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2000 ANNUAL REPORT OF ACTIVITIES BY THE CHERRY CREEK BASIN WATER QUALITY AUTHORITY

DECEMBER 2001

DRAFT

2000 ANNUAL REPORT
OF ACTIVITIES BY THE
CREEK BASIN WATER QUALITY AUTHORITY

Authority Members in 2000:

Arapahoe County
Arapahoe Water and Wastewater Authority
City of Aurora
Cottonwood Water & Sanitation District
Denver Southeast Suburban Water & Sanitation District
Douglas County
City of Greenwood Village
Inverness Water & Sanitation District
Meridian Metropolitan District
Parker Water & Sanitation District
Stonegate Center Metropolitan District
Town of Castle Rock
Town of Parker

DECEMBER 2001

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EXECUTIVE SUMMARY

The 1982 Clean Lakes Study of Cherry Creek Reservoir determined that eutrophication of the reservoir could negatively impact beneficial uses of the reservoir, although it was originally built for flood control. The reservoir and surrounding state park serve as an important source of recreation, presently and historically. The Cherry Creek Basin Water Quality Authority (Authority), initially created by an intergovernmentalagreement, 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.

During 2000, the Authority was comprised of Arapahoe and Douglas Counties, the cities of Aurora and Greenwood Village, the towns of Castle Rock and Parker, and seven water and wastewater special districts — Arapahoe, Cottonwood, Inverness, Meridian, Parker, Pinery, and Lincoln Park (previously known as Stonegate Center). This Board was recently "reconstituted" in 2001, as noted herein.

A. Point Source Allocation and Loadings

In 1985, an in-reservoir phosphorus standard of 35 µg/L was adopted by the Colorado Water Quality Control Commission (CWQCC) to maintain a seasonal mean chlorophyll goal of 15 µg/L. Subsequently, a phosphorus total maximum daily load (TMDL) was prepared for the reservoir allocating loads among point sources, background, and nonpoint sources within a total annual phosphorus load of 14,270 pounds. In September 2000, following a hearing before the Colorado WQCC, the standard for Cherry Creek Reservoir was changed to a July - September value of 15 µg/L of chlorophyll 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 pounds/year.

This report summarizes Authority activities related to site applications and development reviews, as well as data collected by the Authority in 2000 during its monitoring activities on Cherry Creek Reservoir, the tributary inflows to the reservoir, and the Cherry Creek mainstem upstream of the reservoir.

B. Basin Authority Review of Site Applications and Development Proposals

The Authority reviews Site Applications and Utility Plans for wastewater collection and treatment facilities proposed in the Cherry Creek Basin. These applications are reviewed with a concern for potential impacts on the Cherry Creek Reservoir. During 2000, seven separate proposals were reviewed. Additionally, in an effort to mitigate potential water quality impacts from the continuing development in the Cherry Creek watershed, the Authority has taken an active role as a referral agency in the land use application review process. Land use applications are reviewed against the criteria and standards in the Cherry Creek Reservoir Watershed Stormwater Quality Regulation. During 2000, the authority reviewed and commented on 156 land use applications.

C. Water Quality and Aquatic Biological Monitoring
of Cherry Creek Reservoir Watershed - 2000

Cherry Creek Reservoir

Based on data collected by Chadwick Ecological Consultants, Inc. (CEC), the following statements can be made: 1) the July - September seasonal mean of phosphorus of 81 µg/L in 2000 was identical to the value measured in 1999 and slightly lower than that observed in 1998 (89 µg/L), but higher than the nine-year mean and the underlying goal of 40 µg/L; 2) average July - September chlorophyll content was 25.2 µg/L in 2000, considerably greater than the new standard of 15.0 µg/L, but lower than values measured in 1999 or 1998; and 3) Secchi depth (transparency) averaged 1.0 m in 2000, similar to past years (see table below).

Sampling of aquatic biota and nutrients in reservoir and influent streams, conducted during 2000 by CEC, demonstrated that water transparency varied throughout the year, with lowest values corresponding to periods of high phytoplankton density. Water temperature data suggest that Cherry Creek Reservoir experiences infrequent periods of complete mixing interspersed with periods of minimal thermal stratification during the summer. Data on coliforms indicate that pathogenic bacteria in the reservoir probably do not pose a health risk to recreation.

Water Quality and Total Phosphorus Loads Data for Cherry Creek Reservoir, July - September 1992 - 2000

Year	Chlorophyll *a* (µg/L)	Secchi Depth (ft)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	7,987	9,049	0.92
1993	14.4	1.2	62	826	4,764	6,643	0.71
1994	10.0	1.1	59	1,144	5,053	7,188	0.70
1995	9.4	1.6	48	913	10,598	11,786	0.94
1996	20.5	1.6	62	944	5,852	7,615	0.76
1997	22.3	1.0	96	1,120	6,552	10,447	0.61
1998	26.5	1.0	89	880	15,313	20,820	0.74
1999	28.9	1.0	81	753	20,209	30,032	0.68
2000	25.2	1.0	81	802	13,053	18,584	0.72
9-Year Mean	19.4	1.2	72	928	9,931	13,574	0.75
Median	20.5	1.0	66	913	7,987	10,447	0.72

* Stream, alluvium, and precipitation.

Nutrient and chlorophyll have varied over time, with differences often related to the variation in annual loads from external sources. These data suggest that year-to-year variations in loading, as well as internal loads, play a role in the regulation of levels of nutrients and chlorophyll *a* in the reservoir.

As in previous years, blue-green algae (primarily "micro" blue-green algae) were consistently the most abundant algal group in Cherry Creek Reservoir during 2000. Zooplankton populations (which serve as grazers of algae) were comprised of three to ten species in 2000. No sampling of the fish community in Cherry Creek Reservoir was conducted in 2000 by the Colorado Department of Wildlife, although a fish kill was reported in September 2000 comprised partly of walleye with a few other species. Historically, the reservoir has been dominated by gizzard shad, an effective zooplanktivore. Such planktivorous fish may also be influencing nutrient dynamics in Cherry Creek Reservoir through their predation on zooplankton.

Cherry Creek Watershed Sampling

The Phase I Baseline Water Quality Data Collection Study for the Basin, conducted by John C. Halepaska and Associates, Inc. (JCHA), was begun in 1994 and continued through 2000. Data collected to date indicate that phosphorus concentrations remain relatively constant from upper reaches of the basin (i.e., Cottonwood Canyon where there is no significant development) through the system to the reservoir. Phosphorus concentrations in both the Cherry Creek channel and in the underlying aquifer are generally two to three times higher than that measured in the reservoir. There are no discernable increases in concentrations at monitoring locations downgradient of direct dischargers.

Nitrate-nitrogen concentrations fluctuated throughout 2000, with generally higher concentrations in the alluvium than in the surface water. It appears that a large portion of the nitrate-nitrogen concentration in the groundwater system is from nonpoint sources, such as agricultural uses and leach field discharges.

Increased levels of chloride and sulfate were observed in surface waters in the vicinity of direct discharges. Although concentrations of both chloride and sulfate were below the drinking water standard, sulfate concentrations just prior to entering Cherry Creek Reservoir approach the standard. Irregular elevated gross alpha activity counts in the basin appear to be related to the presence of uranium bearing soils. Total coliform analysis indicates their presence in surface water throughout the study reach; however, total coliform does not persist as the water percolates through the alluvial sediments to the groundwater table. Relatively few of the total coliform counts were fecal coliforms, with the majority being associated with soil bacteria.

Phosphorus Loading

Phosphorus loading from the tributaries to the reservoir, Cherry Creek, Cottonwood Creek, Shop Creek, Belleview drainage, Quincy Drainage, and the Cherry Creek alluvium (all considered to be nonpoint sources), was estimated at 12,276 pounds for 2000. Phosphorus loading from precipitation was 777 pounds during 2000, for a total loading to the reservoir of 13,053 pounds. Phosphorus leaving the reservoir in 2000 through the outflow was 3,688 pounds. The total load of 13,053 pounds entering the reservoir in 2000 met the TMDL of 14,270 pounds.

1. BACKGROUND

The Clean Lakes Study of Cherry Creek Reservoir conducted in 1982 identified that eutrophication of the reservoir could negatively impact the beneficial uses of the reservoir (Denver Regional Council of Governments [DRCOG] 1984). The Clean Lakes Study identified phosphorus as the major nutrient causing algal productivity and, therefore, potential eutrophication of the reservoir. Based on the Clean Lakes Study in 1985, the Colorado Water Quality Control Commission (CWQCC) established an in-reservoir total phosphorus standard of 35 µg/L to maintain an average in-reservoir chlorophyll *a* level at concentrations no higher than 15 µg/L during the "growing season" (both defined as a July - September seasonal mean). These standards were recently re-evaluated in September 2000 at a hearing before the CWQCC. Following this hearing, the CWQCC set a new chlorophyll *a* standard of 15 µg/L (July through September mean), not to be exceeded in nine out of ten years, with an underlying total phosphorus goal of 40 µg/L (July through September mean).

During 1985, the Cherry Creek local governments (cities, counties, and special districts), private interests, and representatives of the state and federal agencies developed a total maximum daily load (TMDL) of 14,270 pounds total phosphorus annual load and strategies to meet the reservoir standard and TMDL. The TMDL was presented in the Cherry Creek Basin Water Quality Management Master Plan (DRCOG 1985) and approved by the CWQCC. Also, portions of the Master Plan were adopted as the "Regulations for Control of Water Quality in Cherry Creek Reservoir" (Section 4.2.0, 5 C.C.R. 3.8.11), effective December 30, 1985. The TMDL and Master Plan were approved by the U.S. Environmental Protection Agency (USEPA) Region VIII office. In May of 2001, the CWQCC approved an annual allowable total phosphorus load (TMAL) of 14,270 pounds.

In 1985, an intergovernmental agreement was executed by the local governments within the Cherry Creek Basin, forming the Cherry Creek Basin Water Quality Authority (Authority). The Authority was created to develop and implement the means to protect the water quality of Cherry Creek Basin and Reservoir, while allowing economic development to occur. In 1987, the Colorado Legislature's Water and Water Quality Subcommittee conducted hearings on legislation to create a water quality management agency for the Cherry Creek Basin. Legislation introduced and enacted in the 1988 General Assembly statutorily created and empowered the Authority. Additional legislation in 2001 has reconstituted the Authority as follows:

One member from each County with property within the Authority	=	2
One member from each Municipality	=	7
One member for all Special Districts	=	1
Seven members appointed by the Governor	=	7
Total members of Authority Board	=	**17**

2. PURPOSE OF THE ANNUAL REPORT

The purpose of this Annual Report is to inform the Colorado Water Quality Control Commission, the Colorado State Parks Department, the U.S. Army Corp of Engineers, and other interested parties of the Authority's reservoir and watershed monitoring activities during 2000.

3. DESCRIPTION OF CHERRY CREEK RESERVOIR AND WATERSHED

Originally built for flood control, Cherry Creek Reservoir is owned and operated by the U.S. Army Corps of Engineers. The reservoir, with a surface area of approximately 850 acres (344 ha), and surrounding land was leased to the State of Colorado for use as the Cherry Creek State Recreation Area in 1957. The 3,915 acre-park (1,584 ha) almost immediately received extensive recreational use, a pattern that has continued to the present day. The reservoir and surrounding State Park serve as an important urban recreational site, providing opportunities for a variety of activities, including sport fishing, boating, swimming, bicycling, bird watching, and hiking. Additionally, the State Park provides important wildlife habitat.

