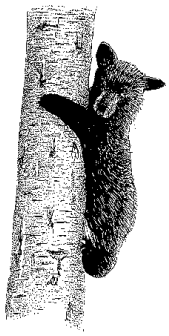
Bear Creek Watershed Report 2002:



Annual Report & Water Quality Summary Sheets

June 2003

Prepared for the Bear Creek Watershed Association
For Information Contact

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The Bear Creek Watershed Association is the designated water quality management agency for the Bear Creek Watershed. The Association implements the *Bear Creek Reservoir Control Regulation* (Regulation #74). The control regulation assures watershed point and nonpoint source water quality compliance consistent with adopted stream standards and classifications.

Table of Contents

Introduction

The Bear Creek Watershed Association (Association) is the designated water quality management agency for the Bear Creek Watershed as recognized by the Denver Regional Council of Governments in *the Metro Vision 2020 Clean Water Plan* (DRCOG 1998). Water quality data was originally collected as part of an intense one-year *Bear Creek Reservoir Clean Lake Study* (DRCOG 1989). A generally continuous collection of surface quality data has been done in the watershed and reservoir beginning in 1990. Data collection has included specific chemical, physical and biological parameters.

The Bear Creek Reservoir Control Regulation (Regulation #74) defines the water quality goal, wasteload allocation for total phosphorus, monitoring program and other control strategies for the Bear Creek Watershed. The Association is responsible for implementing the control regulation. The Association also produces a summary data report for the Water Quality Control Commission and Water Quality Control Division. The report characterizes water quality monitoring activities, data tabulation, and general trends in the Bear Creek Watershed including water quality and wastewater management efforts.

The long-term management strategies of the Association have improved water quality at the reservoir and within the watershed. The trophic status of the reservoir has shifted from hypertrophic-eutrophic toward the eutrophic-mesotrophic boundary. All major wastewater treatment plants are in compliance with the control regulation and meet specific wasteload allocations. Several minor plants have shown compliance problems and/or lack of reporting to the Association. Overall, the point source nutrient loading to the reservoir is well controlled. Nonpoint source reductions of total phosphorus will be a major focus in the near future. Activities of the Association are limited due to funding and resource constraints.

Association Management Program

The Association includes the City of Lakewood, Town of Morrison, Clear Creek County, Jefferson County, Park County, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water and Sanitation District, Kittredge Sanitation and Water District, Willowbrook Water and Sanitation District, Forest Hills Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation (also called Singing River Ranch), Brook Forest Inn, Bear Creek Development Corporation (Tiny Town), Bear Creek Cabins, Geneva Glen and Aspen Park Metropolitan District.

The Association provides the framework and opportunity for joint participation in planning, coordinating and review activities for the purpose of implementing a continuing area wide water quality and wastewater management program for the Bear Creek Watershed. Membership entities are general-purpose governments, special districts and all other National Pollutant Discharge Elimination System (NPDES) dischargers within the Bear Creek Watershed as permitted by the Water Quality Control

Division. The Association's memorandum of understanding and by-laws describe the roles, responsibilities and meeting requirements of the management agency, operating agencies and general-purpose governments as related to water quality management activities in the Bear Creek Watershed.

The management agency implements water quality and management strategies, decides on the need for and specific characteristics of wastewater treatment processes and details implementation within specified parameters (Table 1). A watershed Association approach provides an opportunity to coordinate water quality activities at a local level. The Association provides three primary benefits:

1. Ensures an effective watershed level water quality management program consistent with the *Bear Creek Reservoir Control Regulation* and the *Metro Vision 2020 Clean Water Plan*;

2. Ensures cost effective local wastewater management systems within the parameters of the *Metro Vision 2020 Clean Water Plan* and wastewater discharge permits; and

3. Identifies activities that meet water quality compliance.

Wastewater Treatment Facilities

Major operating agencies in the watershed include the Town of Morrison, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water and Sanitation District, Kittredge Sanitation and Water District, Forest Hills Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation, and Aspen Park Metropolitan District. The four minor operating agencies are Brook Forest Inn, Bear Creek Development Corporation, Bear Creek Cabins, and Geneva Glen. The lack of reporting to the Association from these minor operating agencies is problematic and hinders the effective development of wastewater management strategies.

The total phosphorus wasteload allocation for all point sources in the Bear Creek Watershed is 5,255 pounds per year. The reporting point source total annual phosphorus discharges are shown fact sheet 9. The Association believes the intent of the control regulation is clear in requiring all treatment facilities to be in compliance and report this information to the Association for incorporation into the annual report. Major reporting treatment facilities are well within their wasteload allocations.

Status of Total Maximum Annual Load (TMAL)

The Bear Creek Reservoir Control Regulation (Regulation #74, Appendix A) incorporates the total maximum annual load that controls wasteload allocations for point sources and the allowable nonpoint source load. The total maximum annual load will result in the Bear Creek Reservoir meeting all designed uses and classifications. The total maximum annual load describes prohibitions, standards, concentrations, and

effluent limitations on the extent of specifically identified pollutants that may discharge into the watershed. The elements of the Bear Creek total maximum annual load as approved by Region VIII Environmental Protection Agency and the Water Quality Control Commission are shown in Table 1.

Table 1 Bear Creek Watershed TMAL Elements

Allocation	Endpoints	Target
Point Source Wasteload Allocation	Total phosphorus effluent poundage limit	The total wasteload allocation for all point sources of phosphorus in the Bear Creek Watershed is 5,255 pounds per year. Each individual discharger is limited to an annual wasteload of total phosphorus (pounds per year), except under trading provisions. Reserve pool maintained for future dischargers.
	Total phosphorus effluent concentration limit	Point source discharges can't exceed a total phosphorus effluent concentration of 1.0 mg/l as a 30-day average, except under trading provisions.
Margin of Safety (MOS)	Implicit MOS	A margin of safety is built into the wasteload and nonpoint source allocations as an implicit MOS.
Nonpoint Source Load Allocation	Reservoir narrative standard	Jefferson County, Clear Creek County, Park County, municipalities, and districts in the Bear Creek Watershed will implement best management practices for control of erosion and sediments.
	Monitoring trophic status indicators	At a minimum, local entities in the watershed will ensure that water quality monitoring is conducted on Turkey Creek, Bear Creek, and in Bear Creek Reservoir on a monthly basis to measure the phosphorus loading reaching the reservoir and other factors which affect the water quality, as well as the attainment of beneficial uses for the reservoir, including meeting the reservoir narrative standard. Data results must be reported to the Water Quality Control Commission and Water Quality Control Division.

Colorado Department of Transportation Monitoring Program

The Colorado Department of Transportation (CDOT) conducts a special surface water quality-monitoring program along the U.S. 285 corridor through the Turkey Creek drainage. Phased construction activities have resulted in ongoing highway construction. CDOT does independent water quality monitoring to evaluate the

effectiveness of BMPs being used during construction. CDOT continues involvement with the Association through the regular meeting program.

Turkey Creek, a major tributary to Bear Creek, flows directly into Bear Creek Reservoir. Water-quality concerns in the Reservoir and downstream in the South Platte River have heightened sensitivity to activities in the Turkey Creek watershed that potentially impact water quality. U.S. Highway 285 is a major route into the Denver metropolitan area from the west. Growth and development in the area served by U.S. Highway 285 has resulted in increased traffic volumes and created the need for expansion of the roadway. The Colorado Department of Transportation has underway with a significant construction effort along parts of Highway 285 that transect the Turkey Creek drainage.

Exponent and TDS Consulting, CDOT contractors, did a four year effort of monitoring water quality at several locations in Turkey Creek and evaluating the effectiveness of construction-related BMPs implemented by CDOT associated with the U.S. Highway 285 project. For 2003 (the fifth year), TDS is working under a task order with Carter-Burgess for the Turkey Creek monitoring and is assisted by Clear Creek Consultants (CCC). This will be the last year of monitoring in the Turkey drainage by CDOT representing post-construction data. The monitoring program provides data reflecting the impacts of increased residential and commercial development throughout the watershed. Intermittent CDOT presentations before the Bear Creek Watershed Association (BCWA) during 2002 have described results of the monitoring program, the dynamic aspects of the program required to adapt to the progression of construction, and some of the information benefits it has provided to date to CDOT and BCWA interested parties.

Water Quality Monitoring and Management Program

The monitoring program characterizes water quality inflow into Bear Creek Reservoir from Bear Creek and Turkey Creek, outflow from Bear Creek Reservoir as a tail-water discharge and downstream water quality. The reservoir is monitored at a single representative station located in the central pool beyond the Bear Creek and Turkey Creek inlets. The monitoring program was reviewed in 2001 and updated as the *2002-2005 Bear Creek Watershed: Sample Analysis Plan (SAP) And Quality Assurance Project Plan (QAPP)* (Bear Creek Watershed Association 2001). This monitoring plan provides the basis for all monitoring activities in the Bear Creek Watershed.

Monitoring Sites

The five routine monitoring stations and reservoir station are as follows (*2002-2005 Bear Creek Watershed: Sample Analysis Plan (SAP) And Quality Assurance Project Plan (QAPP),* Bear Creek Watershed Association 2001):

1. Mainstem of Turkey Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the City of Lakewood Maintenance Yard;

2. Mainstem of Bear Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the bridge at the western edge of the park;

3. Tail-water discharge from Bear Creek Reservoir in the concrete channel which starts the lower Bear Creek;

4. Mainstem of Bear Creek about 1-mile below Bear Creek Reservoir; and

5. Bear Creek Reservoir, center of main pool beyond the Bear Creek and Turkey Creek Inlets.

Parameters And Sampling Program

The monitoring program provides necessary data to make statistical water quality trend assessments and verify the effectiveness of control and alternative management programs. The minimum required physical, chemical and biological components listed in the control regulation and shown in Table 2.

Sample Frequency

The routine watershed-monitoring program focuses on inputs to and outputs from Bear Creek Reservoir. There are 16 reservoir and stream samples taken per calendar year with biweekly monitoring in May, June, July and August, and monthly for other months. There may be some sample periods in the winter where Bear Creek Reservoir cannot be sampled due to poor ice conditions. The stream sampling program is conducted without reservoir sampling. The stream input and output-sampling program targets data collection for all months within a calendar year. A maximum of 16 stream data sets will be collected per year. If a winter reservoir monitoring set cannot be taken due to unsafe conditions, then the reservoir monitoring set will be added at a later time period to the annual monitoring program, which will result in a total of 16 monitoring sets per calendar year within the reservoir. The E. coli sample frequency is listed in Table 2.

Table 2 2002-2005 Water Quality Parameters

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Physical/Field			
Discharge (cu m/s)	X		X
Specific Conductance (umhos/cm)	X	X (Profile)	X
Secchi (meters)		X (Single Measurement)	
Dissolved Oxygen (mg/l)	X	X (Profile)	X
Temperature (C)	X	X (Profile)	X

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Total Suspended Sediments (mg/l)	X	X (3 Depths)	X
pH (standard unit)	X	X (3 Depths)	X
Biological			
E. Coli (cts/100ml)	X (April to October)	X (March to November)	X (April to October)
Chlorophyll a (ug/l)		X (Surface Sample)	
Phytoplankton		X (Surface Sample)	
Zooplankton		X (Vertical Tow)	
Nutrients			
Ammonia (ug/l)	X		X
Nitrate (ug/l)	X	X (3 Depths)	X
Total Particulate Phosphorus (ug/l)	X	X (3 Depths)	X
Total Dissolved Phosphorus (ug/l)	X	X (3 Depths)	X
Ortho-Phosphorus (ug/l)	X	X (3 Depths)	X
Total Phosphorus (ug/l)	X	X (3 Depths)	X

Trophic Indicators

The reservoir-monitoring program provides data for use in assessing compliance with the reservoir narrative standard. Therefore, monitoring parameters are also trophic state indicators. The watershed program evaluates nutrient loading trends and balances for nitrogen and phosphorus species. Secchi depth and total suspended solids characterize the clarity of the water column. Algal productivity is measured by chlorophyll a samples and phytoplankton characterization. Since the growing season is critical for reservoir compliance as defined in the Bear Creek Reservoir Control Regulation (Regulation #74), then monitoring program targets additional sampling during this season.

Stormwater Management

The Association is concerned with the quality of dry-weather and stormwater runoff associated with significant development sites. Significant development sites are generally related to urban development construction activities. The Association has developed a project specific monitoring guidance report (BCWA 1996c). However, the Association has no direct responsibility for regulating development activities or implementing site-specific water quality or stormwater control facilities. The Association works with its members through local review processes to ensure that development follows the watershed water quality management strategy using the best available

management practices. The Association reviews BMPs and makes recommendations as requested by local governments. Jefferson County and the City of Lakewood began stormwater permitting programs in 2002. Fact sheet 24 defines the Lakewood stormwater program.

Jefferson County hired stormwater staff ad began storm drain outfall mapping. Additional staff will locate outfalls in the Jefferson permit coverage area. A majority or all of the Jefferson County permit coverage area is expected to be completed in 2003. A storm drain marking program is anticipated to begin this fall. Affected county staff received stormwater regulation training and compliance assistance such as the Road and Bridge Department with construction site permitting requirements. Jefferson County supported the Colorado Water Protection program for a radio advertisement. This organization assisted Jefferson County with Phase II compliance under the Public Ed element of the stormwater permit. Jefferson County is one of many Phase I and II entities that donated to this public service announcement. Jefferson County Stormwater Management Program shared a booth with Long Range Planning at the Evergreen Earthday Event on April 19. In 2003 staff will design a standard change to require developers to include the iron grate storm drain "No dumping" message and custom manhole covers on R-30 inlets. Jefferson County Staff are adding stormwater section to the County's Community Plans as they are revised including North Plains, Central Plains and Evergreen Community plans. The goal is to have citizens understand stormwater runoff, Right -of- way, cost, infiltration, groundwater recharge, pollution prevention and techniques that can be used to approximate predevelopment hydrology so that rezoning and subsequent development have less impact than previous development techniques.

The Board of County Commissioners approved staff to research a utility fee for unincorporated residents and businesses related to capital improvement projects, development design review, and storm sewer maintenance. The county created a flyer for sediment and erosion control and a Jefferson County stormwater management brochure. These are handed out to citizens getting building permits or inquiring about land development. Also, there is a display on the 3 rd floor near planning and zoning on erosion and sediment control samples. The display is titled, "Drought, Landscaping, and Water Quality - Where do you fit in?" The display includes erosion control blanket samples, rice wattle, invisible structures products, and silt fence with pictures of proper use. The county hands out Xeriscape information to interested citizens

Onsite System Management Plan

Water quality impacts are occurring from onsite wastewater systems in a number of specific areas in the Bear Creek Watershed. However, the presence and nature of these problems is not been well verified or rigorously documented in the watershed. In fact, few well-documented studies have been done in Colorado that directly link water quality or health risks with onsite wastewater systems. Examples of identified impacts include elevated nitrate and/or bacteria levels in ground water used for drinking water, and nutrient loadings adversely affecting surface waters. Researchers from Colorado

State University identified many mountain homes potentially using bacterial laden well water caused by misplacement of leach fields *(How Safe Is Mountain Well Water,* CSU 1972). Other studies done by the Colorado State University and local health department document elevated nitrates in groundwater for specific locations.

Although few site-specific studies have been completed, it appears that substantial cumulative loadings of nutrients to Bear Creek Watershed waters are likely occurring in some areas where there are a significant total number and density of onsite wastewater systems. There are areas of known nitrate contamination and increased nitrate levels in ground water in areas of high density (lots less than one acre) and a significant number of homes.

