Bear Creek Watershed Report 2005:

Annual Report & Water Quality Summary Sheets

Officers: Alan Searcy and Michelle DeLaria

Members: Lakewood, Morrison, Clear Creek County, Jefferson County, Park County, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water & Sanitation District, Kittredge Sanitation & Water District, Willowbrook Water & Sanitation District, Forest Hills Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation, Aspen Park Metropolitan District, Conifer Metropolitan District, Brook Forest Inn, Bear Creek Development Corporation, Geneva Glen, Davidson Lodge & The Fort Restaurant

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The Bear Creek Watershed Association protects & restores water & environmental quality within the Bear Creek Watershed from the effects of land use

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Bear Creek Watershed Association

Management Agency and Watershed Association

The Bear Creek Watershed Association (Association) is the water quality management agency for the Bear Creek Watershed (Figure 1) as recognized by the Denver Regional Council of Governments in *the Metro Vision 2020 Clean Water Plan* (DRCOG 1998).

The Association was formed in 1981 to help management water quality within the area drained by Bear Creek and Turkey Creek from the Bear Creek Reservoir to the headwaters. The Association has made several structural and management adjustments with the addition of new membership. The current Association members and associated agencies are shown in Table 1. The watershed has 16 permitted wastewater treatment facilities. Several of the treatment works are minor systems that serve specific uses (e.g., restaurants, lodges, outdoor schools). Eight facilities have active participation with the Association and are considered major treatment works. All eight associated members are generally active participants and provide support to the Association's management program.

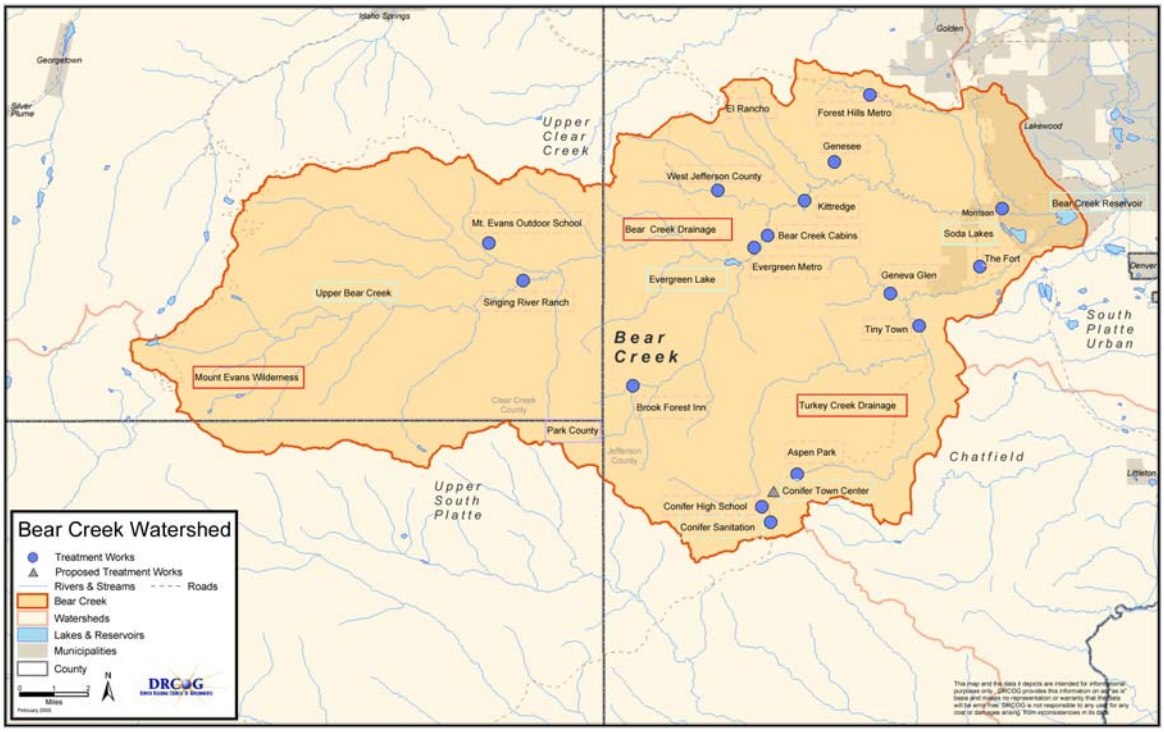


Figure 1 Bear Creek Watershed

Besides being a local management agency affiliated with DRCOG, the Association is responsible for implementing the Bear Creek Reservoir Control Regulation (Regulation #74). This state water quality regulation defines specific water quality goals, wasteload allocation for total phosphorus, monitoring program and other control strategies for the Bear Creek Watershed. The Association is responsible for

monitoring and implementing the control regulation. The Association provides summary data for the Water Quality Control Commission and Water Quality Control Division.

Table 1 Association Members, Associates and Wastewater Treatment Plants

Members and Associates	Wastewater Discharger	Association Participation
Counties		
Jefferson County		**Active**
Clear Creek County		**Active**
Park County		**Not Active**
City and Towns		
City of Lakewood		**Active**
Town of Morrison	**Yes**	**Active**
Water & Sanitation Districts		
Aspen Park Metropolitan District	**Yes**	**Active**
Bear Creek Cabins	**Yes**	**Not Active**
Brook Forest Inn	**Yes**	**Not Active**
Conifer Sanitation Association	**Yes**	**Active**
Conifer Metropolitan District	**Yes**	**Active**
Evergreen Metropolitan District	**Yes**	**Active**
Forrest Hills Metropolitan District	**Yes**	**Not Active**
Genesee Water & Sanitation District	**Yes**	**Active**
Geneva Glenn	**Yes**	**Not Active**
Jefferson County School District (Conifer High School & Evans Outdoor School)	**Yes**	**Intermittent**
Kittredge Water & Sanitation District	**Yes**	**Active**
Singing River Ranch	**Yes**	**Not Active**
The Fort Restaurant	**Yes**	**Intermittent**
Tiny Town Foundation, Inc.	**Yes**	**Not Active**
West Jefferson County Metropolitan District	**Yes**	**Active**
Associate Agencies		
Aspen Park Homeowners Association		**Active**
Colorado Department of Transportation		**Intermittent**
Denver Regional Council of Governments		**Active**
Department of Public Health & Environment		**Active**
Jefferson County Health Department		**Active**
Natural Resources Conservation Service		**Active**
U.S. Army Corps of Engineers		**Active**

Water Quality Management

Water quality data was originally collected as part of an intense one-year *Bear Creek Reservoir Clean Lake Study* (DRCOG 1989-1990). 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 Association water quality management program targets five general areas:

1. Implementing monitoring and reporting requirements contained in the Bear Creek Reservoir Control Regulation #74. The Association finances and maintains a comprehensive water quality monitoring network and makes all data publicly available.

2. Water quality maintenance and enhancements within Bear Creek Reservoir (Figure 4 and Table 2). The reservoir quality was determined to not meet assigned beneficial uses during a Clean Lakes Study (DRCOG 1990). The tropic state of the reservoir showed advanced signs of eutrophication that affected aquatic life, water supplies and agricultural uses. The reservoir trophic state was listed as hypertrophic, which is considered very poor water quality. The Association was assigned under state law the responsibility to monitor and implement strategies to shift the tropic state of the reservoir back to amore desirable mesotrophic-eutrophic state. The trophic status of the reservoir has shifted from hypertrophic-eutrophic toward the eutrophic-mesotrophic boundary.

Figure 2 Sediment Loading on Lower Turkey Creek at Denver Water Diversion

3. A second long-term management strategy of the Association is to improve water quality within the watershed, including Turkey Creek drainage (Figure 2; active sedimentation) and Bear Creek drainage (Figure 3; special flow study). The Association is concerned about sources of water contamination, excess erosion and sedimentation, and other environmental threats that degrade watershed quality. The Association is actively investigating potential concerns about the trout fishery in the mainstem of Bear Creek from the Evergreen Lake to the Harriman Diversion in Morrison. The Association is conducting a number of detailed water chemistry, flow analysis, biological and environmental studies (e.g., habitat) in this stream reach. The Association tracks watershed issues and develops recommendations to resolve problems.

Figure 3 Flow Studies at Bear Creek above Evergreen

Figure 4 Bear Creek Reservoir

Bear Creek Dam - construction of the dam was authorized in 1968 and was completed in 1982. The dam was constructed in two segments including the main embankment and the south embankment.

Bear Creek Lake is less than 1 mile long and has an average depth of 48 feet. The lake drains an area of approximately 236 square miles. The multi-purpose pool measures 110-surface-acres and has a storage capacity of 2,000 acre-feet.

Reservoir Outlet Structure

Shoreline Erosion

4. The Association is responsible for short and long-term wastewater planning and wasteload allocation compliance. The Association maintains a plan for wastewater service within the watershed and tracks compliance of treatment facilities in meeting the intent of the control regulation. The Association as a management agency affiliate with the Denver Regional Council of Governments helps direct development and maintenance of wastewater utility plans and consistency with the Metro Vision Plan. All major wastewater treatment plants are in compliance with the control regulation and Metro Vision Plan, and meet specific wasteload allocations. Several minor plants had compliance problems and/or lack of reporting to the Association. Overall, the point source nutrient loading to the reservoir is well controlled.

5. The Association monitors and will develop management strategies directed toward nonpoint source pollution. The Association encourages use of best management practices that protect the watershed from excess erosion and sedimentation. Nonpoint source reductions of total phosphorus are a growing focus of the Association. Watershed restoration activities and nonpoint source projects are limited due to funding limitations and other resource constraints.

Table 2 Bear Creek Reservoir Construction Facts

The Dam
Type: Rolled Earth Fill
Height:
Main Embankment 179.5 feet
South Embankment 65.0 feet
Length:
Main Embankment 5,300 feet
South Embankment 2,100 feet
Width of Top:
Main Embankment-30 feet
South Embankment-30 feet
Fill Quantity:
South Embankment 770,000 cubic yards
Main Embankment 11,345,000 cubic yards
The Spillway
Type: Earthen Cut
Capacity: 153,500 cfs
The Outlet Works
Type: Circular 7 ft in diameter
Capacity: 2,000 cfs
The Lake and Watershed
Bear Creek Watershed Drainage above dam: 236 sq. miles
Storage Capacity: 78,000 ac-ft
Surface Acres (max. pool): 718 acres
Surface Acres (multi-purpose pool): 110 acres
Maximum depth: 48 feet when constructed (current max: 35')
Length of multi-purpose pool: 0.5 miles
Width of multi-purpose pool: 0.4 miles
Capacity of multi-purpose pool: 2,000 ac-ft

Public Access: Association Web Site

In order to make the Association information and data more accessible to the public and membership, the Association developed and maintains a Web Site: www.bearcreekwatershed.org. The web site characterizes water quality monitoring activities, data tabulation, and general trends in the Bear Creek Watershed including water quality and wastewater management efforts.

Bear Creek Association Program

Vision

The Bear Creek Watershed Association protects and restores water and environmental quality within the Bear Creek Watershed from the effects of land use.

Mission

The Bear Creek Watershed Association identifies, defines, collectively develops, maintains and implements a local environmental and water quality monitoring, management plan and watershed-based program for the Bear Creek Watershed that meets reservoir and watershed applicable water quality standards and beneficial use classifications as adopted by the Colorado Water Quality Control Commission.

Watershed Goals

In addition to watershed management goals, the reservoir has reservoir-specific goals.

The Association supports a watershed approach and recognizes the value of a comprehensive management plan that remains collaborative, flexible and effective.

Goal 1. The Association implements measures as contained in the Bear Creek Reservoir Control Regulation #74 and as periodically amended by the Commission.

Goal 2. The Association develops and disseminates an annual report, fact sheets with a complete data transfer to the Water Quality Control Division. The Association works closely and cooperatively with the Division in water quality management.

Goal 3. The Association implements a trading program consistent with the Bear Creek Reservoir Control Regulation (Regulation #74) trading provisions for point to point source trades and point to nonpoint source trades.

Goal 4. The Association maintains a water quality monitoring program that includes special studies and routine monitoring as described and maintained in an approved Quality Assurance Project Plan with stated standard operating procedures and a sample analysis plan. The water quality and environmental monitoring program may include surface, groundwater, and stormwater, to meet the requirements of the control regulation or other applicable regulations (local and state).

Goal 5. The Association will share collected environmental and water quality data through a collaborative process. As such, the Association expects to be a primary source of water quality data.

Goal 6. The Association monitors and implements programs to determine the trophic behavior of the reservoir, which in turn helps assure that associated recreation, aquatic life and water supply goals are met within the watershed.

Goal 7. The Association acknowledges a reproducing Brown Trout Fishery in the mainstem of Bear Creek from Evergreen to Morrison and supports efforts to maintain this fishery.

Goal 8. The Association directs or encourages programs designed to control point source wasteload allocations and nonpoint source loadings to such an extent to protect water quality and beneficial uses within the watershed.

Goal 9. The Association evaluates impact of septics systems on watershed quality and makes appropriate recommendations for management.

Goal 10. The Association identifies and tracks environmental and water quality parameters and constituents /conditions considered as stressors in the watershed and incorporate findings into the management program and annual report, as appropriate.

Goal 11. The Association encourages local land-use entities (Counties) to reduce sediment loading to Bear Creek Reservoir by maintaining and enforcing sediment and erosion control regulations.

Goal 12. The Association determines potential solutions to existing nonpoint source problems; including preferred best management practices (BMPs); develop a long-range milestone schedule for implementation of BMPs.

Goal 13. The Association helps increase public awareness of nonpoint source pollution potential, prevention, restoration and involvement in watershed management; develop an education program; make provisions for public review of program progress and success. The Association maintains a Web site as a public information source. The Association encourages and supports citizen involvement in the management program.

Goal 14. The Association analyses the economic forces and incentives; establish economic priorities; develop cost alternatives; assess local and state funding sources; determine responsible agencies.

Goal 15. The Association has a dual funding process that (1) seeks funding to support required management and/or monitoring and (2) pursues supplemental funding necessary for water and environmental mitigation.

Goal 16. The Association serves as a land use referral agency to Jefferson and Clear Creek Counties related to water and environmental quality.

Goal 17. The Association evaluates existing and proposed regulatory programs and assesses relationship to management program.

Goal 18. The Association determines the type and quantity of additional technical or water quality monitoring information is necessary and required for future programs; defining the water quality objectives to be achieved; estimating the loading reduction to be achieved.

Goal 19. The Association assess if formal agreements need to be made to ensure inter- and intra-jurisdictional cooperation.

Goal 20. The Association ensures an effective regional water quality management program consistent with the regional planning agency.

Goal 21. The Association ensures a cost effective local wastewater management systems consistent with the control regulation and regional planning.

Goal 22. The Association identifies management activities that ensure water quality compliance within the watershed.

Goal 23. The Association reviews and approves wastewater utility plans associated with dischargers within the watershed.

Goal 24. The Association maintains by-laws and rules of operation.

Goal 25. The Association will hold Board meetings open to the public on a frequent basis and maintain a record of meetings.

Goal 26. The Association supports restoration activities related to water and environmental quality in the watershed through cooperative and collaborative processes.

Goal 27. The Association acknowledges the linkage between water quality and water supply and as such addresses water supply issues that could affect water or environmental quality within the watershed.

Reservoir Goals

Goal 1. The Association monitors and implements programs to determine the trophic behavior and trends of the reservoir.

Goal 2. The City of Lakewood assists the Association with supplemental reservoir monitoring.

Goal 3. The Association targets the reduction of the annual total phosphorus loading to the reservoir from both point and nonpoint sources found in the watershed; targeting a near-term 75% reduction of point source loads and 35-50% reduction of nonpoint source loads within 10-20 years.

Goal 4. The Association reservoir management strategies directly support the City of Lakewood's focus on improving the reservoir fishery and enhanced recreational potential, along with habitat in Bear Creek Park.

Goal 5. The Association supports a two-story fishery of mixed warm and cold water species in the reservoir.

Goal 6. The Association supports a reservoir site-specific narrative standard that focus on maintaining the long-term trophic state within the reservoir near the Meso-Eutrophic boundary:

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.

Goal 7. The Association will be kept informed and/or directly involved with any proposed changes to the Bear Creek Reservoir water storage or other reservoir and/or distribution supply proposals.

Association Watershed Plan

The Association is developing a comprehensive watershed plan that will be used for management and implementation. The Association watershed plan draws together the many documents developed by the Association since 1981 and provides a more concise direction for future management and planning. The watershed plan will serve to document strategies and processes. The Association anticipates completion of the watershed plan by late 2006.

Bear Creek Reservoir Control Regulation

The Association is responsible for implementing the Bear Creek Reservoir Control Regulation # 74. The control regulation assures watershed point and nonpoint source water quality compliance is consistent with adopted Colorado stream standards and classifications. The Association maintains a water quality-monitoring program designed to assure compliance with adopted standards and classifications and the Bear Creek Reservoir Control Regulation #74.

