1.61	1.73	1.85	2.47	3.42	2.00	2.74
17	1.10	1.47	1.15	2.32	2.84	8.07	3.22	1.87	2.42	3.26	2.07	2.70
18	1.14	1.50	1.16	1.56	2.91	26.12	3.93	14.68	2.15	3.19	2.21	2.38
19	1.17	1.74	1.17	2.05	2.04	15.58	1.93	1293.94	2.35	3.14	2.35	2.24
20	1.19	2.50	1.09	1.70	2.05	3.46	1.81	953.51	2.45	2.64	2.93	2.21
21	1.67	1.91	1.08	1.64	1.75	13.71	1.75	10.72	5.42	2.10	3.09	2.32
22	1.66	1.65	1.14	2.36	1.56	10.34	1.53	5.02	7.34	2.13	2.55	2.62
23	1.28	1.80	1.15	20.83	1.48	3.07	1.77	4.53	2.38	2.14	2.61	3.02
24	1.26	1.60	1.16	17.40	1.75	2.33	3.30	4.07	1.67	2.09	2.54	3.78
25	1.22	1.37	1.12	7.13	1.61	2.14	1.94	3.74	1.63	2.22	2.28	2.67
26	1.26	1.43	1.10	5.20	1.52	3.04	1.63	3.23	1.76	2.23	2.16	2.80
27	1.16	1.39	1.08	3.87	1.71	2.21	1.93	6.00	1.60	2.25	2.13	2.93
28	1.29	1.36	1.08	3.74	1.61	2.36	2.21	8.06	5.45	2.24	2.23	2.88
29	1.79	1.83	1.16	3.90	2.22	2.03	3.47	2.92	2.01	2.19	2.35	2.67
30	1.62		1.15	5.02	1.90	5.52	2.01	2.56	2.76	2.09	2.48	2.61
31	1.52		1.22		1.76		1.74	2.64		2.22		2.51
Total	47.22	40.88	39.29	154.82	97.62	121.95	62.13	2384.90	81.14	144.61	81.68	77.83
Mean	1.52	1.41	1.27	5.16	3.15	4.06	2.00	76.93	2.70	4.66	2.72	2.51
Max	2.95	2.50	1.75	20.83	16.50	26.12	3.93	1293.94	7.34	32.18	8.74	3.78
Min	1.01	0.97	1.08	1.22	1.48	1.08	1.27	1.50	1.60	1.70	1.88	2.19

2004
Cottonwood Creek 2
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.54	3.05	3.92	1.82	8.98	2.06	5.83	1.96	3.73	4.16	14.20	4.10
2	3.49	3.19	3.41	1.84	9.04	1.99	2.70	1.49	4.77	3.87	15.06	4.32
3	3.49	1.91	2.96	13.09	4.40	1.93	2.27	1.49	4.23	3.54	5.02	3.97
4	3.57	1.99	3.72	10.04	3.38	1.79	2.17	1.17	3.83	3.46	4.86	3.92
5	3.42	1.94	3.66	5.47	2.94	1.66	1.89	1.82	3.75	3.47	4.77	3.98
6	3.51	1.86	3.18	3.79	2.63	1.59	1.90	8.92	3.92	14.81	4.64	4.00
7	3.71	1.91	3.15	2.70	2.53	1.55	1.82	4.45	3.59	4.55	4.34	4.19
8	3.64	2.02	3.17	7.12	2.37	1.56	2.17	2.52	3.58	3.34	4.15	4.07
9	3.54	2.14	3.15	10.76	2.44	1.45	2.81	2.03	3.61	3.22	4.02	4.07
10	3.44	2.41	3.12	13.77	2.38	1.36	2.81	5.40	3.50	3.25	5.26	4.02
11	3.42	3.00	2.44	6.37	2.65	1.19	2.31	14.13	3.42	3.26	5.64	3.97
12	3.36	2.87	2.34	12.85	4.01	1.16	2.10	16.98	3.34	3.36	5.45	3.75
13	2.48	2.86	2.17	5.74	12.45	1.02	1.82	3.80	3.26	14.30	4.99	4.07
14	2.48	2.64	2.09	3.74	11.74	1.14	1.82	3.02	3.11	4.72	4.86	4.07
15	2.54	2.64	1.96	3.63	5.34	1.24	1.88	2.88	2.95	4.03	4.77	4.01
16	1.74	2.64	1.95	3.58	3.23	5.13	3.56	2.74	2.98	4.07	4.72	4.16
17	2.10	3.06	2.13	2.74	3.52	8.91	4.78	2.75	3.07	4.03	4.68	4.31
18	2.13	3.07	2.03	2.17	4.42	15.10	4.87	2.90	3.08	4.08	4.72	4.45
19	2.31	3.34	1.98	2.59	2.65	6.32	2.78	252.00	3.11	4.12	4.80	4.14
20	2.32	4.56	1.97	2.89	2.73	3.45	2.24	187.44	3.22	4.16	5.17	4.07
21	2.96	4.24	1.82	3.03	1.94	11.32	2.03	10.50	4.29	4.24	5.45	4.03
22	4.20	3.36	1.73	4.82	1.81	9.66	1.99	5.71	14.61	4.30	5.26	4.02
23	2.96	3.40	1.99	15.02	1.78	6.65	1.82	3.91	3.22	4.30	4.99	3.79
24	2.86	3.37	1.91	14.56	1.63	4.37	3.61	3.58	3.11	4.23	4.72	3.41
25	2.83	2.59	1.96	10.09	2.69	4.24	2.52	3.73	3.08	4.18	4.55	3.76
26	2.97	2.63	1.88	6.59	2.41	5.30	2.17	3.65	3.07	4.27	4.03	3.98
27	2.84	2.68	1.82	5.14	2.23	3.65	1.82	3.73	3.14	4.21	4.17	4.01
28	2.74	2.61	1.76	3.86	2.32	4.04	1.82	16.03	5.17	4.13	3.87	3.92
29	4.05	3.42	1.82	3.22	2.10	3.49	4.87	14.04	3.14	4.21	4.18	4.20
30	3.72		1.82	5.73	2.06	6.10	3.48	3.69	4.29	4.09	4.14	4.12
31	3.54		1.81		2.06		2.52	3.56		4.07		4.03
Total	95.93	81.37	74.83	188.76	116.86	120.42	83.18	592.03	117.15	144.03	161.48	124.93
Max	4.20	4.56	3.92	15.02	12.45	15.10	5.83	252.00	14.61	14.81	15.06	4.45
Min	1.74	1.86	1.73	1.82	1.63	1.02	1.82	1.17	2.95	3.22	3.87	3.41
Ac-ft	189.94	161.11	148.16	373.74	231.38	238.44	164.70	1172.22	231.95	285.17	319.74	247.35