In some surface water basins, phosphorus loadings from onsite wastewater systems are a potentially significant water quality factor. Phosphorus loading into Bear Creek Reservoir has caused adverse water quality impacts that have led to the development of a control regulation to control phosphorus loadings. Water quality monitoring in the Bear Creek Watershed over a 15-year period has shown that there is a phosphorus-loading problem in Bear Creek Reservoir. Screening surveys completed by the Association show elevated levels of phosphorus in areas with a higher density of on-site wastewater systems, such as the community of Idledale (Bear Creek Watershed Association, 1998; 1997 Bear Creek Watershed Association Annual Report; Bear Creek Watershed Association, 1997a, *Management Program Review and 1990-1995 Water Quality Summary*).

The Association recognizes the need for a comprehensive septic management plan for the watershed that addresses the nutrient loading issue. The county members of the Association should take the lead in developing a septic management program. The Denver regional Council of Governments is in the process of developing a septic management plan guidance document. Once this guidance document is accepted the Council's Board of Directors, the guidance can be used to assess the septic management program needs of the watershed.

Member Activities of Interest

City of Lakewood Reservoir Aeration Program Upgrade

The City of Lakewood maintains a reservoir aeration program. This aeration system increases the amount of dissolved oxygen throughout the water column. The program helps support the fishery goal of the Association for the reservoir. This aeration effort has proven to be a successful management practice and the continued operation is necessary to maintain quality in the reservoir. The aeration system was replaced with a more efficient system that is designed to de-stratify the reservoir water column and introduce more uniform aeration within the reservoir main pool.

Groundwater Studies in Turkey Creek Drainage

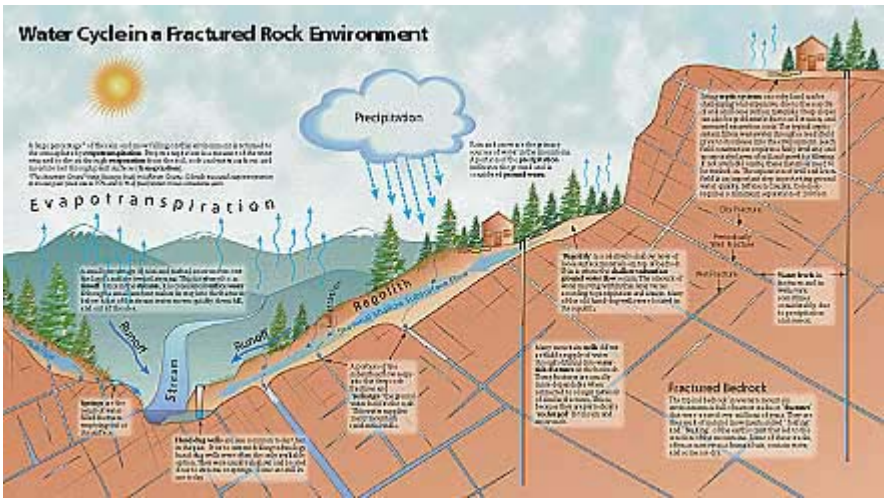
The U.S.G.S. report titled: "Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson County, Colorado, 1998–2001" determine groundwater management and water balance in the 47.2-square-mile Turkey Creek watershed, in Jefferson County southwest of Denver, Colorado. This drainage basin is relatively steep with about 4,000 feet of relief and is in an area of fractured crystalline rocks of Precambrian age. Water needs for about 4,900 households in the watershed are served by domestic wells and individual sewage-disposal systems. Hydrologic conditions are described on the basis of contemporary hydrologic and geologic data collected in the watershed from early spring 1998 through September 2001. The water resources are assessed using discrete fracture-network modeling to estimate porosity and a physically based, distributed-parameter watershed runoff model to develop estimates of water-balance terms.

Results from the watershed model provide simulated estimates for water-balance terms in a contemporary simulation (January 1, 1999, through September 30, 2001) using precipitation and adjusted temperature data from within the watershed, and in a long-term simulation (October 1, 1948, through September 30, 1999) using precipitation and temperature data from near the watershed. The results of both simulations indicate that, on a watershed scale, base-flow reservoirs consistently contain about enough water to cover the watershed with 0.1 to 0.2 inch of water. The long-term simulations indicate that during a year with about 14 inches of precipitation, the watershed base-flow reservoir may have about a -0.06 inch change in contents during periods with relatively small amounts of recharge. The results from watershed simulations also indicate that contents of base-flow reservoirs vary within the watershed; base-flow reservoirs contain little or no recoverable water for significant portions of many years in about 90 percent of the watershed. In areas where base-flow reservoirs contain no water, the only source of water for wells is water that has percolated to relatively deep parts of the system that are not associated with local streamflow; water withdrawn under these conditions will need to be replaced before base flow can resume. Estimates of the amount of water withdrawn by wells in 2001 in the Turkey Creek watershed are equal to a watershed depth of about 0.43 to 0.65 inch (about 0.0012 to 0.0018 inch per day).

Water Smarts: A Homeowner's Guide to Mountain Groundwater

This public education booklet was created by Jefferson County with the generous assistance of many local, state, federal and private organizations. Funding for the printing was made possible through the Clean Water Act, Section 319 Grant funds, administered by the U.S. Environmental Protection Agency and the Colorado Department of Public Health and Environment. The booklet focuses on groundwater issues in the fractured bedrock environment typical of Jefferson County, and the Rocky Mountains. Topics include ground water hydrology, water quality, wells, septic systems, water rights, and lifestyle impacts. A "Questions and Answers" section, as well as definitions and resources provide additional information. Throughout, you will find references to the Jefferson County Mountain Groundwater Resource Study. This case

study gives a "real-world" look at some of the concepts being presented.



Also included is a pullout poster entitled, "**Water Cycle in a Fractured Rock Environment**," that visually depicts many of the booklet's concepts.

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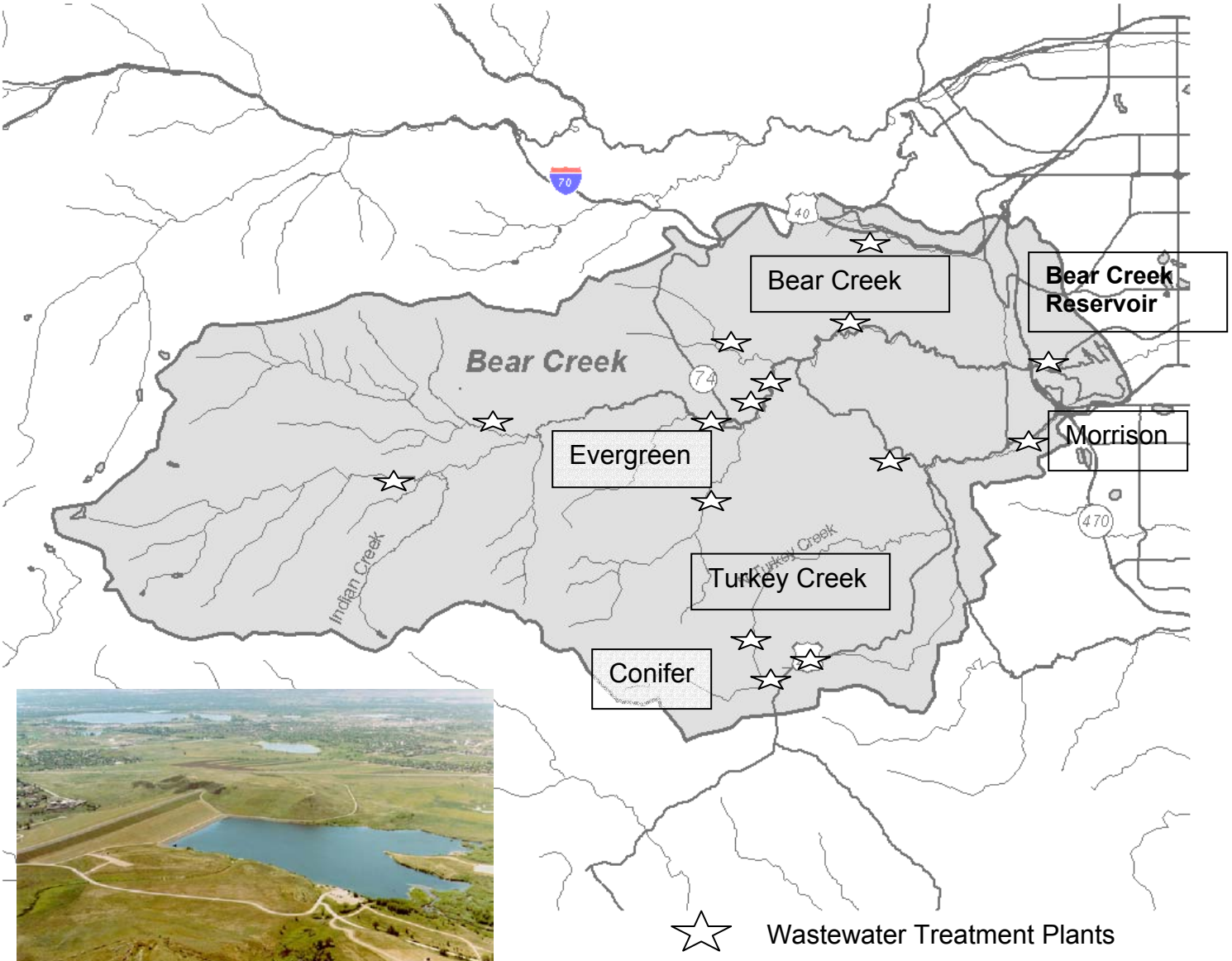
Water Quality Fact Sheets

The water quality monitoring program is characterized in a series of fact sheets. These fact sheets are designed to provide specific information about the water quality and management program that can be used for multiple purposes independent of the other fact sheets. The fact sheets denote both the 2002 water quality within the watershed and Bear Creek Reservoir, as wells, the long-term trends.

1. Bear Creek Watershed

Bear Creek Reservoir receives drainage from the Bear Creek and Turkey Creek with drainage from Park County, Clear Creek County and Jefferson County. The total watershed area is 83,665 acres. The reservoir is at an elevation of 5600 feet, while the mountains that form the upper boundary are at an average elevation of 10,000 feet.

The watershed contains the Town of Morrison and the communities of Evergreen, Genesee, Kittredge, El Rancho, Idledale, Indian Hills, Tiny Town, Bergen Park, Conifer, Aspen Park, Brook Forest, Sprucedale, Marshdale and Brookvale.



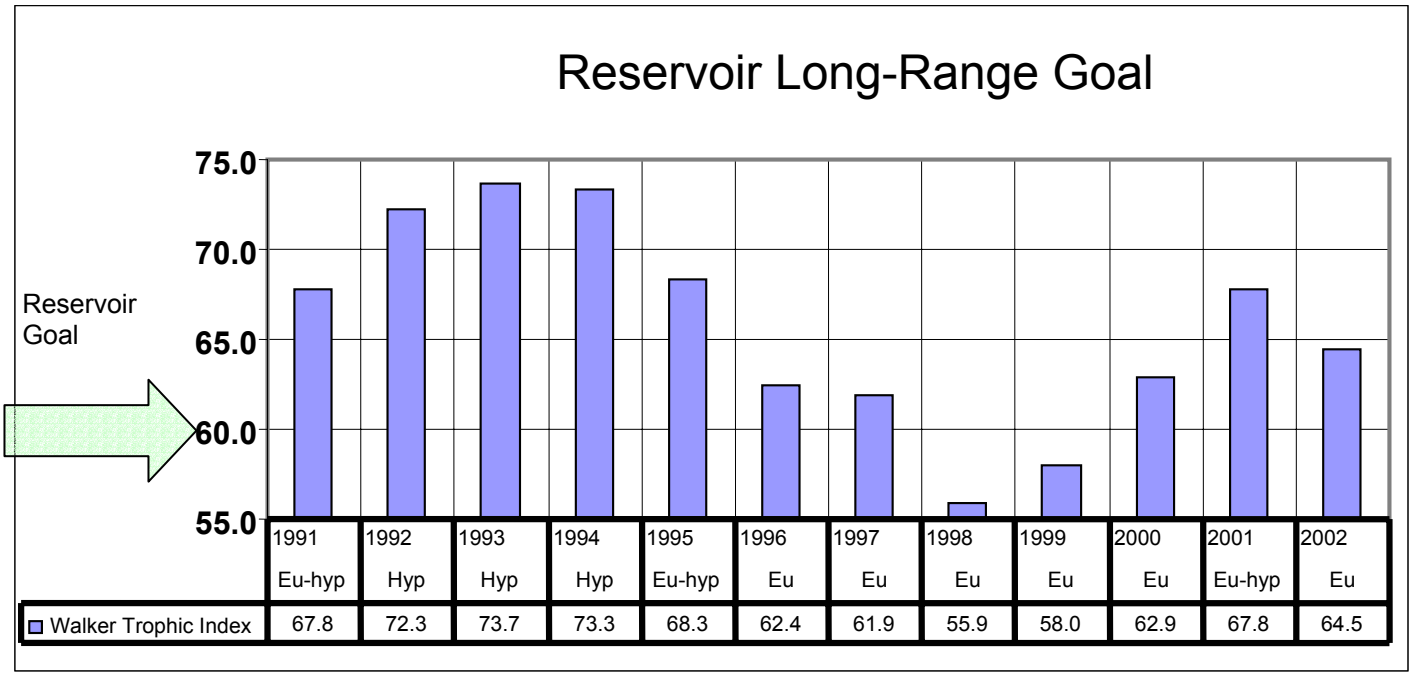
Bear Creek Reservoir, Jefferson County

2. Water Quality Goal and Narrative Standard for Bear Creek Reservoir

Bear Creek Reservoir has a water quality goal established by the Water Quality Control Commission instead of a numeric standard. The reservoir goal, defined as a site-specific narrative standard, reads as follows:

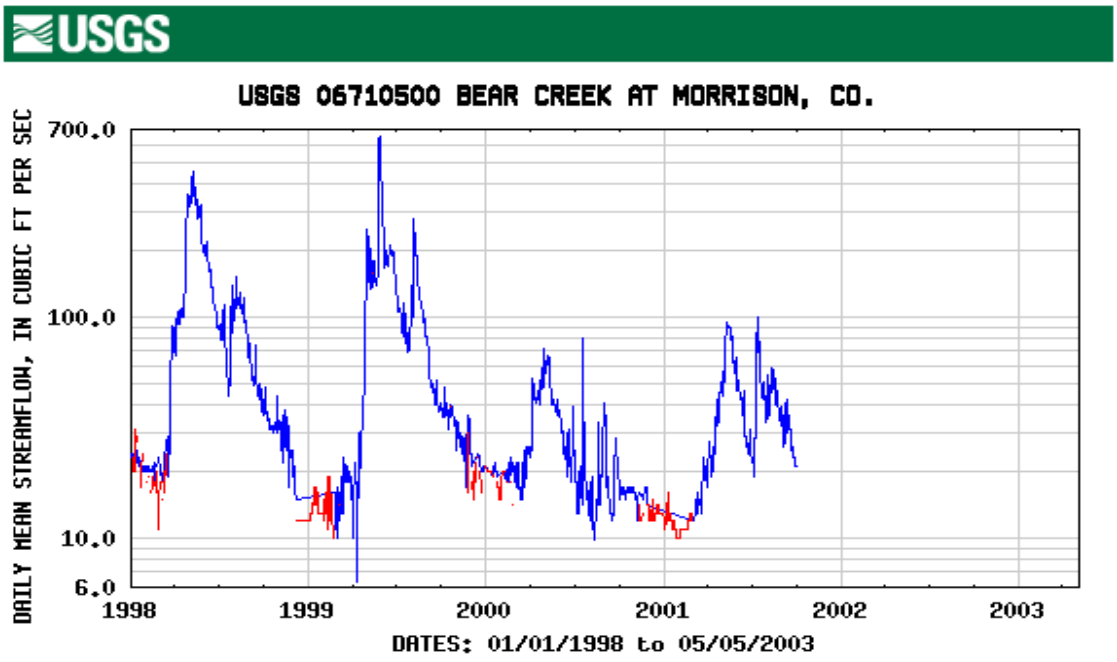
> *Concentrations of total phosphorus in Bear Creek Reservoir shall be limited to the extent necessary to prevent stimulation of algal growth to protect beneficial uses. Sufficient dissolved oxygen shall be present in the upper half of the reservoir hypolimnion layer to provide for the survival and growth of cold-water aquatic life species. Attainment of this standard shall, at a minimum, require shifting the reservoir trophic state from a eutrophic and hypereutrophic condition to a eutrophic and mesotrophic condition, based on currently accepted limnological definitions of trophic states*.