Total Maximum Annual Load

The Bear Creek Reservoir Control Regulation #74 incorporates the total maximum annual load (TMAL) that controls total phosphorus wasteload allocations for point sources and the allowable nonpoint source load for the Bear Creek Watershed (Figure 1). The TMAL, which is consistent with a total maximum daily load, results in the Bear Creek Reservoir meeting designed beneficial uses and classifications as listed in regulation #38. The reservoir has a narrative standard based on established trophic indices. The TMAL 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 TMAL as approved by Region VIII Environmental Protection Agency and the Water Quality Control Commission are shown in Table 1. The total maximum annual load distributions of total phosphorus by sources are based on the following formula:

Total Maximum Annual Load (TMAL) = Chatfield Watershed (reservoir base-load + background sources + wasteload allocation) + Upper South Platte River Watershed (reservoir base-load + background sources) + Margin of Safety (MOS).

Table 3 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.

2005 Amended Control Regulation

In 2005, the Association in cooperation with Water Quality Control Division staff recommended changes to the control regulation for a rulemaking hearing held in March 2005. The major Water Quality Control Commission changes included:

- Addition of new definitions;
- Adjusted the wasteload allocations for total phosphorus;
- Recognized three new wastewater treatment facilities;
- Added wastewater treatment facility trading provisions;
- Clarified nonpoint source control responsibilities for onsite wastewater management regions;
- Removed Appendix A on monitoring and replacing it with a quality assurance project plan; and
- Changed annual reporting requirements.

Wastewater Treatment Facilities Wasteload Allocations

The Control Regulation sets a total phosphorus wasteload allocation for all point source dischargers in the Bear Creek Watershed. The total annual wasteload is 5,255 pounds of total phosphorus per year. This wasteload is distributed among the permitted dischargers based on need and projected growth. 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.

Reservoir 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. Table 4 depicts critical reservoir trophic parameters and associated 2005 data.

Table 4 Bear Creek Reservoir 2005 - Selected Trophic Indicators

Trophic Indicator	Reservoir
Chlorophyll	
Average Growing Season Chlorophyll-a [ug/l (surface waters only)]	15.5
Peak Chlorophyll-a [ug/l]	75.5
Phosphorus	
Average Annual Total Phosphorus [ug/l]	39.2
Seasonal Annual Total Phosphorus [ug/l]	45.8
Peak Annual Total Phosphorus [ug/l]	161
Average Annual Ortho Phosphorus ug/l]	13.8
Seasonal Average Ortho Phosphorus [ug/l]	18.9
Peak Annual Ortho Phosphorus [ug/l]	113.1
Nitrogen	
Average Annual Nitrate-Nitrogen [ug/l]	207
Seasonal Average Nitrate-Nitrogen [ug/l]	150
Peak Annual Nitrate-Nitrogen [ug/l]	565
Clarity	
Average Annual Secchi Depth (m)	2.1
Seasonal Average Secchi Depth [meters]	1.5
Total Suspended Sediments	
Annual Average Total Suspended Sediments [mg/l]	6.7
Seasonal Average Total Suspended Sediments [mg/l]	7.4
Peak Total Suspended Sediments [mg/l]	12.5
Phytoplankton Species	

Trophic Indicator	Reservoir
Phytoplankton Species Co-dominant Species	Diatom - *Asterionella formosa*
	Diatom - *Aulacoseira italica var. tenuissima*
	Green – *Chlorella minutissima*
	Green - Choricystis minor
	Green – *Monomastrix sp*
	Cryptophyta- *Plagioselmis nannoplanctica*
	Chrysophyta - *Chromulina sp.*
	Bluegreen - *Aphanizomenon flos-aquae*
	Bluegreen - *Aphanothece smithii*
	Bluegreen - *Microcystis wesenbergii*
	Bluegreen - *Pseudanabaena mucicola*
	Bluegreen - *Woronichinia naegeliana*
	Bluegreen - *Anabaena flos-aquae*
Peak Phytoplankton Density	753,600 (Aphanizomenon)
Zooplankton Diversity	37 Species

Listing Issues, Special Studies & Water Quality Recommendations

Segment 1a Bear Creek

Based on a recommendation by the Association, Bear Creek segment 1a was placed on the 2002 Colorado monitoring and evaluation list. Decreased flows in 2001 supposedly began to stress resident trout populations, based on local reporting claims made to the Water Quality Control Division, but not presented to the Association. In 2002, Bear Creek was subjected to worst drought on record for the stream with stream flow dropping below measurable values in the middle of the summer. The Association recognized the naturally caused low flow affected trout populations. Consequently, the Association implemented special instream monitoring efforts beginning in the summer of 2001 and continuing through 2005 to obtain scientifically defensible data to characterize the potential chemical changes at low flow conditions. The Association focused this special monitoring on in-situ temperature, ammonia and pH.

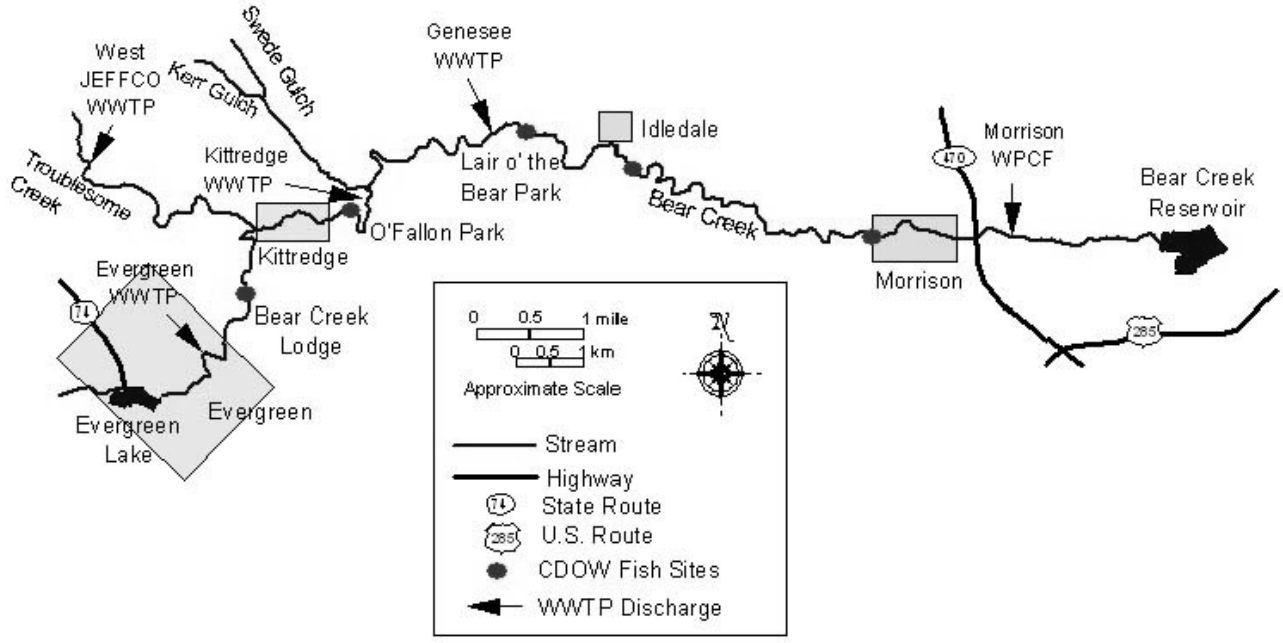
Bear Creek segment 1a is on the 2004 Colorado Monitoring and Evaluation List (Regulation #94) for continued evaluation of the listed parameters of concern associated with aquatic life use, ammonia and temperature (Figure 5). The Association has collected over 15,000 water quality data records for various parameters in the watershed at a cost of about $450,000. This extensive data record has been used to assess the watershed's compliance with conditions listed in regulation #74. The Association has used a watershed-based approach with specific emphasis on water quality within Bear Creek Reservoir. Loading from the watershed has been treated as a reservoir load. However, the Association has and will continue to be protective of water quality throughout the watershed.

The Association supplemental water quality-monitoring program for Bear Creek segment 1a is incorporated into the base watershed routine monitoring program. Appendix A is a supplemental monitoring summary report for 2005 data collected in segment 1a. A separate data file containing all stream monitoring data and information is available electronically from the Association. The Association is applying the same

rigorous quality control and quality assurance program to this supplemental monitoring effort as used in the base monitoring program. As long as Bear Creek segment 1a is on the monitoring and evaluation list, the Association will continue supplemental monitoring and data analysis and evaluation.

It is not appropriate or scientifically accurate to list the stream segment for aquatic life, temperature or ammonia impairment based on available long-term water quality data record. The Association's long-term water quality monitoring program data record, supported by a Water Quality Control Division approved water quality assurance and quality control plan, does not support an impaired stream status based on water chemistry for temperature or ammonia nitrogen.

Figure 5 Bear Creek Segment 1a



Trout Studies

The suspected aquatic life impairment is based on trout stress in one out of nine years of available shocking information collected by the Colorado Division of Wildlife. The 2002 trout population stress and decline was caused by the lowest flow conditions ever recorded for Bear Creek segment 1a segment with 100-years of flow record available at the downstream Morrison U.S. Geological Survey gauging station.

Chadwick Ecological Consultants completed a report titled U*pdate of the Status of Trout Populations in Bear Creek, Jefferson County, Colorado 1994-2003* (Chadwick 2003). The report evaluated historic trout populations using data collected by the Colorado Division of Wildlife. The report concludes that the drought of 2002 interrupted many established spatial and temporal trout populations in Bear Creek. The report shows the general downstream migration of Brown and Rainbow Trout caused by low flow conditions. The number of adult trout was reduced in 2002 at the upper survey

sites. The number of adult trout remained low at the upper two sites in 2003. The report shows good classes of young of the year in both 2002 and 2003.

The trout population in 2003 was recovering with the total density of trout per acres, based on Division of Wildlife surveys, higher than in most previous years. Adult trout began to migrate back upstream and new classes of young trout were found throughout segment 1a. The long-term purported decline in native trout population is not supported by fish surveys. The Colorado Division of Wildlife analysis fish surveys do not support the purported decline in trout populations prior to 2002 drought conditions. In fact, the surveys show a very health population of reproduction Brown Trout and a good population of Rainbow Trout. The 2002 drought season stressed the trout populations in the upper reaches of Segment 1a where flows were reduced to zero or near zero. The survey indicated a general downstream migration of trout into those lower reaches with some flow.

Trout surveys were completed by the Colorado Division of Wildlife in September 2005. The Colorado Division of Wildlife performed an electro-fishing fish counts in Segment 1a on September 14-15, 2005. Seven locations were surveyed (moving upstream to downstream): Keys on the Green, Downtown Evergreen, Bear Creek Cabins, O'Fallon Park, Lair o' the Bear Park, below Idledale and at the west end of Morrison. The good return of fish density and numbers as reported by the Division of Wildlife in 2005 is a strong indicator that the stream segment will have a natural recovery from the drought stress. Consequently, it is not accurate to claim that fish populations have been permanently impacted by stream water quality. In fact, the temporary decline in trout populations simply occurred due to lack of stream flow caused by severe drought conditions.

Macroinvertebrate Assessment

The macroinvertebrate integrity of Bear Creek segment 1a was assessed by collecting macroinvertebrate at four sites along Bear Creek on June 11, 2005: Bear Creek Park, Lair o' the Bear Park, O' Fallow Park, and Upstream Evergreen wastewater treatment plant effluent outfall. Association members used a Surber Stream-bottom sampler (After Brewer and McCann, 1982) and standard sampling protocol.

Other Special Activities

The Association is involved in a number of ongoing activities that are directed at water quality, habitat and environmental evaluations. These activities and special studies provide a basis for helping the Association and affiliated agencies make reasonable and necessary water quality recommendations. Besides the major assessment activities, the Association does:

- Special flow study that measures flows at eight discrete transects at the fishery monitoring stations using USGS gaging data as upstream and downstream controls. This study will evaluate the gains and losses within the system and will be used to determine hydrographic fluctuations.

- The routine water quality monitoring program maintained by the Association has not demonstrated a temperature or ammonia toxicity problem; consequently the

supplemental monitoring effort will assess gaps in the monitoring routine monitoring program. Expand the temporal and spatial monitoring efforts on the stream. Once the more detailed stream data is analyzed, the Association can determine the best location and sampling protocol to characterize segment 1a.

- The Association will obtain water quality data that can be used in future stream modeling and predictions. Additional evaluation and modeling of the temperature information is necessary to determine a management strategy for the stream.

- The listing for aquatic life requires stream characterization to assess how the trout populations are responding to both natural and human induced alternations. The supplemental data set will allow the Association to determine if chemical affects are part of the problem.

- Evaluate the cause and affect response to stream chemistry and recommend a management strategy to the Association.

- In cooperation with the WQCD, collected data on stream habitat, stream pebble counts and macroinvertebrates.

- Review and acceptance of the Association quality assurance and project plan.

Segment 1c Bear Creek Reservoir

The Bear Creek Watershed Association and the City of Lakewood (member of the Association) maintain separate water quality monitoring programs on Bear Creek Reservoir segment 1c. The Association monitoring program is designed to assess the trophic state of the reservoir and compliance with the Bear Creek Reservoir Control Regulation # 74. The Association is responsible for implementing the control regulation. The City of Lakewood maintains an aeration system in the reservoir as part of the control strategies to restore and enhance the reservoir water quality consistent with the control regulation. The Lakewood monitoring program has been designed to determine the effectiveness of their aeration system. These two monitoring programs are complimentary and essential to the water quality management goals of the Association.

The Association and Lakewood are addressing three water quality topics of interest within the reservoir:

1. Low Dissolved Oxygen - The 2002 and 2003 Colorado Monitoring and Evaluation Lists have identified Bear Creek Reservoir as potentially impaired due to low dissolved oxygen concentrations in the water column during the growing season. Lakewood installed a new expanded aeration system to resolve the dissolved oxygen problem. The Association and Lakewood are documenting this success and will provide evidence for delisting of this problem from the 2006 list.

2. Elevated Reservoir pH - The 2003 and 2003 routine water quality-monitoring programs maintained by the Bear Creek Watershed Association and the City of Lakewood monitoring program measured several water column pH values in

excess of the Colorado State upper limit standard of 9.0 pH units. No pH problems recorded in 2005 monitoring program. Elevated pH values are generally indicative of excess algal primary productivity in shallow reservoir systems. A more detailed collection of pH data with a greater temporal and special distribution of samples was done by Lakewood in 2005 to determine the magnitude of this potential problem. A wider fluctuation in pH readings shows in recent data sets and maybe related to algal productivity caused by internal nutrient loading from reservoir bottom sediments. The Association and Lakewood will continue monitoring evaluations.

3. Reservoir Temperatures Not Supportive of Cold Water Classification - The near surface temperatures in the reservoir have shown an increasing trend over the last five years with numerous measurements in excess of 20 degrees centigrade (C), which is the upper limit for a cold water class 1 waterbody in Colorado. The water column in 2005 from June through August was above 20 C. Additional evaluation and modeling of the temperature information is necessary to determine a management strategy for the reservoir. A question the Association needs to query is if the reservoir classification is correct.

Water Quality Monitoring

Routine Monitoring 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. A complete copy of the monitoring plan is maintained on the Association web site: www.bearcreekwatershed.org.

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.

Table 5 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	(Profile)	X
Secchi (meters)		(Single measurement)	
Dissolved Oxygen (mg/l)	X	(Profile)	X
Temperature (C)	X	(Profile)	X
Total Suspended Sediments (mg/l)	X	(3 Depths)	X
pH (standard unit)	X	(3 Depths)	X
Biological			
E. Coli (cts/100ml)	(April to October)	(March to November)	(April to October)
Chlorophyll a (ug/l)		(Surface Sample)	
Phytoplankton		(Surface Sample)	
Zooplankton		(Vertical Tow)	
Nutrients			
Ammonia (ug/l)	X		X
Nitrate (ug/l)	X	(3 Depths)	X

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Total Particulate Phosphorus (ug/l)	X	(3 Depths)	X
Total Dissolved Phosphorus (ug/l)	X	(3 Depths)	X
Ortho-Phosphorus (ug/l)	X	(3 Depths)	X
Total Phosphorus (ug/l)	X	(3 Depths)	X

Segment 1a Permanent Monitoring Station

The Bear Creek Watershed Association at their April 14, 2003 Association meeting established the Bear Creek segment 1a monitoring station called *Lair O' The Bear* open space park. This monitoring station will provide a good water quality characterization of upper Bear Creek. The monitoring station switch began for the May 2003 sampling set. There were no changes to the monitoring parameters, quality controls or sampling procedures. The Association's quality assurance plan is modified to show this sample location change.

