East Canyon Reservoir

Diagnostic Feasibility Clean Lakes Study

By
Harry Lewis Judd
Project Officer

July 15, 1999
Utah Department of Environmental Quality
Division of Water Quality
Salt Lake City, Utah

This study was conducted in cooperation with the United States Environmental Protection Agency, Region VIII

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ACKNOWLEDGMENTS

The East Canyon Reservoir: Diagnostic/feasibility Study by the Division of Water Quality within the Department of Environmental Quality, is a product of technical assistance and support of a large number of people not all of who are mentioned below.

Appreciation is extended to the staff of the Division of Water Quality's monitoring section for their assistance in conducting the water quality monitoring and providing field information that has assisted in the evaluation of pollutant sources in East Canyon Reservoir watershed. A special thanks to those individuals through cooperative agreements have participated in the gathering of water quality data utilized to evaluate conditions in East Canyon Creek and East Canyon Reservoir. Specifically, we would like to thank the staff of Snyderville Basin Wasterwater Treatment Plant for their assistance in this effort.

Special recognition is given to members of the East Canyon Technical Advisory Committee under the direction of Richard Bojanowski and Ray Loveless, Water Quality Director for Mountainland Association of Governments for their assistance in evaluation of information and their contributions to understanding the dynamics of the system and local perspective related to this project.

We also appreciate the assistance from other agencies and individuals in the collection of biological and other related data used in this report. Specifically the Division of Wildlife Resource personnel for their assessments related to riparian corridor and the fisheries throughout the watershed, the Bureau of Reclamation for their assistance in evaluating the toxicity of metals in the food chain, and the Utah Automated Geographic Reference Center.

Finally, we appreciate the financial support received for the project from the Environmental Protection Agency. We recognize and appreciate the interest and support of Dr. David Rathke, the Clean Lakes Coordinator for Region VIII for his guidance and assistance.

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EXECUTIVE SUMMARY

East Canyon Reservoir is a valuable freshwater resource in Utah. Recreation, wildlife, agriculture, and water supply are key beneficial uses served by the lake. The area's value as a recreational resource is highlighted by over 300,000 user days at the state park surrounding the reservoir during peak use years in the 1980's and a significant number of visitors at East Canyon Resort at the south end of the reservoir. The fishery is the focal point of activity at the reservoir as shown by visitation records. Water from the reservoir is used primarily downstream for irrigation on downstream lands, recreation and for municipal and industrial purposes in the urban area of Davis and Weber Counties with proposals to return water to the upper watershed for snow making, culinary and other residential uses.

According to the Utah Department of Wildlife Resources, the fishery in East Canyon Reservoir has deteriorated as a result of poor water quality. Oxygen concentrations below 10 meters, drop to near zero during the mid to late summer period, and surface water temperatures may approach levels that are lethal to many fish.

This report summarizes water quality data through 1997, but the focus of the discussions extends primarily through 1996. We acknowledge that Snyderville Basin Sewer Improvement District (SBSID) has implemented a biological phosphorus removal component for some of their effluent, but an in-depth discussion of reductions achieved or their impact on the reservoir has not been incorporated into this report. Findings reported in this report indicate that an excessive total phosphorus load is responsible for a degradation of water quality and impairment for the defined cold water fishery. The average concentration of total phosphorus in the water column has consistently exceeded the State pollution indicator for phosphorus of 25 ug/L. For the period 1992-97 the average total phosphorus concentration in the water column of the Division of Water Quality (DWQ) data set is 117 ug/L. A review of past studies and current findings indicate that current loadings of available phosphorus are such that the reservoir is on the boundary between eutrophic and hyper-eutrophic condition and the reservoir has exhibited an increasing eutrophication trend in recent years. Currently the waters of East Canyon Creek and Reservoir are defined in Utah's 303(d) list as impaired.