Cherry Creek Reservoir was designed as a terminal stormwater storage facility, intended to hold runoff water that would then be discharged to maintain an acceptable downstream flow and a predetermined lake level. The reservoir, along with subsurface flows from below the dam, has maintained Cherry Creek downstream of the reservoir in a free-flowing condition. As a storage facility with regulated outflows, upstream flows have, over 40 years, accumulated sediment to depths of up to 6 meters at the outlet works with an average overall depth of almost 3 meters. The water in the reservoir undergoes chemical changes with its exposure to the influences of sediments, sunlight, temperature, and wind, all of which influence algal growth.

The reservoir's watershed includes approximately 245,500 acres (99,350 hectares). The northern portion of the watershed has been urbanizing over the past ten years, especially in the subbasins immediately adjacent to the reservoir. Developed land uses include high-moderate density suburban residential areas, large lot subdivisions, commercial and light industrial parks, and office buildings. Traditional agricultural and agribusiness uses are still present, but mostly in the southern half of the watershed.

4. AUTHORITY REVIEW OF SITE APPLICATIONS

The Authority reviews site applications and utility plans for wastewater collection and treatment facilities proposed in the Cherry Creek Basin. Site application reviews address protection of the Cherry Creek Reservoir specifically with respect to phosphorus and water quality in general, protection of downstream water supplies, adequacy of proposed design processes, and capacity and process designations identified in the Master Plan.

Site applications are reviewed against the following documents:

- Regulation No. 22, "Regulation for Site Application Process" (April 1998),
- Cherry Creek Basin Water Quality Management Master Plan (1989) and Watershed Plan 2000 (June 2000),
- Regulation No. 72, "Cherry Creek Reservoir Control Regulation" (May 1998),
- Metro Vision 2020 Clean Water Plan: "Wastewater Utility Plan Guidance", Denver Regional Council of Governments (DRCOG) (January 2001), and
- Policy 96-1, "Design Criteria Considered in the Review of Wastewater Treatment Facilities," expiration date May 31, 2001 ("Colorado guidance").

The Authority reviewed the following submittals in 2000:

Parker Water and Sanitation District - Challenger Park Lift Station - The Parker Water and Sanitation District submitted a Site Application for the Challenger Park Lift Station (December 1999). The Site application proposed that existing gravity sewers would convey wastewater flow to the Lift Station, which would pump the wastewater by force main under Cherry Creek and discharge to an existing sanitary sewer and ultimately to the District's South AWT Wastewater Treatment Facility. A recommendation for the approval of the site application was made in February 2000. The Authority approved the site application on _____.

Lone Tree Creek Wastewater Treatment Facility - Lone Tree Creek Wastewater Treatment Facility submitted a Site Application Engineering Report (February 2000) and an Interim Wastewater Utility Master Plan (March 2000) to modify the existing treatment processes, expand the land application area, and increase hydraulic capacity. A recommendation for approval of the submittal was made subject to conditions related to achieving a specified phosphorus limit and identifying emergency response procedures. The Authority conditionally approved the site application on _____.

Inverness Water and Sanitation District - The Inverness Wastewater Treatment Plant submitted a Wastewater Utility Plan and a Site Application (July 2000) for the plant modification and expansion. Review comments recommended submittal of three technical support documents, which were later submitted and a recommendation for the approval of the site application was made. The Authority approved the site application on _____.

Meridian Metropolitan District - Bradbury/Meridian Northwest Lift Station - Meridian Metropolitan District submitted a Site Application (September 2000) for the Bradbury/Meridian Northwest Lift Station. The Authority conditionally recommended approval for the site application pending the submission of missing sections of the report. The missing sections were received and a recommendation for the approval of the site application was made. The Authority approved the site application on _____.

Plum Creek Wastewater Authority - Castlewood Ranch Development - The Castlewood Ranch Development submitted a Preliminary Design Memorandum and Site Application (September 2000) for the

Castlewood Lift Station No. 1. The proposed location of the lift station is within the Cherry Creek Basin. However, the lift station will pump wastewater to a collection system where flow is directed to the East Plum Creek Basin. The Plum Creek Wastewater Authority agreed to treat the waste originating from the lift station and the Town of Castle Rock will manage and operate the lift station. The Site application was reviewed and found to be an inadequate submittal that did not address key items required by Denver Regional Council of Governments Wastewater Utility Plan Guidance or the Authority. Additional information was requested to appropriately evaluate this submittal. When supplemental information was provided, a recommendation for approval of the site application was made in January 2001. The Authority approved the site application on _____.

Pinery Water and Wastewater District - The Pinery submitted a Wastewater Utility Plan (October 2000) to modify and expand the Pinery Wastewater Treatment Plant. The plan included both the Wastewater Utility Plan and the Site Application for expansion. A recommendation for the approval of the site application was made and the Authority approved the site application on _____.

Inverness Water and Sanitation District - Dry Creek Medical Campus Lift Station - The Dry Creek Medical Lift Station Site Application submittal included items that were incomplete or required some clarification prior to completing the review. In particular, there was concern regarding the impacts on the Inverness Water and Sanitation District. Brown and Caldwell recommended disapproval of this site application due to incompleteness, errors and oversized pumps. All issues were addressed and a recommendation for the approval of the site application was made in 2001. The Authority approved the site application on _____.

5. AUTHORITY REVIEW OF DEVELOPMENT PROPOSALS

The Cherry Creek Basin continues to experience growing development. To mitigate potential water quality impacts from construction activities and urbanization, the Authority developed a strategy to improve coordination with land use agencies to address development and storm drainage quality. This strategy includes taking an active role in the development review process.

The Authority took an active role as a referral agency in the land use application review process. The Authority reviews focus on point and nonpoint pollutant source impacts and water quality considerations related to the proposed land use projects. The land use applications are reviewed against the criteria and standards in the Cherry Creek Reservoir Watershed Stormwater Quality Regulation.

5.1 Cherry Creek Reservoir Watershed Stormwater Quality Regulation

In 1999, the Authority adopted Stormwater Quality Regulations related to construction activities and post-construction control of stormwater quality. The purpose of these Regulations is to:

- Recommend substantive requirements to control the quality of stormwater runoff in the Cherry Creek Basin from private and public property, and to

- Reduce the loads of contaminants reaching Cherry Creek and Cherry Creek Reservoir in furtherance of health, safety, and general welfare in the Cherry Creek Basin.

The Regulations establish minimum requirements for technical measures (BMPs) that address construction erosion and sediment control and water quality enhancement for completed developments (permanent BMPs). The BMPs address impacts from residential, commercial, mining, and industrial development. The regulations also address protection of groundwater drinking supplies and stream preservation areas. A program to monitor and enforce BMP implementation is addressed by the Regulation.

The Authority recommends that each municipality and county within the Cherry Creek Basin adopt standards and criteria substantially similar to these Requirements and implement and enforce the standards and criteria within their jurisdictions. The recommended BMP requirements are necessary to reduce and maintain nonpoint source and stormwater phosphorus loads below their load allocation, in accordance with the TMDL set forth in the Cherry Creek Control Regulation.

5.2 Development Reviews

The Authority reviewed and commented on 156 land use applications, or an average of 13 reviews per month (Table 1).

TABLE 1: Sources of land use application referrals.

Land Use Planning Agency	Number of Land Use Applications
Arapahoe County	66
City of Aurora	6
Douglas County	18
Town of Parker	66
Total	**156**

6. CHERRY CREEK RESERVOIR WATERSHED MONITORING ACTIVITIES

6.1 CHERRY CREEK RESERVOIR

6.1.1 Cherry Creek Reservoir - Summary of Data

Based on the past nine years of monitoring, the following observations can be made:

- The seasonal mean concentration of phosphorus measured in 2000 was identical to levels measured in 1999 and were less than that measured in 1997 or 1998 (Table 2). The nitrogen concentration measured in 2000 was slightly lower than in 1999. The 1992 - 2000 July - September seasonal means of total phosphorus (ranging from 48 to 96 µg/L) have all greatly exceeded the previous standard of 35 µg/L, as well as the current goal of 40 µg/L. Average chlorophyll content in 2000 was lower than that observed in 1999 or 1998. Chlorophyll *a* concentrations have been greater than 20 µg/L since 1996. Only three of the last nine (1993-1995) met the new standard of 15.0 µg/L.

TABLE 2: Water quality and total phosphorus loads data for Cherry Creek Reservoir, July - September 1992 - 2000.

Year	Chlorophyll *a* (µg/L)	Secchi Depth (ft)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	7,987	9,049	0.92
1993	14.4	1.2	62	826	4,764	6,643	0.71
1994	10.0	1.1	59	1,144	5,053	7,188	0.70
1995	9.4	1.6	48	913	10,598	11,786	0.94
1996	20.5	1.6	62	944	5,852	7,615	0.76
1997	22.3	1.0	96	1,120	6,552	10,447	0.61
1998	26.5	1.0	89	880	15,313	20,820	0.74
1999	28.9	1.0	81	753	20,209	30,032	0.68
2000	25.2	1.0	81	802	13,053	18,584	0.72
9-Year Mean	19.4	1.2	72	928	9,931	13,574	0.75
Median	20.5	1.0	66	913	7,987	10,447	0.72

* Stream, alluvium, and precipitation.

- Lake transparency (as measured by Secchi depth) has remained relatively constant over the past nine years.
- Annual total phosphorus loads have averaged 9,931 pounds/year over this nine-year period (Table 2), meeting the TMAL of 14,270 pounds each year, except for 1998 and 1999. The exceedances of the TMAL (referred to as a TMDL prior to May 2001) in 1998 and 1999 appeared to be related to considerably increased inflows during these years (Table 2). While both flows (18,584 ac/ft) and phosphorus load (13,053 lbs) exceeded the nine-year mean value in 2000, the TMAL for total phosphorus was not exceeded.

6.1.2 Annual Reservoir Monitoring Activities - 2000

The aquatic biological and nutrient monitoring study on Cherry Creek Reservoir and selected off-lake sampling sites (tributary streams) was conducted by CEC in 2000. The study was designed to characterize the potential relationships between nutrient loading (both in-lake and external) and reservoir algal productivity (as measured by chlorophyll *a* concentrations). Dr. John Jones of the University of Missouri is a consulting limnologist retained in 1992 by the Authority to evaluate the status and condition of Cherry Creek Reservoir, and to make recommendations regarding reservoir modeling and dynamics. As part of this effort, Dr. Jones also performed water quality testing on 20% of the reservoir samples as a quality assurance check in 2000. These data can be found in the *2000 Annual Monitoring Report* (CEC 2001, Appendix A). The specific objectives of this study included the following:

- Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus species, in Cherry Creek Reservoir, tributaries to the reservoir, and the reservoir outflow.

- Determine loading rates of phosphorus to Cherry Creek Reservoir from tributaries and precipitation, and the amount leaving the reservoir through its outlet.