2004
Cottonwood Creek 2
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	1.96	1.61	2.26	0.84	7.73	0.97	3.98	0.91	2.11	2.45	16.38	2.40
2	1.93	1.71	1.87	0.84	7.80	0.93	1.37	0.66	2.97	2.22	18.11	2.59
3	1.93	0.88	1.55	14.28	2.66	0.89	1.10	0.66	2.51	1.96	3.20	2.30
4	1.99	0.93	2.11	9.23	1.84	0.82	1.04	0.49	2.19	1.90	3.05	2.26
5	1.88	0.90	2.06	3.63	1.54	0.74	0.88	0.84	2.13	1.92	2.97	2.31
6	1.95	0.86	1.70	2.16	1.33	0.71	0.88	7.65	2.26	17.60	2.87	2.32
7	2.09	0.88	1.68	1.37	1.26	0.69	0.84	2.70	2.00	2.78	2.60	2.48
8	2.04	0.95	1.69	5.39	1.16	0.69	1.04	1.26	1.99	1.82	2.45	2.38
9	1.97	1.02	1.68	10.33	1.21	0.64	1.45	0.95	2.02	1.73	2.34	2.38
10	1.89	1.18	1.66	15.54	1.17	0.59	1.45	3.56	1.93	1.75	3.43	2.34
11	1.88	1.57	1.20	4.55	1.34	0.51	1.12	16.24	1.87	1.76	3.79	2.30
12	1.83	1.49	1.14	13.84	2.33	0.49	1.00	22.24	1.82	1.83	3.61	2.13
13	1.23	1.48	1.04	3.89	13.14	0.42	0.84	2.16	1.76	16.57	3.18	2.38
14	1.23	1.33	0.99	2.12	11.91	0.48	0.84	1.59	1.65	2.94	3.05	2.38
15	1.27	1.33	0.91	2.03	3.50	0.53	0.87	1.49	1.54	2.35	2.97	2.33
16	0.79	1.33	0.91	2.00	1.74	3.31	1.98	1.40	1.56	2.38	2.94	2.45
17	1.00	1.61	1.02	1.40	1.95	7.63	2.99	1.41	1.62	2.35	2.90	2.58
18	1.01	1.62	0.95	1.04	2.67	18.17	3.06	1.51	1.63	2.39	2.94	2.70
19	1.13	1.81	0.93	1.30	1.34	4.50	1.42	910.84	1.65	2.42	3.01	2.44
20	1.13	2.79	0.92	1.50	1.39	1.90	1.08	677.49	1.73	2.45	3.35	2.38
21	1.55	2.52	0.84	1.59	0.90	11.23	0.95	9.93	2.56	2.52	3.61	2.35
22	2.49	1.83	0.78	3.03	0.83	8.68	0.93	3.87	17.18	2.57	3.43	2.34
23	1.55	1.86	0.93	18.01	0.81	4.85	0.84	2.25	1.73	2.57	3.18	2.16
24	1.48	1.84	0.88	17.08	0.73	2.63	2.02	1.99	1.65	2.51	2.94	1.87
25	1.46	1.30	0.91	9.31	1.36	2.52	1.26	2.11	1.63	2.47	2.78	2.13
26	1.55	1.33	0.87	4.79	1.18	3.46	1.04	2.05	1.62	2.55	2.35	2.31
27	1.47	1.36	0.83	3.32	1.07	2.05	0.84	2.11	1.68	2.50	2.46	2.33
28	1.40	1.31	0.80	2.21	1.13	2.36	0.84	20.13	3.35	2.43	2.22	2.26
29	2.36	1.88	0.84	1.73	1.00	1.93	3.06	16.06	1.68	2.50	2.47	2.49
30	2.11		0.84	3.88	0.97	4.26	1.92	2.08	2.56	2.40	2.44	2.42
31	1.97		0.83		0.97		1.26	1.98		2.38		2.35
Total	51.50	40.65	37.63	162.24	79.98	89.58	44.15	1720.61	74.58	100.96	117.00	72.85
Mean	1.66	1.45	1.21	5.41	2.58	2.99	1.42	55.50	2.49	3.26	3.90	2.35
Max	2.49	2.79	2.26	18.01	13.14	18.17	3.98	910.84	17.18	17.60	18.11	2.70
Min	0.79	0.86	0.78	0.84	0.73	0.42	0.84	0.49	1.54	1.73	2.22	1.87

2004
Cottonwood Creek Peoria 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.60	1.70	1.45	0.86	6.77	0.61	1.85	0.72	2.09	2.76	3.72	0.94
2	0.59	1.26	1.09	0.84	2.14	0.60	1.05	0.72	1.02	1.54	1.13	0.92
3	0.65	0.86	0.92	38.54	1.29	0.50	0.82	0.72	0.79	1.17	0.99	0.90
4	0.58	1.23	0.79	17.30	1.07	0.43	0.75	2.14	1.01	1.45	0.98	0.91
5	0.53	1.44	2.41	1.81	0.82	0.47	0.70	18.79	0.99	43.79	0.93	0.92
6	0.52	1.77	1.70	0.93	0.73	0.45	0.73	8.40	0.83	3.70	0.92	0.93
7	0.55	1.53	1.23	0.74	0.66	0.38	0.64	2.66	0.77	1.86	0.92	0.93
8	0.55	1.30	0.95	37.12	0.67	0.44	0.61	1.72	0.80	1.38	0.93	0.93
9	0.56	1.21	0.92	16.46	0.77	0.48	1.26	1.42	0.70	1.21	0.93	0.93
10	0.57	0.95	0.90	28.59	0.70	0.44	1.59	6.27	0.68	1.11	1.16	0.94
11	0.58	1.28	0.86	9.80	1.20	0.38	0.79	9.14	0.70	1.13	1.07	0.93
12	0.58	1.01	0.89	1.27	5.34	0.36	0.60	1.89	0.67	30.90	0.99	0.93
13	0.57	1.05	0.92	2.67	11.24	0.38	0.50	1.19	0.66	2.97	0.93	0.94
14	0.58	0.95	0.90	1.08	3.03	0.39	0.43	0.92	0.62	1.80	0.93	0.95
15	0.58	0.92	0.91	0.68	1.46	0.41	0.64	0.74	0.62	1.48	0.92	0.99
16	0.58	0.93	0.93	0.64	1.00	2.98	1.02	0.65	0.59	1.26	0.92	0.97
17	0.56	0.96	0.97	0.60	2.36	9.87	2.39	0.69	0.60	1.14	0.97	0.94
18	0.55	0.94	0.92	0.59	1.09	31.31	2.62	100.28	0.59	1.11	0.99	0.92
19	0.58	0.86	0.92	0.60	0.33	7.15	1.19	133.40	0.67	1.15	0.96	0.90
20	0.82	1.52	0.90	0.64	0.26	2.00	0.86	6.30	0.87	1.11	1.07	0.92
21	0.73	1.75	0.92	1.19	0.09	26.05	0.69	2.95	9.24	1.21	1.02	1.03
22	0.63	1.50	0.93	7.67	0.09	4.60	0.56	1.81	7.21	1.25	1.15	0.95
23	0.62	1.01	0.93	37.87	0.09	1.72	1.45	1.10	1.79	1.29	0.97	0.93
24	0.67	0.90	0.92	11.75	0.35	1.29	2.07	1.06	1.17	1.39	0.93	0.92
25	0.64	1.17	0.92	3.16	0.78	1.23	1.23	1.21	1.71	1.41	0.93	0.92
26	0.63	1.15	0.92	1.98	0.58	1.59	1.11	0.84	1.35	1.37	0.95	0.92
27	0.62	0.99	1.23	2.80	0.55	1.23	1.07	8.49	3.26	1.34	0.98	0.92
28	0.61	1.78	1.37	0.22	0.55	1.33	1.39	3.79	6.05	1.38	1.25	1.01
29	0.59	2.62	0.98	0.52	0.89	1.28	2.90	1.58	1.74	1.37	0.98	0.99
30	0.60		0.72	12.62	1.15	5.05	1.30	1.11	4.82	1.39	0.95	0.97
31	0.80		0.74		0.90		1.03	1.89		6.25		0.97
Total	18.84	36.52	32.02	241.55	48.95	105.39	35.83	324.61	54.64	123.67	32.45	29.18
Max	0.82	2.62	2.41	38.54	11.24	31.31	2.90	133.40	9.24	43.79	3.72	1.03
Min	0.52	0.86	0.72	0.22	0.09	0.36	0.43	0.65	0.59	1.11	0.92	0.90
Ac-ft	37.29	72.31	63.39	478.27	96.92	208.67	70.94	642.73	108.18	244.86	64.26	57.77