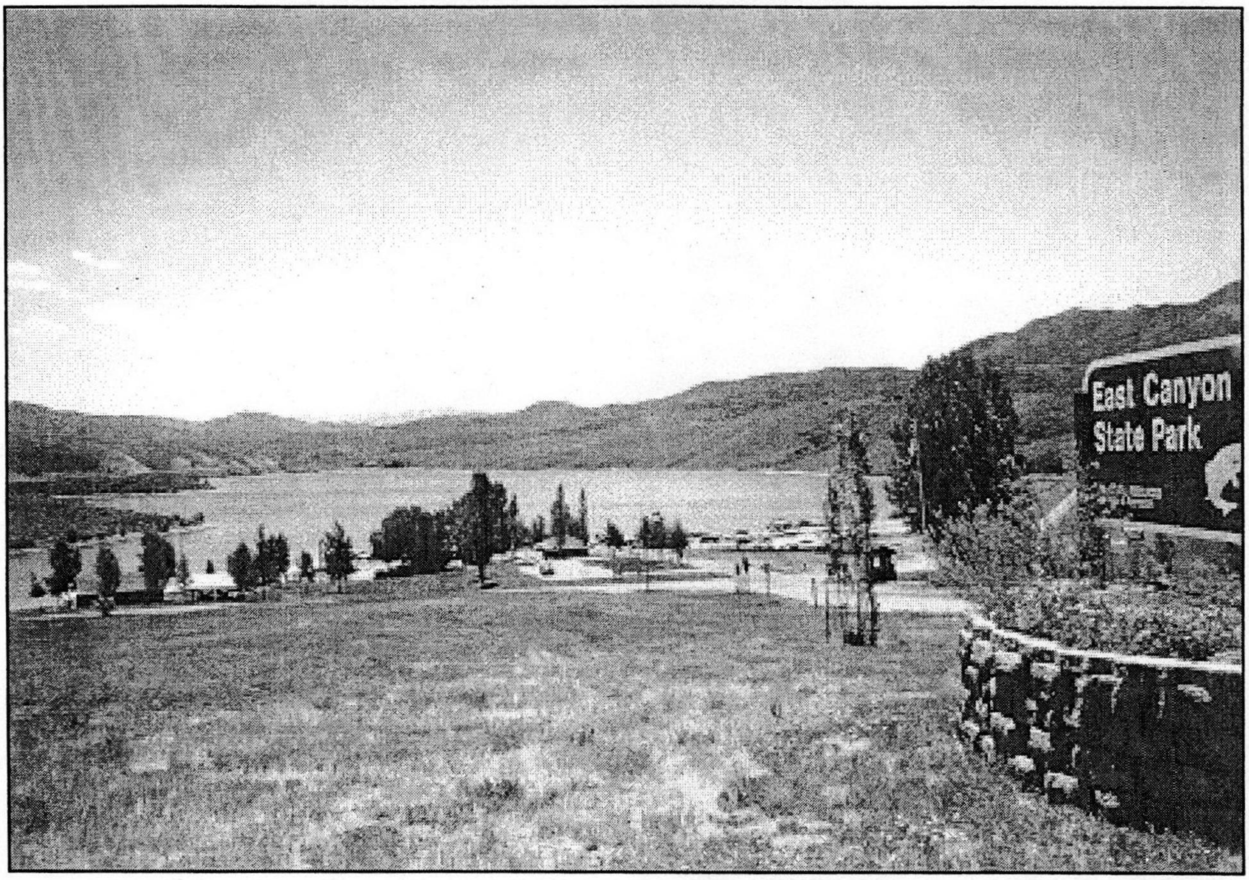
Waters listed on Utah's 303(d) list require the development of Total Maximum Daily Loads (TMDL's) for those stressors or pollutants identified as causes of the impaired water quality. The objective of the TMDL process is to restore water quality for the impaired defined beneficial uses by identifying all significant sources of pollutants and designing strategies to reduce or eliminate those sources. In addition to restoring the cold water fishery, it is also important to protect for the culinary water use and for water-based recreation uses.

The primary focus of the proposed restoration plan for the reduction of total phosphorus within the system is on the controllable significant sources of sediment and phosphorus including: Snyderville Basin wastewater treatment plant (SBWWTP); urban runoff; construction activities associated with residential, business and recreation areas; agricultural related activities; and at risk riparian corridor conditions. The primary goals defined for the reservoir are to reduce total phosphorus loadings to the point where trophic state index values are in the mesotrophic range (40-50), shift the algal community dominance away from blue-green species composition, reduce temperature regimes in the epilimnion, and reduce anoxic conditions present in the hypolimnion.