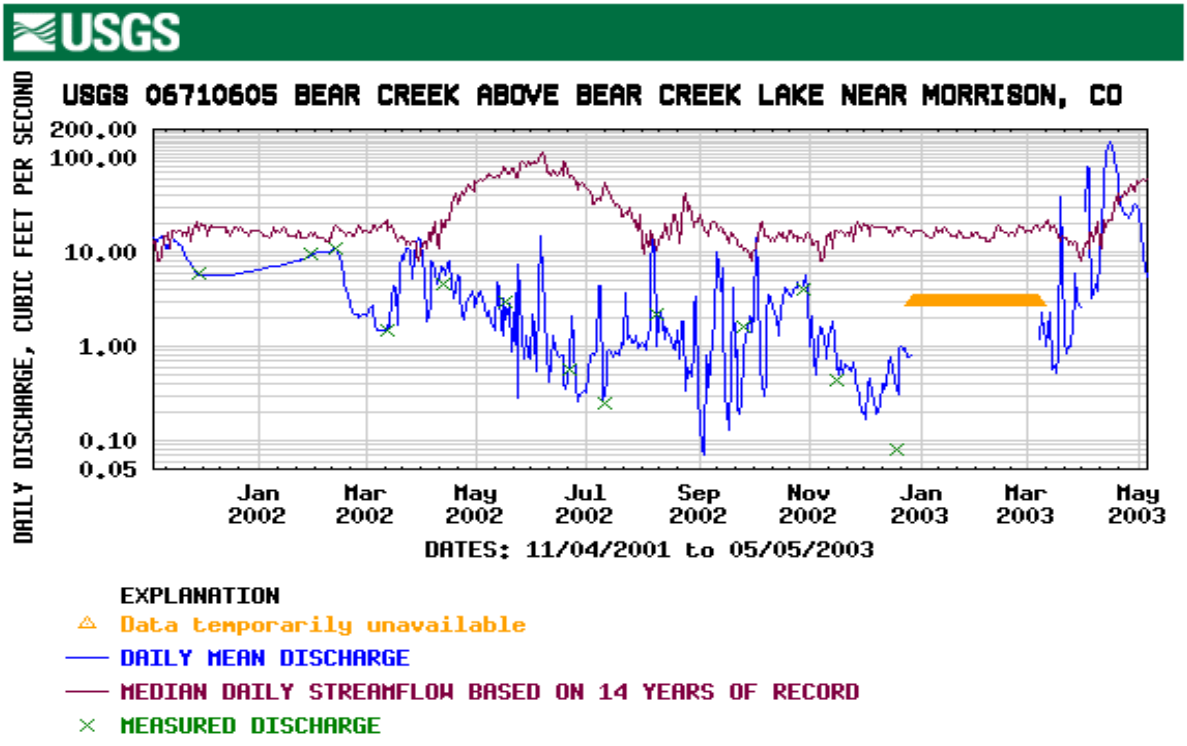
The Bear Creek management program has reduced average total phosphorus concentrations entering the reservoir. Effective point source controls with a sediment and erosion control program by Jefferson County are responsible for this phosphorus reduction. The trophic status (overall measure of quality) has moved toward a desirable mesotrophic-eutrophic range. The goal for the reservoir is to balance the trophic state based on either the Walker Seasonal Trophic model (developed for reservoir in Clean Lakes Study as goal) or the Carlson index in the lower eutrophic range. In terms of the Walker index shown below, the long-range goal is to maintain an index value of less than 60 as a composite Walker trophic index during the growing season. Since many factors influence the trophic state, it requires a long-term management program to change a reservoir quality toward the mesotrophic-eutrophic boundary.



3. USGS 1998-2003 Bear Creek at Morrison Stream Flow Records

The top graph shows 1998-2001 flow records and the lower graph shows 2002 daily mean discharge in Bear Creek. The 2002 flows (blue line) were substantially below the median daily streamflow (14 years of total record).

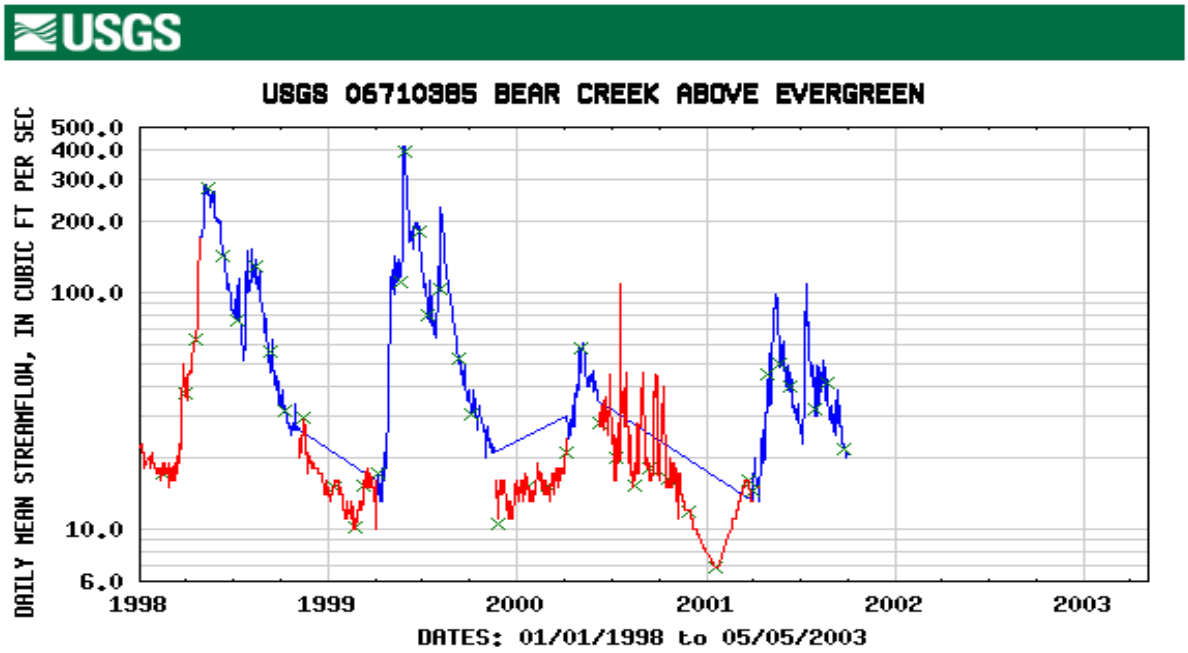


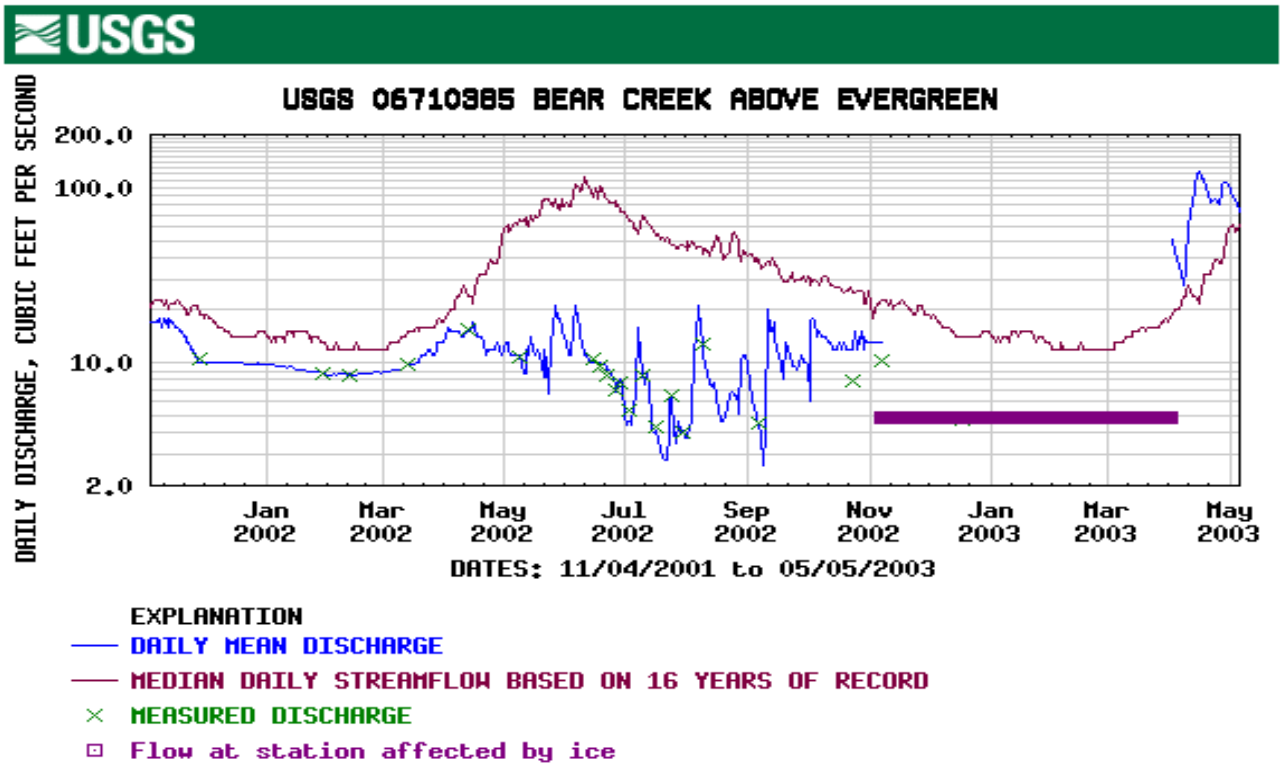


Provisional Data Subject to Revision

4. USGS 1998- 2003 Bear Creek at Evergreen Stream Flow Records

The top graph shows 1998-2001 flow records and the lower graph shows 2002 daily mean discharge in Bear Creek above Evergreen. The 2002 flows (blue line) were substantially below the median daily streamflow (16 years of total record).



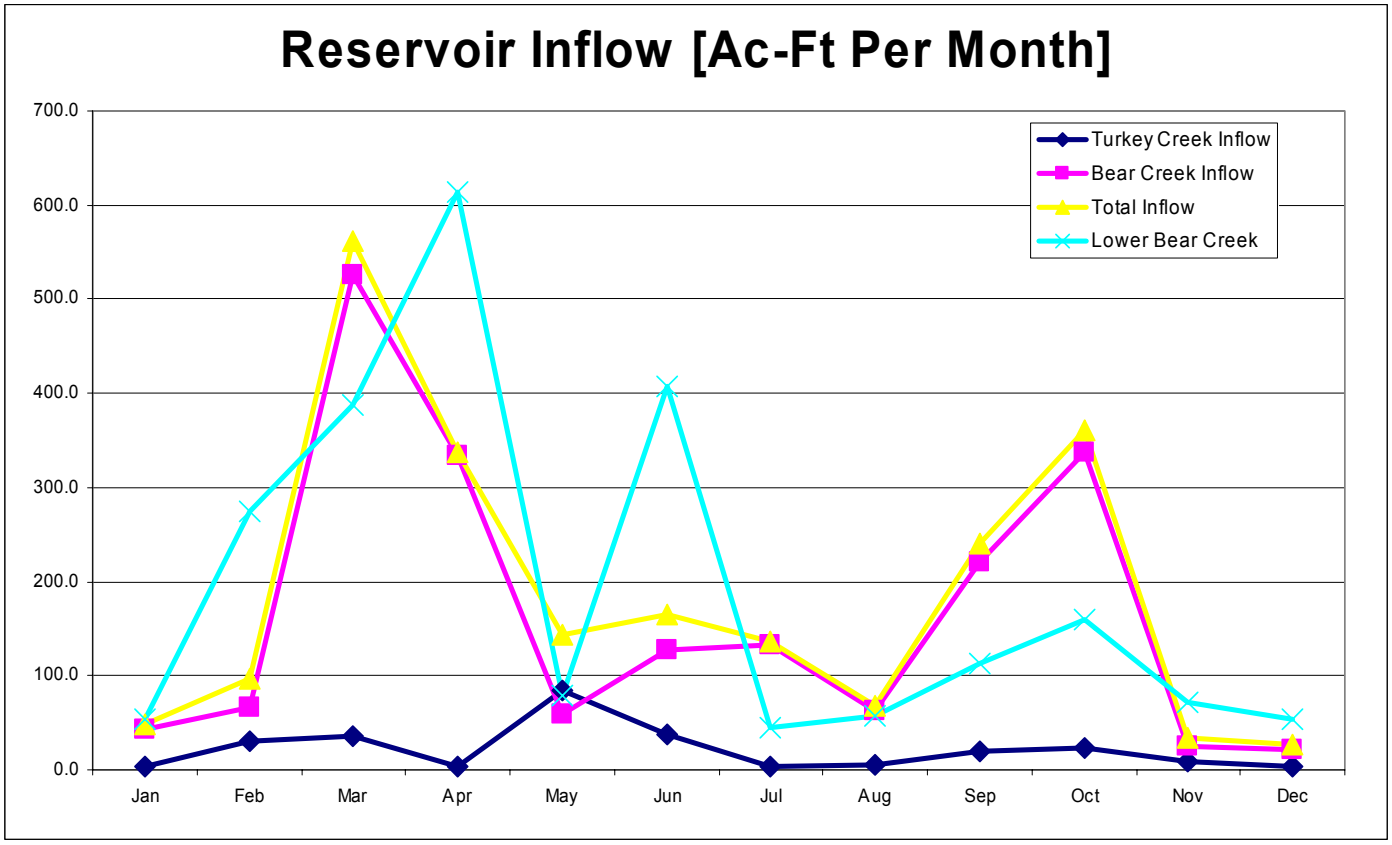


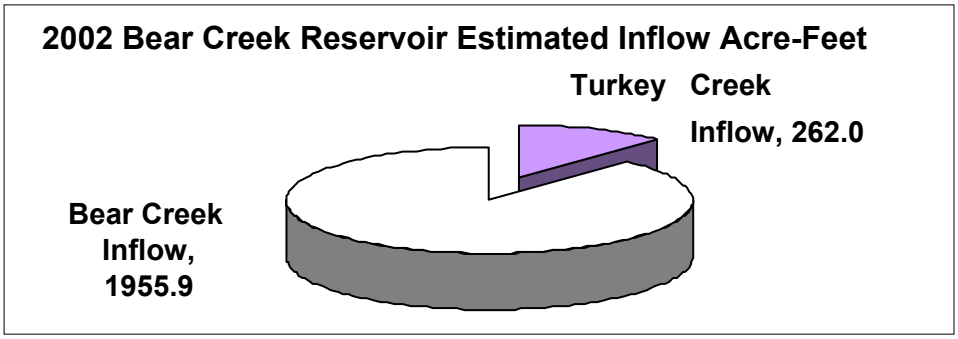
Provisional Data Subject to Revision

5. Bear Creek Reservoir Inflow Flow Records

2002 was a drought year and the Bear Creek Watershed was characterized by extremely low flows. Bear Creek Flows were lower than the recording instrumentation could reasonable measure for several months. Most water coming down Bear Creek and Turkey Creek during the growing season was diverted for beneficial purposes. The estimated inflow into Bear Creek Reservoir was 2,220 acre-feet.