- Determine biological productivity in Cherry Creek Reservoir, as measured by chlorophyll *a* concentrations and algal densities. Additionally, determine the species composition of the algal and zooplankton communities.

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

Sampling in 2000 was conducted at 15 sites, 14 of which were established during past sampling efforts (CEC 1995, 1996, 1997, 1998a, 1999, 2000). This included three sites in Cherry Creek Reservoir, 11 sites on influent streams, and one site on Cherry Creek downstream of the reservoir (Fig. 1). Site CC-10a was added in 1999. The Authority also contracted with State Parks Department to provide field sampling of summer in-lake water quality samples. Due to unstable ice on the reservoir in January and December, the sampling season in 2000 for water chemistry and biota was from February through November.

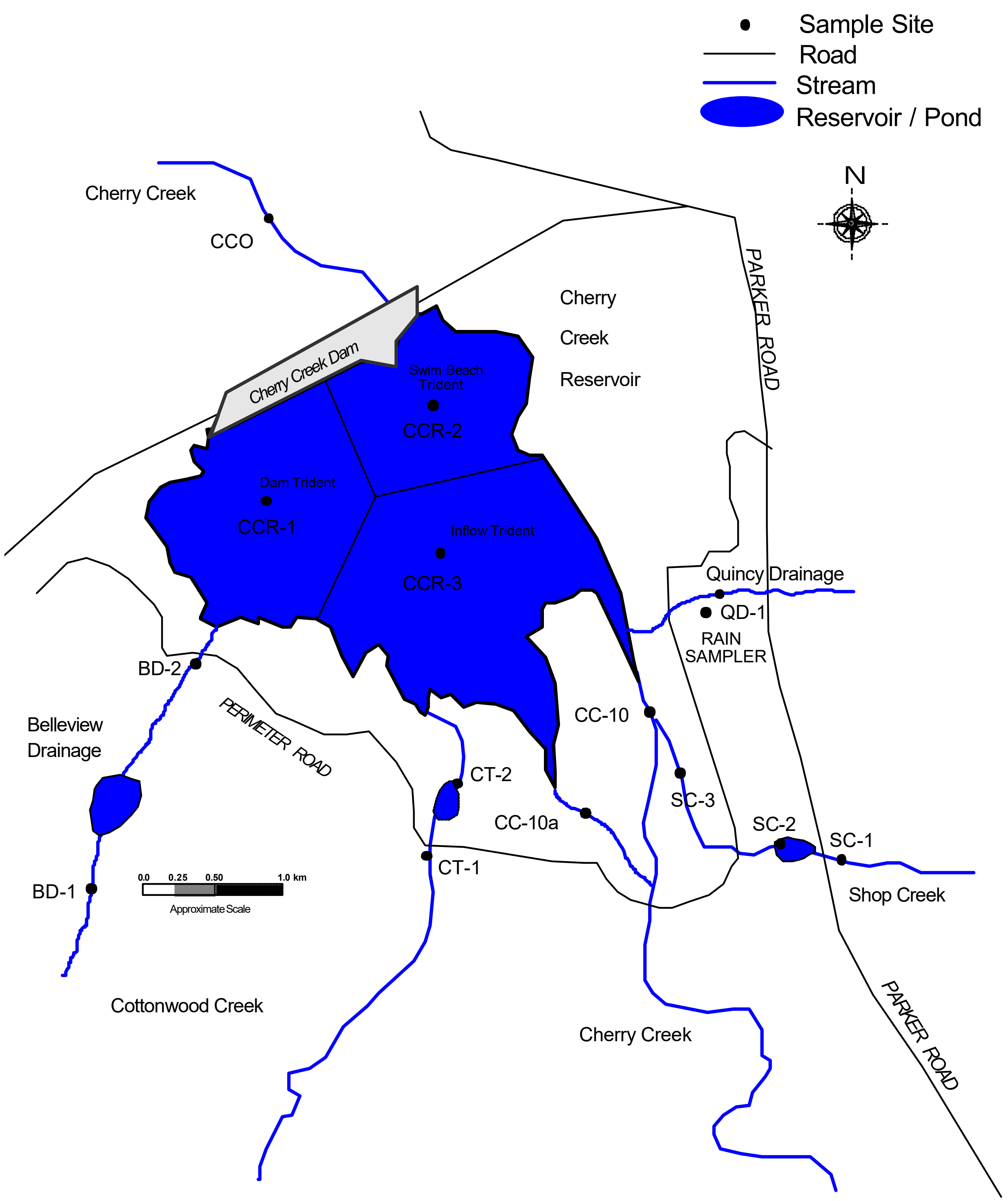

FIGURE 1: Sampling sites on Cherry Creek Reservoir and influent streams, 2000.

Water transparency (or water clarity as measured by Secchi disk depth) in 2000 was greatest in July, and generally decreased until the end of the sampling season in November (CEC 2001). In 2000, the water clarity was also monitored with a combined-deck photometer using the 1% transmissivity to approximate the photic zone. Periods of high water transparency generally corresponded to periods of low phytoplankton (algae) densities. Similar relationships have been observed since 1994. In addition, the density of phytoplankton explained 38% of the variation in Secchi depth in 2000 (CEC 2001).

Analysis of past Cherry Creek Reservoir temperature profiles conducted by Dr. Jones indicated that stratification occurs when there is a >2• C difference between surface and bottom temperatures. Differences of approximately 1• C suggest a recent mixing event (Jones 1998). Using the above criteria, Cherry Creek Reservoir experienced two periods of slight thermal stratification in 2000 (Fig. 2). These periods of stratification occurred in May-June and then again in July. Dissolved oxygen concentrations were periodically reduced in the lowest levels of the reservoir. However, dissolved oxygen concentrations at the bottom of the reservoir usually did not drop to anoxic levels (Fig. 3).

Concentrations of *Escherichia coli*, which are an indicator of the potential presence of pathogenic organisms, were measured between May and October 2000. In 2000, the concentration of *E. coli* in Cherry Creek Reservoir ranged from below the detection limit of 2 *E. coli* cells/100 mL to 23 *E. coli* /100 mL. The data indicated that pathogenic bacteria probably do not pose a risk to recreation activities in the main body of the reservoir.

During the July through September period, concentrations of total phosphorus from composite samples averaged 81 µg/L in 2000 (Table 2). This value exceeded the numeric standard of 35 µg/L established in 1985, as well as the 40 µg/L goal established in September 2000, and was greater than the nine-year median value of 66 µg/L. Total nitrogen averaged 802 µg/L from surface samples during 2000, noticeably lower than the nine-year mean. Nutrient profile samples collected in 2000 showed a well mixed reservoir in spring and fall with brief periods of apparent stratification and nutrient release from the bottom sediments through the summer (Fig. 4).

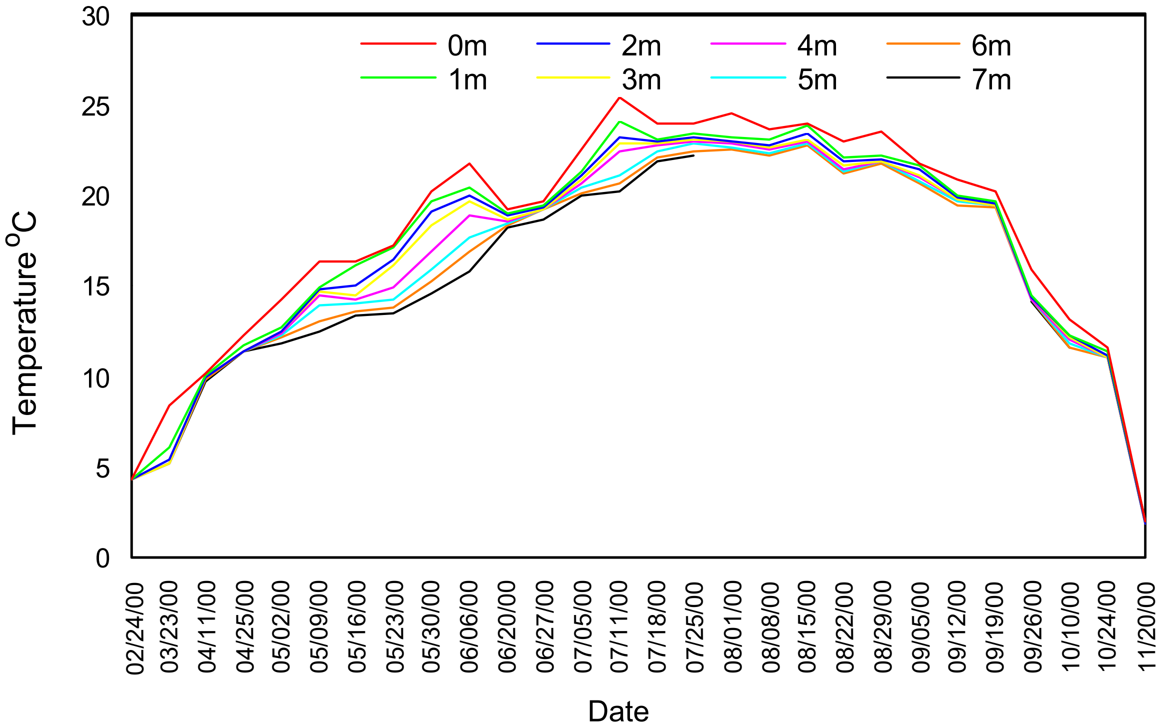

FIGURE 2: Temperature (• C) profiles recorded during routine monitoring at CCR-2 in 2000.

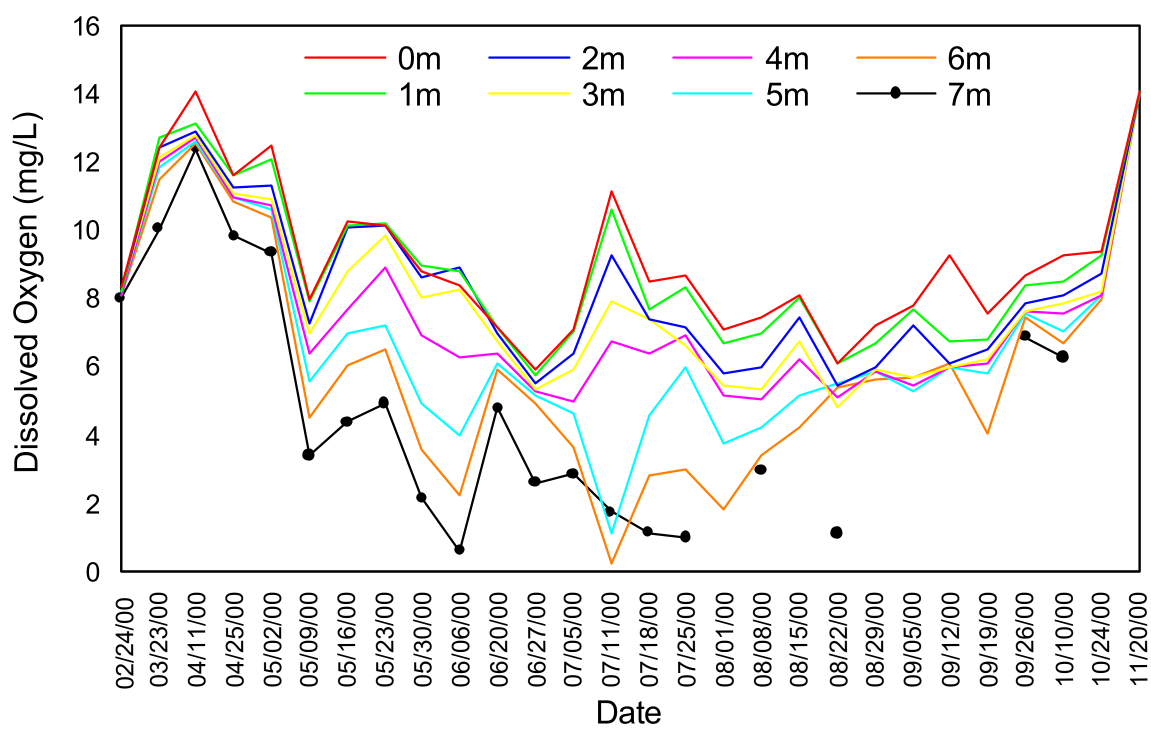

FIGURE 3: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at CCR-2 in 2000.