2004
Cottonwood Creek Peoria 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	mg/L A	Aug	Sept	Oct	Nov	Dec
1	0.15	0.61	0.49	0.23	5.92	0.15	0.70	0.05	0.19	0.84	1.29	2.10	0.27
2	0.15	0.40	0.32	0.23	0.86	0.15	0.31	0.05	0.19	0.30	0.53	0.34	0.26
3	0.16	0.23	0.26	157.87	0.41	0.12	0.22	0.05	0.19	0.21	0.36	0.29	0.25
4	0.14	0.38	0.21	33.61	0.32	0.10	0.20	0.07	0.86	0.29	0.49	0.28	0.25
5	0.13	0.48	1.04	0.67	0.22	0.11	0.18	0.39	39.33	0.29	202.66	0.26	0.26
6	0.13	0.65	0.61	0.26	0.19	0.11	0.19	0.19	8.73	0.23	2.08	0.26	0.26
7	0.13	0.53	0.38	0.20	0.17	0.08	0.16	0.08	1.22	0.20	0.70	0.26	0.26
8	0.14	0.42	0.27	146.68	0.17	0.10	0.15	0.07	0.62	0.22	0.45	0.26	0.26
9	0.14	0.38	0.26	30.57	0.20	0.11	0.40	0.06	0.47	0.18	0.38	0.26	0.26
10	0.14	0.27	0.25	88.26	0.18	0.10	0.55	0.15	5.17	0.18	0.34	0.35	0.27
11	0.14	0.41	0.23	11.57	0.37	0.08	0.21	0.21	10.20	0.18	0.34	0.32	0.26
12	0.14	0.29	0.25	0.40	3.90	0.08	0.15	0.07	0.72	0.17	102.61	0.29	0.26
13	0.14	0.31	0.26	1.23	14.92	0.09	0.12	0.06	0.37	0.17	1.45	0.26	0.27
14	0.14	0.27	0.25	0.32	1.50	0.09	0.10	0.05	0.26	0.16	0.67	0.26	0.27
15	0.14	0.26	0.25	0.18	0.49	0.09	0.16	0.05	0.19	0.16	0.50	0.26	0.28
16	0.14	0.26	0.26	0.16	0.29	1.46	0.30	0.05	0.17	0.15	0.40	0.26	0.28
17	0.14	0.27	0.28	0.15	1.01	11.73	1.03	0.05	0.18	0.15	0.35	0.28	0.27
18	0.14	0.27	0.26	0.15	0.33	105.28	1.19	0.93	501.50	0.15	0.33	0.28	0.26
19	0.14	0.23	0.26	0.15	0.07	6.53	0.37	0.93	667.10	0.17	0.35	0.27	0.25
20	0.22	0.52	0.25	0.16	0.06	0.78	0.24	0.15	5.21	0.24	0.34	0.32	0.26
21	0.19	0.64	0.26	0.37	0.02	73.71	0.18	0.09	1.44	10.40	0.38	0.30	0.30
22	0.16	0.51	0.26	7.40	0.02	3.00	0.14	0.07	0.67	6.63	0.39	0.35	0.27
23	0.16	0.29	0.26	152.56	0.02	0.62	0.49	0.06	0.33	0.66	0.41	0.28	0.26
24	0.17	0.25	0.26	16.22	0.08	0.41	0.82	0.05	0.31	0.36	0.46	0.26	0.26
25	0.16	0.36	0.26	1.61	0.21	0.39	0.39	0.06	0.38	0.62	0.47	0.26	0.26
26	0.16	0.35	0.26	0.77	0.14	0.55	0.33	0.05	0.23	0.44	0.45	0.27	0.26
27	0.16	0.29	0.38	1.32	0.14	0.38	0.32	0.19	8.91	1.69	0.44	0.28	0.26
28	0.15	0.66	0.45	0.05	0.14	0.43	0.45	0.11	2.16	4.85	0.45	0.39	0.29
29	0.15		0.28	0.13	0.25	0.41	1.39	0.06	0.55	0.63	0.45	0.28	0.29
30	0.15		0.19	18.52	0.35	3.54	0.42	0.06	0.34	3.26	0.45	0.27	0.28
31	0.21		0.20		0.25		0.30	0.07	0.72		5.13		0.28
Total	4.50	10.78	9.50	672.00	32.93	210.80	12.14		1258.90	34.15	326.08	10.40	8.26
Mean	4.56	10.16	9.21	671.76	27.26	210.65	0.39		40.61	1.14	10.52	0.35	0.27
Max	4.42	9.76	8.88	671.53	26.40	210.50	1.39		667.10	10.40	202.66	2.10	0.30
Min	8.75	20.31	18.12	1185.66	58.92	421.18	0.10		0.17	0.15	0.33	0.26	0.25

2004
Cottonwood Creek Peoria 2
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.70	0.53	0.56	0.01	13.83	0.67	2.21	0.91	7.21	3.23	3.93	1.55
2	0.68	0.44	0.54	0.55	2.18	0.62	1.12	0.88	1.63	1.58	1.76	1.46
3	0.74	0.42	0.51	19.80	1.63	0.44	0.73	1.13	1.00	1.11	1.01	1.16
4	0.67	0.61	0.48	13.87	1.24	0.27	0.65	2.01	2.28	1.17	1.01	1.04
5	0.55	0.80	0.60	5.66	0.68	0.31	0.62	21.51	1.46	20.37	1.00	1.20
6	0.48	0.56	0.50	3.62	0.52	0.31	0.67	7.49	1.14	15.57	0.96	1.51
7	0.62	0.43	0.45	3.90	0.50	0.23	0.58	13.36	1.11	5.53	0.93	1.48
8	0.62	0.42	0.45	8.27	0.49	0.26	0.47	3.70	1.03	1.67	1.00	1.30
9	0.64	0.41	0.44	12.38	0.50	0.31	1.13	2.71	0.77	1.11	1.10	1.26
10	0.64	0.41	0.45	19.95	0.49	0.31	1.87	7.11	0.65	0.56	3.95	1.24
11	0.57	0.58	0.46	19.13	0.50	0.23	0.76	10.29	0.57	0.54	1.90	1.11
12	0.17	0.57	0.47	19.93	2.60	0.22	0.57	2.82	0.54	0.52	1.52	1.11
13	0.71	0.48	0.51	16.19	13.12	0.22	0.46	1.49	0.53	20.10	1.53	1.13
14	0.96	0.43	0.30	8.30	1.47	0.23	0.40	1.18	0.63	7.25	1.14	1.11
15	0.41	0.42	0.25	5.07	0.95	0.25	0.81	1.02	0.65	2.57	1.07	1.11
16	0.41	0.41	0.20	0.98	0.55	2.45	1.15	0.95	0.58	1.53	1.12	1.11
17	0.41	0.41	0.21	1.14	0.53	8.64	3.62	2.14	18.19	1.18	1.19	1.75
18	0.41	0.41	0.21	1.11	6.47	15.22	3.91	12.96	0.75	1.13	1.16	1.58
19	0.41	0.42	0.12	1.30	1.71	11.39	1.47	290.67	0.70	1.08	1.55	1.21
20	0.48	0.73	0.14	1.15	0.75	3.35	0.91	14.98	0.87	1.13	1.15	1.00
21	0.57	0.76	0.17	1.97	0.15	8.68	0.68	7.75	10.94	1.10	2.65	0.97
22	0.49	0.57	0.32	2.02	0.12	8.94	0.56	2.71	3.25	1.08	1.71	0.91
23	0.46	0.56	0.30	18.18	0.11	2.13	1.48	1.57	1.46	1.07	1.63	1.02
24	0.42	0.54	0.08	19.98	0.31	1.44	2.75	1.50	1.23	1.07	1.48	1.00
25	0.41	0.50	0.04	18.37	0.94	1.28	1.38	1.18	0.87	1.05	1.36	0.95
26	0.41	0.46	0.02	10.05	0.64	2.03	1.15	0.92	0.77	1.05	1.14	1.22
27	0.42	0.45	0.06	4.48	0.56	1.53	0.87	16.85	4.20	1.10	1.06	1.24
28	0.42	0.50	0.39	1.81	0.57	1.47	0.56	36.56	5.11	1.10	1.04	1.24
29	0.44	0.87	0.18	1.52	0.95	1.26	3.23	15.24	1.70	1.06	1.24	1.12
30	0.41		0.03	5.55	1.70	6.34	1.71	10.86	5.89	1.07	1.26	1.03
31	0.59		0.01		1.03		1.12	8.46		7.53		1.02
Total	16.32	15.11	9.43	246.24	57.79	81.04	39.56	502.93	77.71	107.24	44.55	37.15
Max	0.96	0.87	0.60	19.98	13.83	15.22	3.91	290.67	18.19	20.37	3.95	1.75
Min	0.17	0.41	0.01	0.01	0.11	0.22	0.40	0.88	0.53	0.52	0.93	0.91
Ac-ft	32.32	29.93	18.67	487.56	114.43	160.46	78.33	995.80	153.87	212.33	88.20	73.56