Days	31	28	31	30	31	30	31	31	30	31	30	31	Annual ac-ft/yr
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turkey Creek Inflow	4.3	30.1	36.3	3.2	84.7	38.3	3.5	5.5	20.0	22.5	9.3	4.3	262.0
Bear Creek Inflow	43.4	66.1	525.7	334.6	58.6	127.1	132.3	63.2	220.2	337.4	25.7	21.7	1955.9
Total Inflow	47.7	96.2	562.0	337.8	143.3	165.4	135.8	68.7	240.1	359.9	35.0	26.0	2217.9
Lower Bear Creek	54.3	274.5	387.3	613.0	79.7	406.9	44.2	58.3	113.2	160.3	71.2	54.3	2316.9





6. Bear Creek Watershed Association Management Activities

The Association provides the framework and an opportunity for joint participation in planning, coordinating and reviewing activities to implement a continuing water quality and wastewater management program for the Bear Creek Watershed. Membership entities are general-purpose governments, special districts and holders of discharger permits. The Association's memorandum of understanding and by-laws describe the roles, responsibilities and meeting requirements of the management agency, operating agencies and general-purpose governments as related to water quality management.

Management Activity	Status
Wastewater Management	
Compliance by wastewater treatment facilities and control regulation	Major facilities met permit limits; small facilities still have a reporting and compliance problem
Wastewater utility planning	Development & review of wastewater utility plans & management strategies; coordination; information exchange; Utility plans for Evergreen, West Jefferson, Kittredge and Conifer; City & County Denver (Wastewater service to Denver Red Rock Park linked with Morrison); Aspen Park Metro District; The Fort Restaurant (Septic System); Wastewater strategy for Aspen Park
Aspen Park Metropolitan District	New wastewater treatment plant for Aspen Park area
Reservoir and Regional Park Management	
Hypolimnetic aeration in reservoir; operating during growing season	City of Lakewood manages system; provides an annual report to Association; installed new aeration system
Park facilities support recreational uses	Park management program; sediment & erosion control
Water Quality Monitoring	
Long-term trend monitoring program for reservoir inputs, reservoir and output	Monitoring program with periodic review by Association and WQCD; annual data report; model support; trend studies
Special Studies	Fishery and temperature [special reports]
Turkey Creek groundwater study	Implementation of strategies
CDOT construction-monitoring program	Ongoing effort by CDOT; reports to Association
Water Quality Monitoring Council	Data swap for Association and Lakewood
Data Management	
Place historical water quality data in EPA STORET	Historical Access data-set uploaded into STORET; data base maintained in spreadsheet for membership
Watershed Management	
Construction project review and recommendations	Reviewing construction actions and providing appropriate comments; develop and review site-specific BMPs
Membership involvement and review; Management program effectiveness	Monitoring program review; on-going efforts in evaluating membership involvement and public processes
Stormwater Management	
Jefferson County & City of Lakewood Stormwater Management Programs	Public education; mapping; resource allocations; local partnerships

7. Nonpoint Source Management Strategy for Bear Creek Watershed

The management of nonpoint sources in the Bear Creek Watershed is a component of the planning and management program and a tool for implementing the adopted total maximum annual load control strategy for total phosphorus. Based on water quality monitoring data, point source controls have significantly reduced their phosphorus loading to Bear Creek Reservoir. However, phosphorus reduction from nonpoint sources will be required to maintain the reservoir goal at the mesotrophic and eutrophic boundary as measured by modeled trophic indexes.
A series of management strategies are used to help address nonpoint source problems. The implementation of a nonpoint source program is severely limited by available resources. Unless additional resources are identified, the Association can't pursue an aggressive nonpoint source control program. Additionally, the Association membership has limited nonpoint source implementation authority.

Summary of Management Strategies	Summary Of Implementation Tools
1. Local support	1. Local involvement in associated programs & activities; presentations; information source
2. Stable funding source	2. Seek nonmember funding and grants
3. Provide recommendations to WQCD/ WQCC	3. Data & annual reports; triennial review of control regulation
4. Characterize trends in water quality	4. Maintain a trend water quality monitoring network to measure inputs & output from the reservoir
5. Track nutrient loading by Bear Creek & Turkey drainage systems	5. Characterize nutrient loading by the two major drainage systems
6. Maintain watershed & reservoir models	6. Maintain & use reservoir models (Trophic index, Secchi depth and nutrient loading) developed during the Clean Lake Study
7. Annually review water quality management program & best management practices	7. Maintain a list of appropriate best management practices for review
8. Involved in total maximum daily load allocations	8. Conduct appropriate TMDL screenings using established methods, as required
9. Develop & implement water quality education efforts & technology transfer	9. Develop & maintain list of stakeholders; provide information and assistance as requested
10. Actively promote the implementation of water quality projects & activities	10. Maintain a repository of documents, data & other information; support local water quality plans and efforts as feasible
11. Maintain a nonpoint source/stormwater management program	11. Maintain an education implementation plan; support County processes; review documents as appropriate
12. Support other watershed efforts and groups	12. Continued involvement in Turkey Creek groundwater study, ISDS regulation review & sediment & erosion control regulation review

8. Wasteload Allocations & 2002 Total Phosphorus Pounds Discharged

The total wasteload allocation for all point sources of phosphorus in the Bear Creek Watershed is 5,255 pounds per year. Each individual discharger in the Bear Creek Watershed is limited to an annual wasteload of total phosphorus, which can't be exceeded, except as provided for in trading provisions. Point source discharges can't exceed a total phosphorus effluent concentration of 1.0 mg/l as a 30-day average except as provided in trading provisions. All point source dischargers are required to meet the 1.0 mg/l total phosphorus concentration effluent limitation and the annual total phosphorus allocation established in the Bear Creek Reservoir Control Regulation. The Bear Creek Cabins is out of compliance. Additionally, the Water Quality Control Division should treat the lack of reporting from several other small treatment plants as a noncompliance problem with the Bear Creek Reservoir Control Regulation.

Treatment Plant	**TMAL Phosphorus Pounds/ year**	**2002 Phosphorus Pounds/ year**
Evergreen Metropolitan District	1,500	**743**
West Jefferson County Metro District	1,500	**926**
Genesee Water and Sanitation District	1,015	**304**
Town of Morrison	600	**116**
Kittredge Sanitation and Water District	240	**67**
Forest Hills Metropolitan District	80	**50**[1]
Jefferson County Schools - Conifer High School	125	**3**
Conifer Center Sanitation Association	40	**5**
West/Brandt Foundation - Singing River Ranch	30	**NR**[2]
Mary Ann Gallagher - Brook Forest Inn	5	**NR**[2]
Bear Creek Development Corp. - Tiny Town	5	**NR**[2]
Jefferson County Schools – Mt. Evans Outdoor School	5	**3.1**
Bear Creek Cabins (Bruce & Jayne Hungate)	5	**5**[3]
Geneva Glen	5	**NR**[4]
Aspen Park Metropolitan District	38	**NR**[5]
Reserve Pool	100	**62**[5]
Total Point Source Phosphorus Wasteload	**5,255 lbs/year**	**2,322**

1-Forest Hills Metro District has trade agreement with West Jefferson County Metro District and is in compliance with permit, which lists 47.7 pounds of phosphorus allowed in trade.

2-NR - No Report Provided to Association. The Association recommends a non-reporting facility be issued a notice of noncompliance with the Bear Creek Reservoir Control Regulation.

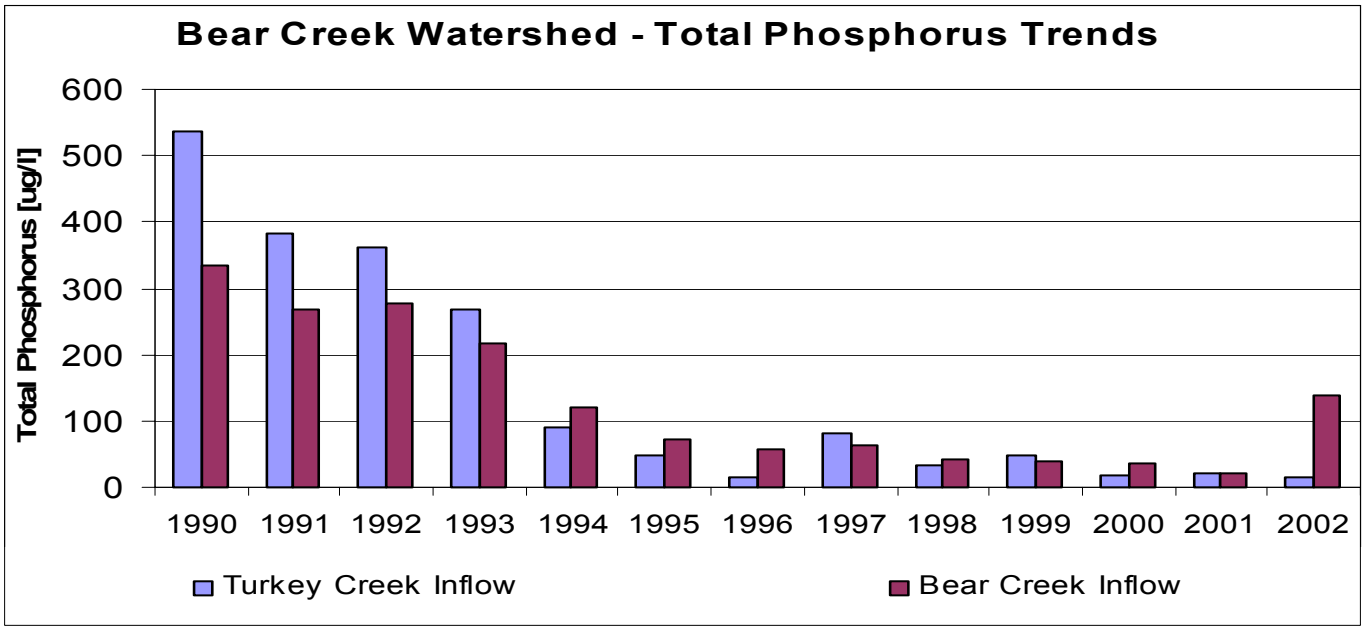
3-The Bear Creek Cabins exceeded total phosphorus monthly allocations 5 times in two years and may have exceeded the annual total phosphorus allocation. The wastewater flow projections reported in the Discharge Monitoring Reports are suspect as low and don't reflect occupancy. The Association recommends the facility be issued a notice of noncompliance.

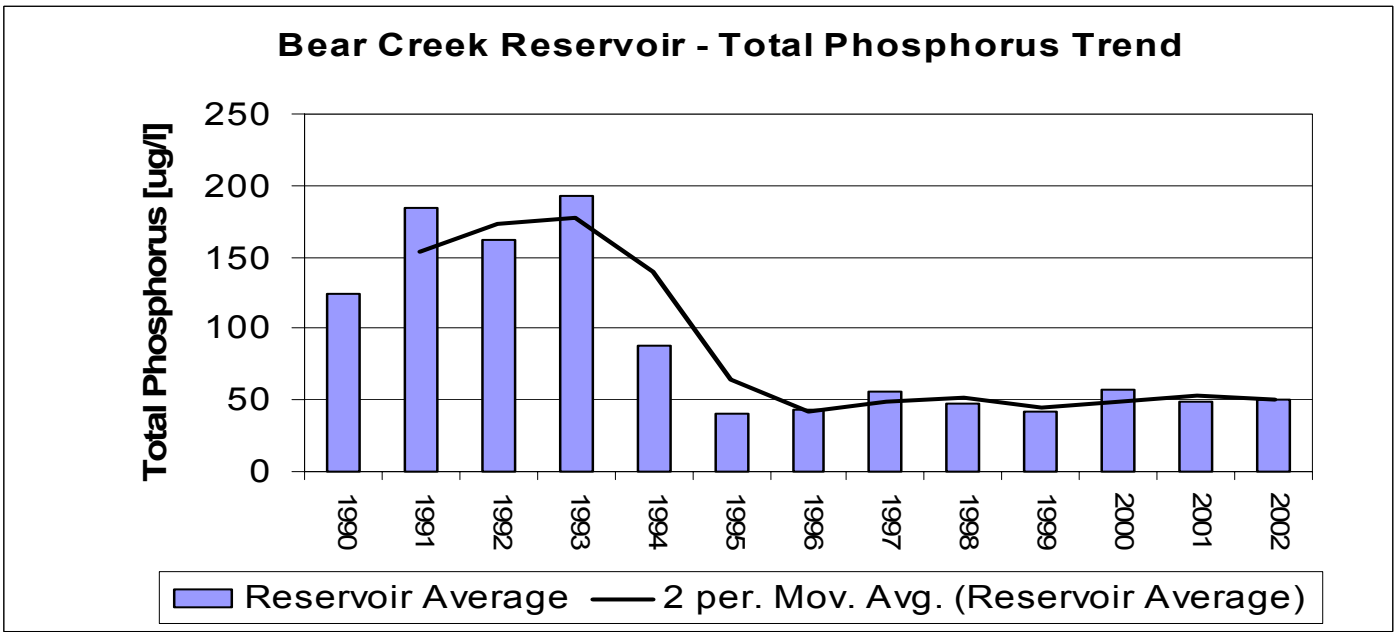
4-The Geneva Glen treatment plant is not discharging, but no report provided to the Association.

5-38 pounds of the reserve pool is allocated to the Aspen Park Metropolitan District, Treatment plant under construction

9. Total Phosphorus Trends for Bear Creek Watershed & Reservoir

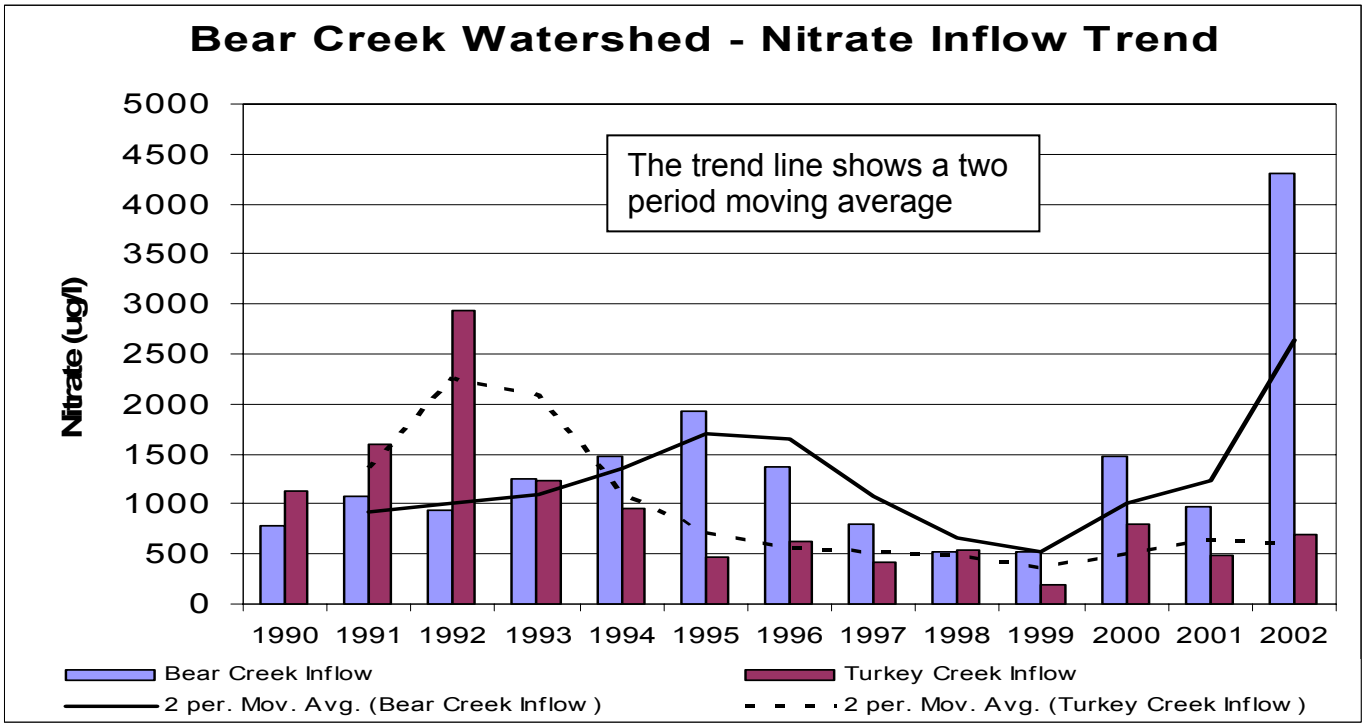
The monitoring program measures total phosphorus into Bear Creek Reservoir and within the water column. The total phosphorus target for the reservoir is to maintain the water column average below 60 ug/l. This target goal has been achieved through point source management over the last eight-years. Controlling total phosphorus source inputs is also a control strategy for reducing chlorophyll levels in the reservoir and meeting the reservoir narrative standard. The low flow in Bear Creek impacted the total phosphorus concentration measured at the Morrison site where less water was available for dilution of the Morrison treatment plant effluent. Consequently, the increased Bear Creek total phosphorus was associated with drought & low flow conditions.