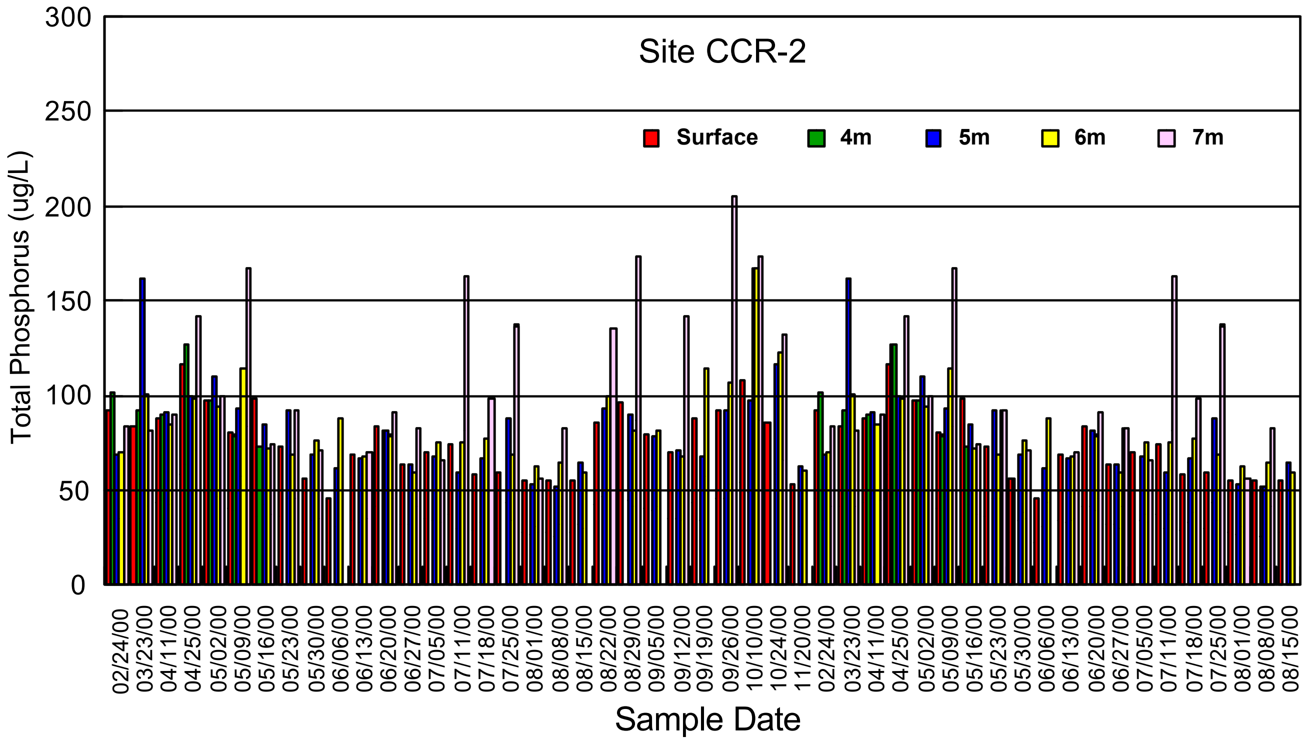

FIGURE 4: Phosphorus concentrations from profile samples at Site CCR-2, Cherry Creek Reservoir, 2000.

Phytoplankton densities and species richness varied throughout 2000 (CEC 2001). Blue-green algae were typically the most abundant algal group during February-November 2000 with small, "micro" blue-green algae predominant. They were responsible for most of the variability in phytoplankton densities, comprising 73% of the total algal densities in 2000. This pattern of blue-green algae dominance has been exhibited throughout the 1987 - 2000 monitoring period. A new taxonomist using state-of-the-art methods analyzed the phytoplankton samples in 2000. These new methods resulted in a data set of much higher quality than had previously been produced for Cherry Creek Reservoir. This increase in data quality resulted in an apparent increase in density and taxa richness in 2000, relative to previous years. It is likely that these observed increases are artifacts of the methodology, and do not reflect actual changes in the reservoir biology.

Concentrations of chlorophyll *a* were measured to be 25.2 µg/L as a July - September mean in 2000 (Table 2). Although this value was lower than that observed in 1999 (28.9 µg/L), it still exceeded the new standard of 15 µg/L. The abundance of larger bodied algae can contribute to these higher chlorophyll values.

Zooplankton communities in Cherry Creek Reservoir were dominated by cladocerans or copepods in spring and fall 2000 (CEC 2001). Protozoans were absent in the zooplankton community until late June 2000, after which they exhibited high densities through September. Following this peak, protozoans decreased over the rest of the year. Rotifers dominated densities for periods in September, October, and November 2000. As in past years, larger algae-grazing zooplankton, such as cladocerans, exhibit reduced densities in late summer, coincident with higher chlorophyll levels.

From 1985 to 1999, ten fish species and two hybrids have been stocked by the Colorado Division of Wildlife in Cherry Creek Reservoir. Channel catfish, rainbow trout, and walleye have been stocked every year. The fish community in Cherry Creek Reservoir is dominated by gizzard shad, an effective zooplanktivore (CEC 1998a, 1999). This species is capable of suppressing zooplankton populations, potentially leading to increased phytoplankton (algae) densities. Planktivorous species, such as gizzard shad, in Cherry Creek Reservoir are probably reducing zooplankton populations below what they would be without such intense predation, thus influencing nutrient dynamics of the reservoir (i.e., by affecting phytoplankton abundance and potential chlorophyll levels). Two separate fish kills were reported in the reservoir in September 2000. These kills primarily affected walleye. The cause of these fish kills is not known but may be related to increased parasitic infestation of their gills.

6.2 CHERRY CREEK MAINSTEM

6.2.1 Phase I Baseline Water Quality Data Collection Study for Cherry Creek Mainstem

The Phase I Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin watershed was initiated in August 1994, and has been operated continuously through calendar year 2000. This study is being conducted for the Authority by John C. Halepaska and Associates, Inc. (JCHA 2001).

As part of this study, water quality data are collected at ten surface water stations from Castlewood Canyon to Cherry Creek Reservoir and from nine alluvial ground water well locations from just downstream of Franktown to Cherry Creek Reservoir (Table 3).

TABLE 3: Water Quality Monitoring Stations for Phase I Baseline Study

Surface Water[1]	Location
Castlewood	0.2 mile north of the USGS Cherry Creek near Franktown gaging station
CC-1	1 mile south of Scott Road
CC-2	¾ mile south of Stroh Road
CC-3	1 mile south of West Parker Road (not a water quality sampling location)
CC-4	½ mile south of Lincoln Avenue
CC-5	½ mile north of Lincoln Avenue
CC-6	on Arapahoe/Douglas County Lin
CC-7	¾ mile south of Arapahoe Road (not a water quality sampling location)
CC-8	½ mile north of Arapahoe Road
CC-9	in Cherry Creek State Park, near Nature Center
Ground Water[1]	
MW-1	monitoring well adjacent to Pinery production well #6
MW-2	monitoring well E-2 downgradient of Pinery discharge
MW-3	Parker KOA production well
MW-4b [2]	Parker NPDES monitoring well M-3
MW-5	monitoring well adjacent to Arapahoe Loyd #2 production well
MW-6	monitoring well adjacent to Arapahoe Race #1 production well
MW-7	monitoring well adjacent to Arapahoe Ford #2 production well
MW-8	Arapahoe Deem production well
MW-9	monitoring well in Cherry Creek State Park near Nature Center
Kennedy	Denver production well adjacent to Kennedy Golf Course

1) See Fig. 1 for station locations.
2) Replaced MW-4 in January 1995 when MW-4 was abandoned due to development.

During calendar year 2000, the Phase I Water Quality Data Collection Study included water quality monitoring for (1)phosphorus and nitrogen species, (2) chloride, sulfate and total dissolved solids, (3) select metals with secondary drinking water standards (iron and manganese), (4) evaluation of gross alpha activity, (5) evaluation of the presence of trihalomethanes (chloroform), (6) evaluation of biological activity in both the surface water and ground water (total coliform analyses), and (7) evaluation of biological activity in the surface water related to wastewater discharges (fecal coliforms). This water quality monitoring parameter list represents an expansion from the parameters monitored during the first year of the study and was designed to better characterize water quality conditions in the Cherry Creek mainstem (Table 4). There were some reductions in the parameters being analyzed in 2000 based on identification of the principal parameters of concern in the baseline data collection effort.

TABLE 4: Water Quality Monitoring Parameters List

Monthly Water Sampling[1)]	
Ammonia	Chloride
Nitrate	Sulfate
Total Dissolved Phosphorus	Total Suspended Solids[2)]
Soluble Reactive Phosphorus	Total Volatile Suspended Solids[2)]
Total Phosphorus [2)]	Total Coliform
Semi-Annual Sampling[1)]	
Gross Alpha	
Manganese [3)]	
Iron [3)]	
Annual Sampling[1)]	
Chloroform	

1) At all ground water and surface water sampling sites.
2) Analyzed only in surface water samples.
3) Total concentrations measured in surface water samples and dissolved concentrations measured in ground water samples.

All flow and water quality monitoring in the Phase I baseline study is conducted using standardized quality assurance/quality control (QA/QC) procedures based on a QA/QC manual which was prepared to describe the procedures to be used for all field measurements and sample collection (JCHA, June 1994).

6.2.2 Water Quality Summary

The water quality data collected to date indicates that phosphorus concentrations in both the Cherry Creek channel and in the underlying alluvial aquifer are generally low (0.1 to 0.3 mg/L) and consistent both spatially and temporally (Fig. 5). Where there are some increases in soluble reactive phosphorus concentrations in the surface water through the study reach, there is virtually no difference in soluble reactive phosphorus concentrations in the ground water (Fig. 6). There are no discernable impacts at monitoring locations downgradient of direct dischargers that would imply dischargers are currently impacting phosphorus loads to the reservoir (Fig. 6). In fact, using phosphorus concentration and flow data at Castlewood Canyon as background, comparing these data to comparable concentration and flow data at Cherry Creek Reservoir, and including discharge monitoring report (DMR) data from each direct discharger, indicates that non-point phosphorus loads are consistently greater than 90 percent of the total load entering Cherry Creek Reservoir from the mainstem of Cherry Creek. This is indicative of natural geologic conditions, where phosphorus in the form of calcium phosphate in the soil is mobilized by surface runoff and ground water underflow.