Segment 1a Supplemental Monitoring

The Bear Creek supplemental monitoring program collects a data record in the summer growing season of the diurnal fluctuation of temperate at multiple sites within selected sections of Bear Creek. The 2005 Bear Creek sampling and monitoring plan for temperature/pH/dissolved oxygen/conductivity and ammonia is outlined below:

Temperature Datalogger Monitoring Locations (14)
(Continuous hourly measurements, June-September)

- Above Evergreen Lake (at gaging station)
- Evergreen Lake, near dam—Surface, 10' down
- Above EMD WWTP effluent
- EMD WWTP effluent
- WJCMD WWTP effluent
- O'Fallon Park (east end-above Kittredge WWTP effluent)
- KSWD WWTP effluent
- Lair o' the Bear Park (west end-above GWSD WWTP effluent)
- GWSD WWTP effluent
- Below Idledale (at McGoldrick Bridge)
- Morrison gaging station (west end of town, above Harriman Diversion)
- Above Morrison WWTP effluent (start of Bear Creek Segment 1b)
- Morrison WWTP effluent

Weekly pH/DO/Temperature/Conductivity Manual Monitoring Locations (15)
(Alternating weekly morning/afternoon monitoring)

- Above Evergreen Lake (at gaging station)
- Evergreen Lake, near dam—Surface, 10' down
- Evergreen Lake, middle
- Above EMD WWTP effluent
- Below Bear Creek Cabins
- Below Troublesome Gulch
- O'Fallon Park (West end)
- O'Fallon Park (east end-above Kittredge WWTP effluent)
- Kerr Gulch (at Hwy 74 bridge)
- Lair o' the Bear Park (west end-above GWSD WWTP effluent)
- Above Idledale (west end of town)

- Below Idledale (at McGoldrick Bridge)
- Morrison gaging station (west end of town, above Harriman Diversion)
- Above Morrison WWTP effluent (start of Bear Creek Segment 1b)

Weekly Ammonia Sampling Locations (12)
(Sampling coordinated with WWTP effluent ammonia sampling)

- Above Evergreen Lake (at gaging station)
- Above EMD WWTP effluent
- Below Bear Creek Cabins
- Below Troublesome Gulch
- O'Fallon Park (west end)
- O'Fallon Park (east end-above Kittredge WWTP effluent)
- Kerr Gulch (at Hwy 74 bridge)
- Lair o' the Bear Park (west end-above GWSD WWTP effluent)
- Above Idledale (west end of town)
- Below Idledale (at McGoldrick Bridge)
- Morrison gaging station (west end of town)
- Above Morrison WWTP effluent (start of Bear Creek Segment 1b)

Plan Summary

- Evergreen Metropolitan District (EMD) will be responsible for sampling and data collection at locations listed above. EMD, West Jefferson County Metropolitan District (WJCMD), Kittredge Water and Sanitation District (KWSD), Genesee Water and Sanitation District (GWSD) and the Town of Morrison will be responsible for providing effluent data collected at their respective WWTP's, including analytical results.
- Interval frequency for temperature dataloggers is once per hour (24 per day). This frequency allows for approximately 75 days of data collection. The dataloggers in wastewater plant discharges shall remain for approximately 60 days, while dataloggers located in the stream will be retrieved and downloaded on a monthly basis.
- Frequency of manual pH/Temperature/DO/Conductivity data collection will be weekly at the temperature datalogger locations (all sites except WWTP effluents) and other sites noted above. Manual monitoring will be performed morning/afternoon in an alternating weekly schedule. Morning data collection will begin at approximately 07:00 in Evergreen and ending in Morrison at approximately 13:00. Afternoon data collection will begin at approximately 12:00 in Evergreen and ending in Morrison at approximately 18:00. Weekly monitoring also provides for checking the integrity of the dataloggers.
- Frequency of manual pH/Temperature/DO/Conductivity data collection in Evergreen Lake will be weekly at the temperature datalogger locations at the dam and at a location defined as the middle of the Lake.
- WWTP effluent data will be collected as part of the typical plant process control performed daily. Effluent pH/Temperature/DO will be recorded and ammonia sampling performed in accordance with the requirements of each WWTP discharge permit. Total ammonia will be analyzed for WWTP effluents by the method allowing for the lowest detection limit. Parameters will then be factored in to determine unionized ammonia.
- Stream ammonia sampling will be performed concurrently with weekly pH/Temperature/DO/Conductivity data collection, with analyses for total ammonia performed by an approved analytical laboratory. Unionized ammonia values will be calculated. Locations for weekly ammonia sampling are listed above. Additionally, stream ammonia sampling will be performed concurrently with pH/Temperature/DO/Conductivity data collection at sites other than listed above, as deemed useful for baseline information. The scheduled stream sampling day will coincide with effluent sampling performed by WWTP.
- Additional stream/lake samples will be obtained for manganese, iron and other analytes for background information.
- Two in-stream locations (O'Fallon Park and Lair o' the Bear Park) will be profiled for pH, Temperature, DO and Conductivity over a 24-hour period. Hourly measurements will be taken. This monitoring will be performed on a weekly schedule, alternating between sites.
- An EPA Bioassessment will be performed to help determine aquatic life use status. In-stream parameters including a macroinvertebrate study, substrate analysis, aquatic vegetation evaluation and fish counts will be incorporated to evaluate aquatic life. District staff will perform some sampling and evaluation, while other parameters will be sampled and identified by ecological

consultants. Algae identification will also be performed in Evergreen Lake. Ecological consultants will summarize the bioassessment data gathered.

- Flow measurement will be obtained by gages above Evergreen Lake and above the Town of Morrison. Weekly gage graphs will be downloaded and printed. Manual flow measurements will be obtained as deemed necessary, if flows drop below a predetermined setpoint above Evergreen Lake. Flow locations will include the gaging station above Evergreen Lake, above EMD's WWTP discharge, the O'Fallon Park pedestrian bridge and Corwina Park. Staff gages will be installed as indicators of rising or dropping flows, not substitutes for actual measurements.
- Weather data (High/low temperature, precipitation) from the NWS station at the EMD WWTP will be obtained on a monthly basis.
- Emergency situation: In the event of a fish kill that is reported to EMD or other Association members, monitoring for pH/Temperature/DO/Conductivity will be performed above the event site, at the site and a location 1-2 miles downstream, and ammonia sampling will be performed at the same locations. Upstream WWTP operations will be evaluated to determine potential influence.
- Calibrations of portable equipment will be documented prior to each use and Certificates of Calibration for all equipment will be obtained.
- GPS points will be obtained for all sampling and monitoring locations.
- NIST certifications and Certifications of Compliance will be obtained for each temperature datalogger used in the study.
- The tentative study dates for extensive data collection will be June 1 through September 30.
- An ecological consultant will generate a report and provide expert comment and testimony, as required, for BCWA.

Management Program

Purpose of Association

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, Aspen Park Metropolitan District, Conifer Metropolitan District (Conifer Town Center) and The Fort Restaurant.

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.

Community Outreach

Earthday

The Association helps with Evergreen Earthday activities and provides information to the community on water quality management and environmental issues. The Association develops and distributes educational materials on request. Members of the Association are available for local presentations and training programs.

Community Plans for Aspen Park Village Center and Evergreen

Jefferson County Planning and Zoning Division has benefited from the support of the Bear Creek Watershed Association respect for recommendations in the community plans. The Association and its members have held public meetings to review development proposals and worked with the community to write a strategy for wastewater treatment in the Aspen Park-Conifer Village Center. The Evergreen community has benefited from the attendance and expertise that Bear Creek Watershed members have provided in the land use planning meetings. Water quantity and quality are the two most important issues that the community plan participants discussed. Thanks to the review and continued interest of the Bear Creek Watershed Association, the County's more recent plan updates recommend strategies to protect the water quality in the southern mountains of Jefferson County.

Colorado Geological Survey

Special study by Karen Berry (Colorado Geological Survey) assessing the transferability of a water erosion model. Karen is working with the NRCS, Jefferson County, and other local agencies to gather slope, detailed soils, drainage, rangeland and other land use parameters. The data is used to develop model input files for Turkey Creek. The Association is a supporting group for the study and will valuate the completed model for use in watershed management.

As part of the Central Plains Community Plan, the Colorado Geological Survey defined hazards. Jefferson County has mapped many of the hazards and constraints in the county with assistance from the Colorado Geological Survey, United States Geological Survey, Colorado State Forest Service, and the Federal Emergency Management Agency. Geologic hazards have been classified into Low, Moderate, and High categories. Hazards should be identified, eliminated, mitigated and/or avoided to

prevent the loss of life, property, or costly remediation and to protect the public health and environment. Potential problems need to be identified early in the planning and development process before economic losses and environmental damage occur.

Highway Reconstruction

The Association works with CDOT and Jefferson County to monitor water quality in Bear Creek during highway reconstruction projects. The Association tries to assure that a project will cause only minor short-term water quality degradation during construction.

Long-Range Planning and Jefferson County Reviews

The Association works closely with Jefferson County planning and actively reviews any development proposal that could affect watershed environmental or water quality. The Association is a referral agency for Jefferson County.

Coyote Gulch Nonpoint Source Project

The erosion problem on Coyote Gulch is persistent and the erosion area is not stable as evidenced by the amount of lateral erosion that occurred during an about 10-year runoff event in the end of June. Entire sections of cut banks were eroded into the reservoir. The reservoir showed substantial additional sediment deposition at the mouth of Coyote Gulch. The Association recommends a full reconstruction/ restoration level project targeted for 2006. The Association and Lakewood will be responsible for water quality studies and characterization. The potential annual total phosphorus reduction from full restoration of lower Coyote Gulch is estimated at 2,042 pounds.

Water Quality Monitoring and 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 2005 water quality within the watershed and Bear Creek Reservoir, as wells, the long-term trends.

Wastewater Discharge Impacts To Fishery

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, *Evaluation Of The Effects Of Wastewater Treatment Plants On Trout Populations In Bear Creek, Jefferson County, Colorado, 1994-2001* [Chadwick Ecological Consultants, Inc., 2002], 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. However, this trend was reversed during the 2002 drought year due to the downstream migration of both Rainbow and Brown Trout. The general trend occurs in all sampling years, except 2002. 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 during recent years.

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 and elevated temperatures in sections of Bear Creek 1a. This combination of low water with elevated temperatures clearly stressed resident trout populations of Bear Creek. However, the reality is that high quality wastewater discharges provide most of the flow, which allowed resident fish population to survive an extreme natural disaster.

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 2003. Fact sheet 24 defines the Lakewood stormwater program.

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. In addition, there is a display on the 3rd 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 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.

City of Lakewood Reservoir Aeration Operation

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.

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Water Quality Control Commission. 2005. *Bear Creek Watershed Control Regulation, 4.6.0 (5CCR 1002-19)*. The Code of Colorado Regulations, The Public Record Corporation.

Fact Sheet 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.

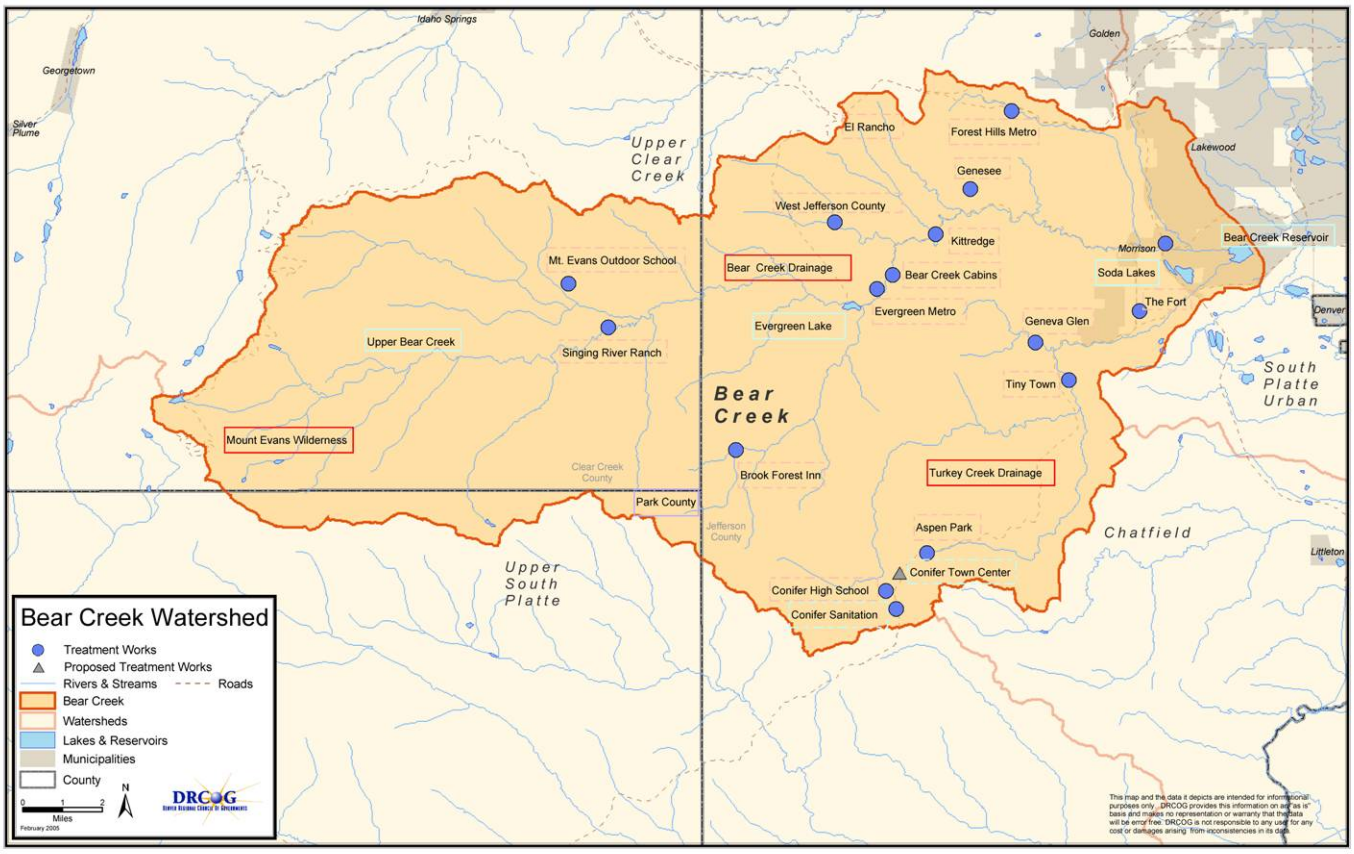


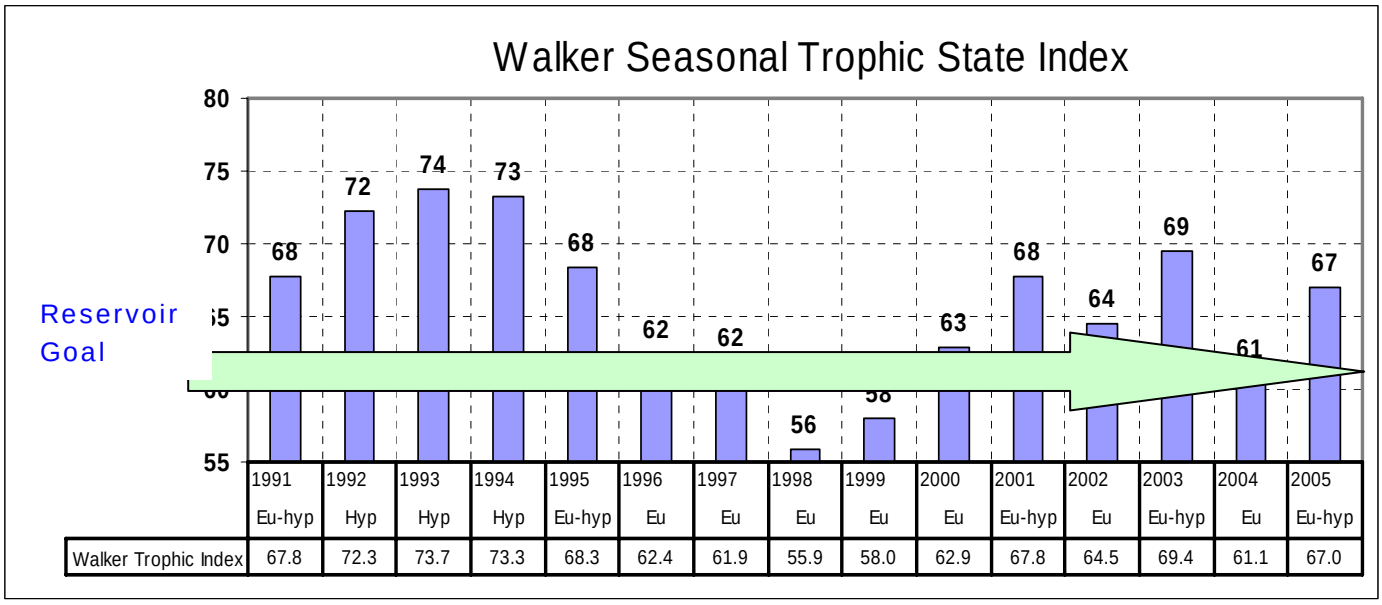
Figure 6 Bear Creek Reservoir, Jefferson County

Fact Sheet 2. Water Quality Goal & Narrative Standard 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.



Fact Sheet 3. USGS 1900-2005 Bear Creek at Morrison Drought Review

The graph shows 1901-2005 flow records near Morrison on Bear Creek. This site depicts the long-term flow trend in Bear Creek. 2002 was the lowest flow on record for lower Bear Creek segment 1a in over 100 years of record with other low periods in 1954, 1963, and 1978. The 2003-2005 streamflow record shows a recovery to near normal flows. 2005 continued the drought recovery trend; however, several months of 2005 streamflow data were well below normal conditions. The streamflow record at Morrison shows a weak long-term cycle with 10-20 years between lower flow events. A statistical analysis of flow record shows about a 25% decreasing trend over the period of record. Generally, low flow periods are followed by several years of increased flows. Consequently, fish species in Bear Creek are subjected to very divergent flow patterns over a decadal period.