2004
Cottonwood Creek Peoria 2
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.22	0.16	0.17	0.00	12.32	0.21	0.83	0.29	4.31	1.36	1.78	0.54
2	0.21	0.13	0.16	0.17	0.82	0.19	0.37	0.28	0.57	0.55	0.63	0.50
3	0.23	0.13	0.15	22.86	0.57	0.13	0.23	0.37	0.32	0.37	0.33	0.38
4	0.21	0.19	0.15	12.37	0.41	0.08	0.20	0.74	0.87	0.39	0.33	0.34
5	0.17	0.25	0.18	2.99	0.21	0.09	0.19	26.47	0.50	24.04	0.32	0.40
6	0.14	0.17	0.15	1.59	0.16	0.09	0.21	4.57	0.37	15.07	0.31	0.52
7	0.19	0.13	0.13	1.76	0.15	0.07	0.18	11.62	0.37	2.90	0.30	0.51
8	0.19	0.12	0.13	5.33	0.15	0.08	0.14	1.64	0.33	0.59	0.32	0.44
9	0.20	0.12	0.13	10.24	0.15	0.09	0.37	1.08	0.24	0.37	0.36	0.42
10	0.20	0.12	0.13	23.16	0.15	0.09	0.68	4.22	0.20	0.17	1.79	0.42
11	0.17	0.18	0.14	21.52	0.15	0.07	0.24	7.55	0.17	0.16	0.69	0.37
12	0.05	0.17	0.14	23.13	1.02	0.06	0.17	1.14	0.17	0.16	0.53	0.37
13	0.22	0.14	0.15	16.11	11.27	0.06	0.14	0.51	0.16	23.48	0.53	0.37
14	0.31	0.13	0.09	5.36	0.50	0.07	0.12	0.39	0.19	4.34	0.38	0.36
15	0.12	0.12	0.07	2.55	0.30	0.07	0.25	0.33	0.20	1.01	0.35	0.37
16	0.12	0.12	0.06	0.32	0.17	0.95	0.38	0.30	0.18	0.53	0.37	0.36
17	0.12	0.12	0.06	0.37	0.16	5.72	1.59	0.80	19.70	0.39	0.40	0.62
18	0.12	0.12	0.06	0.37	3.66	14.49	1.77	11.05	0.23	0.37	0.38	
19	0.12	0.12	0.03	0.44	0.61	8.92	0.51	763.65	0.22	0.35	0.54	
20	0.14	0.23	0.04	0.38	0.23	1.43	0.29	39.35	0.27	0.37	0.38	
21	0.17	0.24	0.05	0.72	0.04	5.75	0.21	4.82	8.34	0.36	1.05	
22	0.15	0.17	0.09	0.74	0.03	6.03	0.17	1.08	1.37	0.35	0.61	
23	0.14	0.17	0.09	19.70	0.03	0.80	0.51	0.55	0.50	0.35	0.57	
24	0.12	0.16	0.02	23.23	0.09	0.49	1.10	0.52	0.41	0.35	0.51	
25	0.12	0.15	0.01	20.05	0.30	0.43	0.47	0.39	0.28	0.34	0.46	
26	0.12	0.14	0.00	7.28	0.20	0.75	0.38	0.30	0.24	0.34	0.37	
27	0.12	0.13	0.02	2.14	0.17	0.53	0.27	17.26	1.95	0.36	0.35	
28	0.13	0.12	0.11	0.65	0.17	0.50	0.17	69.34	2.58	0.36	0.34	
29	0.13	0.22	0.05	0.53	0.31	0.42	1.36	14.52	0.60	0.35	0.41	
30	0.12		0.01	2.91	0.60	3.55	0.61	8.25	3.18	0.35	0.34	
31	0.18		0.00		0.33		0.29	5.52		4.61		
Total	4.78	4.49	2.80	228.98	35.11	52.21	14.38	998.91	49.04	85.10	16.01	7.29
Mean	0.16	0.15	0.09	7.63	1.17	1.74	0.46	32.22	1.63	2.75	0.53	0.43
Max	0.31	0.25	0.18	23.23	12.32	14.49	1.77	763.65	19.70	24.04	1.79	0.62
Min	0.05	0.12	0.00	0.00	0.03	0.06	0.12	0.28	0.16	0.16	0.30	0.34