When determining a phosphorus budget for the Cherry Creek system, it is important to note both addition and removal of phosphorus from the system. There are five principal municipal water supply entities in the upper Cherry Creek Basin which utilize Cherry Creek alluvial aquifer wells, Arapahoe Water and Wastewater Authority, City of Aurora, Cottonwood Water and Sanitation District, Parker Water and Sanitation District, and the Pinery Water and Sanitation District. Average phosphorus concentrations from sites near these wells from the Phase I baseline ground water quality data base were used to estimate annual loads removed from the Cherry Creek alluvium due to this well pumping. These removals are summarized in Table 7, and show a total of 3,868 pounds removed in 2000. When consideration is given to the volume of phosphorus removed by municipal alluvial well pumping, there is actually a net *decrease* in phosphorus load as a result of the municipal activities (pumping and discharging combined).

For calendar year 2000, the phosphorus loading to Cherry Creek Reservoir from the mainstem of Cherry Creek upstream of Cherry Creek Reservoir (and upstream of CC-10, the CEC monitoring site upon which the final loading values are based) is approximately 4,304 pounds (2,545 pounds from surface water and 1,759 pounds from ground water). For comparison purposes, the annual loading in the mainstem upstream of the reservoir in 1999 was estimated at 8,375 pounds (6,530 pounds from surface water and 1,845 pounds from ground water). The decrease in phosphorus load (95 percent) is related to lower surface flows in 2000 than in 1999. Phosphorus concentrations remained virtually unchanged from 1999 to 2000 in both the surface water and the ground water.

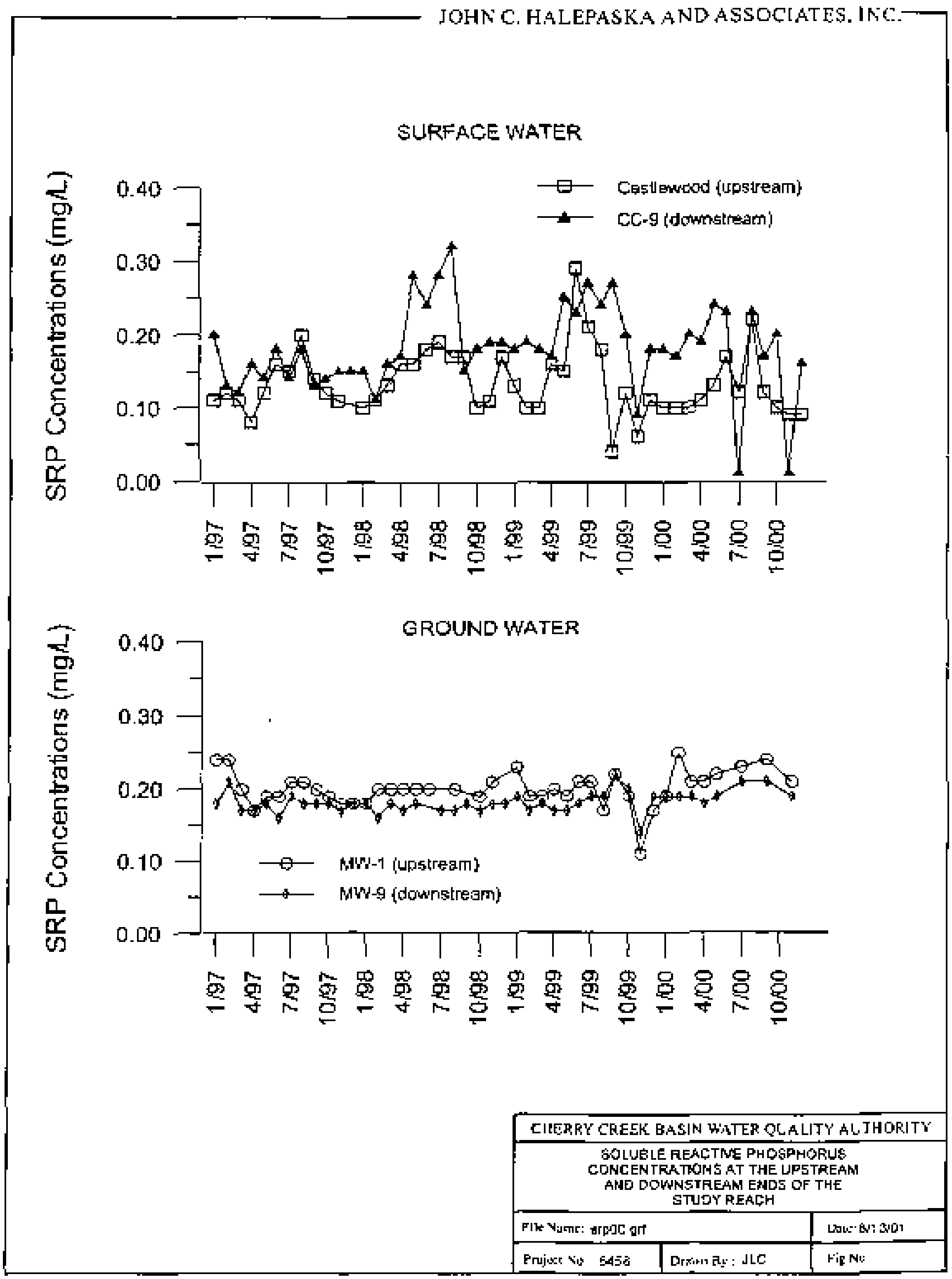

FIGURE 5: Soluble reactive phosphorus concentrations at the upstream and downstream ends of the study reach.

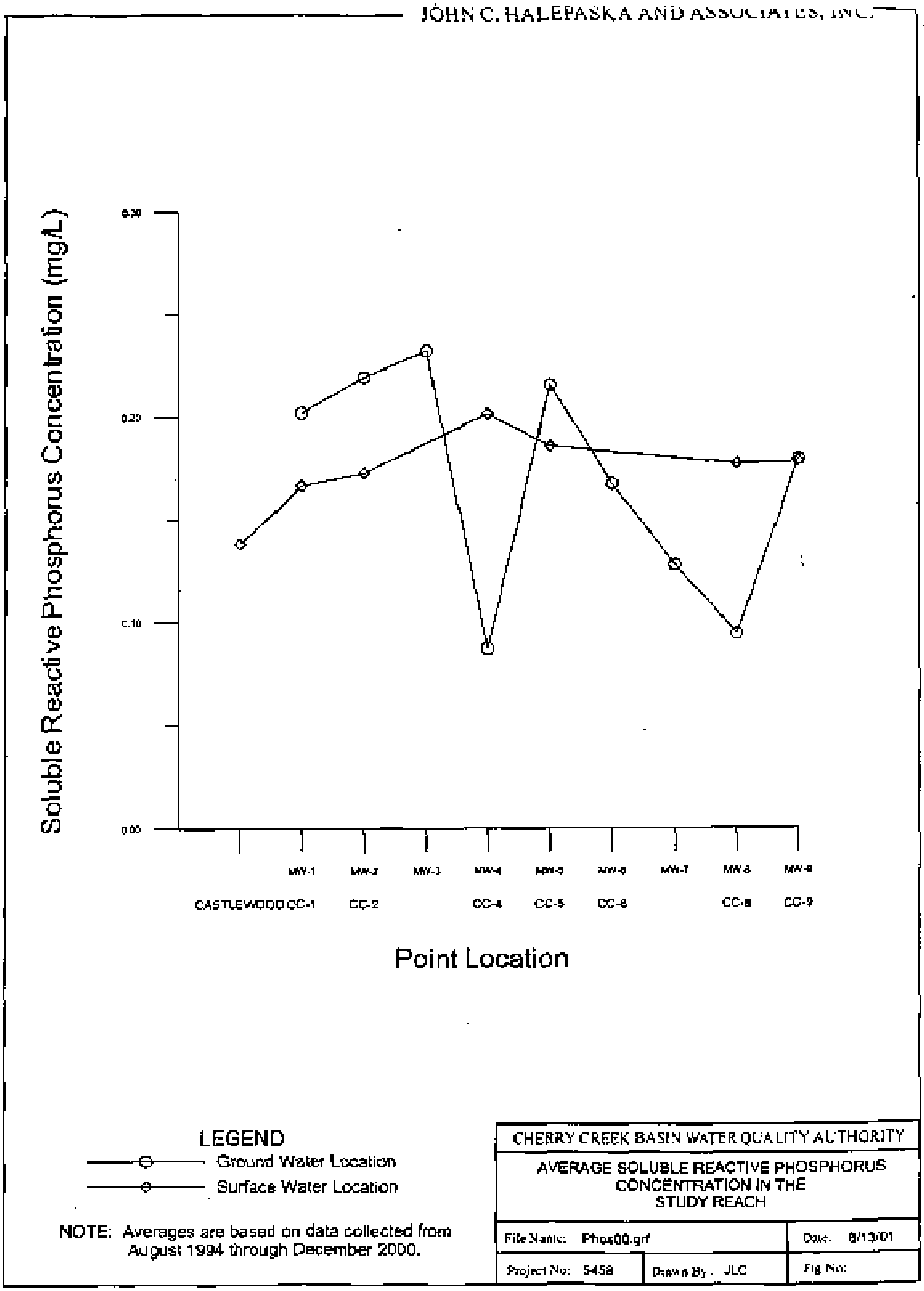

FIGURE 6: Average soluble reactive phosphorus concentration in the study reach.

While phosphorus concentrations remained relatively steady from the upstream end of the study reach to the downstream end (Cherry Creek Reservoir) (Fig. 6), nitrate-nitrogen concentrations fluctuated significantly throughout the study reach (Fig. 7). Concentrations during 2000 generally ranged from non-detectable (less than 0.05 mg/L) to greater than 9 mg/L.

The fluctuations in nitrate-nitrogen concentrations may be caused by several different mechanisms. There appears to be some correlation between increased nitrate-nitrogen concentrations and direct discharge releases. However, as one moves downgradient from the direct discharges, nitrate-nitrogen concentrations tend to decline rapidly (Fig. 7). This is generally not expected, as nitrate is a conservative ion that does not attenuate over distance, except due to dispersion. However, this is a shallow water table system, where phreatophytes (riparian plants) can be assimilating nitrate. It is also a somewhat layered system, where varying screened sections in the wells can contribute to the variations in concentration.

Overall, nitrate-nitrogen concentrations in the surface water increase from an average of 0.24 mg/L at Castlewood Canyon to 0.51 mg/L at CC-9 (just upstream of Cherry Creek Reservoir). Nitrate-nitrogen concentrations in the alluvial ground water are higher than in the surface water, with an average concentration at MW-1 (just downstream of Castlewood Canyon) of 1.19 mg/L, and an average nitrate-nitrogen concentration at MW-9 of 1.31 mg/L. These indicate a relatively minor overall increase in nitrate-nitrogen concentrations, with the absolute concentrations being approximately an order of magnitude less than the drinking water standard (10 mg/L). It should also be noted that there is a relatively large nitrate-nitrogen component in the ground water at the upstream end of the study reach, most likely related to agricultural uses of the land in the upper portion of the basin, and also potentially from leach field discharges.