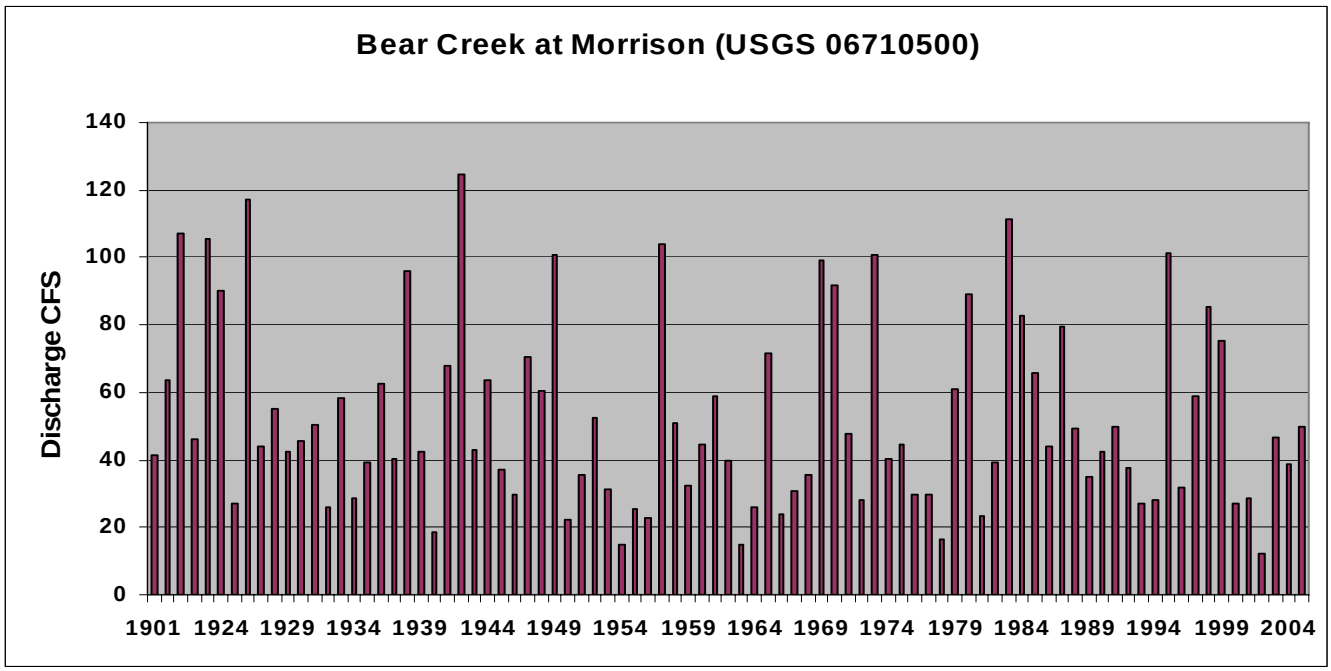
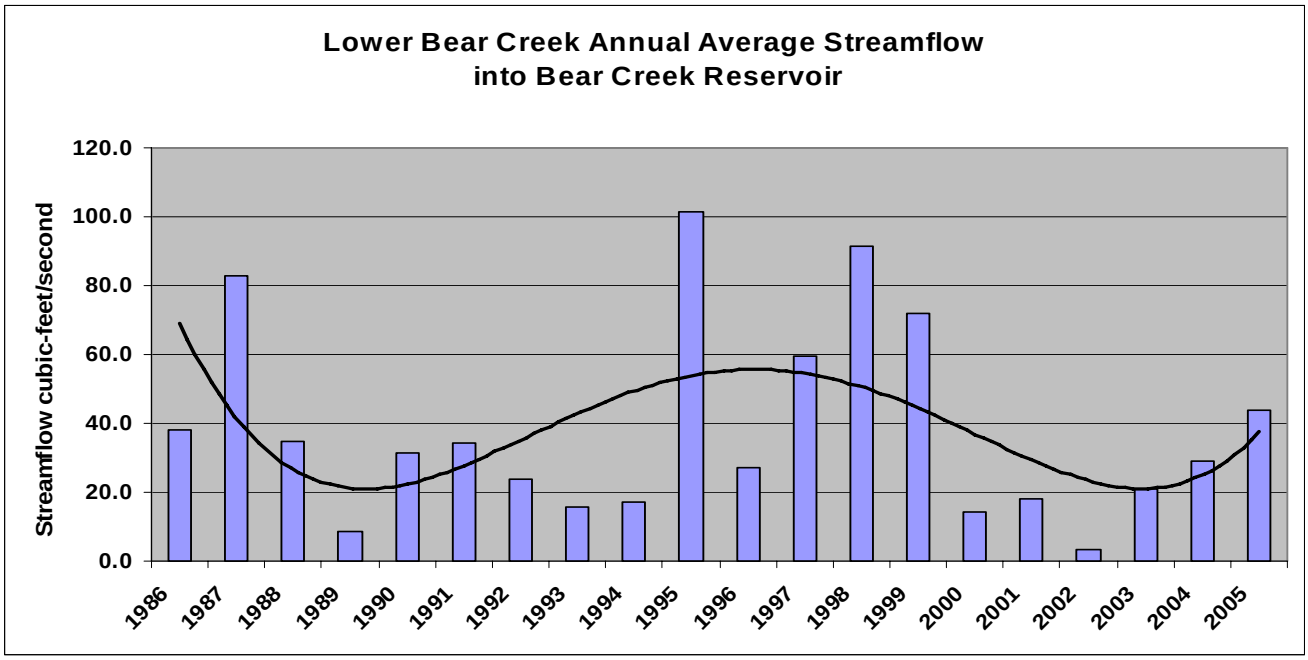
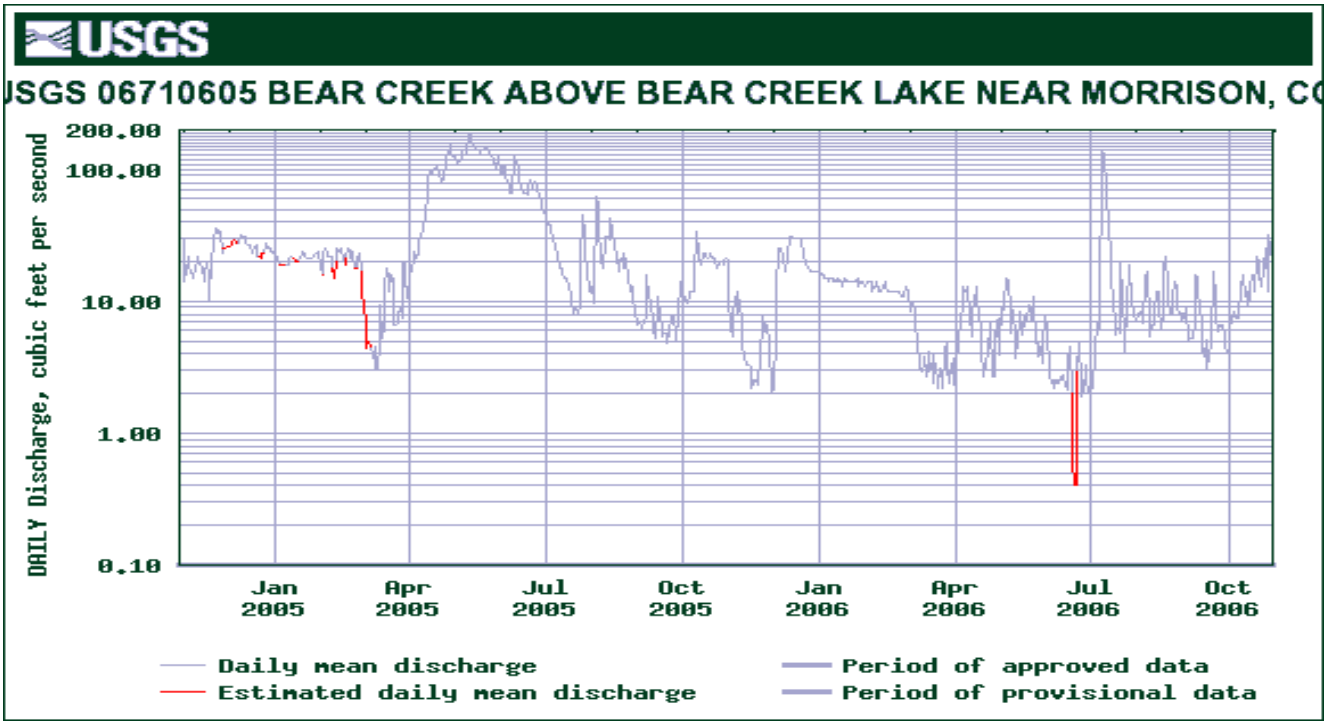


Figure 7 Lower Turkey Creek (left) and Upper Bear Creek (right)

Fact Sheet 4. USGS Lower Bear Creek Streamflow Records (Segment 1b)

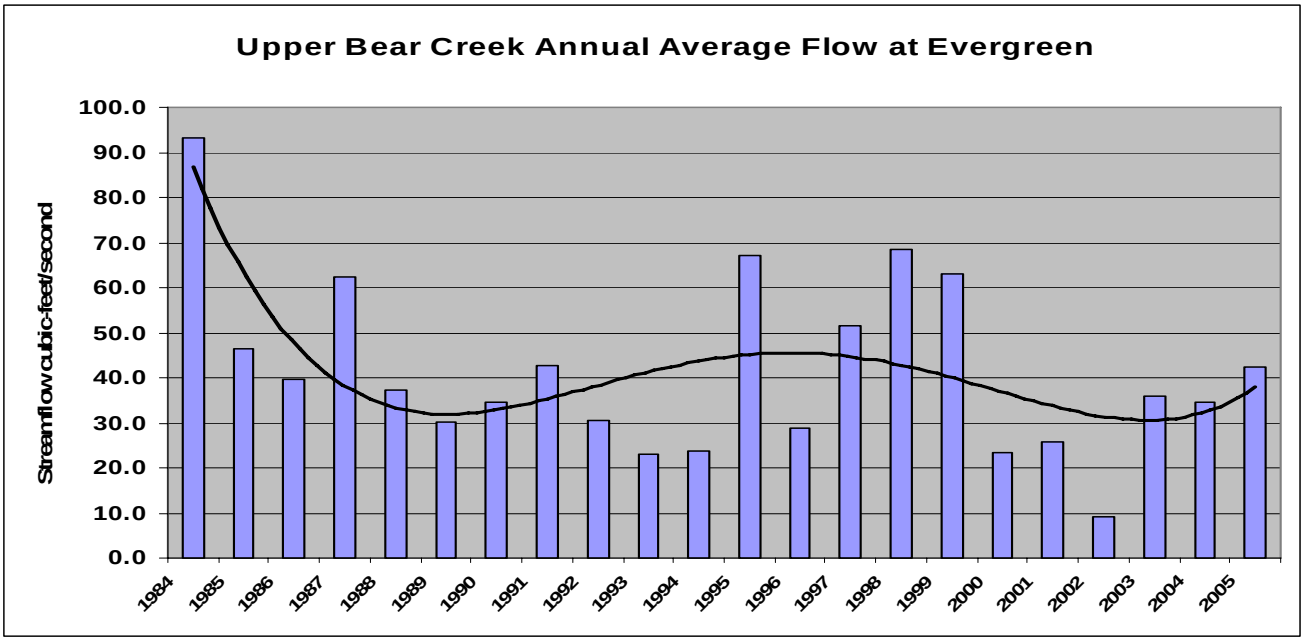
The top graph shows 1986-2005 flow records and the lower graph shows 2005 to recent daily mean discharge in Bear Creek. While Bear Creek demonstrates flow recovery in 2005, the system remains low compared with the wetter mid 1990's period.

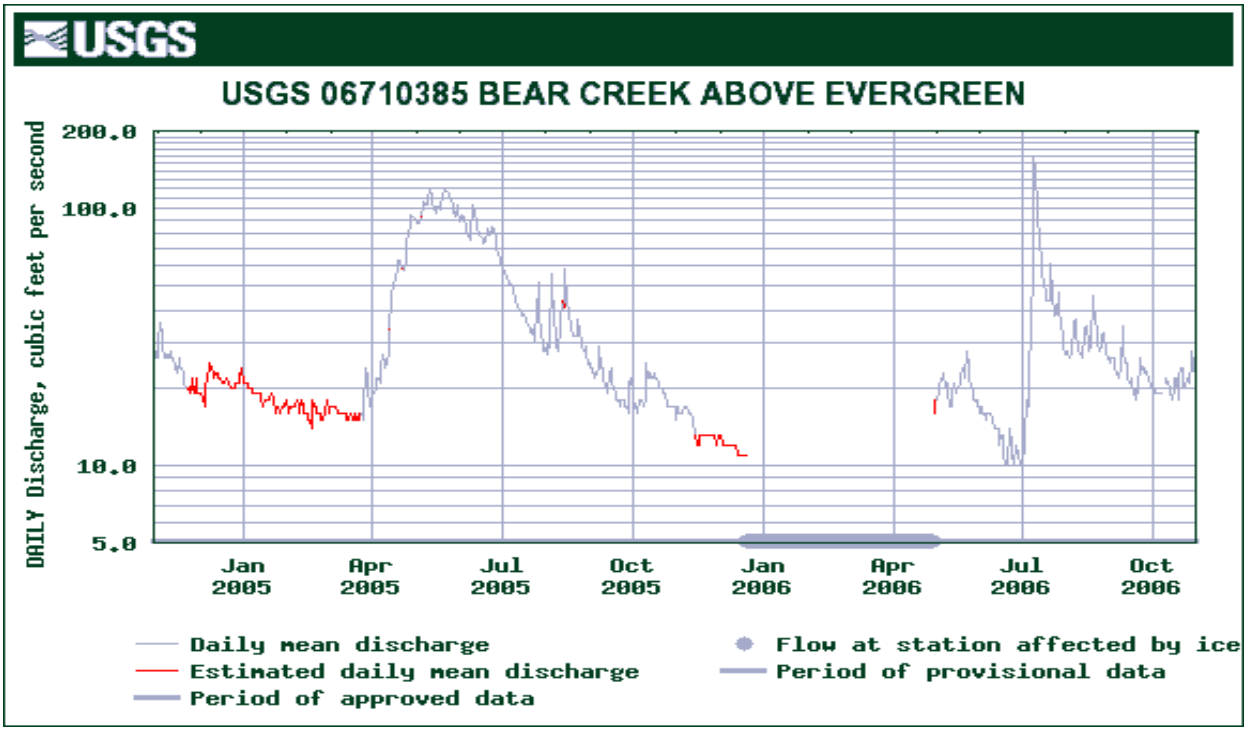




Fact Sheet 5. USGS Bear Creek at Evergreen Stream Flow Records

The top graph shows 1984-2005 flow records at the Keys on the Green USGS station and the lower graph show 2004 to recent daily mean discharge in Bear Creek above Evergreen Lake. Improved flow conditions are evident in the upper portions of Bear Creek. The 2005 flows (blue line) were near the median daily streamflow (16 years of total record).



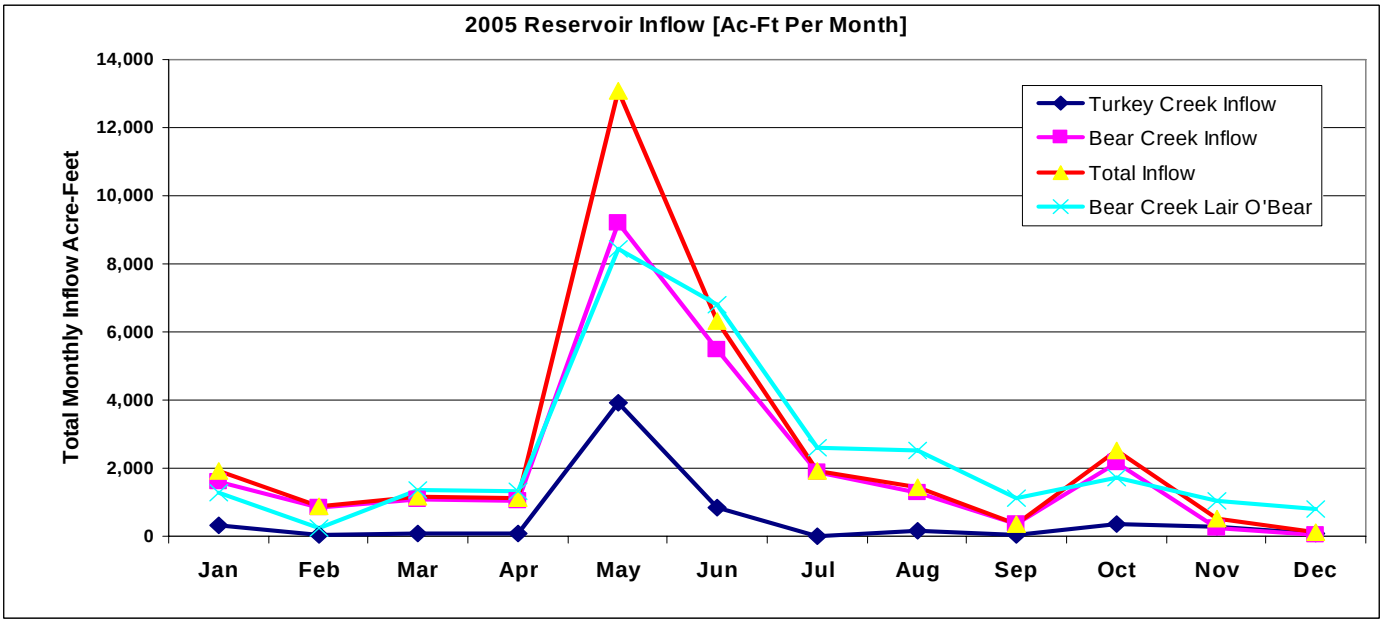


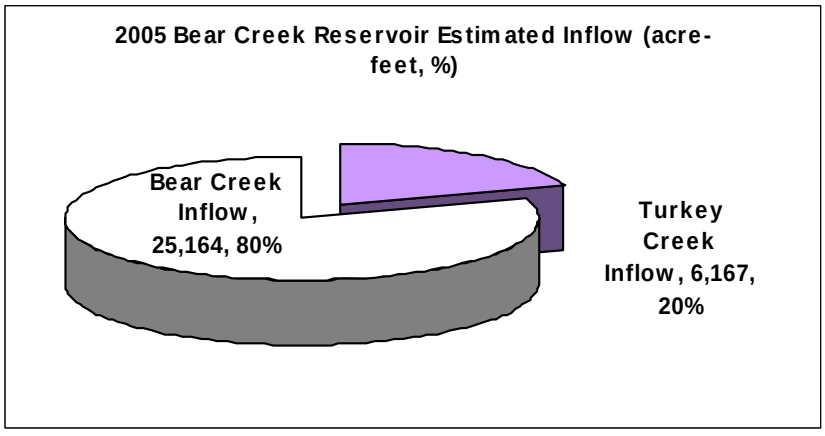
Fact Sheet 6. Bear Creek Reservoir Inflow Flow Records

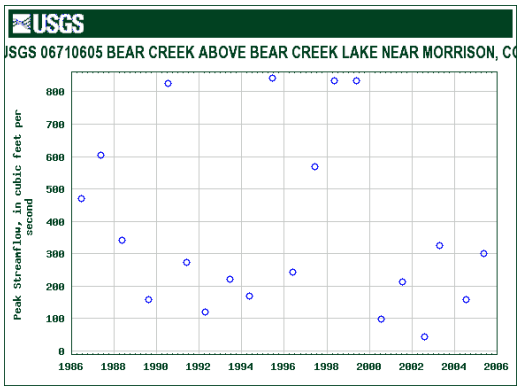
2005 was a drought recovery year and the Bear Creek Watershed was characterized by near average flows. The estimated inflow into Bear Creek Reservoir was 31,330 acre-feet.