2004
Shop Creek 3
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.40	0.69	0.84	0.40	3.08	0.06	1.43	0.02	0.05	0.18	0.82	0.53
2	0.40	0.44	0.56	0.40	0.74	0.05	0.37	0.01	0.04	0.06	0.23	0.18
3	0.40	0.40	0.48	2.97	0.56	0.04	0.25	0.01	0.04	0.06	0.11	0.16
4	0.44	0.44	0.37	2.28	0.13	0.04	0.11	0.01	0.06	0.06	0.06	0.40
5	0.40	0.56	1.31	1.54	0.27	0.03	0.07	0.72	0.04	0.11	0.05	0.48
6	0.40	0.60	0.69	0.82	0.26	0.03	0.07	7.01	0.04	1.85	0.05	0.14
7	0.40	0.44	0.42	0.40	0.20	0.02	0.06	0.40	0.04	0.34	0.04	0.10
8	0.40	0.40	0.41	1.81	0.18	0.03	0.02	0.11	0.04	0.11	0.03	0.09
9	0.40	0.40	0.37	1.26	0.17	0.04	0.03	0.11	0.04	0.09	0.03	0.07
10	0.40	0.40	0.40	1.65	0.15	0.03	0.28	0.11	0.04	0.08	0.08	0.07
11	0.40	0.40	0.40	0.69	0.13	0.04	0.13	0.75	0.04	0.09	0.14	0.07
12	0.40	0.56	0.40	0.52	0.10	0.05	0.11	0.16	0.03	0.09	0.04	0.06
13	0.40	0.40	0.40	0.60	3.41	0.04	0.03	0.10	0.04	0.83	0.05	0.06
14	0.40	0.40	0.40	0.54	2.47	0.03	0.01	0.08	0.04	0.24	0.05	0.06
15	0.40	0.40	0.40	0.52	0.74	0.04	0.01	0.05	0.03	0.11	0.04	0.05
16	0.40	0.40	0.40	0.48	0.37	0.17	0.01	0.04	0.03	0.09	0.04	0.08
17	0.40	0.40	0.40	0.51	0.15	0.99	0.08	0.01	0.03	0.09	0.05	0.09
18	0.40	0.40	0.40	0.60	0.10	2.44	0.01	3.21	0.02	0.09	0.05	0.04
19	0.40	0.40	0.40	0.60	0.10	3.18	0.01	72.24	0.02	0.09	0.05	0.04
20	0.56	0.69	0.40	0.60	0.11	0.55	0.01	13.26	0.03	0.06	0.12	0.04
21	0.52	0.56	0.40	0.47	0.10	1.15	0.01	2.62	0.75	0.03	0.13	0.11
22	0.40	0.44	0.40	1.05	0.10	0.92	0.01	1.85	0.12	0.06	0.07	0.08
23	0.40	0.40	0.40	2.97	0.11	0.16	0.65	1.64	0.04	0.06	0.06	0.07
24	0.40	0.43	0.40	2.28	0.14	0.14	1.04	0.19	0.03	0.03	0.06	0.19
25	0.40	0.39	0.40	0.90	0.13	0.14	0.21	0.05	0.04	0.03	0.06	0.46
26	0.40	0.35	0.40	0.67	0.10	0.22	0.10	0.04	0.03	0.03	0.06	0.49
27	0.44	0.33	0.56	0.50	0.04	0.13	0.12	0.04	0.04	0.03	0.17	0.23
28	0.40	0.45	0.48	0.30	0.03	0.23	0.31	4.10	0.04	0.03	0.07	0.13
29	0.40	1.98	0.40	0.48	0.22	0.14	0.84	1.25	0.03	0.03	0.08	0.08
30	0.40		0.40	0.60	0.07	1.15	0.15	0.26	0.30	0.03	0.19	0.05
31	0.56		0.40		0.06		0.09	0.30		0.04		0.05
Total	12.98	14.59	14.56	29.40	14.53	12.28	6.62	110.74	2.12	5.11	3.08	4.75
Max	0.56	1.98	1.31	2.97	3.41	3.18	1.43	72.24	0.75	1.85	0.82	0.53
Min	0.40	0.33	0.37	0.30	0.03	0.02	0.01	0.01	0.02	0.03	0.03	0.04
Ac-ft	25.70	28.89	28.82	58.22	28.77	24.31	13.10	219.27	4.19	10.13	6.10	9.41

2004
Shop Creek 3
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.39	0.68	0.82	0.39	3.00	0.06	1.40	0.02	0.05	0.18	0.80	0.51
2	0.39	0.43	0.55	0.39	0.72	0.05	0.36	0.01	0.04	0.05	0.22	0.18
3	0.39	0.39	0.47	2.90	0.54	0.04	0.24	0.01	0.04	0.05	0.11	0.15
4	0.43	0.43	0.37	2.23	0.13	0.04	0.11	0.01	0.06	0.05	0.06	0.39
5	0.39	0.54	1.28	1.50	0.27	0.03	0.06	0.70	0.04	0.10	0.04	0.46
6	0.39	0.59	0.68	0.80	0.25	0.03	0.06	6.84	0.04	1.80	0.05	0.14
7	0.39	0.43	0.41	0.39	0.19	0.02	0.06	0.39	0.04	0.34	0.04	0.09
8	0.39	0.39	0.40	1.77	0.18	0.03	0.02	0.11	0.04	0.11	0.03	0.09
9	0.39	0.39	0.37	1.23	0.17	0.04	0.03	0.11	0.04	0.09	0.03	0.07
10	0.39	0.39	0.39	1.61	0.15	0.03	0.27	0.11	0.04	0.08	0.08	0.07
11	0.39	0.39	0.39	0.68	0.13	0.03	0.13	0.73	0.03	0.09	0.14	0.07
12	0.39	0.54	0.39	0.50	0.10	0.05	0.11	0.15	0.03	0.09	0.04	0.06
13	0.39	0.39	0.39	0.59	3.33	0.04	0.03	0.10	0.04	0.81	0.05	0.06
14	0.39	0.39	0.39	0.53	2.41	0.03	0.01	0.08	0.04	0.24	0.05	0.06
15	0.39	0.39	0.39	0.50	0.72	0.04	0.01	0.05	0.03	0.11	0.04	0.05
16	0.39	0.39	0.39	0.47	0.36	0.17	0.01	0.04	0.03	0.09	0.04	0.08
17	0.39	0.39	0.39	0.50	0.15	0.96	0.08	0.01	0.02	0.09	0.05	0.08
18	0.39	0.39	0.39	0.59	0.09	2.38	0.01	3.13	0.02	0.09	0.05	0.04
19	0.39	0.39	0.39	0.59	0.10	3.11	0.01	57.28	0.02	0.09	0.05	0.04
20	0.54	0.68	0.39	0.59	0.11	0.53	0.01	10.52	0.03	0.05	0.11	0.04
21	0.50	0.54	0.39	0.45	0.10	1.12	0.01	2.56	0.73	0.03	0.13	0.11
22	0.39	0.43	0.39	1.02	0.10	0.90	0.01	1.81	0.11	0.06	0.07	0.07
23	0.39	0.39	0.39	2.90	0.11	0.15	0.64	1.61	0.04	0.06	0.06	0.07
24	0.39	0.42	0.39	2.23	0.13	0.14	1.02	0.18	0.03	0.03	0.06	0.18
25	0.39	0.38	0.39	0.88	0.13	0.14	0.20	0.05	0.03	0.03	0.06	0.45
26	0.39	0.35	0.39	0.65	0.10	0.21	0.10	0.04	0.03	0.03	0.06	0.48
27	0.43	0.32	0.54	0.48	0.04	0.13	0.12	0.04	0.03	0.03	0.17	0.22
28	0.39	0.44	0.47	0.30	0.03	0.22	0.30	4.00	0.03	0.03	0.07	0.13
29	0.39	1.94	0.39	0.47	0.21	0.14	0.82	1.22	0.03	0.03	0.08	0.08
30	0.39		0.39	0.59	0.07	1.12	0.15	0.25	0.29	0.03	0.18	0.05
31	0.54		0.39		0.06		0.09	0.29		0.04		0.05
Total	12.67	14.25	14.21	28.71	14.19	11.99	6.46	92.45	2.07	4.99	3.01	4.64
Mean	0.41	0.49	0.46	0.96	0.46	0.40	0.21	2.98	0.07	0.16	0.10	0.15
Max	0.54	1.94	1.28	2.90	3.33	3.11	1.40	57.28	0.73	1.80	0.80	0.51
Min	0.39	0.32	0.37	0.30	0.03	0.02	0.01	0.01	0.02	0.03	0.03	0.04