Two water quality parameters that appear to be affected by direct discharges in the Upper Cherry Creek Basin are chloride and sulfate concentrations. Both parameters show increasing trends in the vicinity of direct discharges. Overall, the chloride concentrations are increasing from approximately less than 10 mg/L at the upstream end of the study reach to approximately 40 mg/L upstream of Cherry Creek Reservoir (Fig. 8). Parker Water and Sanitation District discharges to Cherry Creek between Sites CC-2 and CC-4, and a distinct increase in chloride concentration is evident in the streamflow. Likewise, the Pinery discharges to rapid infiltration basins between Sites MW-1 and MW-2, and a significant change in chloride concentration is noted in the alluvial ground water (Fig. 8). The increase in chloride concentrations at Site CC-8 may be related to land application of secondary effluent at the Valley Country Club and/or irrigation return flows from turf farms still operating in the area.

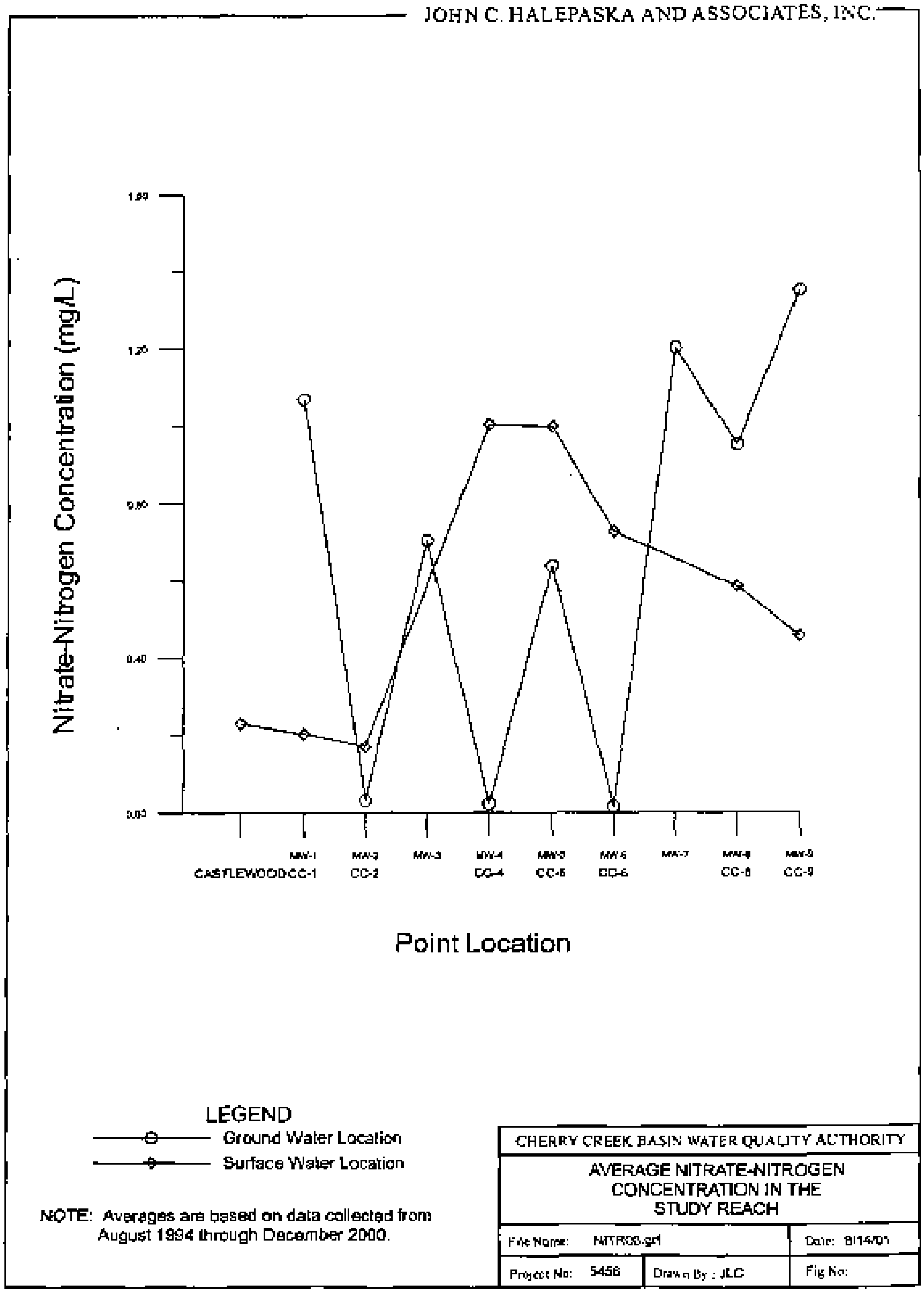

FIGURE 7: Average nitrate-nitrogen concentrations in the study reach.

Sulfate concentrations have exhibited a similar trend of increasing concentrations downgradient of direct discharges, with a general trend of increasing concentrations throughout the study reach. Sulfate concentrations are generally in the range of 10 to 20 mg/L at the upstream end of the study reach in both surface water and ground water, while concentrations are reaching 120 to 160 mg/L in the surface water and 150 to 200 mg/L in alluvial ground water prior to entering Cherry Creek Reservoir. Given a drinking water standard of 250 mg/L, sulfate concentrations are approaching the standard. Since aluminum sulfate is the chemical that is generally used to remove phosphorus in the advanced wastewater treatment process, there appears to be a tradeoff between lowering phosphorus levels to meet the Cherry Creek Reservoir Control Regulation, maintaining acceptable sulfate concentrations in the creek channel and in the alluvial aquifer. This is a concern, and direct dischargers are evaluating this relationship and the possibility of using alternative chemicals for phosphorus removal.

From 1995 through 1999, semi-annual samples for metals for primary and secondary drinking water standards were analyzed. This provided a baseline for metals that were being observed during the semi-sampling events. Based on a review of these data, only iron and manganese were consistently being measured above the detection limits. Therefore, for calendar year 2000, the semi-annual sampling for metals was reduced to iron and manganese.

In the semi-annual sampling for iron and manganese, elevated values were observed in both the surface water and ground water, although concentrations exceeding the drinking water standards were more prevalent in the surface water. No consistent trends were observed for either iron or manganese, with sporadic elevated concentrations occurring throughout the study reach. This is indicative of natural geologic conditions where iron and manganese may be present in the vicinity of a monitoring well, or they are present in the stream channel sediments and are being taken into solution in the surface flow.

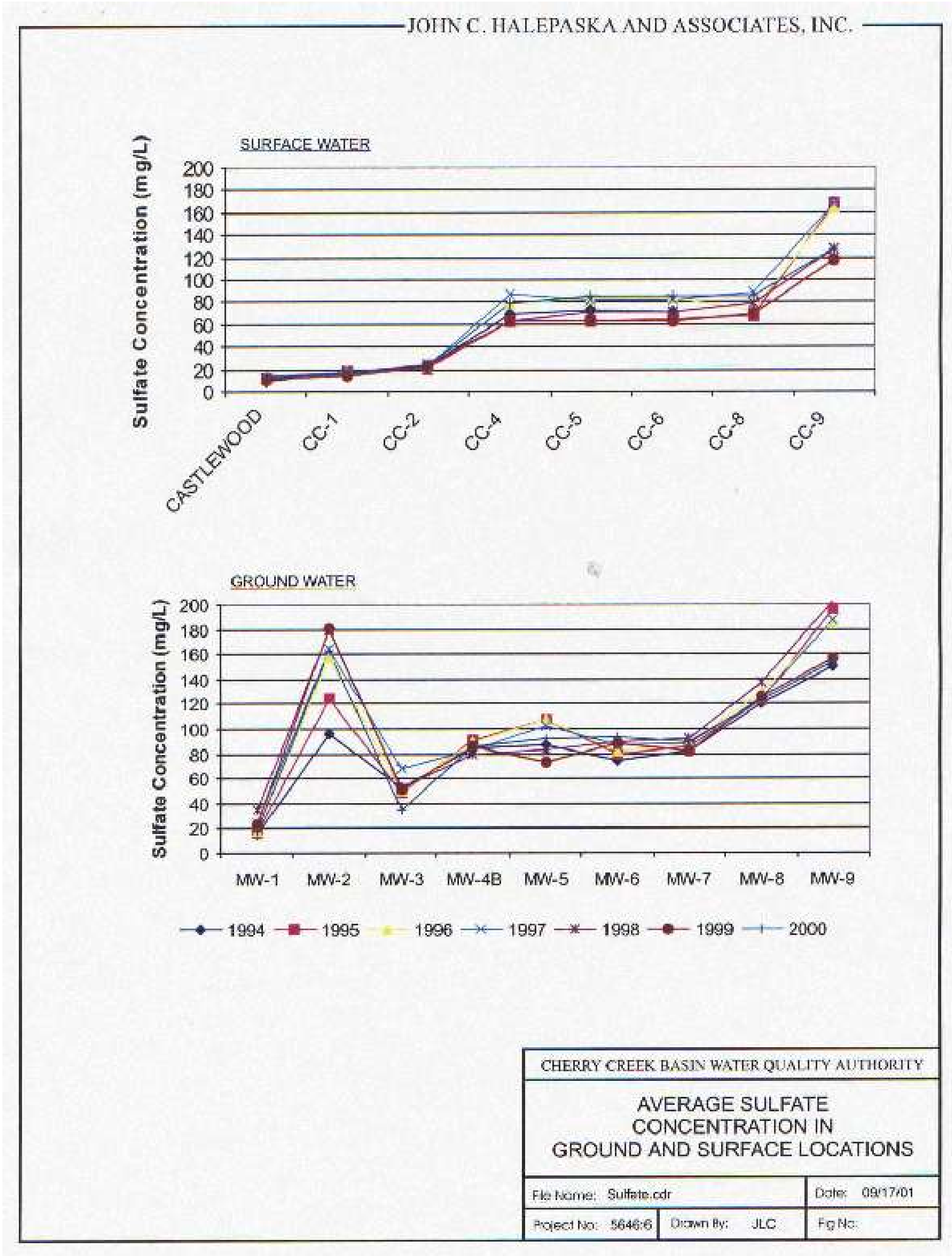

FIGURE 8: Chloride concentration trend in surface and ground water.