Ac-ft/month Bear Creek Reservoir

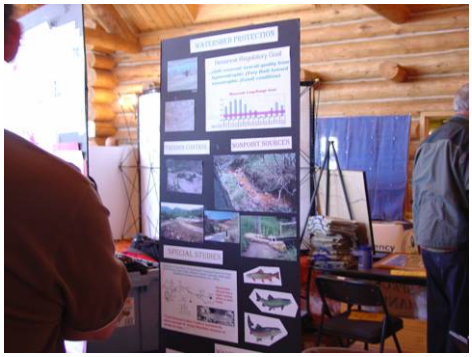
Days	31	28	31	30	31	30	31	31	30	31	30	31	Annual ac-ft/yr
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turkey Creek Inflow	320.8	56.9	65.1	63.0	3906.9	833.9	16.1	156.2	39.0	357.4	280.7	71.5	6,167.5
Bear Creek Inflow	1580.8	842.1	1088.1	1053.0	9184.9	5471.3	1886.0	1296.0	340.4	2150.6	239.0	31.4	25,163.7
Total Inflow	1901.6	899.0	1153.2	1116.0	13091.8	6305.2	1902.2	1452.2	379.4	2508.0	519.7	102.9	31,331.2
Bear Creek Lair O' Bear	1266.3	246.3	1364.5	1320.5	8448.5	6793.3	2590.2	2505.6	1125.8	1701.1	1048.6	789.7	29,200.5







Fact Sheet 7. 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, Conifer Sanitation; Conifer Metropolitan District, Morrison; Aspen Park Metro District; The Fort Restaurant; Aspen Park Metro District, Conifer Metro District, Cragmont
Aspen Park & Conifer Management Plan	Aspen Park wastewater treatment plant for Aspen Park area;
	Revised wastewater management strategy
	Conifer Town Center/ Metropolitan District new wastewater treatment plant;
Reservoir and Regional Park Management	
Hypolimnetic aeration in reservoir; operating during growing season	City of Lakewood manages system; provides an annual report to Association; operated new aeration system; supplemental reservoir monitoring and dissolved oxygen evaluation
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 Segment 1a [special reports]
Nonpoint Source Assessment	Coyote Gulch total phosphorus contributions; sediment load
Lakewood Reservoir & Park Monitoring	Dissolved Oxygen Studies; nutrient load; sediment & erosion
Data Management	
Database maintenance	Data base maintained in spreadsheet for membership
Web Site	Monthly Data reported on Web Site www.bearcreekwatershed.org.
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; membership involvement processes
	Public Processes – Earthday, Newspaper
Stormwater Management	
Jefferson County & City of Lakewood Stormwater Management Programs	Public education; mapping; resource allocations; local partnerships

Fact Sheet 8. Bear Creek Watershed Nonpoint Source Management Strategy

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 phosphorus loading to Bear Creek Reservoir. However, phosphorus reduction from nonpoint sources is required to maintain the reservoir goal at the mesotrophic & eutrophic boundary as measured by modeled trophic indexes. A series of management strategies help address site-specific nonpoint source problems. The implementation of a nonpoint source program is severely limited by available Association resources. Also, the Association membership has limited nonpoint source implementation authority. The Association is involved in a nonpoint source project to help restore severe erosion on Coyote Gulch (Shown in Photograph). Coyote Gulch could be contributing up to 2,000 pounds of total phosphorus per year directly into Bear Creek Reservoir.

Summary of Management Strategies	Summary Of Implementation Tools
1. Local support	1. Local involvement in associated programs & activities; presentations; information source 2. Referral agency for land use projects in Jefferson County and Clear Creek County 3. Review agency for community plans 4. Provide data and information support to other agencies and special projects
2. Stable funding source	5. Seek nonmember funding and grants
3. Provide recommendations to WQCD/ WQCC	6. Data & annual reports; triennial review of control regulation; rulemaking hearings; informational hearings
4. Characterize trends in water quality	7. Maintain a trend water quality monitoring network to measure inputs & output from the reservoir
5. Track nutrient loading by Bear Creek & Turkey drainage systems	8. Characterize nutrient loading from the two major drainage systems: Turkey Creek & Bear Creek
6. Maintain watershed & reservoir models	9. 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	10. Maintain a list of appropriate best management practices for review
8. Involved in total maximum daily load allocations	11. Conduct appropriate TMDL screenings using established methods, as required
9. Develop & implement water quality education efforts & technology transfer	12. Develop & maintain list of stakeholders; provide information and assistance as requested
10. Actively promote the implementation of water quality projects & activities	13. 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	14. Maintain an education implementation plan; support County processes; review documents as appropriate
12. Support other watershed efforts and groups	15. Continued involvement in groundwater studies, ISDS regulation review & sediment & erosion control regulation review

Fact Sheet 9. Wasteload Allocations & 2005 Total Phosphorus Pounds

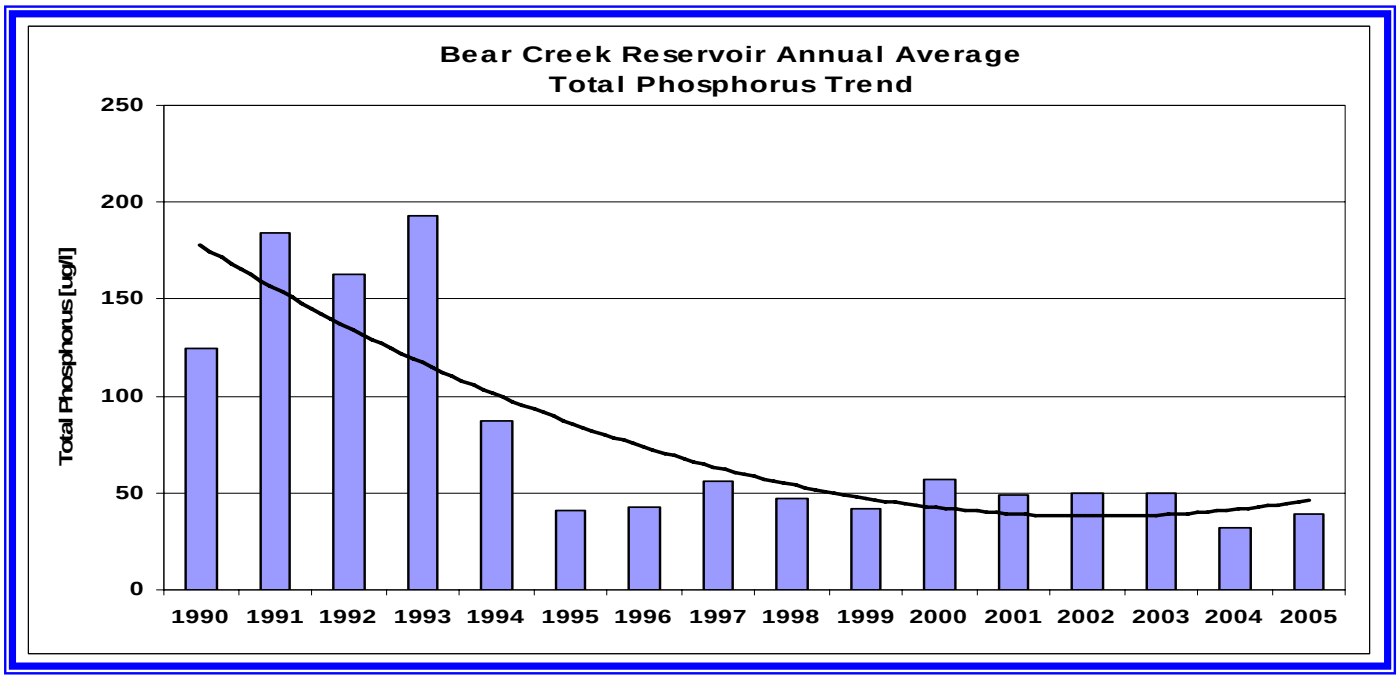
The total wasteload allocation for all point sources of phosphorus in the Bear Creek Watershed is 5,255 pounds per year. Each individual discharger in the Bear Creek Watershed is limited to an annual wasteload of total phosphorus, which can't be exceeded, except as provided through trading provisions. 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 as a permit condition and this data has not traditionally been provided to Association. The annual total phosphorus allocation established in the Bear Creek Reservoir Control Regulation is reported below. The Association recommends all "non-reporting" operators be given notice by the WQCD that they are not incompliance with the intent of the control regulation.

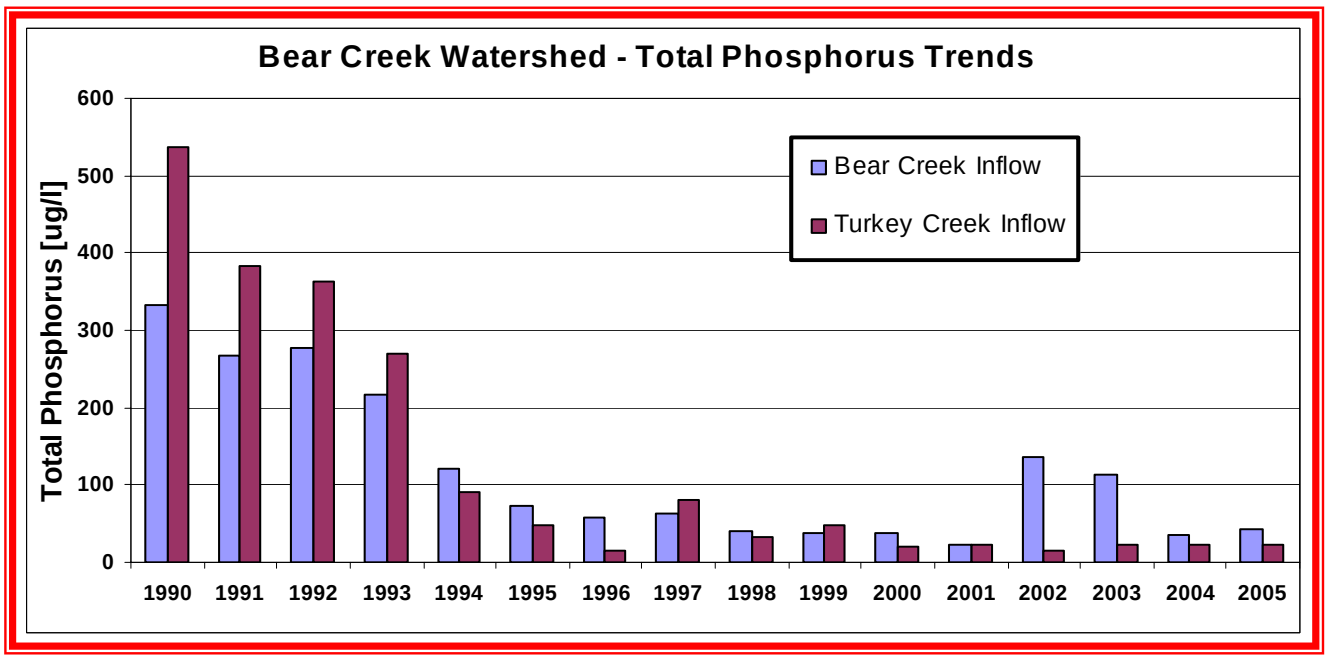
Treatment Works/ Operator	TMAL Phosphorus Pounds/ year	2005 Phosphorus Pounds/ year
Evergreen Metropolitan District	1,500	631.40
West Jefferson County Metro District	1,500	676.34
Genesee Water and Sanitation District	1,015	280.8
Town of Morrison	600	71
Kittredge Sanitation and Water District	240	66.89
Forest Hills Metropolitan District	80	(247.8)[1]
Jefferson County Schools - Conifer High School	110	1.5
Jefferson County Schools – Mt. Evans Outdoor School	20	5.9
Conifer Center Sanitation Association	40	9
West/Brandt Foundation - Singing River Ranch[8]	30	No Report
Mary Ann Gallagher - Brook Forest Inn	5	No Report
Bear Creek Development Corp. - Tiny Town	5	No Report
Bear Creek Cabins (Bruce & Jayne Hungate)	5	No Report
Geneva Glen	5	0[4]
Aspen Park Metropolitan District	40	0[5]
The Fort Restaurant	18	0[6]
Conifer Town Center	40	0[7]
Reserve Pool	2	Not used
Total Point Source Phosphorus Wasteload	**5,255 lbs/year**	**1,689.44**

1 Forest Hills Metro District has trade agreement with West Jefferson County Metro District and complies with permit. The 247.8 pounds is added into the West Jefferson County allocation, which were 428.58 pounds.
2 NR - No Report Provided to Association.
3 The Bear Creek Cabins exceeded total phosphorus monthly allocations 5 times in two years and may have exceeded the annual total phosphorus allocation.
4 The Geneva Glen treatment plant is not discharging as reported to the Association.
5 Site Approval and permit; treatment plant constructed; no monitoring data in 2005.
6 Septic system over 10,000 gallons per day; site application in progress; No established monitoring
7 Site Approval; treatment plant design and permit; under construction.
8 This treatment works was reported to Association as "inactive", although the permit remained active; This treatment works has compliance problems and requires a wastewater utility plan

Fact Sheet 10. Total Phosphorus Trends for Watershed & Reservoir

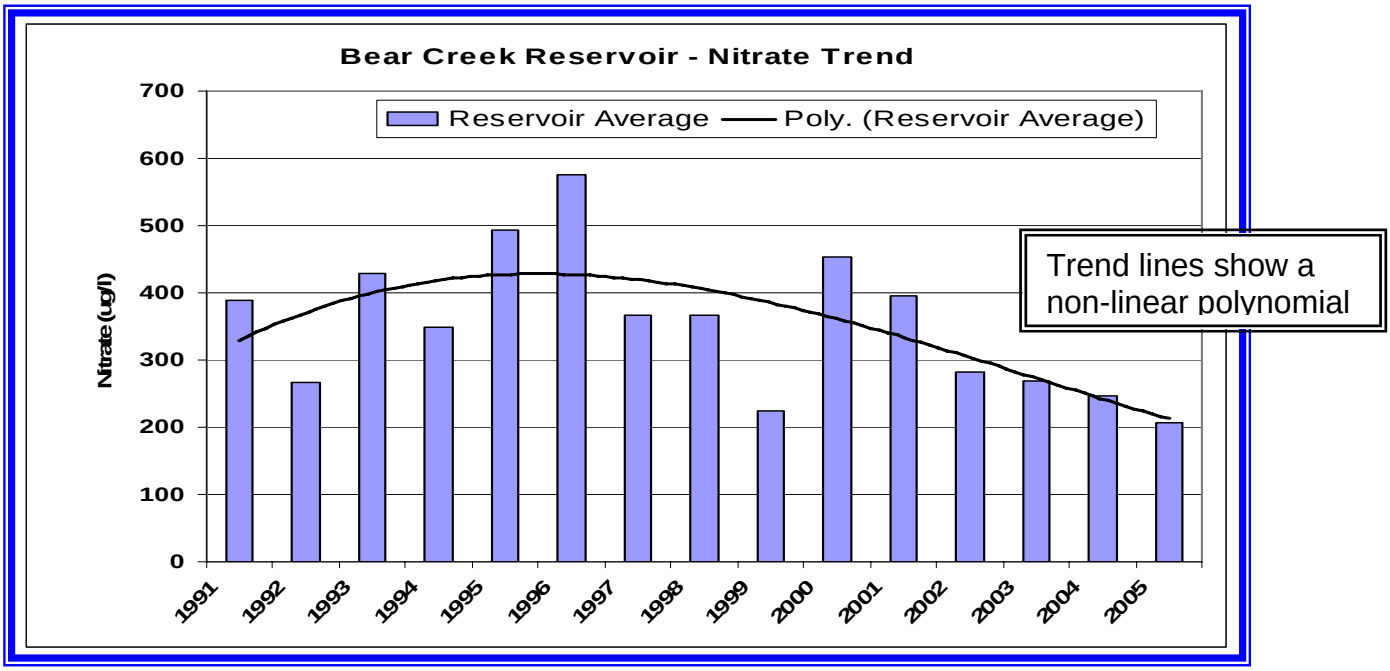
The monitoring program measures total phosphorus into Bear Creek Reservoir and within the water column. The total phosphorus target for the reservoir is to maintain a water column average below 60 ug/l. This target goal has been achieved through point source management from 1995-2005. Controlling total phosphorus source inputs is also a control strategy for reducing chlorophyll levels in the reservoir and meeting the reservoir narrative standard. The reduced total phosphorus loading in 2005 meets the Association management goal.