2004

Cherry Creek Precipitation (in.)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0.12	0.05	0	0.41	0	0.13	0	0	0.25	0.02	0
2	0	0	0.03	0	0	0	0	0	0	0	0	0
3	0	0	0	0.45	0	0	0	0.05	0	0	0	0
4	0.01	0.11	0	0.43	0	0	0	0.03	0.12	0.01	0	0
5	0	0.12	0.09	0	0	0	0	0.3	0	0.51	0	0
6	0	0.06	0.03	0	0	0	0.01	0.47	0	0.48	0	0
7	0	0	0	0	0	0	0	0.02	0	0	0	0
8	0	0	0	0.37	0	0	0	0	0	0	0	0
9	0	0	0	0.17	0	0	0	0	0	0	0	0
10	0	0	0	0.24	0	0.01	0.21	0	0	0	0.25	0
11	0	0	0	0.04	0	0	0.02	0.38	0	0	0.04	0
12	0	0.12	0	0	0	0	0	0.04	0	0	0	0
13	0	0	0	0.1	0.64	0	0	0	0	0.59	0	0
14	0	0	0	0	0.19	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0.02	0	0.03
16	0	0	0	0	0	0	0.1	0	0	0	0	0.1
17	0	0	0	0	0	0.32	0.13	0	0	0	0.02	0
18	0	0	0	0	0	0.28	0	3.2	0	0	0.02	0
19	0	0	0	0	0	0.48	0	0.22	0	0	0	0
20	0.1	0.31	0	0	0	0	0	0	0	0	0.18	0
21	0.07	0.11	0	0	0	0.58	0	0	0.56	0	0	0.05
22	0	0	0	0.2	0	0	0.04	0	0.05	0	0.16	0.04
23	0	0	0	0.35	0	0	0.13	0	0	0	0.1	0.01
24	0	0	0	0.47	0	0	0.1	0	0	0	0	0
25	0	0	0	0.01	0.02	0	0	0	0	0	0	0
26	0	0	0	0.06	0	0.06	0.04	0	0	0	0	0
27	0.01	0	0.03	0	0	0.01	0	0.56	0.23	0	0	0
28	0	0.07	0.03	0	0	0.09	0	0.01	0	0	0.33	0.33
29	0	0.29	0	0.04	0	0	0.25	0	0.01	0	0.07	0.07
30	0		0	0.14	0.14	0.28	0.06	0	0.23	0	0.01	0.01
31	0.1		0		0		0.01	0.06		0.36		0
Total	0.29	1.31	0.26	3.07	1.40	2.11	1.23	5.34	1.20	2.22	1.20	0.64
Mean	0.01	0.05	0.01	0.10	0.05	0.07	0.04	0.17	0.04	0.07	0.04	0.02
Max	0.10	0.31	0.09	0.47	0.64	0.58	0.25	3.20	0.56	0.59	0.33	0.33
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	20.59	93.01	18.46	217.97	99.40	149.81	87.33	379.14	85.20	157.62	85.20	45.44

2004
Cherry Creek Precipitation
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.93	0.39	0.00	3.17	0.00	1.01	0.00	0.00	1.94	0.15	0.00
2	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	3.48	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00
4	0.08	0.85	0.00	3.33	0.00	0.00	0.00	0.23	0.93	0.08	0.00	0.00
5	0.00	0.93	0.70	0.00	0.00	0.00	0.00	2.32	0.00	3.95	0.00	0.00
6	0.00	0.46	0.23	0.00	0.00	0.00	0.08	3.64	0.00	3.72	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	1.86	0.00	0.08	1.63	0.00	0.00	0.00	1.94	0.00
11	0.00	0.00	0.00	0.31	0.00	0.00	0.15	2.94	0.00	0.00	0.31	0.00
12	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.77	4.96	0.00	0.00	0.00	0.00	4.57	0.00	0.00
14	0.00	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.23
16	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.77
17	0.00	0.00	0.00	0.00	0.00	2.48	1.01	0.00	0.00	0.00	0.15	0.00
18	0.00	0.00	0.00	0.00	0.00	2.17	0.00	17.35	0.00	0.00	0.15	0.00
19	0.00	0.00	0.00	0.00	0.00	3.72	0.00	1.70	0.00	0.00	0.00	0.00
20	0.77	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00
21	0.54	0.85	0.00	0.00	0.00	4.49	0.00	0.00	4.34	0.00	0.00	0.39
22	0.00	0.00	0.00	1.55	0.00	0.00	0.31	0.00	0.39	0.00	1.24	0.31
23	0.00	0.00	0.00	2.71	0.00	0.00	1.01	0.00	0.00	0.00	0.77	0.08
24	0.00	0.00	0.00	3.64	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.08	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.46	0.00	0.46	0.31	0.00	0.00	0.00	0.00	0.00
27	0.08	0.00	0.23	0.00	0.00	0.08	0.00	4.34	1.78	0.00	0.00	0.00
28	0.00	0.54	0.23	0.00	0.00	0.70	0.00	0.08	0.00	0.00	2.56	2.56
29	0.00	2.25	0.00	0.31	0.00	0.00	1.94	0.00	0.08	0.00	0.54	0.54
30	0.00		0.00	1.08	1.08	2.17	0.46	0.00	1.78	0.00	0.08	0.08
31	0.77		0.00		0.00		0.08	0.46		2.79		0.00
Total	2.25	10.14	2.01	23.77	10.84	16.34	9.52	33.92	9.29	17.19	9.29	4.96
Mean	0.07	0.35	0.06	0.00	0.35	0.54	0.31	1.09	0.31	0.55	0.31	0.16
Max	0.77	2.40	0.70	0.00	4.96	4.49	1.94	17.35	4.34	4.57	2.56	2.56
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 E

Biological Data

2004 CHERRY CREEK PHYTOPLANKTON
COMPOSITE

GENUS/SPECIES	3/30/2004	4/21/2004	5/19/2004	5/24/2004	6/9/2004	6/23/2004	7/7/2004	7/21/2004	8/4/2004	8/18/2004	9/1/2004	9/15/2004	10/20/2004	11/16/2004
BACILLARIOPHYTA														
Order Centrales														
Aulacoseira granulata var. *angustissima*					40	30	80	60	5				140	495
Aulacoseira sp.		120		40		480		12		4		25	610	11680
Cyclotella meneghiniana								5		10		18	1	25
Cyclotella ocellata		320	160			640	7520	1280	560	10	10		5	80
Cyclotella sp.									400	960	3680	60	20	2000
Stephanodiscus agassizensis		20	10	5	310	500	10	40			10		2	
Stephanodiscus hantzschii	10			240	1360	160	240	10	240				10	
Stephanodiscus niagarae					5	5							1	
Order Pennales														
Asterionella formosa		35	10					40						40
Diatoma tenuis														15
Navicula cryptocephala	5													
Navicula sp.		5												
Nitzschia acicularis	40						10	20	5					5
Nitzschia gracilis	7320	45	10				40		35	10				5
Nitzschia palea		5					30	240		10				
Nitzschia paleacea									160					
Puncticulata bodanica	1	5				5								
Synedra delicatissima var. *angustissima*	20					15	10		15	20		5	160	10
Synedra radians		75	25	125	125	120	20	40	20			1		10
Synedra rumpens var. *familiaris*			250	50			30	90						
Synedra rumpens var. *fragilarioides*								120						
Synedra ulna var. *chaseana*		5						1						
Tryblionella apiculata									5					
CHLOROPHYTA														
Actinastrum hantzschii			640											
Ankistrodesmus falcatus										30	60			
Carteria sp.														5
Chlamydomonas globosa	10			10	160	160		5	160				40	40
Chlamydomonas reinhardtii										130	50			
Chlamydomonas sp.						5500								
Chlorella minutissima	15500	13000	22500	31500	4000	9250	11750	5000	49000	130000	64000	12000	21250	47000
Chlorella sp.				560				250		250				
Chlorogonium sp.							20		5		5	5	5	
Closterium acutum var. *variabile*					5	55	10		5		5	1	5	
Closterium sp.														
Coelastrum microporum		40										40		640
Coelastrum sphaericum			160		640		120		240					
Coenococcus sp.								80						
Cosmarium bioculatum var. *depressum*									10					
Crucigenia quadrata	40	160		320	3360									
Crucigenia tetrapedia	800	1120	160	125	1600	125	1760			1280	960	80	80	80
Dictyosphaerium ehrenbergianum				320			320							
Dictyosphaerium pulchellum	80													
Dimorphococcus sp.														
Diplochloris lunata				2720	320				1280	1200	320			