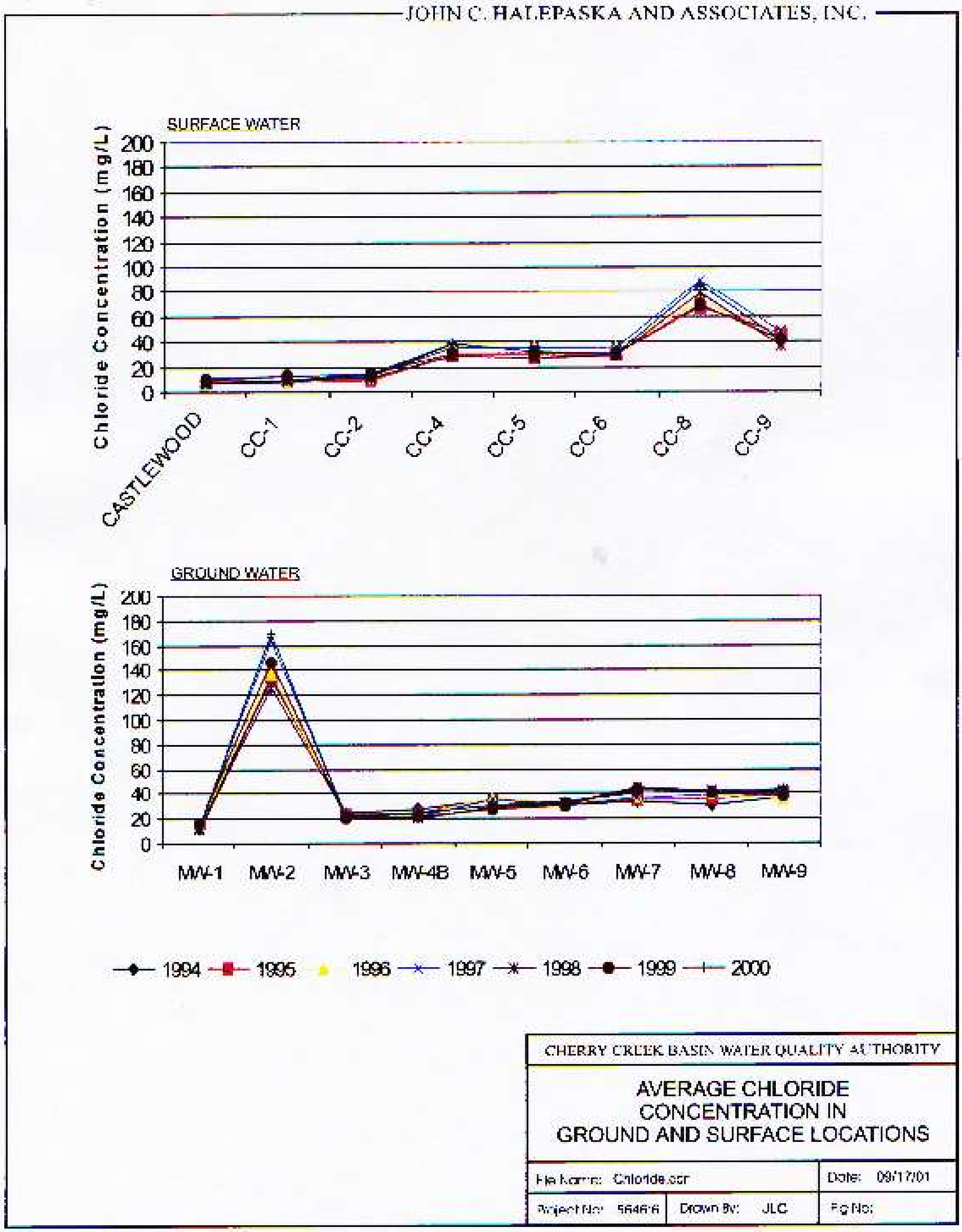

FIGURE 9: Sulfate concentration trend in surface and ground water.

Since 1995, semi-annual samples for gross alpha have been collected to evaluate the presence of radionucliides in both the surface water and ground water in the upper Cherry Creek Basin. In 2000, follow-up analyses for uranium and Radium 226 were added to further evaluate the potential exceedance of the primary drinking water standard for gross alpha.

Gross alpha was used as an indicator of radionucliides, and there were several measured exceedances of the gross alpha standard, both in the surface water and in the ground water. The sporadic elevated gross alpha activity counts are likely related to the natural geology in the area and the presence of uranium in soils near some of the sampling points. Follow-up analyses for uranium and Radium-226 indicated compliance with drinking water standards in some samples, while in others, compliance was inconclusive based on the potential presence of other radionucliides (such as radon).

From 1995 to 1999, semi-annual samples for chloroform were collected to serve as an indicator of trihalomethanes (THMs). Beginning in 2000, chloroform analyses were reduced to annual sampling. Chloroform was tested on a single-event basis in July 2000 to evaluate the presence of THMs (a potential by-product from wastewater treatment plants) in the surface water and in the ground water. The chloroform analyses indicated no detectable chloroform in either the surface water or the ground water.

To evaluate the presence of bacteriological activity in the surface channel, and its potential persistence into the alluvial sediments, total coliform analyses have been conducted since August 1995 on a monthly basis to evaluate the presence of pathogenic organisms. Results of these total coliform analyses have indicated the persistent presence of coliforms throughout the study reach in the surface water in varying concentrations both spatially and temporally. However, similar total coliform analyses of the alluvial ground water indicate that this biological activity does not persist as the water percolates through the alluvial sediments to the water table. This is consistent with the published literature, which indicates that coliform bacteria generally do not persist over any significant time or distance once they enter the soil matrix.

Fecal coliform analyses were added in March 1997 to evaluate what percentage of the observed total coliform counts might be attributable to wastewater discharges. Comparison of fecal coliform to total coliform data to date indicate that the bulk of the coliforms being measured in the upper Cherry Creek watershed are not fecal coliforms. This indicates that the primary coliform counts are related to soil bacteria, which also explains the high coliform counts even at locations above direct dischargers.

The Phase I Baseline Water Quality Data Collection Study is currently ongoing, using the same surface water and ground water sampling stations as was initiated in August 1994.

6.3 PHOSPHORUS LOADING TO THE RESERVOIR

6.3.1 Inflowing Streams

As part of the reservoir influent stream monitoring, phosphorus loading was calculated for Cherry Creek, Cottonwood Creek, Shop Creek, Belleview Drainage, and Quincy Drainage prior to their confluence with the reservoir. Note that for data prior to 1992, values are only available for "water years." A water year (WY) begins on 1 October of the previous year and continues until 30 September.

Total phosphorus loading to the reservoir from Cherry Creek, Cottonwood Creek, Shop Creek, Belleview Drainage, and Quincy Drainage was estimated at 11,827 pounds in 2000 (Table 5). Although total phosphorus loading from the above influent streams exceeded the nine-year mean value, the standardized loading in pounds per acre foot for 2000 was in the range of previous years (Table 6) indicating that, on average, phosphorus concentration did not increase in 2000.

TABLE 5: Phosphorus loading into Cherry Creek Reservoir from influent streams, 2000.

Influent Stream	2000 Phosphorus Loading (lbs)
Cherry Creek	9,984
Cottonwood Creek	1,712
Shop Creek	120
Belleview Drainage	11
Quincy Drainage	0
Total	**11,827**

The reduction in phosphorus loading between 1999 and 2000 was due primarily to the decrease in inflow in 2000 relative to 1999 (Table 6, Fig. 10). However, inflow volume in 2000 was still well over the long-term average of 13,574 ac/ft. Inflow, measured as the change in reservoir elevation by the Army Corps of Engineers, was highest during the spring of 2000 (Fig. 11).

TABLE 6: Phosphorus loading into Cherry Creek Reservoir from tributary streams, 1987 to 2000. Note that data for 1987 to 1991 are based on water years, while data for 1992 to present are based on calendar years.

Source of Data from Streams	Year	Total Annual Inflow (AF)	Total Annual Phosphorus (lbs) from Streams	Total Annual Phosphorus, Standardized (lbs/AF) from Streams
In-Situ 1987	1987	10,960	7,950	0.73
In-Situ 1988	1988	8,960	9,520	1.06
ASI 1990	1989	7,080	7,230	1.02
ASI 1991a	1990	6,700	3,720	0.56
ASI 1991b	1991	7,210	3,860	0.54
ASI 1993	1992	7,098	6,555	0.92
ASI 1994a	1993	4,903	3,473	0.71
C&A 1995	1994	5,851	4,099	0.70
CEC 1996	1995	9,335	8,799	0.94
CEC 1997	1996	5,858	4,468	0.76
CEC 1998	1997	8,243	5,012	0.61
CEC 1999	1998	18,605	13,716	0.74
CEC 2000	1999	27,688	18,776	0.68
Present Study	2000	16,529	11,827	0.72

6.3.2 Precipitation

As measured by the rain gage located on Cherry Creek dam, total precipitation at Cherry Creek Reservoir was 17.8 inches in 2000. This was slightly lower than the annual precipitation measured between 1997 and 1999, but nearly identical to the 1987 - 2000 median of 18.0 inches.

Given the approximate surface area of Cherry Creek Reservoir (850 acres), total phosphorus loading due to precipitation was estimated to be 777 pounds for 2000, which is in the range of historical values (Fig. 10). The mean value for annual loading from precipitation from 1987 - 2000 is 837 pounds.

6.3.3 Outflow

When measuring phosphorus loading in Cherry Creek Reservoir, phosphorus leaving Cherry Creek Reservoir in the outflow from the dam to Cherry Creek downstream of the reservoir is also important. Total phosphorus leaving the reservoir from the outflow was estimated at 3,688 pounds for 2000. While this value is lower than those observed in either 1998 or 1999, it exceeded the 1992 - 2000 mean of 2,733 pounds.

6.3.4 Ground Water

Recent sampling by JCHA has provided data on alluvial ground water quality for the Cherry Creek mainstem. Based on these data, the estimated phosphorus loading to the reservoir from the Cherry Creek alluvium in 2000 was 1,759 pounds. In addition, phosphorus leaving the reservoir through ground water downstream of the reservoir (underflow) was estimated at 1,160 pounds for 2000 (based on an assumed constant water level in the reservoir of 5,550 ft MSL). Given differences in phosphorus concentrations in the alluvium upstream and downstream of the reservoir, it appears that some portion of the alluvial underflow is retained in the reservoir, while the rest flows under the reservoir beneath the keywall. The portion entering the reservoir can be estimated by taking the difference in alluvial phosphorus loads upstream and downstream. This results in an estimated net alluvial phosphorus load retained in the reservoir of 599 pounds in 2000.

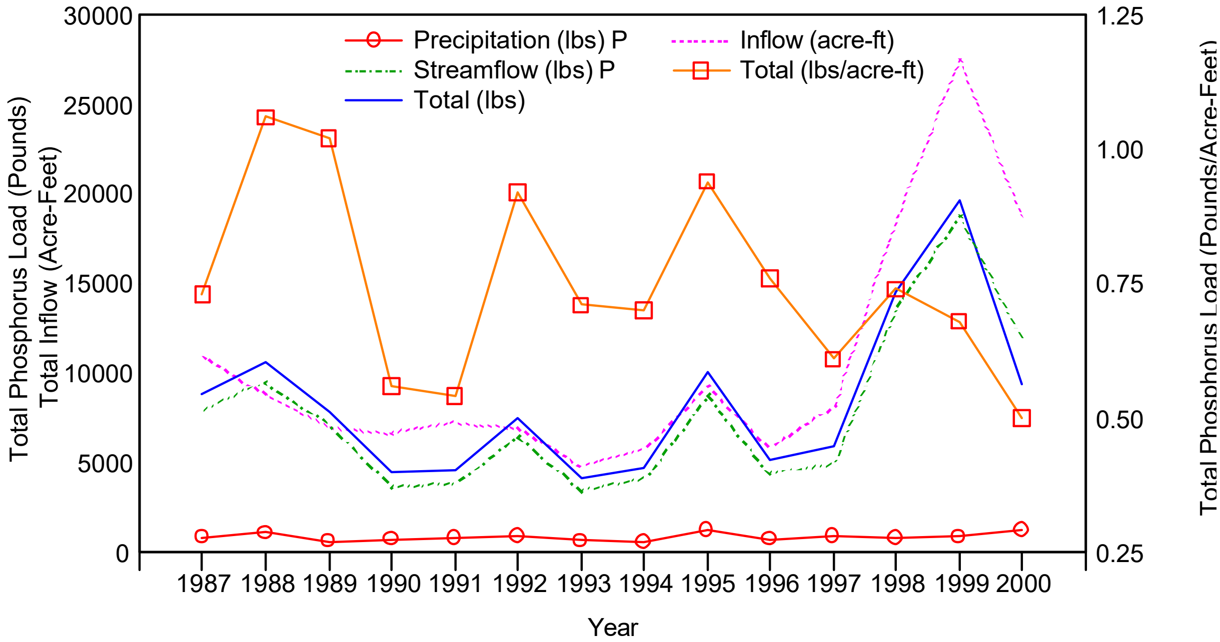

FIGURE 10: Annual phosphorus loading into Cherry Creek Reservoir, 1987 - 2000. Note that values for 1987-1991 are based on water years (October-September), not calendar years.