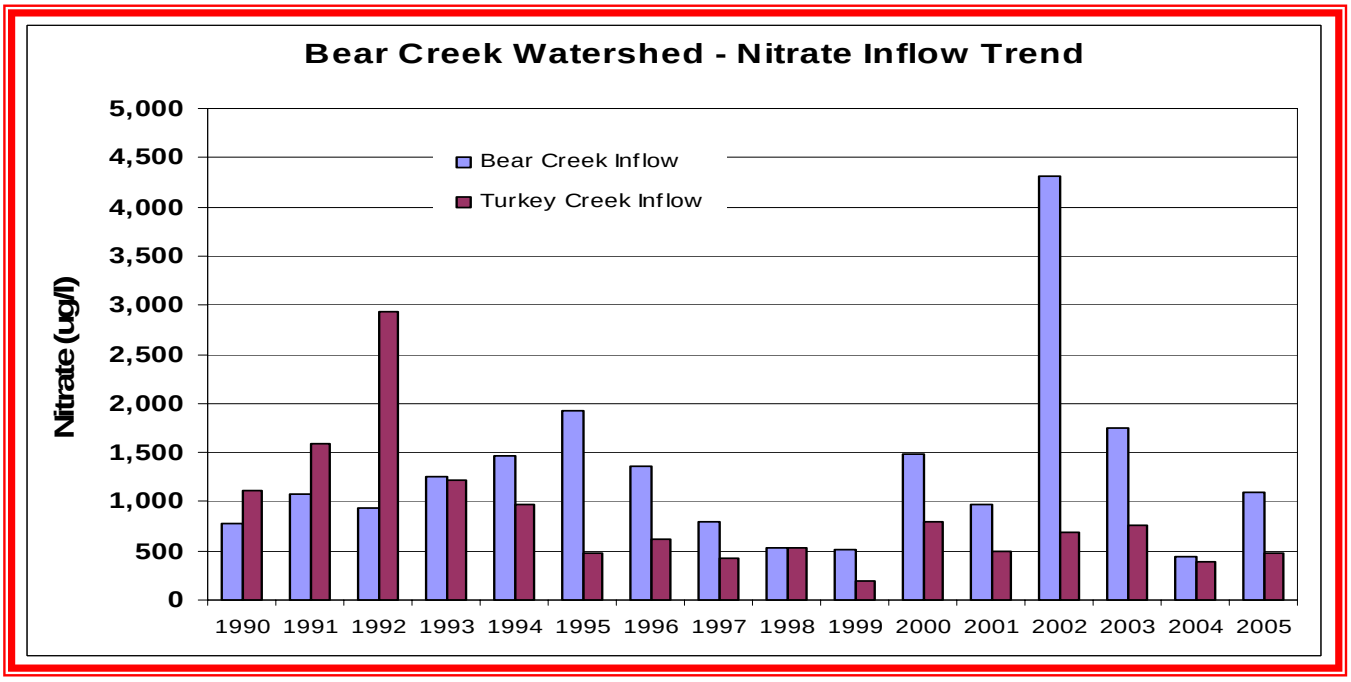




Fact Sheet 11. Nitrate Trends for Watershed and Bear Creek Reservoir

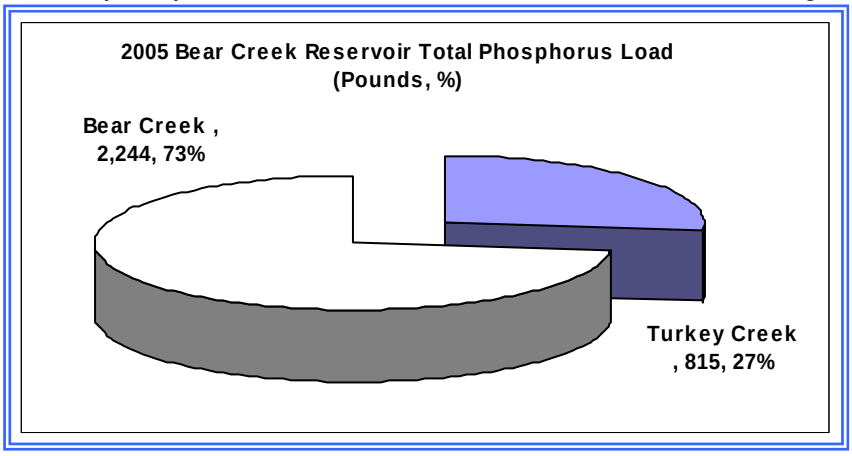
The monitoring program measures inflow nitrate from Turkey Creek and Bear Creek and within Bear Creek Reservoir. In recent years, the concentrations of nitrate reaching the reservoir have increased particularly from the Bear Creek drainage (Lower graphic). However, the total nitrate load into the reservoir has remained relatively constant over the monitoring program. Nitrate is not a water quality problem in the reservoir. The higher 2002-2003 nitrate levels in Bear Creek (lower graph) were associated with low flows, drought conditions and groundwater return flows. The nitrate loading decreased as flow returned to Bear Creek and Turkey Creek.

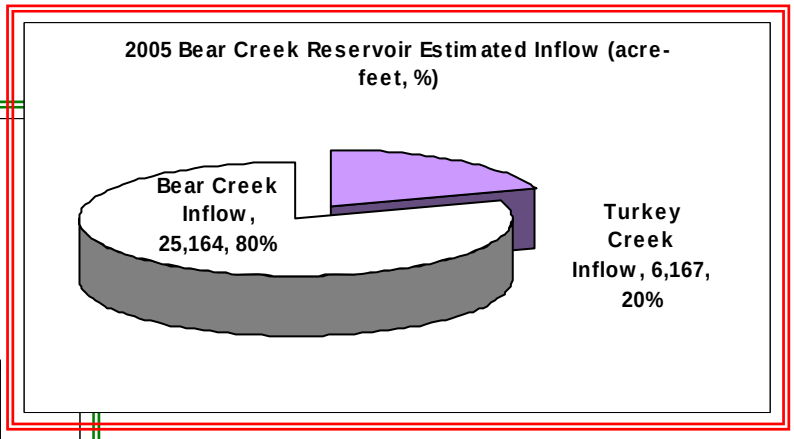


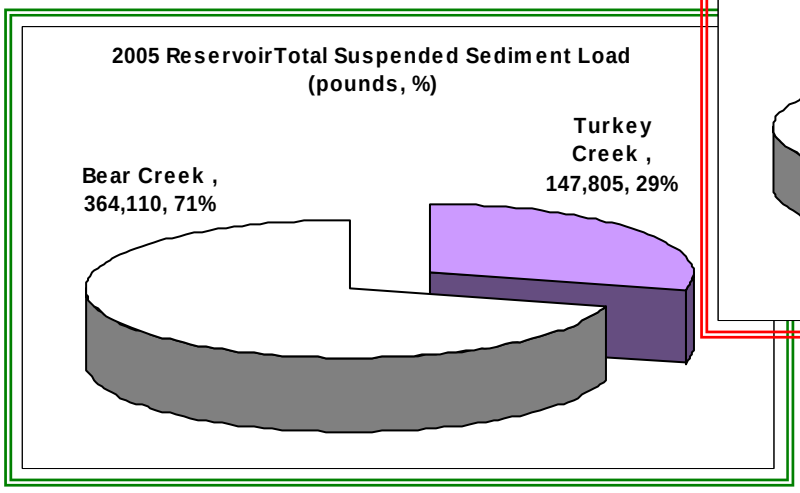


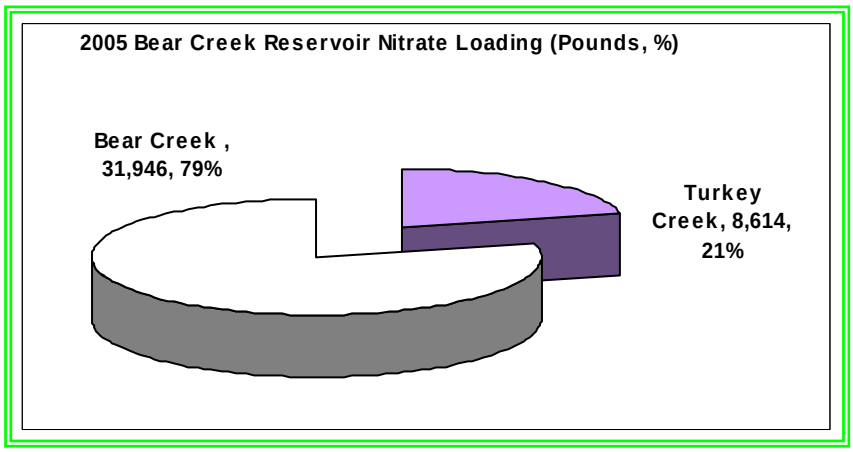
Fact Sheet 12. Phosphorus, Nitrate & Total Suspended Sediment Loads Trends

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 2005 from all sources reaching the reservoir was 3,059 pounds at a flow of 31,330 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. The nitrate (40,050 pounds) and suspended sediment (251,000 pounds) loading was similar to 2004 conditions. There were no nutrient or sediment loading problems in 2005.









Fact Sheet 13. Bear Creek Reservoir 15-Year Data Summary

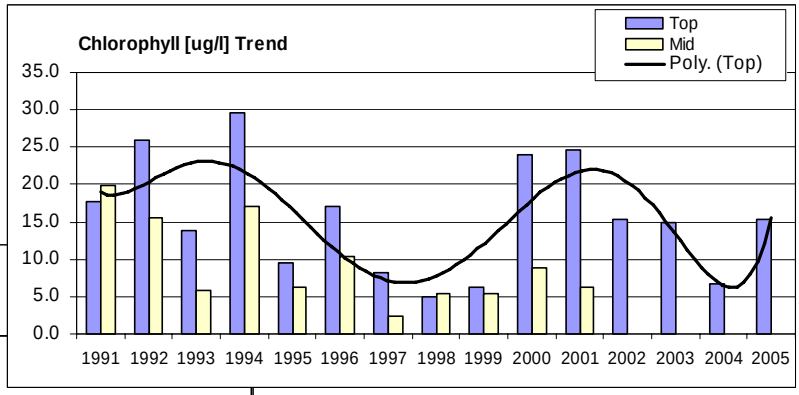
The reservoir program evaluates nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth as key trophic state indicators. These parameters are used to determine compliance with the narrative standard adopted for the reservoir. The summarized reservoir data from 1991 through 2005 are 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.

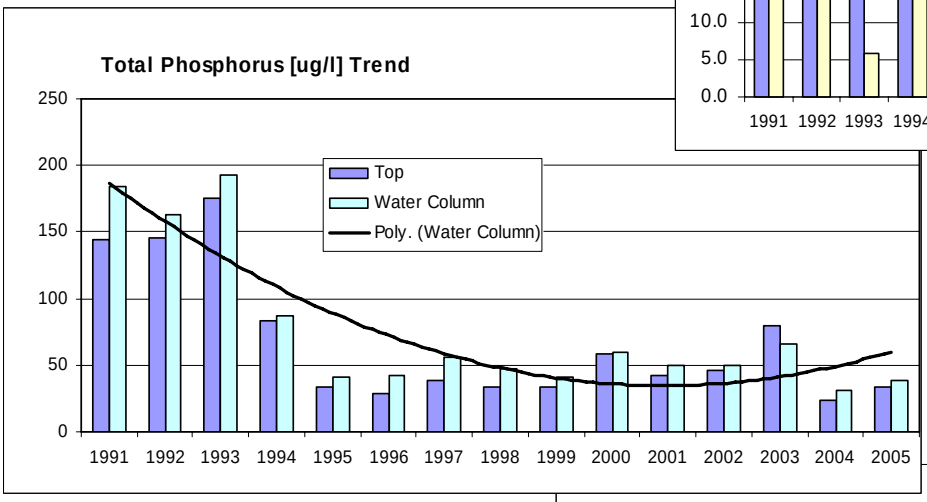
While the nitrogen data has fluctuated over the years, no clear pattern has emerged. However, the surface Chlorophyll concentration declined in 2005. A fully functional reservoir aeration system appears affective. This suggests an internal nutrient loading problem triggering algal blooms can be controlled through reservoir aeration. This is evident by the increased average chlorophyll concentrations in surface waters during 2000 to 2003 when the aeration system was upgraded. Future monitoring and some special studies will 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. Bottom sediments are fine sand, silt and mud.

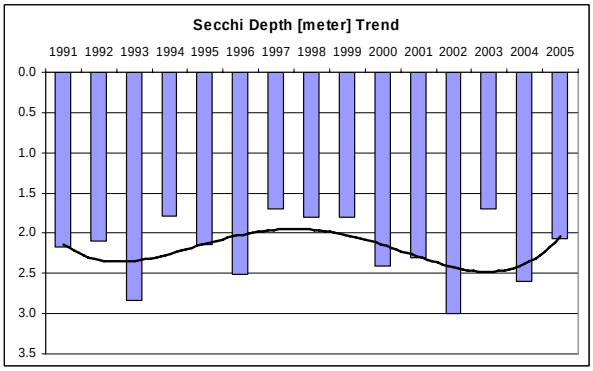
Parameter	Site	Reservoir Annual Average Concentrations															
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	91-05 Mean
Chlorophyll-a (ug/L)	Top	17.7	26.0	13.7	29.7	9.4	17.1	8.2	4.9	6.2	23.9	24.6	15.4	14.8	6.6	15.4	**15.6**
	Mid	19.8	15.5	5.9	17.0	6.2	10.3	2.4	5.4	5.5	8.9	6.3					**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	14.8	6.6	15.4	**12.8**
Nitrate-Nitrogen (ug/L)	Top	442	289	504	382	474	578	393	388	224	431	401	289	268	268	193	**368**
	Mid	381	282	451	356	502	589	365	372	220	443	395	288	271	249	207	**358**
	Bottom	341	228	333	308	503	561	341	342	231	483	390	268	259	224	221	**336**
	Water Column	388	266	429	349	493	576	366	367	225	441	387	282	266	247	207	**353**
Total Phosphorus (ug/L)	Top	144	146	175	83	34	29	38	33	34	59	42	46	79	24	33	**69**
	Mid	138	140	164	79	37	33	45	40	37	57	42	49	63	27	34	**68**
	Bottom	270	201	240	99	52	66	86	69	54	56	64	56	56	44	47	**101**
	Water Column	184	162	193	87	41	43	56	47	42	60	50	50	66	32	38	**80**
Total Suspended Solids (mg/L)	Top	6	7	4	9	6	4	12	6	7	6	7	5	7	3	5.4	**6**
	Mid	8	6	6	8	7	4	15	8	9	5	7	5	6	5	6.2	**7**
	Bottom	19	8	5	9	13	7	22	12	12	8	10	5	8	9	7.4	**10**
	Water Column	11	7	5	9	9	5	16	9	9	6.4	8	5	7	6	6	**7.9**
Secchi Depth (m)	Top	2.17	2.1	2.84	1.79	2.14	2.51	1.7	1.8	1.8	2.4	2.3	3	1.7	2.6	2.1	**2.2**