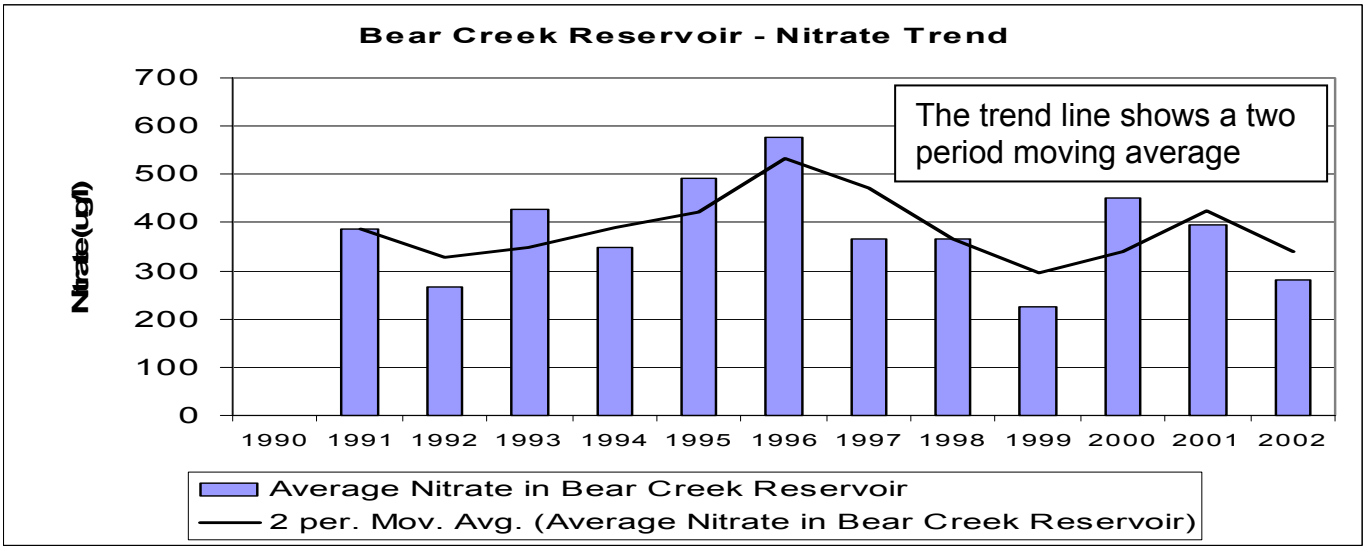




10. Nitrate Trends for Bear Creek Watershed and Bear Creek Reservoir

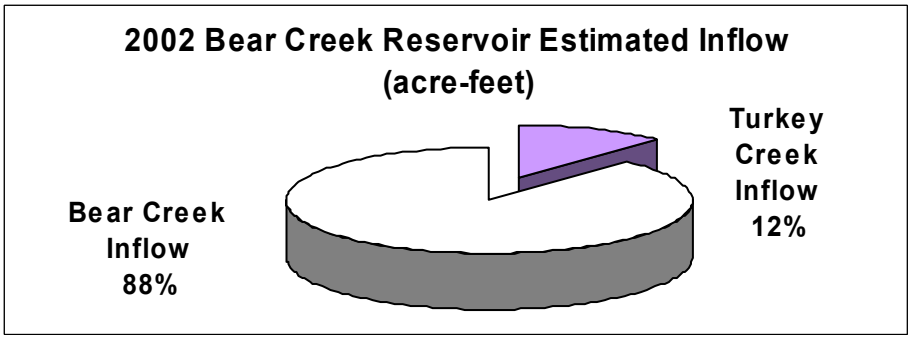
The monitoring program measures inflow nitrate from Turkey Creek and Bear Creek and within Bear Creek Reservoir. In recent years the concentrations of nitrate reaching the reservoir have increased particularly from the Bear Creek drainage. Nitrate has not been a water quality problem in the reservoir. The high 2002 nitrate levels in Bear Creek were associated with low flows and drought conditions. It is suspected that the Morrison Treatment Plant discharge elevated Bear Creek nitrate concentrations, because no flow was available in the stream to dilute the nitrate/ammonia concentrations.

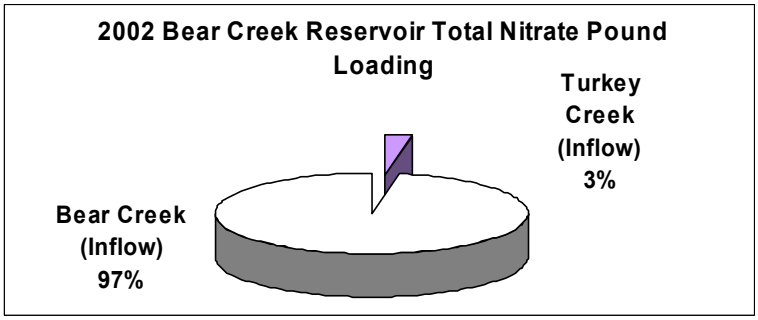


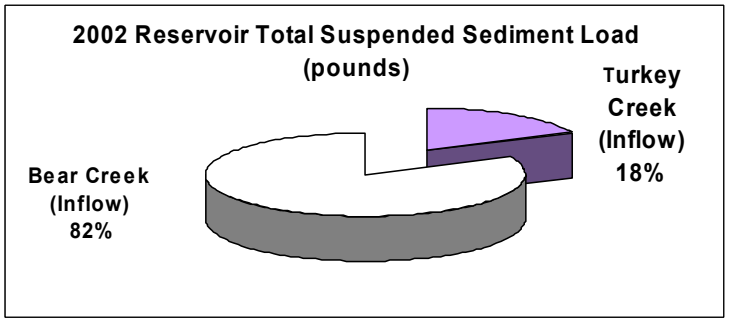


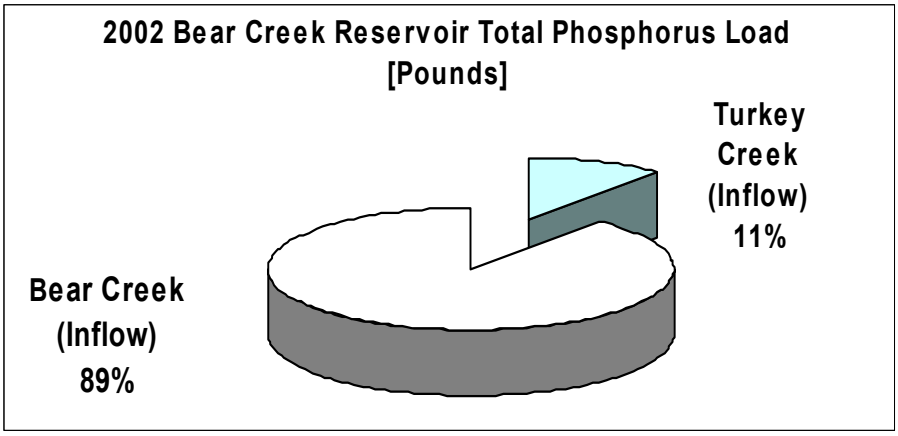
11. Total Phosphorus, Nitrate and Total Suspended Sediment Loads Trends

The monitoring program measures loading into Bear Creek Reservoir from Bear Creek and Turkey Creek. Wastewater treatment plants and a combination of nonpoint sources within the watershed produce the total phosphorus load. The total phosphorus load in 2002 from all sources reaching the reservoir was 480 pounds at an extremely low flow of 2,218 acre-feet. Although the point source discharges of total phosphorus were about 2,000 pounds, the water diversions above the reservoir are removing most of this phosphorus load and inflow water before it reached the reservoir. This is the lowest total phosphorus loading recorded for the reservoir by the Association. The nitrate (15,620 pounds) and suspended sediment (17,520) loading were also well below historic conditions. There were no nutrient or sediment loading problems in 2002.









12. Bear Creek Reservoir 10-Year Data Summary

The reservoir program evaluates nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth as key trophic state indicators. These parameters are used to determine compliance with the narrative standard adopted for the reservoir. The reservoir data from 1991 through 2002 are summarized below. The control program for the watershed has targeted the reduction of total phosphorus reaching the reservoir on an annual basis. The data supports the success of this management effort.

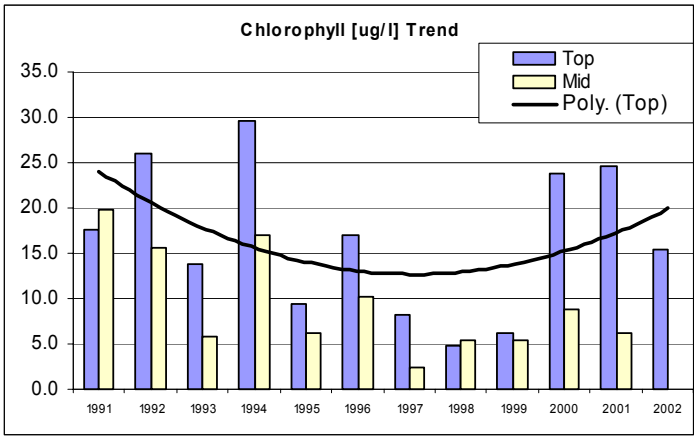
While the nitrogen data has fluctuated over the years, no clear pattern has emerged. However the surface Chlorophyll concentration increased from 2000 and 2002. This suggests an internal nutrient loading problem triggering algal blooms. Additionally, the algal blooms appear to correlate with drier hydrologic conditions. This is evident by the increased average chlorophyll concentrations in surface waters during 2000 to 2002. Future monitoring and some special studies (if this trend continues through 2003-4) will be needed to address the algal production problem in the reservoir.

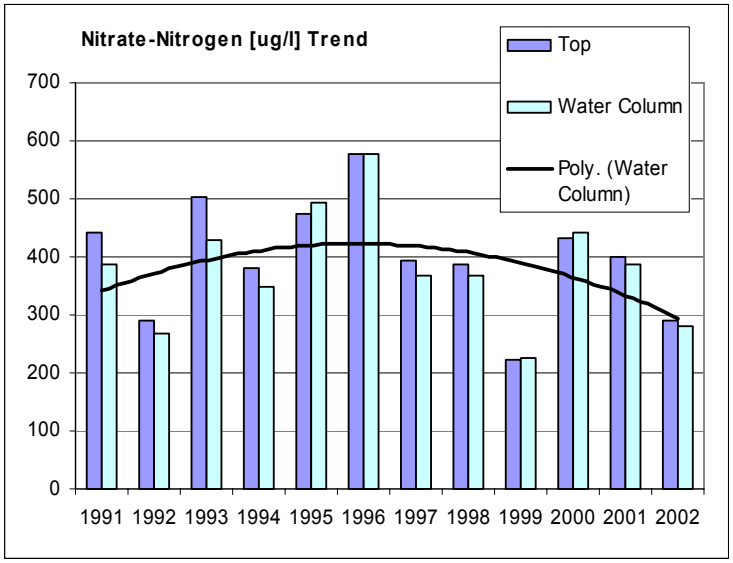
The total suspended sediment load in the reservoir has been generally constant over the monitoring periods with periodic storm events dumping large volumes of sediment into the reservoir. The average depth of the reservoir has declined by over 3 meters (10-11 feet) since 1991.

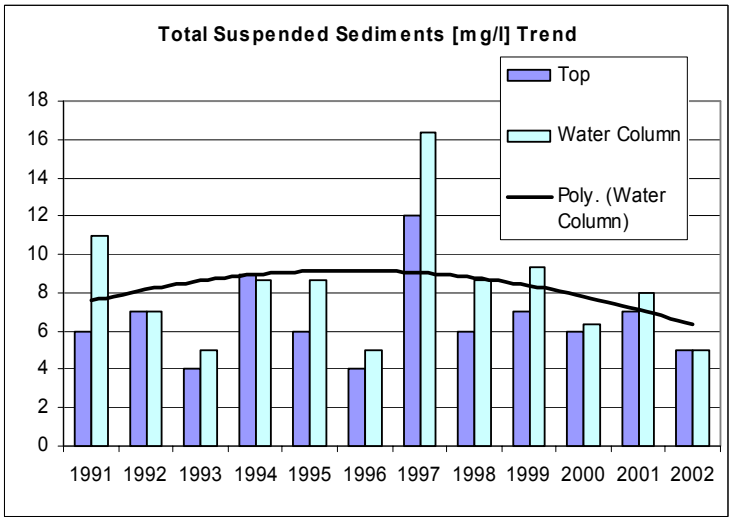
		Reservoir Annual Average Concentrations												
Parameter	**Site**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**91-02 Mean**
Chlorophyll-a (ug/L)	Top	17.7	26.0	13.7	29.7	9.4	17.1	8.2	4.9	6.2	23.9	24.6	15.4	**16.4**
	Mid	19.8	15.5	5.9	17.0	6.2	10.3	2.4	5.4	5.5	8.9	6.3	nd	**9.4**
	Water Column	18.7	20.8	9.8	23.4	7.8	13.7	5.3	5.2	5.9	14.1	14.6	15.4	**12.9**
Nitrate-Nitrogen (ug/L)	Top	442	289	504	382	474	578	393	388	224	431	401	289	**400**
	Mid	381	282	451	356	502	589	365	372	220	443	395	288	**387**
	Bot	341	228	333	308	503	561	341	342	231	483	390	268	**361**
	Water Column	388	266	429	349	493	576	366	367	225	441	387	282	**381**
Total Phosphorus (ug/L)	Top	144	146	175	83	34	29	38	33	34	59	42	46	**72**
	Mid	138	140	164	79	37	33	45	40	37	57	42	49	**72**
	Bot	270	201	240	99	52	66	86	69	54	56	64	56	**109**
	Water Column	184	162	193	87	41	43	56	47	42	60	50	50	**85**
Total Suspended Solids (mg/L)	Top	6	7	4	9	6	4	12	6	7	6	7	5	**7**
	Mid	8	6	6	8	7	4	15	8	9	5	7	5	**7**
	Bot	19	8	5	9	13	7	22	12	12	8	10	5	**11**
	Water Column	11	7	5	9	9	5	16	9	9	6.4	8	5	**8.3**
Secchi Depth (m)	Water Column	2.17	2.1	2.84	1.79	2.14	2.51	1.7	1.8	1.8	2.4	2.3	3	**2.2**

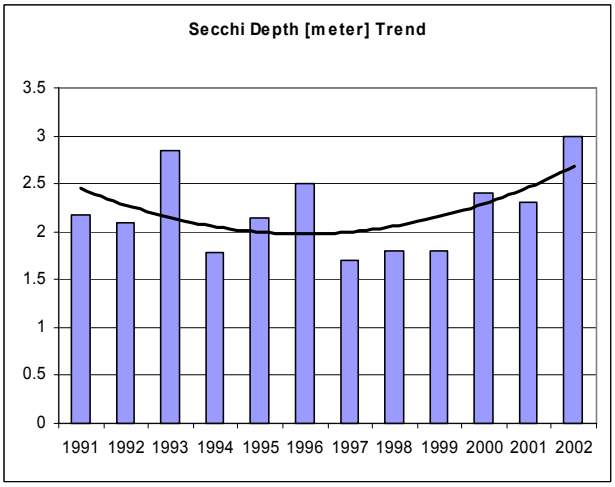
13. Graphics - Bear Creek Reservoir Long-Term Water Quality Trends

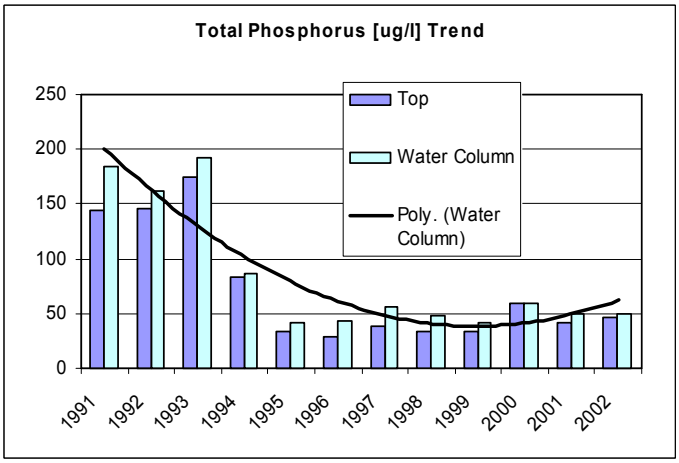
The reservoir program evaluates seasonal, annual and long-term changes in nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth. The reservoir trends from 1991 through 2002 are graphically summarized below. The trend line shows a polynomial curve fit to the data.