GENUS/SPECIES	3/30/2004	4/21/2004	5/19/2004	5/24/2004	6/9/2004	6/23/2004	7/7/2004	7/21/2004	8/4/2004	8/18/2004	9/1/2004	9/15/2004	10/20/2004	11/16/2004
CHLOROPHYTA (cont.)														
Elakatothrix viridis			40		10	15	160		60		10			40
Kirchneriella dianae														
Kirchneriella irregularis						90								
Kirchneriella lunaris	80	160	720		7280	6560	6240	360		560		20		
Kirchneriella obesa	20		20	240				5						40
Lagerheimia genevensis				20			80							
Micractinium pusillum											160			
Monoraphidium contortum														5
Monoraphidium griffithii				10	40		5							
Monoraphidium minutum	40		40		160	160	400	200	80		40			
Monoraphidium mirabile														20
Mougeotia sp.														
Nephrocytium agardhianum		20				880	160		60					
Oocystis apiculata			160		640		320	640	40					
Oocystis borgei				640	320		640		1040	720	80			20
Oocystis lacustris										160				
Oocystis parva														
Oocystis solitaria														
Oocystis sp.														
Pandorina smithii									100	120	80		6	
Pediastrum boryanum			30	50		8		40						40
Pediastrum duplex var. *duplex*						12	110	140				155	8	
Pediastrum duplex var. *gracillimum*					80		340	140	130					
Pediastrum simplex				35	40				60	240	340	15		
Pediastrum tetras				40		40			40		8			
Pseudodictyosphaerium sp.	5000	875		9680	100000	75000	160		520			160	80	4480
Phacotus lenticularis												5		
Pteromonas aculeata									200		10	10	20	25
Quadricoccus sp.			2960	800	2320	320	1920							
Quadrigula sp.					640	800	640	10	160					
Raphidocelis contorta	40			560									80	
Raphidocelis microscopica		800		480	80	1280	2880	2000	640	320	5360		80	400
Scenedesmus acuminatus			240	60	320	100	40	50	100	320	80	10		
Scenedesmus arcuatus var. *gracilis*														
Scenedesmus armatus				800	320	960					320			
Scenedesmus bicaudatus														
Scenedesmus communis	160	60		40	3200	480	40	20	80		320	10	80	20
Scenedesmus ecornis	80	80			1280	480	480	80		160		40	320	
Scenedesmus ellipticus							200	120	80		100			
Scenedesmus intermedius		320	720	1920	4400	2320	3840	480	880	480	1520	80	960	160
Scenedesmus obliquus					320									
Scenedesmus subspicatus			160	80	2560	320	160	80		320				
Schroederia setigera		5	10	5			10	5	120	560	160			
Spermatozopsis exsultans	160							80	80		40			
Spondylosium planum														
Staurastrum sp.							25							
Tetraedron caudatum		40	40	20	10	20		80						
Tetraedron minimum	80	40	1480	800	5840	6560	2400	2080	800	160	20		10	
Tetraedron sp.														
Tetrastrum elegans			160	640	640	960	640		320		80	20	40	320
Tetrastrum staurogeniaeforme		160	640	2560	1280	800	320	640	320	960	80	10	40	640

GENUS/SPECIES	3/30/2004	4/21/2004	5/19/2004	5/24/2004	6/9/2004	6/23/2004	7/7/2004	7/21/2004	8/4/2004	8/18/2004	9/1/2004	9/15/2004	10/20/2004	11/16/2004
CYANOPHYTA														
Anabaena catenula var. *affinis*								630						
Anabaena circinalis						130								
Anabaena flos-aquae					60	300	220	120						
Anabaena perturbata					100	90	700	800	60		28			
Anabaenopsis elenkinii							80							
Aphanizomenon flos-aquae													14	
Aphanizomenon issatschenkoi							600						6	
Aphanocapsa delicatissima	2000						4000	6500	10000			4500	14500	2000
Aphanocapsa incerta		3250	280		4000	38000			50000		16000			
Aphanocapsa sp.														
Aphanothece clathrata		250						8800						
Aphanothece smithii	211250	30000	85000	432000	71250	345000	207500	183500	305000	65000	141000	7500	1250	7500
Chroococcus dispersus									11500	240	3840		190	
Chroococcus limneticus											160			
Cyanobium sp.	250			3000	250	500		1000					250	
Dactylococcopsis fascicularis	6080	400	200	480	400	400	1840	1440	2720	2800	1200	100	320	320
Jaaginema angustissimum												1760		
Jaaginema subtilissima						150								
Merismopedia tenuissima											3200			
Microcystis sp.											160			
Oscillatoria sp.				40										
Planktothrix agardhii					380					2	90	100		
Pseudanabaena limnetica	400		100			140	3830				28	250	40	160
Synechococcus sp.				8000										
CHRYSOPHYTA														
Chromulina sp.	250							125						
Dinobryon divergens							80	5						
Dinobryon sociale var. *americanum*								190	6			5		
Mallomonas sp.	15		35	5	55								20	
EUGLENOPHYTA														
Euglena acus					5				5	1	1	1		
Euglena oxyuris									5	1		1		
Euglena sp.						10		20	5					
Euglena viridis							2		5	5				
Phacus caudatus					5									
Phacus sp.						1			5	1				
Strombomonas gibberosa												1		
Trachelomonas hispida var. *coronata*				5										
Trachelomonas hispida var. *crenulatocelis*											10	8	10	
Trachelomonas varians									5		10	2		
Trachelomonas volvocina					160					40	10			
CRYPTOPHYTA														
Campylomonas (Cryptomonas) marsonii	10	10	65	10				5			20	10	20	480
Campylomonas (Cryptomonas) reflexa	40	25	285	5		10					20	5	50	25
Chroomonas nordstedtii	10		160	800			160		120	160	800	10	240	20
Cryptomonas erosa	15	75		310	40	30	10		25	1	440	38	30	120
Cryptomonas ovata		10												
Cryptomonas rostratiformis		15			5					1	20	5	10	5

GENUS/SPECIES	3/30/2004	4/21/2004	5/19/2004	5/24/2004	6/9/2004	6/23/2004	7/7/2004	7/21/2004	8/4/2004	8/18/2004	9/1/2004	9/15/2004	10/20/2004	11/16/2004
CRYPTOPHYTA (cont.)														
Komma (Chroomonas acuta) caudata	2960	10840	760	160	3440	4160	800	1640	4120	880	4240	80	240	120
Plagioselmis sp.	80					160		10			640	100	3360	640
DINOPHYTA														
Ceratium hirundinella					5		1	1		1	10			
Gymnodinium sp.											10			
Peridiniopsis kulczynskii	25				10	70	1			10	50	5	320	5
Peridiniopsis penardiforme										110		2		
Peridiniopsis polonicum							1	5			10	1		150
HAPTOPHYTA														
Chrysochromulina parva												60		
PRASINOPHYTA														
Nephroselmis olivacea									200			60		
Tetraselmis cordiformis						15	880	1015	215	400	680	420	2720	200
XANTHOPHYTA														
Goniochloris fallax								20						
Isthmochoron lobulatum					1									
Pseudostaurastrum hastatum											2			
Total Density (cells/mL)	252,871	62,390	118,230	500,310	223,871	504,376	264,885	220,369	442,051	208,647	250,587	27,794	47,643	80,085
Total # of Taxa	34	35	34	45	52	53	58	56	57	43	56	47	45	43

APPENDIX F

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.