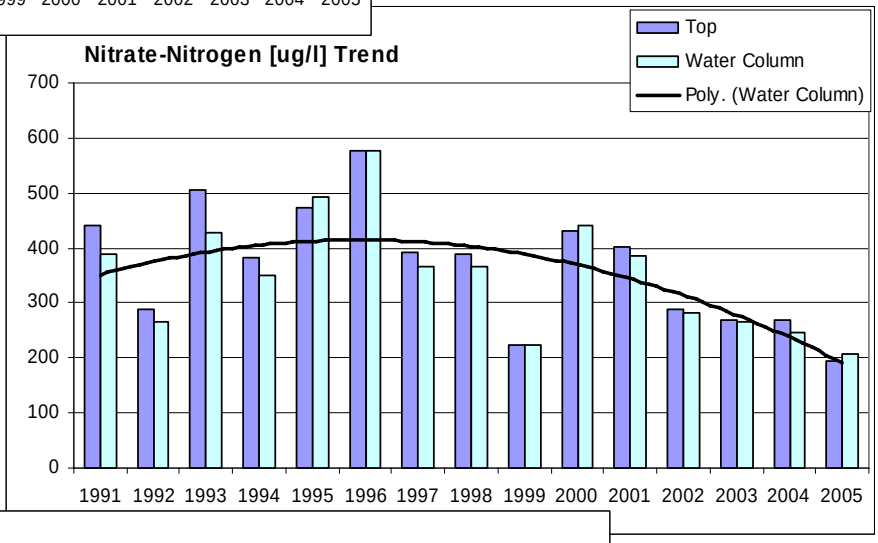
Fact Sheet 14. Bear Creek Reservoir Long-Term Water Quality Trends

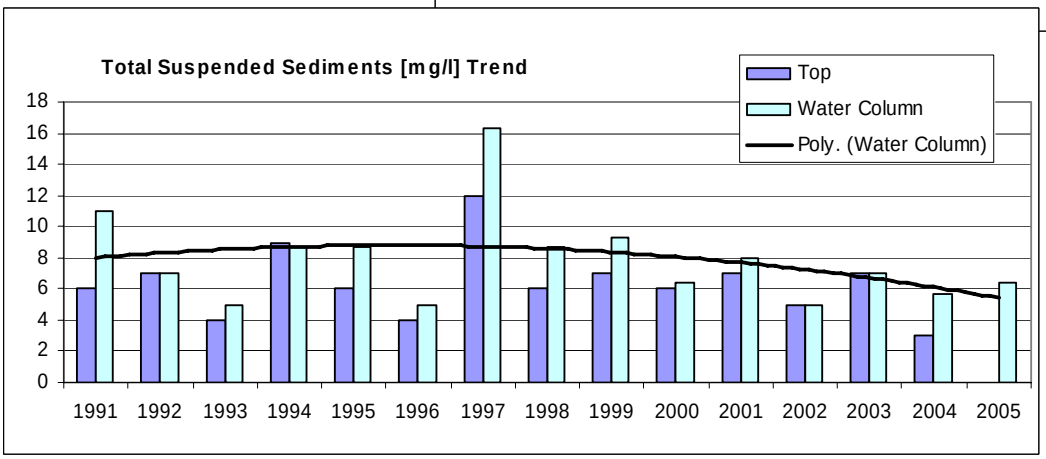
The reservoir program evaluates seasonal, annual and long-term changes in nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth. The reservoir trends from 1991 through 2005 are graphically summarized below. The trend lines show non-linear polynomial curve fits to the data.











Fact Sheet 15. 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 affected water quality in the reservoir and generally helped improve the overall reservoir quality.

Bear Creek Reservoir 2005 - Selected Trophic Indicators

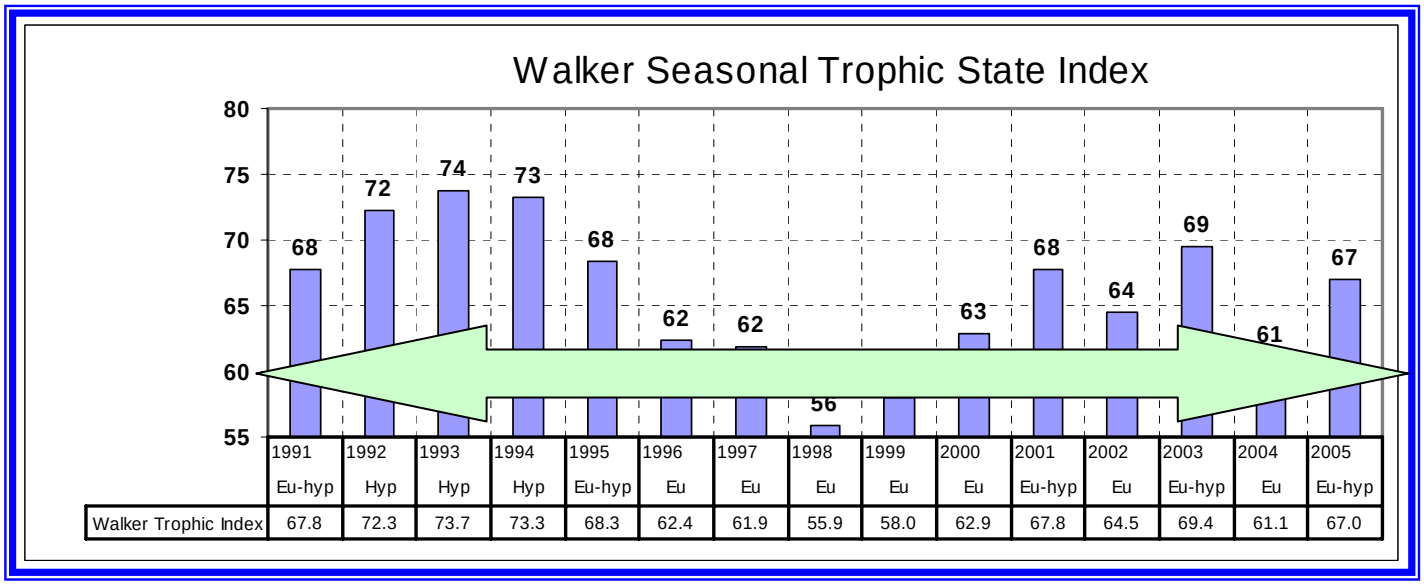
Trophic Indicator	Reservoir
Chlorophyll	
Average Growing Season Chlorophyll-a [ug/l (surface waters only)]	15.5
Peak Chlorophyll-a [ug/l]	75.5
Phosphorus	
Average Annual Total Phosphorus [ug/l]	39.2
Seasonal Annual Total Phosphorus [ug/l]	45.8
Peak Annual Total Phosphorus [ug/l]	161
Average Annual Ortho Phosphorus ug/l]	13.8
Seasonal Average Ortho Phosphorus [ug/l]	18.9
Peak Annual Ortho Phosphorus [ug/l]	113.1
Nitrogen	
Average Annual Nitrate-Nitrogen [ug/l]	207
Seasonal Average Nitrate-Nitrogen [ug/l]	150
Peak Annual Nitrate-Nitrogen [ug/l]	565
Clarity	
Average Annual Secchi Depth (m)	2.1
Seasonal Average Secchi Depth [meters]	1.5
Total Suspended Sediments	
Annual Average Total Suspended Sediments [mg/l]	6.7
Seasonal Average Total Suspended Sediments [mg/l]	7.4
Peak Total Suspended Sediments [mg/l]	12.5
Phytoplankton Species	
Phytoplankton Co-dominant Species	*Asterionella formosa*
	Chlorella minutissima
	Chlorella vulgaris
	Choricystis minor
	Chromulina sp.
	Komma caudata
	Plagioselmis nannoplanctica
	Aphanizomenon flos-aquae
	Aphanocapsa delicatissima
	Aphanothece smithii
	Cyanobium sp.
	Leibleinia (*Lyngbya*)*epiphytica*
	Microcystis aeruginosa
Peak Phytoplankton Density	753,600 (Aphanizomenon)
Zooplankton Diversity	37 species

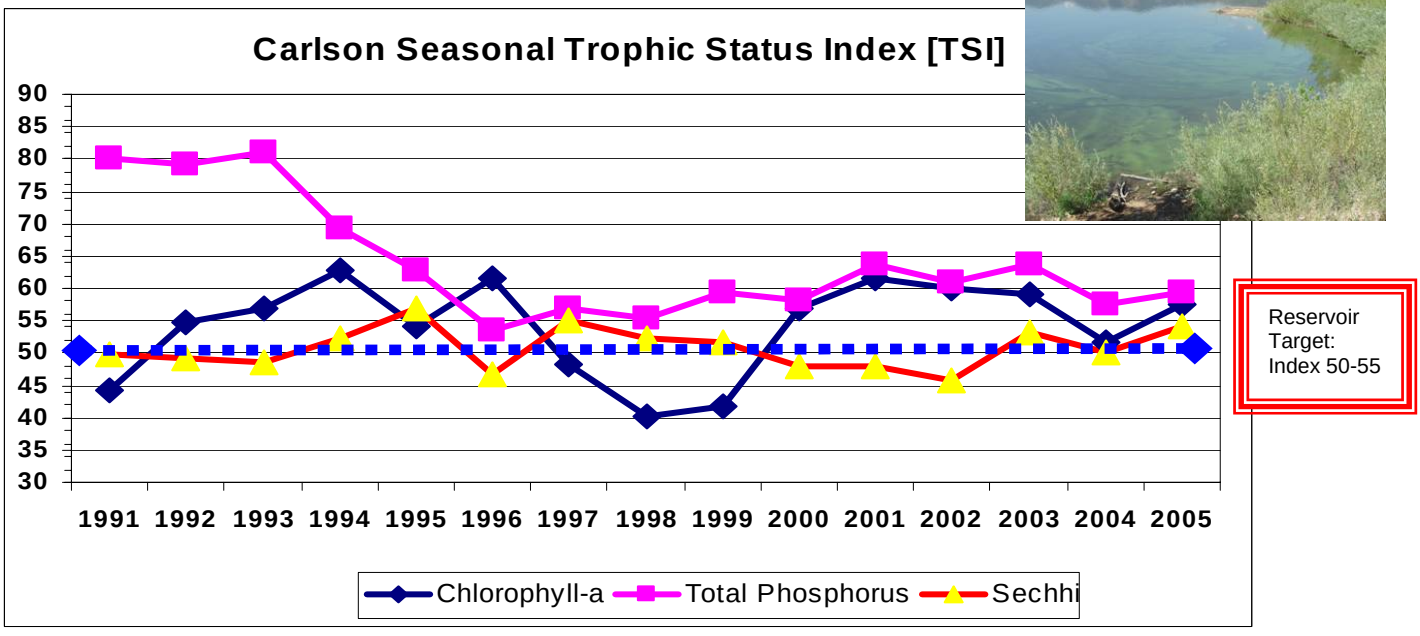
Algal production decreased under the 2005 recovery conditions; even though the total phosphorus loading was low. The algal production consumed most of he nitrate within the water column over the growing season. The growing season Chlorophyll-a concentration is indicative of declining quality or eutrophic-hypertrophic conditions. 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. The dominate phytoplankton species are typical nuisance species.

Fact Sheet 16. Carlson & Walker Reservoir 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.

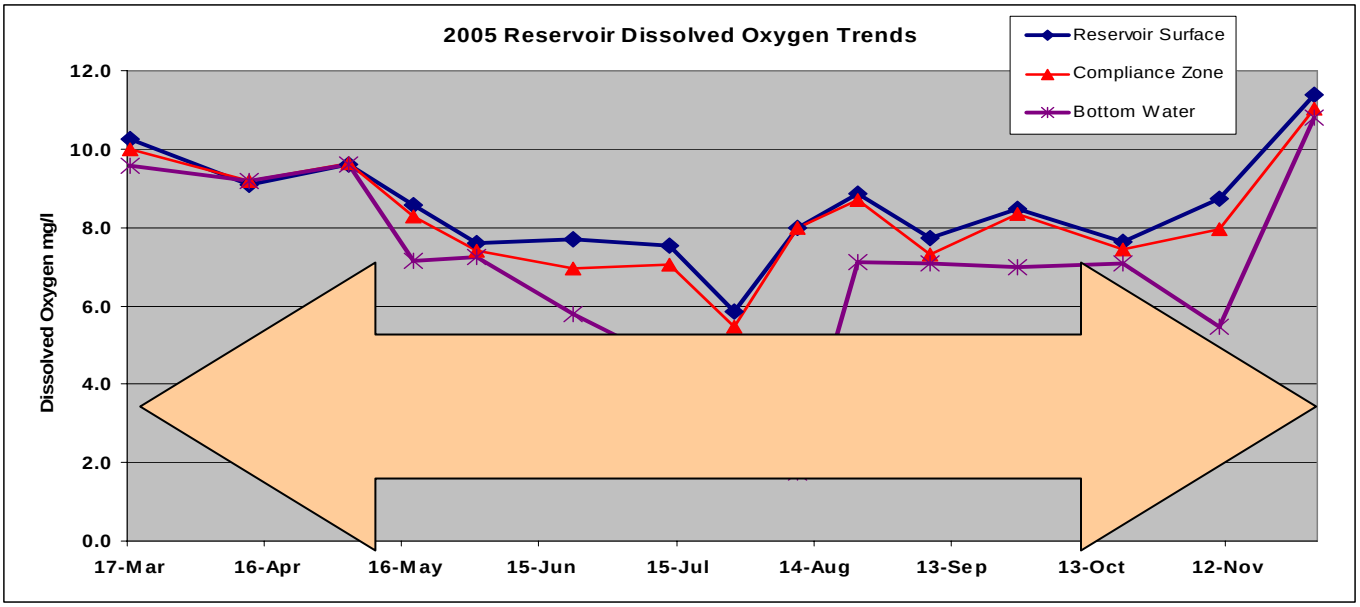
Walker Trophic Index	
25-30	Oligotrophic-Mesotropic
30-45	Mesotrophic
45-50	Mesotrophic-Eutrophic
50-65	Eutrophic
65-70	Eutrophic-Hypereutrophic
>70	Hypereutrophic





Fact Sheet 17. 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, where dissolved oxygen concentrations below 5 mg/l (orange arrow) indicate a potential water quality and biological problem. Low dissolved oxygen concentrations stress aquatic life species.



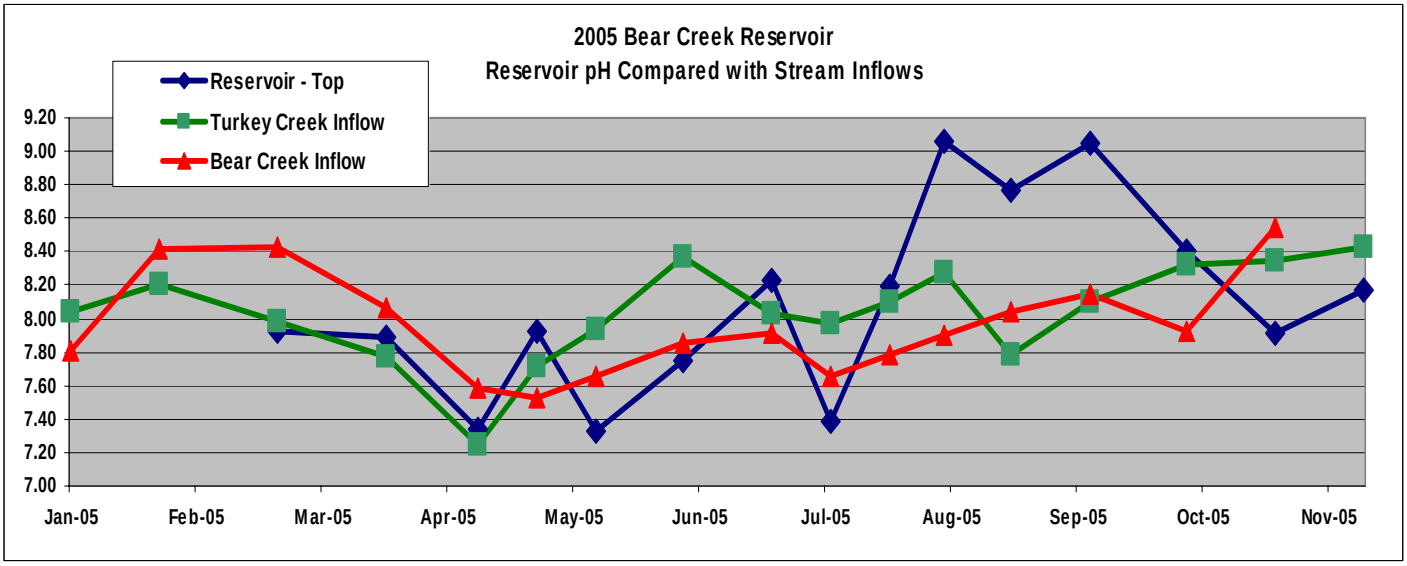
Oxygen levels that remain below 1-2 mg/l for a few hours can result in fish kills. Since fish within the reservoir can migrate to better-oxygenated water, the amount of water column with low dissolved oxygen is an important tropic indicator. Low dissolved oxygen concentrations have commonly occurred 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. The red line in the graphic represents the minimum dissolved oxygen concentrations measured within the reservoir compliance zone. The orange arrow indicates the zone of low dissolved oxygen associated reservoir bottom waters, which occurs during the growing season.

To resolve the low oxygen problem, the City of Lakewood re-established in August of 2002 a new reservoir aeration system in the reservoir. The system extends 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 aeration system has reduced or eliminated reservoir water column stratification, which raises a potential concern about increasing water column temperature. The system is monitored to determine changes to temperature and dissolved oxygen. Based on 2005 data, this new aeration addresses the oxygen problem, doesn't affect temperatures and reduces the potential for stress of aquatic species.