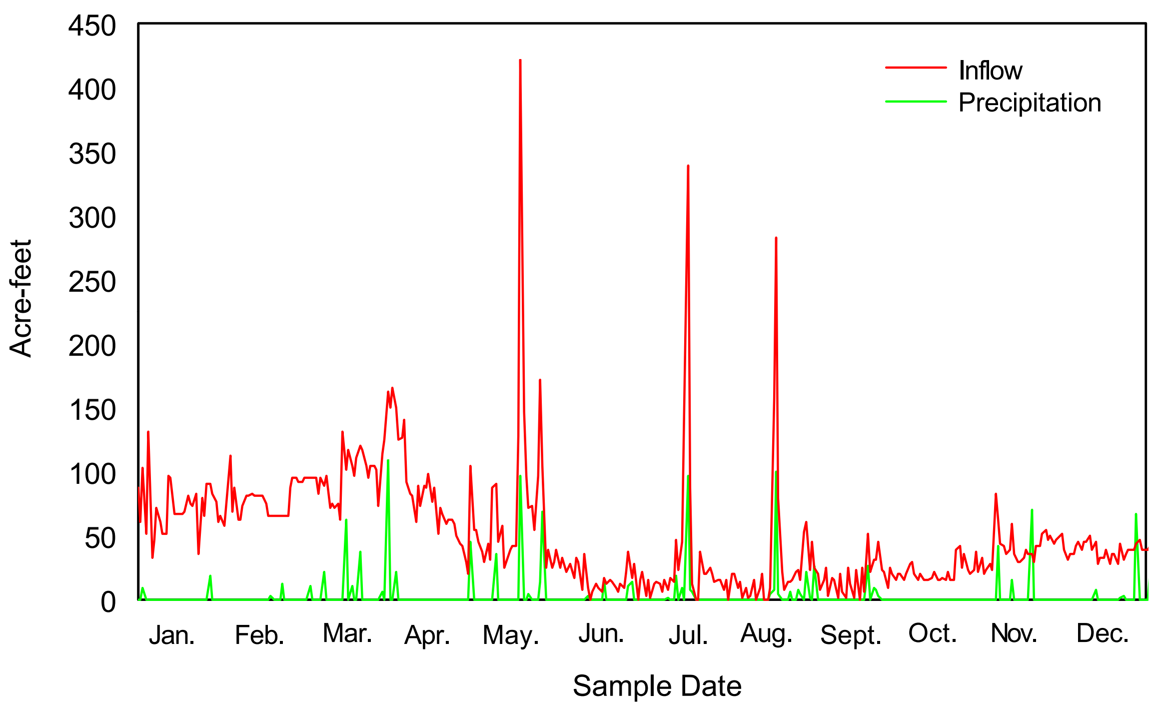

FIGURE 11: Comparison of precipitation and inflow for 2000.

TABLE 7: Summary of phosphorus removed from Cherry Creek Alluvium due to alluvial well pumping, 2000.

Entity	Volume Pumped (ac-ft)	Average Ground Water Phosphorus[1] Concentration (mg/L)	Annual Removal (lbs)
Arapahoe County Water and Wastewater Authority	1,361	0.16	592
City of Aurora	1,797	0.11	538
Cottonwood Water and Sanitation District	740	0.19	382
Parker Water and Sanitation District	1,649	0.21	942
Pinery Water and Sanitation District	1,793	0.29	1,414
Total Pounds Removed through Pumping (2000)			**3,868**

[1] Based on phosphorus concentration data from monitoring well closest to alluvial well(s).

6.3.5 Mass Balance Loadings for Phosphorus

In general, the phosphorus load budget for Cherry Creek Reservoir is comprised of phosphorus inflow (influent streams, precipitation, and alluvium) and reservoir outflow. During 2000, phosphorus contribution from precipitation was an estimated 777 pounds, influent streams contributed 11,827 pounds, and the net alluvial inflow contributed 449 pounds (Fig. 12) for a total load of 13,053 pounds. Outflow from the dam contained an estimated 3,688 pounds in 2000. After totaling the additions and losses, the net loading of phosphorus was estimated at 9,365 pounds during 2000, which was the third highest net loading value on record (Table 8).

The total load 13,053 pounds measured in 2000 met the TMAL of 14,270 pounds established for the Cherry Creek Reservoir. The TMAL (previously referred to as TMDL) was exceeded in both 1998 and 1999 (Table 8). The pounds per acre foot measured in 2000 was well within the range observed in previous years (Table 6), indicating that the primary source for the exceedance of the TMDL in 1998 and 1999 was not higher phosphorus concentrations, but rather was a result of markedly higher inflows.

TABLE 8: Estimated net phosphorus loading (lbs/year) into Cherry Creek Reservoir, 1992 to 2000 (loads for Belleview Drainage were not determined prior to 1997).

Source of Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
Shop Creek	138	136	134	108	116	186	206	162	120	145
Cherry Creek	5,470	2971	3,739	5,372	3,782	3,714	11,665	14,736	9,984	6,839
Cottonwood Creek	947	366	226	3,319	570	1,103	1,830	3,868	1,712	1,549
Belleview Drainage	ND	ND	ND	ND	ND	9	15	10	11	11
Subtotal for Streamflows	**6,555**	**3,473**	**4,099**	**8,799**	**4,468**	**5,012**	**13,716**	**18,776**	**11,827**	**8,525**
Cherry Creek Alluvium*	555	555	470	597	635	520	476	537	449	533
Direct Precipitation	877	736	484	1,202	740	1,020	854	896	777	843
Total Load	**7,987**	**4,764**	**5,053**	**10,958**	**5,843**	**6,552**	**15,313**	**20,209**	**13,053**	**9,970**
Cherry Creek Outflow	1,314	711	993	2,049	992	996	4,207	9,650	3,688	2,733
Net Load	**6,673**	**4,053**	**4,060**	**8,549**	**4,851**	**5,556**	**10,839**	**10,559**	**9,365**	**7,167**

* Based on alluvial inflows minus alluvial outflows, or net alluvial loads.

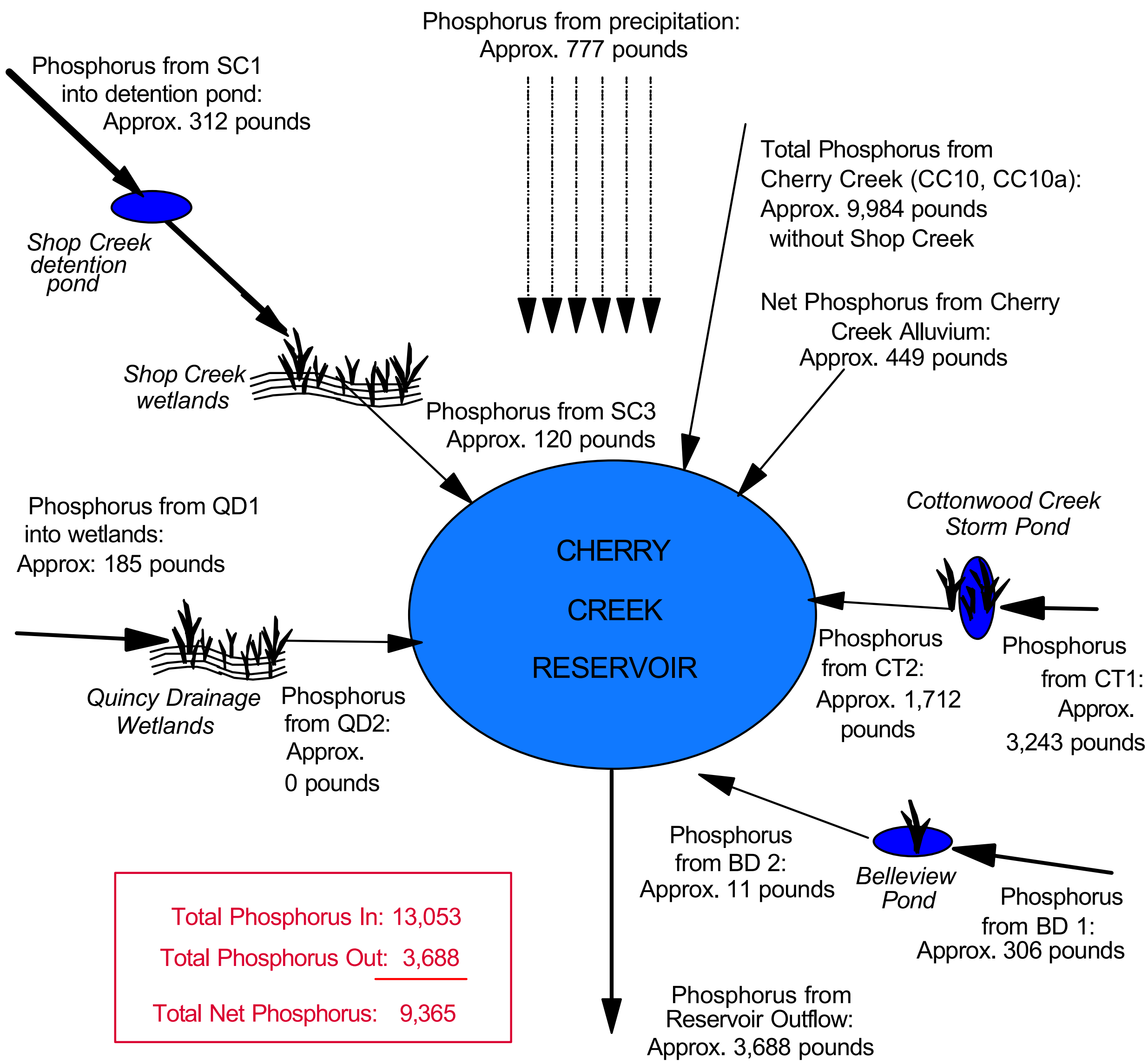

FIGURE 12: Mass Balance Diagram of Phosphorus Loading in Cherry Creek Reservoir, 2000.

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