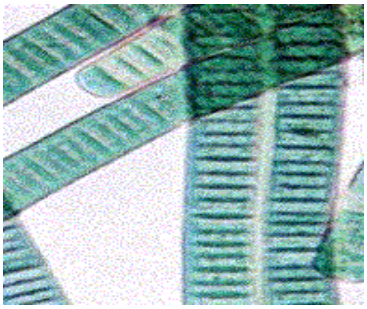
14. Trophic Indicators For Bear Creek Reservoir

Since the management goal is to change Bear Creek Reservoir from a poorer quality hypereutrophic system to a better quality mesotrophic-eutrophic system, the various trophic indicators provide a means to evaluate progress toward this goal. Reservoir water quality models use total phosphorus, Secchi depth and chlorophyll-α levels as indicators of the trophic state of the reservoir. The biological integrity of Bear Creek Reservoir is assessed by monitoring changes in plant (phytoplankton) and animal (zooplankton) communities. The increased abundance within a reservoir of certain types of algae or plants (e.g., blue-green algae or Cyanophyta) indicates declining water quality. Implementation of the watershed management program has impacted water quality in the reservoir and generally helped improve the overall reservoir quality.

Algal production was slightly increased under the 2002 drought hydrologic conditions; even though the total phosphorus loading was lower than historic trends. The algal production consumed most of he nitrate within the water column over the growing season. The growing season Chlorophyll-a concentration is indicative of declining quality or hypertrophic conditions. The data suggests an internal loading problem that can be reduced through an improved reservoir aeration system, which was installed in 2002 by the City of Lakewood.

The following trophic indicators and values are used in the reservoir Walker and Carlson water quality models and a Secchi depth quality prediction model to evaluate the reservoir response to water quality management.

Trophic Indicator	Value in Reservoir
Average Growing Season Chlorophyll-a [ug/l (surface waters only)]	15.4
Peak Chlorophyll-a [ug/l]	43.7
Average Total Phosphorus [ug/l]	50.2
Peak Total Phosphorus	120.9
Peak Ortho Phosphorus	66.3
Secchi Depth [meters]	3.0
Peak Total Suspended Sediments	261
Phytoplankton Species Co-dominant Species	Green – *Chlorella minutissima*
	Chrysophyta - *Chromulina mikroplankton*
	Bluegreen – *Aphanizomenon flos-aquae*
	Bluegreen - *Microcystis aeruginosa*
Peak Phytoplankton Density	93,600 cells/ml (August)

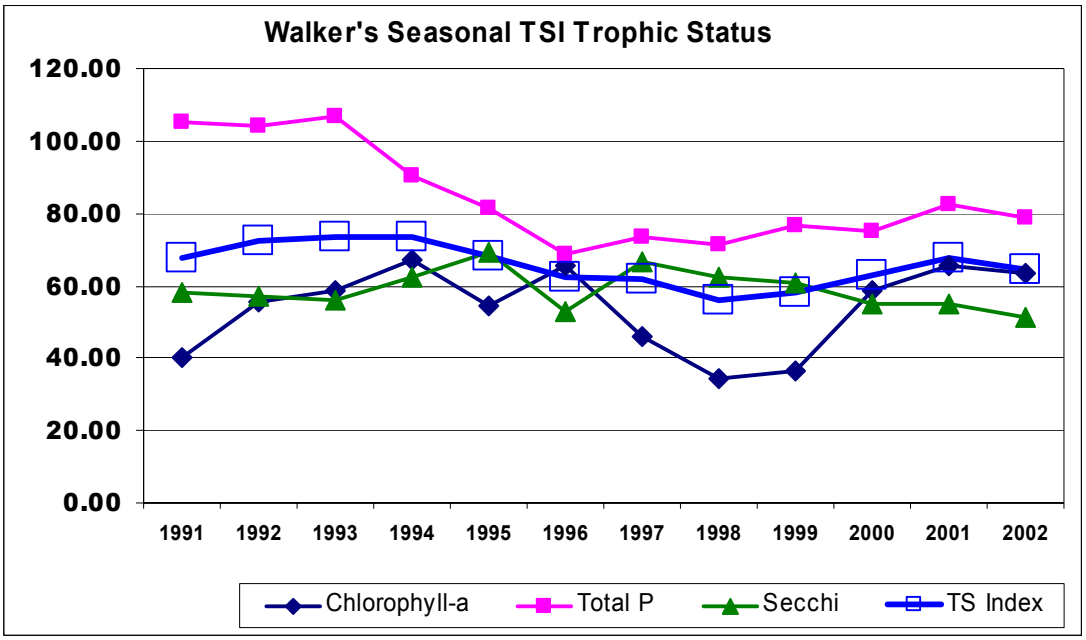


Chlorella

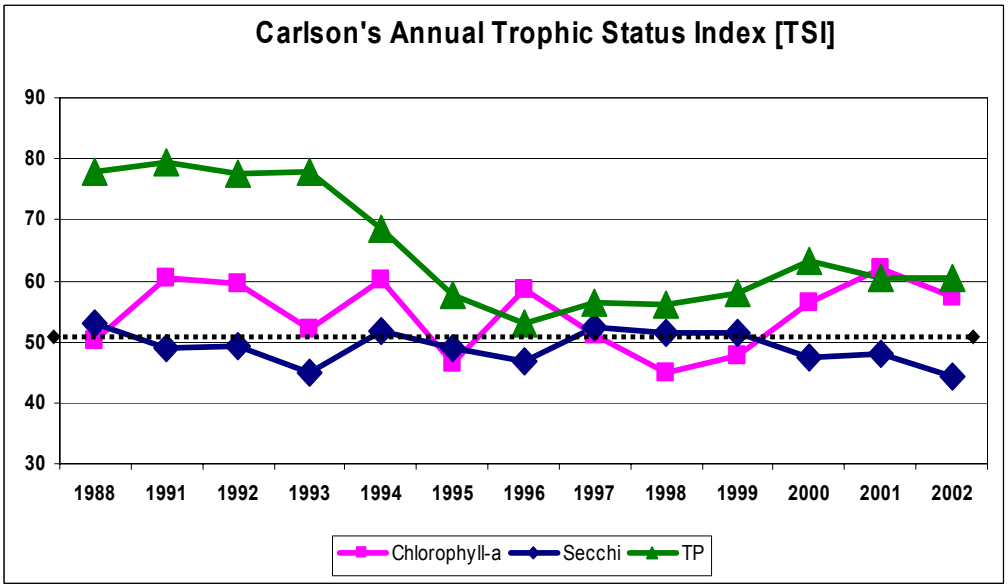
15. Reservoir Trophic State Predicted by Carlson & Walker Trophic Models

Models are used to evaluate the current trophic state: Walker (annual and seasonal); and Carlson (annual and seasonal). Both models use the total phosphorus, Secchi depth and chlorophyll-α levels for the evaluation. The Carlson and Walker models both show the reservoir quality has improved from historic conditions by having the trophic status shift toward the eutrophic-mesotrophic boundary, but the reservoir remains a eutrophic waterbody. Although the point sources are in compliance with the control regulation, the reservoir quality remains in flux. Based on the nonpoint source loading, additional nonpoint source load reductions are needed to stabilize the reservoir at the mesotrophic boundary.

0-25	oligotrophic
25-30	oligotrophic-mesotrophic
30-45	mesotrophic
45-50	mesotrophic-eutrophic
50-65	eutrophic
65+	hypereutrophic



<25	Oligotrophic
25-30	Oligotrophic-Mesotrophic
30-45	Mesotrophic
45-50	Mesotrophic-Eutrophic
50-65	Eutrophic
65+	Hypereutrophic

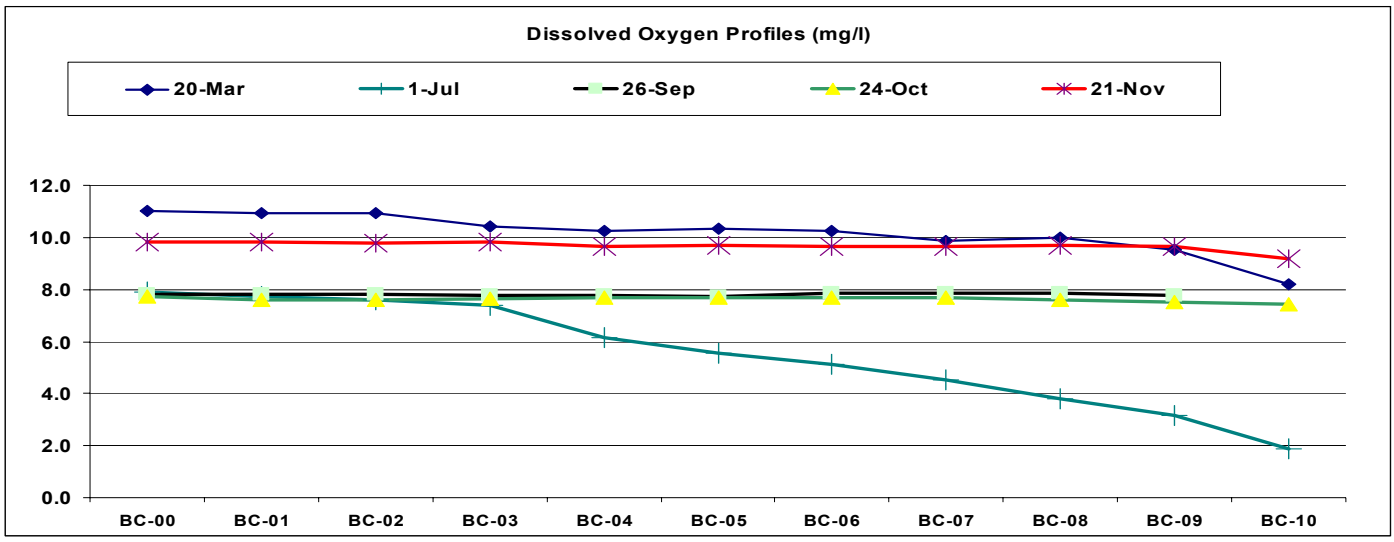


16. Bear Creek Reservoir Dissolved Oxygen Trends

The dissolved oxygen concentrations in the water column are profiled in 1-meter intervals at the central sampling site. Dissolved oxygen is a reservoir trophic indicator measure, where dissolved oxygen concentrations below 5 mg/l can indicate a potential water quality and biological problem. Low dissolved oxygen concentrations can stress aquatic life species. The lower the dissolved oxygen concentration, the greater the potential stress.

Oxygen levels that remain below 1-2 mg/l for a few hours can result in fish kills. Since fish within the reservoir can migrate to better-oxygenated water, the amount of water column with low dissolved oxygen is an important tropic indicator. Low dissolved oxygen concentrations have commonly occurred below 4 meters (about 14 feet) beginning in June and extending through November. Generally, dissolved oxygen concentrations in the water column zero out between 10-13 meters (33-43 feet). However, the dissolved oxygen standard applies to the middle mixing zone (metalimnion) and surface (epilimnion) waters of the reservoir (generally above 4 meters). The low dissolved oxygen values in bottom waters are not a standard exceedence problem.

To resolve this potential low oxygen problem, the City of Lakewood re-established in August of 2002 a new reservoir aeration system in the reservoir. The system extended aeration lines throughout the reservoir to reduce dead spots. The system uses a fine bubble diffuser system to increase total water column aeration with oxygen supplied by an on-shore pump station. This type of aeration system can reduce or eliminate reservoir water column stratification, which raises a potential concern about increasing water column temperature. The system is being monitored to determine changes to temperature and dissolved oxygen. Based on preliminary data, this new aeration is addressing oxygen problem, not affecting temperatures and reducing the potential for stress of aquatic species. The November 2002 oxygen sampling showed saturation conditions throughout the water column.



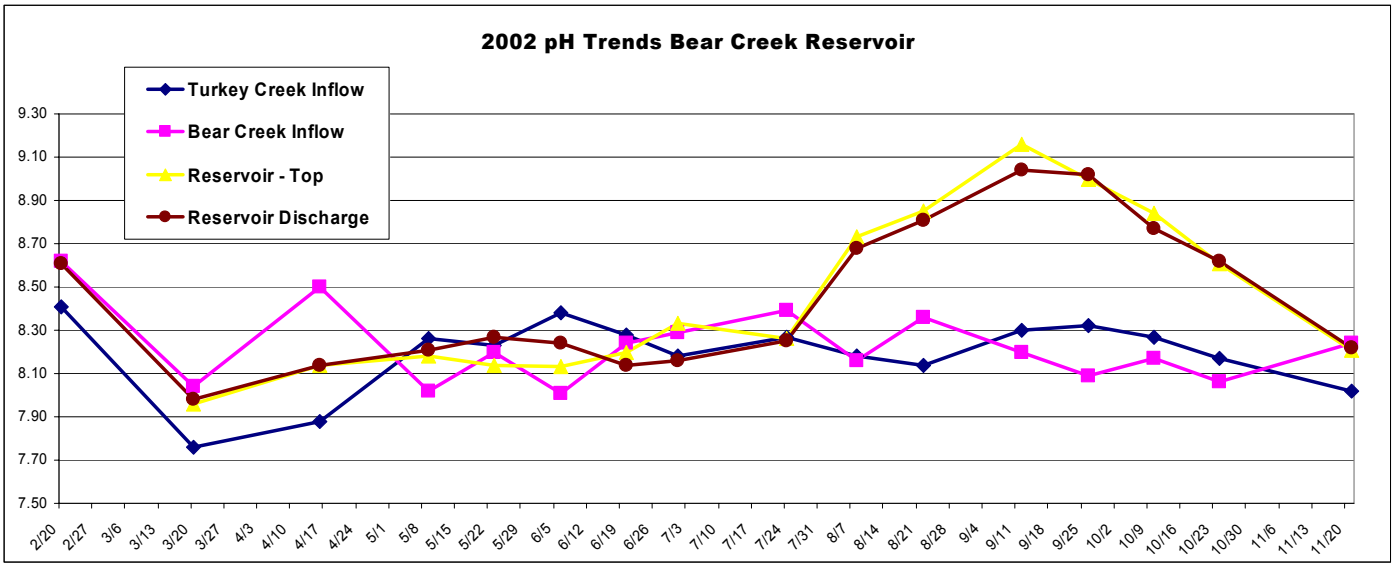
The Basic Standards And Methodologies For Surface Water (5 CCR 1002-31, Regulation #31) -*The dissolved oxygen criterion is intended to apply to the epilimnion and metalimnion strata of lakes and reservoirs. Dissolved oxygen in the hypolimnion may, due to the natural conditions, be less than the table criteria. No reductions in dissolved oxygen levels due to controllable sources are allowed. "Existing quality" shall be the15th percentile for dissolved oxygen.*

17. Bear Creek Watershed and Reservoir pH Trends

The pH values in the water column are profiled in 1-meter intervals at the central sampling site. Water column pH can be a reservoir trophic indicator measure, where pH values above 9.0 indicate a potential water quality and biological problem. The pH scale measures relative quantities of the hydroxyl and hydrogen ions on a scale of 0 to 14. Where the hydrogen ion predominates in acidic solutions [measured as 0 on the scale] and hydroxyl ions predominate in very alkaline solutions [measured as 14 on the scale]. At around pH 7 the numbers of both species present are equal and the water is said to be neutral.