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.*

Fact Sheet 18. 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

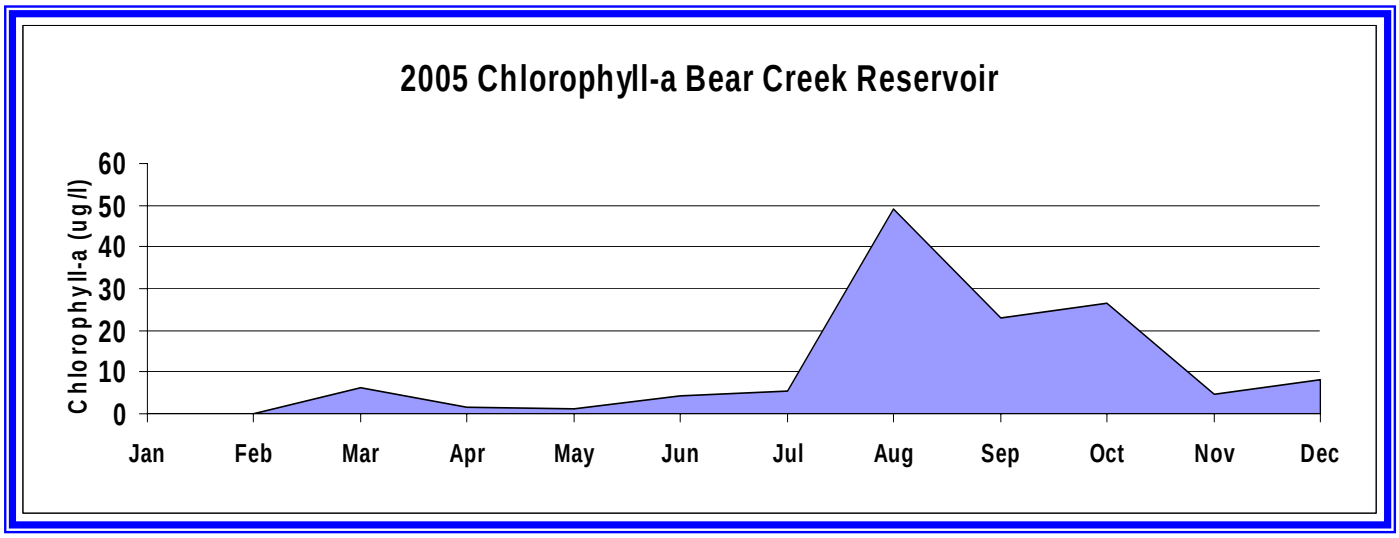


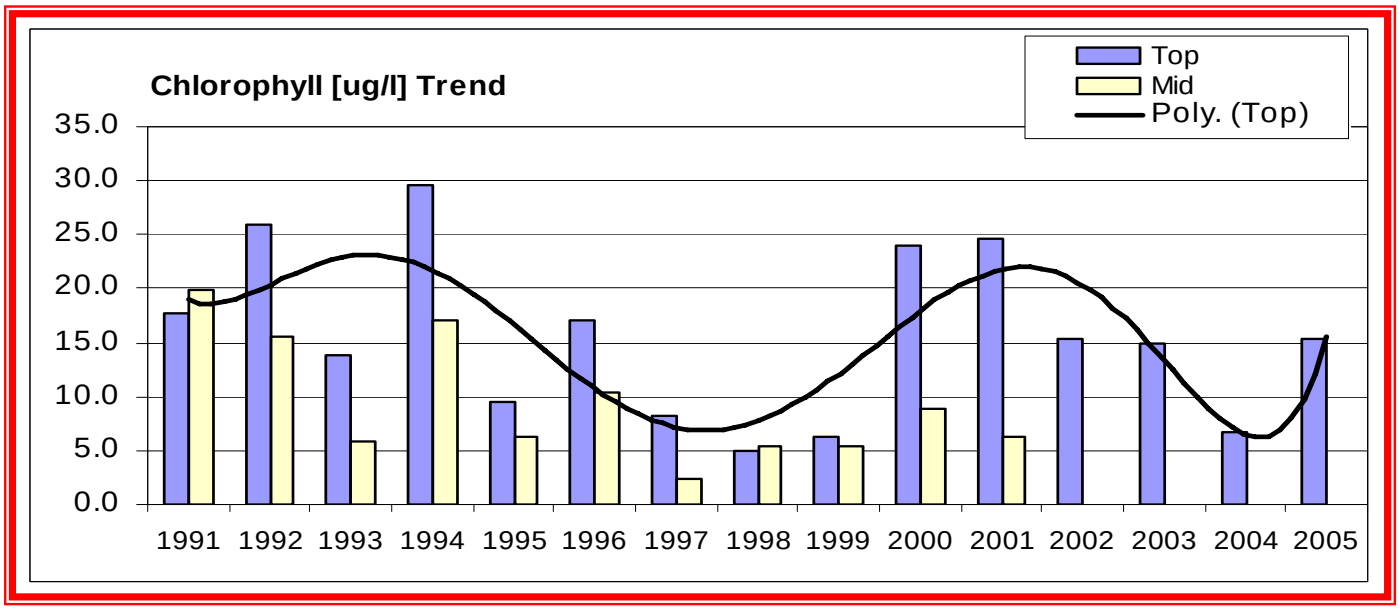
the scale equals a ten-fold increase or decrease. Plant photosynthesis is the main cause of high pH and diurnal pH fluctuations. High alkalinity water [pH > 9.0] can cause direct physical damage to fish skin, gills and eyes. Prolonged exposure of aquatic life to sub-lethal pH levels can cause severe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

The reservoir pH did exceed 9 units twice in 2005. 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 are associated with algal production or phytoplankton biomass. The new aeration system hasn't completely eliminated this water quality problem. Operational adjustments of the aeration system could help reduce the pH fluctuations. The Association is monitoring reservoir pH conditions in 2005-06 to determine cause and affect.

Fact Sheet 19. Bear Creek Reservoir Chlorophyll-a Trends

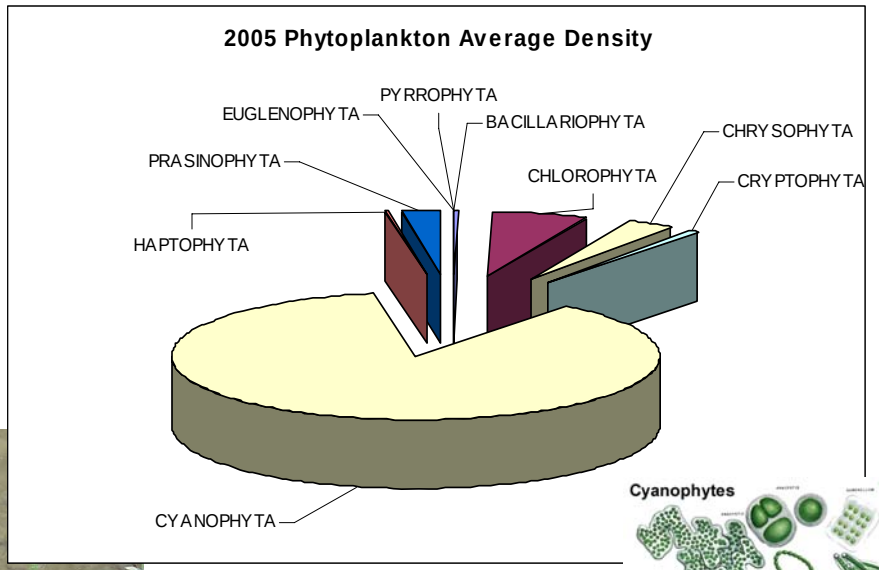
The reservoir-monitoring program provides necessary data to make statistical water quality trend assessments and verify the effectiveness of control and alternative management programs. The concentration of chlorophyll-a within the reservoir water column is a critical measure of the how the reservoir responds to water quality management strategies. The control regulation is designed to reduce the loading of 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 (average growing season value), which is consistent with the intent of the narrative standard. The 2005 growing season chlorophyll-a (15.5 ug/l) was below the target. The annual average chlorophyll-a (14.2 ug/l) was at the annual target. The 75.5 ug/l chlorophyll-a peak value was high and indicates a significant algal bloom.

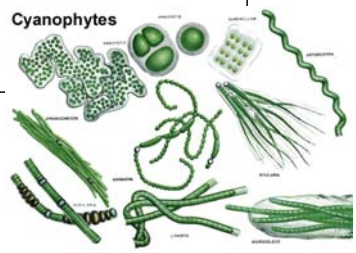


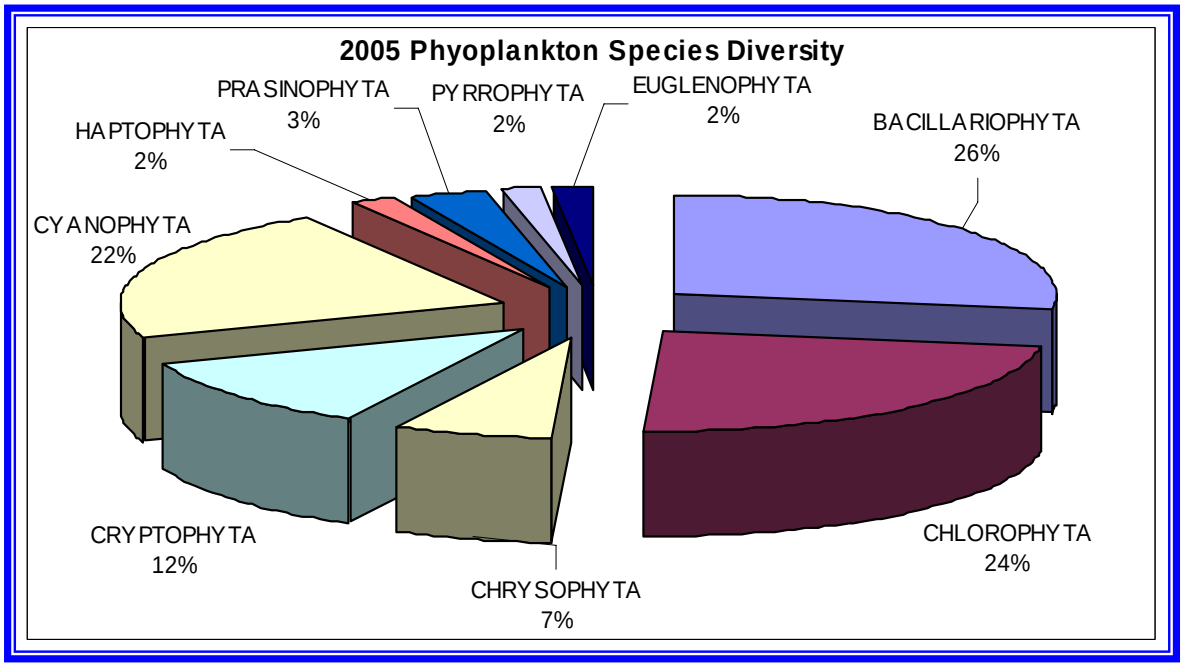


Fact Sheet 20. Bear Creek Reservoir Phytoplankton Distribution

Fact Sheet #1 The biological integrity of Bear Creek Reservoir is 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 2005, the blue-green species made up the majority of the phytoplankton density, but only on the average 22% of plant diversity present in the reservoir. Thirteen species of blue-green algae were found in the reservoir with a maximum total density at 753,600 (Aphanizomenon) cells/ml, which was classified as a major visual algal bloom. The green algae comprised 24% of the species diversity (14 species) with a maximum density of 100,000 cells/ml, which was also classified as a visual algal bloom. The diatoms (Bacillariophyta, Cryptophyta, Haptophyta and Chrysophyta) made up most of the 50% remaining species. Certain species of diatom are problematic from a water supply perspective. No fish kills or algal related problems were reported for the reservoir.







Fact Sheet 21. Bear Creek Reservoir Zooplankton Occurrence

2005 ZOOPLANKTON			
	6/22/05	7/13/05	8/23/05
COPEPODA (10 species)			
Acanthocyclops vernalis		Intermediate	Rare
Diacyclops thomasi	Rare	Common	Rare
Mesocyclops edax	Rare	Intermediate	Common
cyclopoid nauplius	Intermediate	Very Common	Very Common
cyclopoid juvenile	Rare	Very Common	Common
CLADOCERA (9 Species)			
Bosmina longirostris	Rare	Rare	Rare
Daphnia pulex - group	Rare	Very Common	Common
cladoceran juvenile		Intermediate	Rare
ROTIFERA (17 Species)			
Bdelloid rotifer	Rare	Rare	Rare
Polyarthra vulgaris	Rare	Very Common	Rare
Pompholyx sulcata		Rare	Intermediate

A detailed evaluation of zooplankton species presence was assessed from June through August 2005. Species were counted as present without density determinations. 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.

Rotifers have incredible reproductive rates. Population densities often exceed 1,000 individuals per liter. They play important roles in energy flow and nutrient cycling, accounting for more than 50% of the zooplankton production in the reservoir.

Daphnia pulex

Pompholyx sulcata

Bosmina longirostris

Zooplankton are common in the upper regions of the reservoir where assemblages include 17 species of rotifers, nine species of cladocerans and ten species from the class Copepoda. Copepods are usually a dominant group in the reservoir.

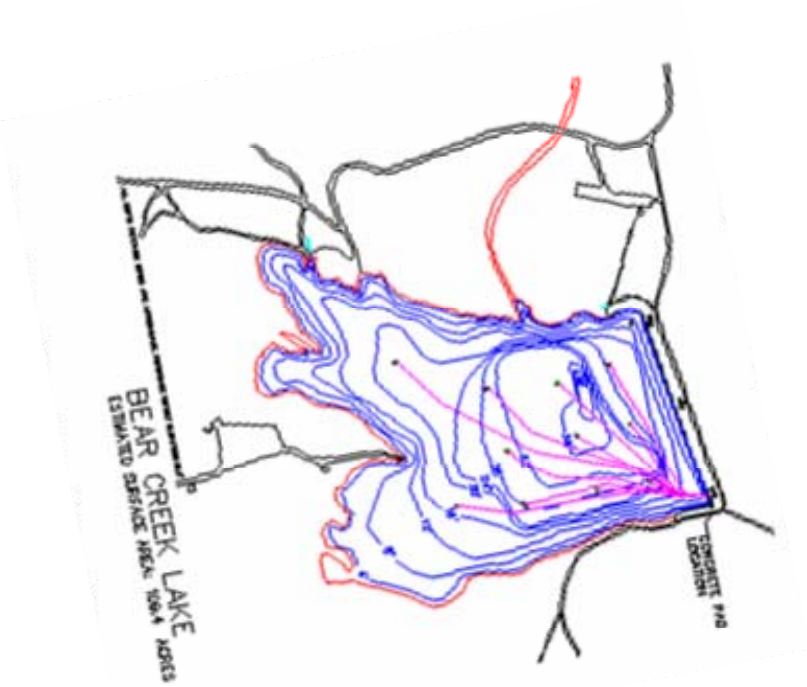
Acanthocyclops

The microcrustacean class Ostracoda is missing from the reservoir, but has been found in other front-range waterbodies. Most species of these three functional groups make their living grazing algae either from the water column or off surfaces. Zooplankton is a vital link for passing energy up the food chain to fish.

Fact Sheet 22. 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**)**

Fact Sheet 23. 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 with more than 500 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 2005:

- 2,629 residents have had access to proper disposal of their hazardous household waste (HHW)
- 9% increase in overall participation over 2001
- 368,431 pounds collected “Door-to-Door” or dropped off at the Center
- 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

Fact Sheet 24. Jefferson County Stormwater Program

Jefferson County stormwater permit activities

- Jefferson County is mandated to improve the quality of stormwater
- General Permit for Stormwater Discharges Associated with Municipal Separate Storm Sewer Systems
- Storm drain marking with Jeffco R1 school
- Storm sewer outfall map to trace sources of potential illicit discharges and illegal dumping
- Added stormwater information to the County's web page
- Revised County's standard for storm sewer inlets, requires "*No Dumping*" insignia on inlets
- Stormwater infiltration techniques encouraged
- Jefferson County provides opportunities for residents and visitors to learn and be involved in environmental stewardship.

Fact Sheet 25. Recreational Uses in Watershed

Jefferson County Open Space

Lair 'o the Bear Park

Acreage: 319 acres
Annual Visitation: 52,000
Activities: Hiking, biking, horseback riding, wildlife viewing, fishing, picnicking

Mount Falcon Park

Acreage: 1,705 acres
Annual Visitation: 118,000
Historical Point of Interest
Activities: Hiking, biking, horseback riding, wildlife viewing, fishing, picnicking

Alderfer/ Three Sisters Park

Acreage: 770 acres
Annual Visitation: 62,500
Activities: Hiking, biking, horseback riding, wildlife viewing, picnicking

Elk Meadow Park

Acreage: 1,650 acres
Annual Visitation: 72,500
Activities: Hiking, running, biking, horseback riding, wildlife viewing, picnicking

Mainstem Bear Creek

Annual Visitation: >275,000
Activities: Trout fishing (cutthroat, brook trout, browns, rainbows), hiking, biking, horseback riding, wildlife viewing, photography, picnicking, historical points of interest

Bear Creek Reservoir

Lakewood Bear Creek Lake Park Acreage: 2,600
Annual Visitation: 350,000
Activities: Fishing (Saugeye, rainbow trout, smallmouth bass, channel catfish, yellow perch, tiger musky), boating, sail boarding, swim beach, hiking, biking, horseback riding, wildlife viewing, picnicking, camping, nature center, educational activities, archery, glider plane flying, special event facilities, historical point of interest