<u>2004</u>

Comparison of data collected during the 2004 field season shows good agreement between C&A and CU for TP, TDP, SRP, nitrate-nitrite, and ammonia (Table F-1). Regression slopes were all significantly different ($p \leq 0.05$) from zero, with slope values ranging from 0.73 to 1.03. Values for R^2 ranged from 0.63 to 0.99. Because of the close correlation between the results from the two labs, values from both labs were averaged. C&A and CU found most values for nitrate-nitrite to be below the analytical detection limit (5 µg/L). This demonstrates good agreement between labs, but prevented the development of a statistical regression. Data from C&A and CU laboratories were compared to detect outliers (Hintze 2001). Outliers were detected (RStudent >2) for total phosphorus on May 24 and October 20, and were omitted from least regression analysis.

TABLE F-1: Summary statistics from comparison between Chadwick & Associates, Inc. laboratories and University of Colorado laboratories for phosphorus and nitrogen species for 2004. ND = no difference; all values were below analytical detection limits.

	p	Slope	R^2	QA/QC Criteria Met
Total Phosphorus	0.00	0.94	0.63	Yes
Total Dissolved Phosphorus	0.00	0.73	0.72	Yes
Soluble Reactive Phosphorus (Orthophosphate)	0.00	0.89	0.97	Yes
Nitrate-Nitrite	0.00	1.03	0.99	Yes
Ammonia	0.00	0.70	0.70	Yes

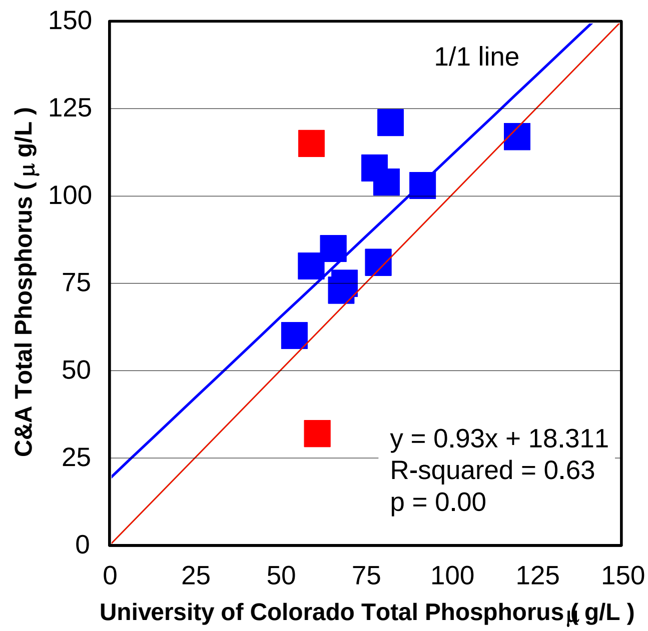


FIGURE F-1: Relationship between Chadwick & Associates, Inc. laboratory total phosphorus and University of Colorado total phosphorus for 2004. Red = outlier omitted for regression analysis.

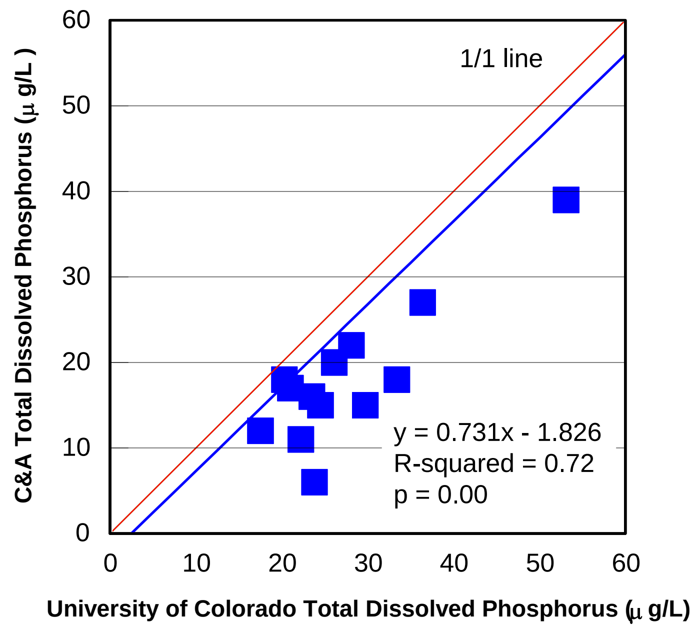


FIGURE F-2: Relationship between Chadwick & Associates, Inc. laboratory total dissolved phosphorus and University of Colorado total dissolved phosphorus for 2004.

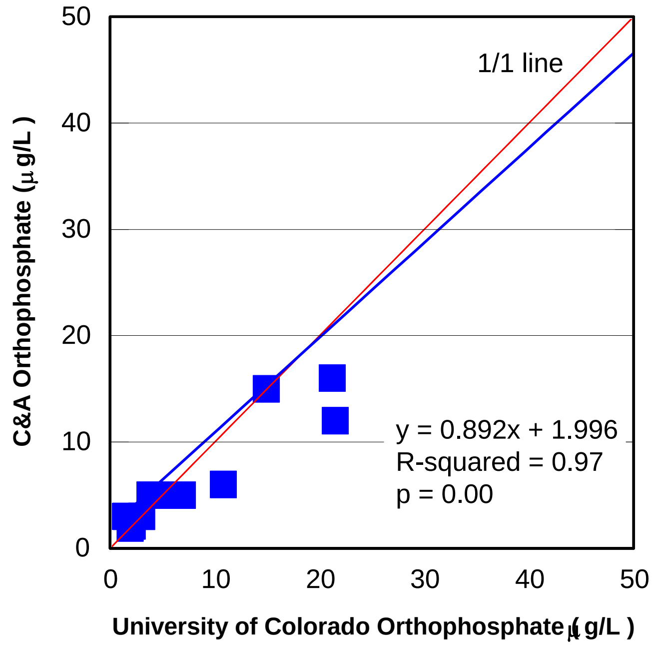


FIGURE F-3: Relationship between Chadwick & Associates, Inc. laboratory orthophosphate and University of Colorado orthophosphate for 2004.

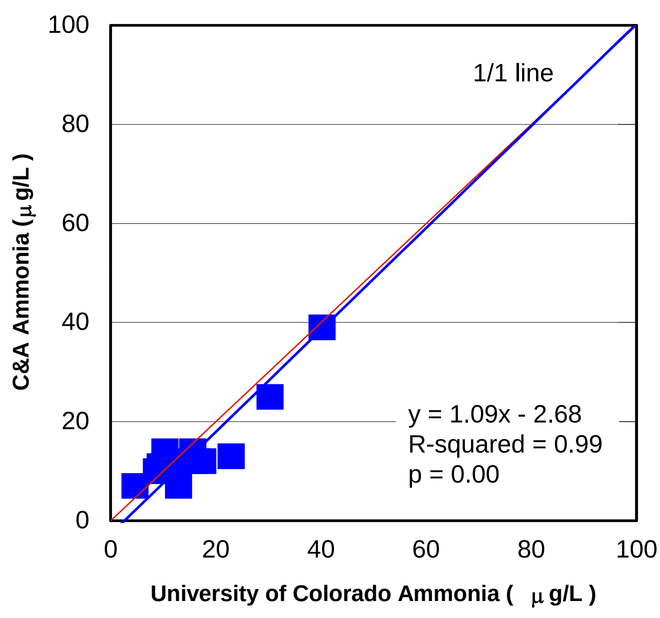


FIGURE F-4: Relationship between Chadwick & Associates, Inc. laboratory ammonia and University of Colorado ammonia for 2004.