The pH scale is a logarithmic measurement of the concentration of hydrogen ions, which means that each one unit change in the scale equals a ten-fold increase or decrease. Plant photosynthesis is the main cause of high pH and diurnal pH fluctuations. High alkalinity water [pH > 9.0] can cause direct physical damage to fish skin, gills and eyes. Prolonged exposure of aquatic life to sub-lethal pH levels can cause severe stress or result in death of species with a narrow pH tolerance.

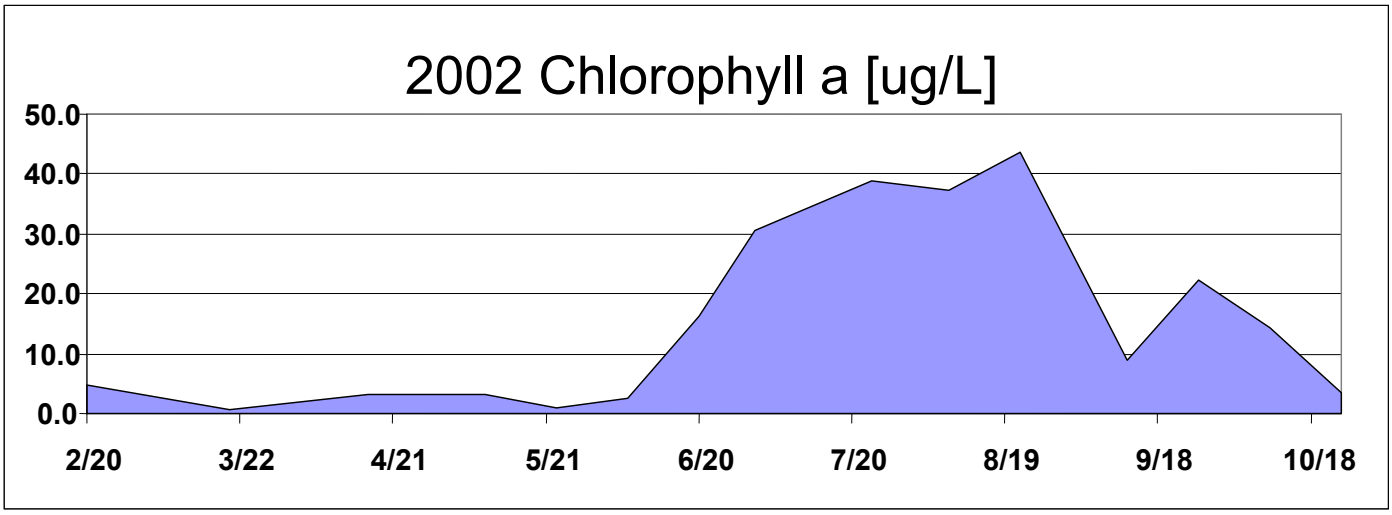
The reservoir pH was in excess of 9 units during the month of September 2002. The inflow water from Bear Creek and Turkey Creek was within expected values and consistent with historical data. Consequently, the factor raising the reservoir pH is an internal mechanism. The elevated pH measurements in the reservoir appear to be associated with algal production; although phytoplankton biomass measurements were relatively low at 17,000 cells/ml. The new aeration system should eliminate this water quality problem. The Association is monitoring reservoir pH conditions in 2003-04 to determine cause and affect.

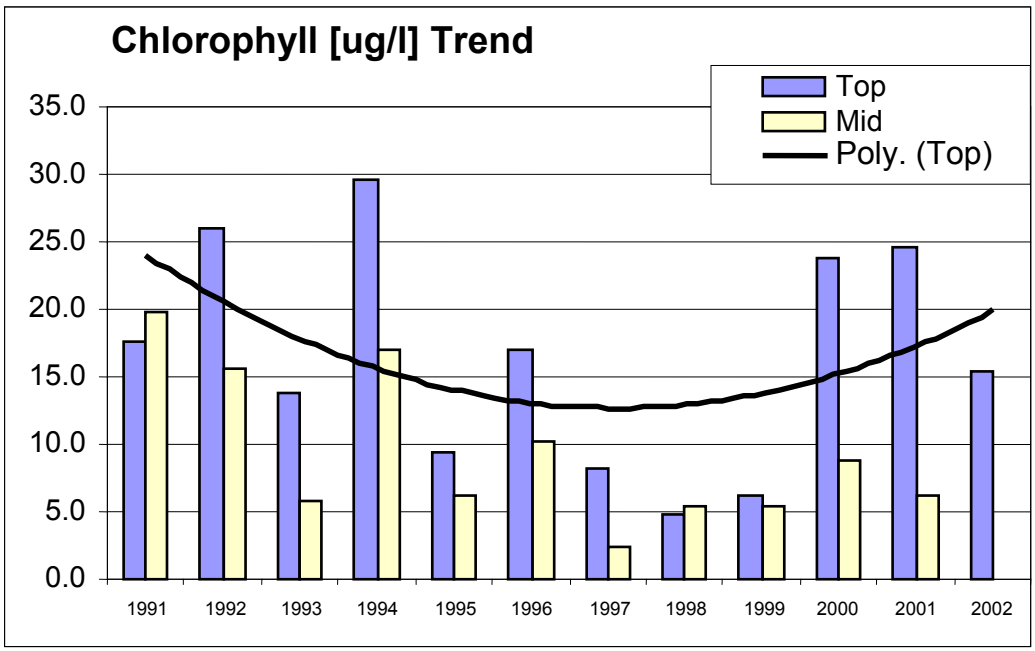


18. Bear Creek Reservoir Chlorophyll-a Trends

The reservoir monitoring program provides necessary data to make statistical water quality trend assessments and verify the effectiveness of control and alternative management programs. The concentration of chlorophyll-a within the reservoir water column is a critical measure of the how the reservoir responds to water quality management strategies. The control regulation is designed to reduce the loading total phosphorus reaching the reservoir and subsequently limiting algal production in the reservoir.

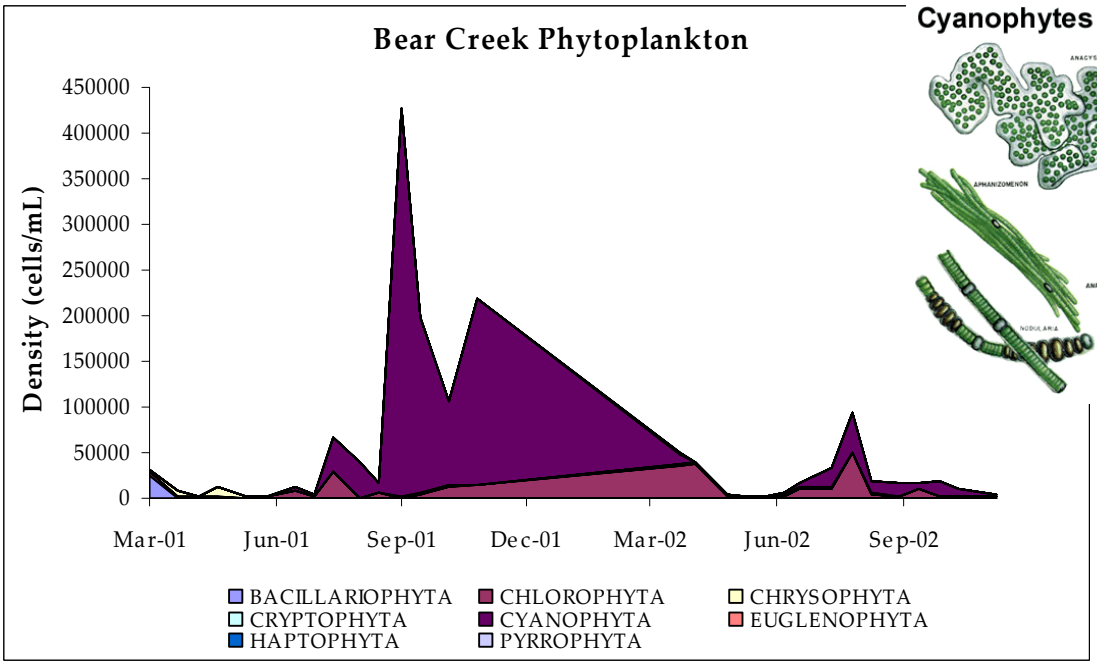
Algal blooms are associated with declining water quality. The target reservoir concentration for the chlorophyll concentrations in the growing season should not exceed 20 ug/l as an average growing season value to be consistent with the intent of the narrative standard. The 2002 growing season chlorophyll-a (15.4 ug/l) was below the target.

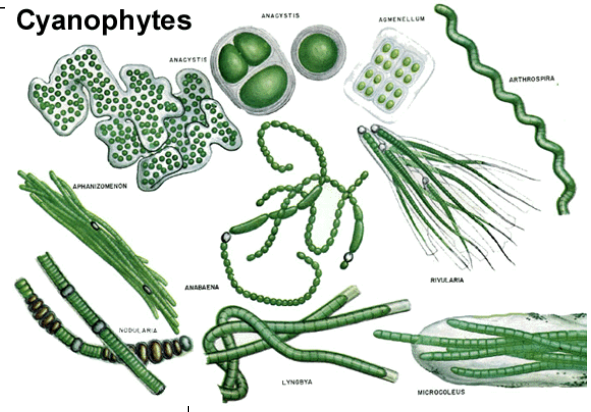


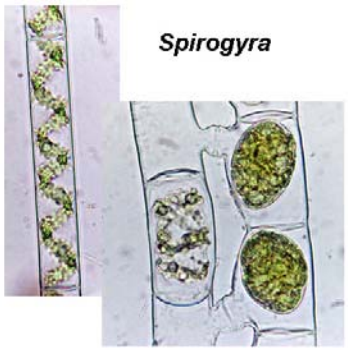


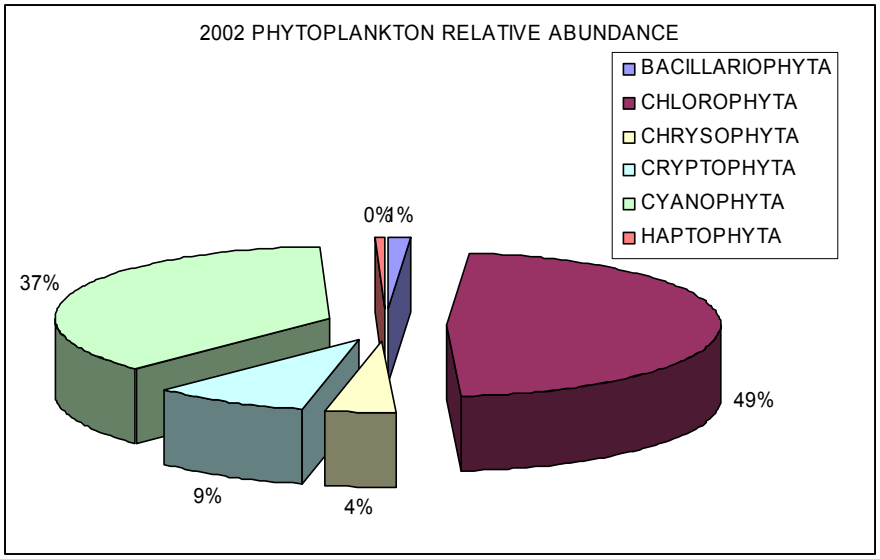
19. Bear Creek Reservoir Phytoplankton Distribution

The biological integrity of Bear Creek Reservoir can be assessed by monitoring changes in growing season plant (phytoplankton) communities. The increased abundance within a reservoir of certain types of algae or plants (e.g., blue-green algae or Cyanophyta) can indicate declining water quality. In 2002, the blue-green species made up on the average 37% of plants present in the reservoir. Twelve species of blue-green algae were found in the reservoir with a maximum total density at 15,000 cells/ml. The green algae comprised 49% of the biomass (7 species) with a density over 50,000 cells/ml in August 2002, which was classified as a visual algal bloom. No fish kills or problems were reported for the reservoir in September or any other month. The diatoms (Bacillariophyta and Chrysophyta) made up 13% of the remaining species. Certain species of diatom can be problematic from a water supply perspective.









20. Bear Creek Reservoir Zooplankton Distribution

A more detailed evaluation of zooplankton species presence was assessed from June through August 2001. Species were counted as present without density determinations. Similar species were identified in 2002, although the survey detail was not as comprehensive as the 2001 survey. The zooplankton species found in the reservoir are divided among three major groups of copepods, cladocerans and rotifers, which are typical of front-range reservoirs.

Zooplankton are common in the upper regions of the reservoir where assemblages include 16 species of rotifers, six species of cladocerans and eight species from the class Copepoda. Copepods are usually a dominant group in the reservoir. The microcrustacean class Ostracoda is missing from the reservoir, but has been found in other front-range waterbodies. Most species of three functional groups make their living grazing algae from either the water column or off surfaces. Zooplankton is a vital link for passing energy up the food chain to fish.

COPEPODA	CLADOCERA	ROTIFERA
Acanthocyclops vernalis	**Alona sp.**	**Asplanchna girodi**
Aglaodiaptomus clavipes	*Bosmina longirostris*	*Brachionus urceolaris*
Diacyclops thomasi	*Chydorus sphaericus*	*Collotheca sp.*
Eucyclops spp.	*Daphnia mendotae*	*Conochilus unicornis*
Leptodiaptomus siciloides	*Daphnia pulex - group*	*Euchlanis dilatata*
Mesocyclops edax	*Leptodora kindti*	*Kellicottia longispina*
Skistodiaptomus pallidus		*Keratella cochlearis*
Tropocyclops prasinus		*Keratella quadrata*
		Lecane (L.) spp
		Lecane (M.) sp.
		Lepadella sp.
		Polyarthra vulgaris
		Pompholyx sulcata
		Synchaeta pectinata
		Trichocerca sp.
		bdelloid

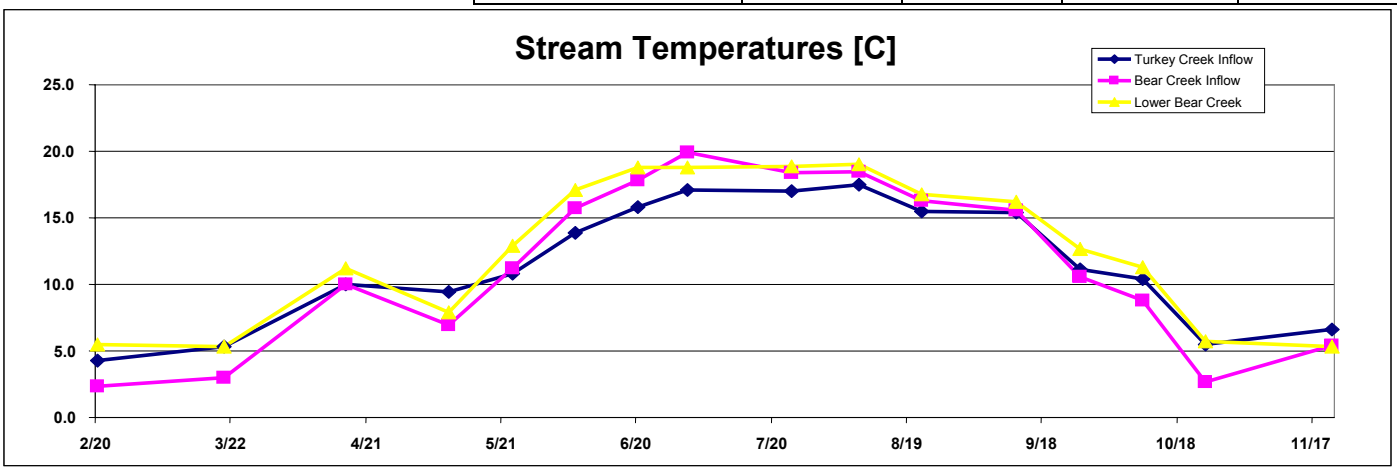
Rotifers are very important because of their incredible reproductive rates. Population densities often exceed 1000 individuals per liter. They play important roles in energy flow and nutrient cycling, accounting for more than 50% of the zooplankton production in some freshwater systems.

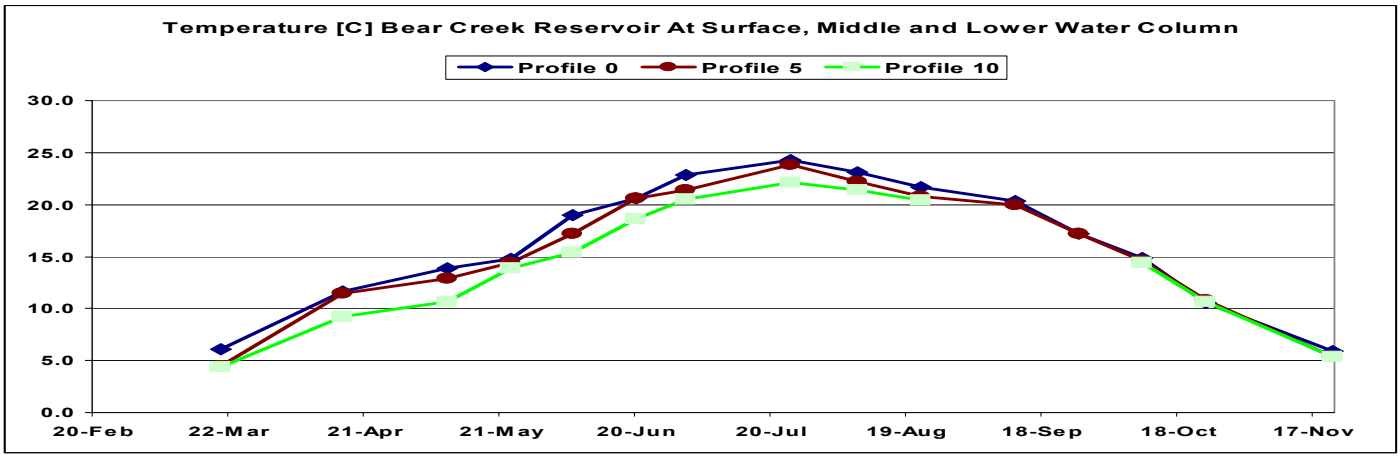
21. Temperature Inflow Trends For Bear Creek, Turkey Creek & Reservoir

Aquatic life species are sensitive to excessive temperature fluctuations. Large changes in water temperature are due to a combination of factors including, geography, season, source inputs (e.g., wastewater) and anthropogenic activities. While the optimum temperature range for trout is below 18 degrees Celsius (C) (64.5 F), trout can survive in waters up to 25 C (77 F). Water temperatures over 25 C can stress trout. Based on temperature measurements in summer months, the reservoir is a marginal cold-water fishery (classified as cold warm fishery), while Bear Creek and Turkey Creek meet temperature requirements for a cold-water fishery.

Optimum Temperature Ranges For Trout

Trout Species	Rearing		Spawning	
	F	C	F	C
Brown	43-64	6.0-18	45-55	7-13
Cutthroat	45-61	7.0-16	48-54	9-12
Rainbow	61-65	16-18	50-60	10-16
Brook	54-65	12-18	45-55	7-13

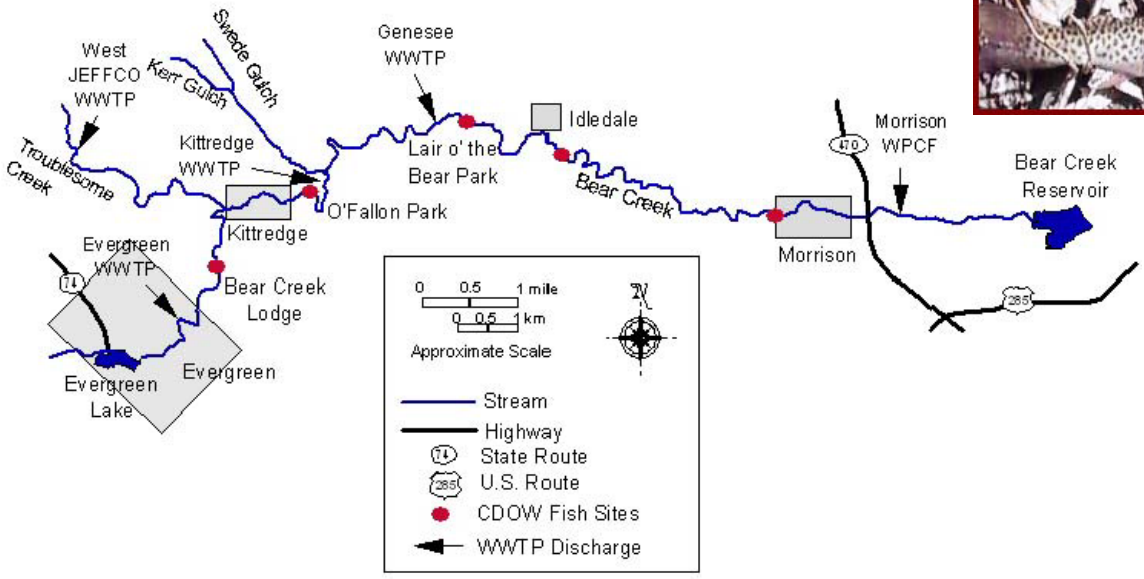




22. Bear Creek Special Trout Population Trend Study

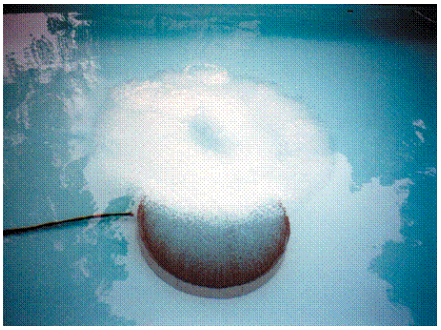
Evaluation Of The Effects Of Wastewater Treatment Plants On Trout Populations In Bear Creek, Jefferson County, Colorado, 1994-2001 [Chadwick Ecological Consultants, Inc., 2002]

The municipalities along Bear Creek divert water from Evergreen Lake and Bear Creek, and discharge wastewater treatment plant effluent back to the stream. The report presents historical fish population data available for Bear Creek, identifies spatial trends in trout populations and shows temporal trends from year to year. The data evaluation assessed status of trout populations to determine changes associated with reported fish kills and temperature effects of wastewater discharges. Brown and rainbow trout populations for Bear Creek decline in density and biomass from upstream near Evergreen downstream to near Morrison. This general trend occurs in all sampling years. The trend relates to the transition of the stream from a coldwater mountain stream to a warm-water plains stream below Morrison. Trout density in 1999 was relatively low at all sites. In 2000 and 2001, trout density and biomass were higher than previous years. A substantial increase in trout density and biomass at all sites occurred between 1999 and 2000. Trout biomass in Bear Creek is consistently above average for Rocky Mountain streams at almost all sites and in most years, and exceeds the biomass criterion for Gold Medal Trout Waters in Colorado. The presence of healthy trout populations at sites downstream of treatment plant discharges indicates no adverse effect on trout populations. Modeling of water temperature indicates discharge of wastewater effluent has a slight cooling effect on Bear Creek. The important factor determining trout population density and abundance is related to the magnitude of spring runoff. In years with high runoff there are fewer trout, and in years of low runoff, trout populations increase. The presence of very strong year classes of both brown and rainbow trout in 2000 indicates conditions during the summer of 2000 were suitable to sustain resident trout populations, including sensitive young trout. The severe drought of 2002 resulted in low flow conditions in which temperatures probably had a detrimental effect on the trout populations of Bear Creek.



23. City Of Lakewood Bear Creek Reservoir Aeration System

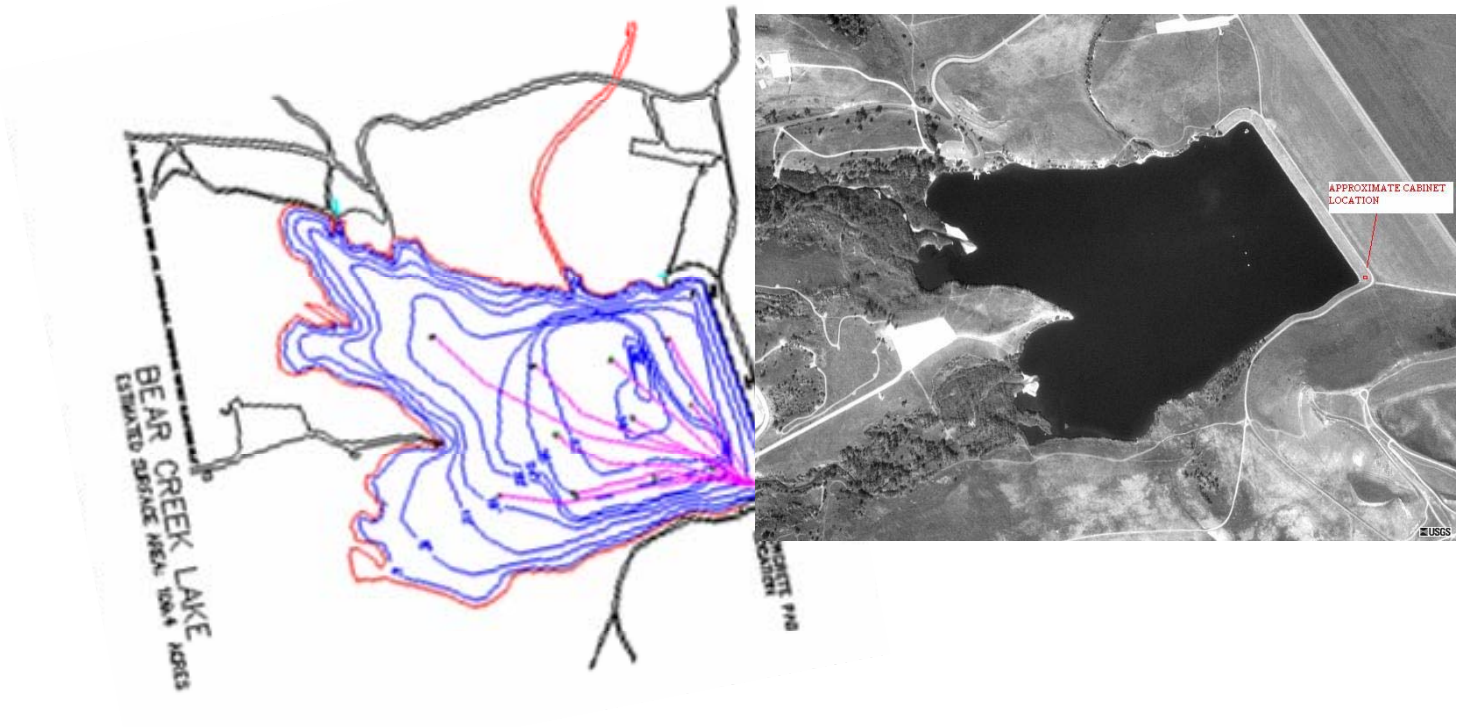
The City of Lakewood maintains an aeration system in Bear Creek Reservoir as a water quality enhancement best management practice consistent with the Bear Creek Reservoir Control Regulation. This aeration system increases the amount of dissolved oxygen in the water column to protect the existing fishery. The original aeration system was designed to oxygenate the water column through a series of anchored towers. This Hypolimnetic aeration system didn't de-stratify the water column. Beginning in 2002 the aeration system began to structural fail from continued freezing in the winter, which resulted in minimal oxygen transfer efficiency. Consequently, the City of Lakewood bid and installed a new complete aeration system in early fall of 2002. This new system has greater coverage throughout the reservoir and much high oxygen transfer potential. Key features of the new aeration system include:



- Eleven Air Diffusion Systems LTC Stainless Steel Modules
- Six Dura-Venturi aerators (From previous installation)
- 22 Million Gallon per Day per Module pumping rate
- Approximately one complete reservoir turnover every 3 days

The aeration system is expected to Increased dissolved oxygen concentrations throughout the entire water column; increased availability of habitat for all fish species (warm and cold); result in pH values that are homogenous and stabilized and cause water column temperatures to be more homogenous throughout the entire water column**.**

Lake Aeration Treatment Systems Operational History: Hypolimnetic Aeration System (1993); Dura-Venturi Installation (1999); ASI Lakebed Aeration System (2002**)**



24. City of Lakewood Stormwater Program

Lakewood provides stormwater education programs in elementary, middle and high schools within the City. Lakewood made presentations and stenciled inlets in 2002 with more than 450 students and teachers. Lakewood staff continues to work with the Colorado Department of Public Health and Environment (CDPHE) to meet the terms of our Phase I National Pollutant Discharge Elimination System (NPDES) permit. Water quality enforcement actions are required by our existing NPDES permit to stop illicit connections and prevent illegal discharges from entering the stormwater conveyance system. In some cases, grease traps from commercial properties such as restaurants or dumpsters may be poorly maintained allowing them to overflow and reach stormwater facilities. Approximately eight contacts have been made in recent months with commercial property owners or tenants regarding pollution prevention.

The dumpster shown above in the upper portion of the picture has not been properly maintained and is allowing unwanted fluids to leak and eventually be washed into the stormwater conveyance system. Lakewood responded to this and other sites requiring expeditious compliance from property owners.

Lakewood supports the Rooney Road Recycling Center (RRRC) as part of our Phase I NPDES permit

Significant Accomplishments:
The following are considered significant accomplishments of the program in 2002:

- 2,629 residents have had access to proper disposal of their hazardous household waste (HHW)
- 8.9% increase in overall participation over 2001
- 368,431 pounds collected “Door-to-Door” or dropped off at the Center during 2002
- Slash program was introduced and approximately 2,750 households utilized the program
- Electronic waste recycling program introduced with 21,891 pounds collected and recycled
- Significant increases in number of pounds of waste collected
- Survey results excellent
- Program is tracking within budget for the period
- The Center and Authority were presented with an award by the State of Colorado for offering the most innovative environmental programs to the residents