In order to achieve this it is recommended that an annual loading to the reservoir be established based on an annual target concentration value of 0.05 mg/L for the waters flowing into the reservoir. A similar endpoint for the stream is recommended with implementation of a pilot riparian corridor project to evaluate the effectiveness of an enhanced riparian canopy and stream bank stabilization on temperature and macrophyte growth to determine if this is an acceptable endpoint or if modification need to be made to restore water quality defined beneficial uses in the impaired stream reaches.

All available evidence indicates that we could expect a favorable response to reductions of "phosphorus loadings" which would reduce productivity and thereby restore impaired water quality.

EAST CANYON RESERVOIR



1.0 INTRODUCTION

East Canyon Reservoir is a large reservoir behind the northern Wasatch Front. Its watershed drains the Snyderville Basin area, the home of several major ski resorts. In addition its close proximity to the population centers on the northern Wasatch Front, the location of a State Park makes this a very popular reservoir for year round recreation.

The current dam, a concrete arch, was created in 1966. Two other dams were constructed prior to the completion of the current concrete, arch dam. The spillway creates a spectacular waterfall off the west side of the dam. The reservoir shoreline is owned by the State of Utah, and public access is generally unrestricted, but vehicular access to the west side of the reservoir is restricted. Reservoir water is protected for a cold water fishery, recreation, agriculture and culinary use. Although the waters have been designated as a culinary water

Location	
County	Morgan
Longitude / Latitude	111 35 20 / 40 54 20
USGS Maps	East Canyon Reservoir -1975
DeLorme's Utah Atlas & Gazetteer™	Page 53, A-6
Cataloging Unit	Lower Weber (16020102)

source, historically the water has been used primarily for agricultural irrigation. Currently there is a move to shift some of this agricultural water back to the upper basin for reuse primarily as culinary water. As urban sprawl continues to displace agricultural lands, the fraction consumed for culinary purposes is expected to increase.

1.1 Recreation

East Canyon Reservoir is located in East Canyon between I-80 and I-84. The primary all year access is U-66 from Morgan (Exit 103 off I-84). Alternate routes via U-65 from the south (Exit 134 off I-80 in Parley's Canyon) or the north (Exit 115 off I-84 in Henefer). U-66 follows the north shore of the reservoir, while U-65 follows the east shore. There is limited access to the southern half of the west shore by a gravel road off U-65. Driving time is about ½ hour from the mouth of either Parley's or Weber Canyons.

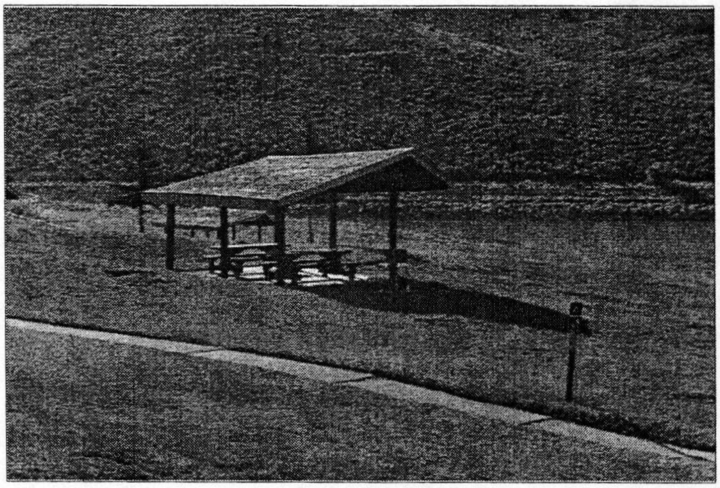


Figure 1.1 State Park Recreational Site

Cross-country skiing, fishing, boating, sailboarding, swimming, camping, picnicking, ice fishing, and water skiing are all popular. Recent usage trends as indicated in Table 2.1 show a decline in the recreational use of the reservoir. During the past fifteen years the average number of visitors to the State Park was 189,512. In 1986 visitations numbers at the park were 312,224 with an average well over 200,000 prior to 1987.

Recreational facilities include a wide concrete boat ramp, modern rest rooms with showers, sewage disposal, a 31 unit campground with a large overflow area, and fish cleaning stations. A concessionaire provides food, meals and boat rentals. The park is located on U-66 on the north shore of the reservoir, one mile west of the junction with U-65. Entrances are well marked. There are no other campgrounds in the area, and little public land is available for dispersed camping. Also East Canyon Resort is located near the southern end of the reservoir with a wide range of facilities available to the public.

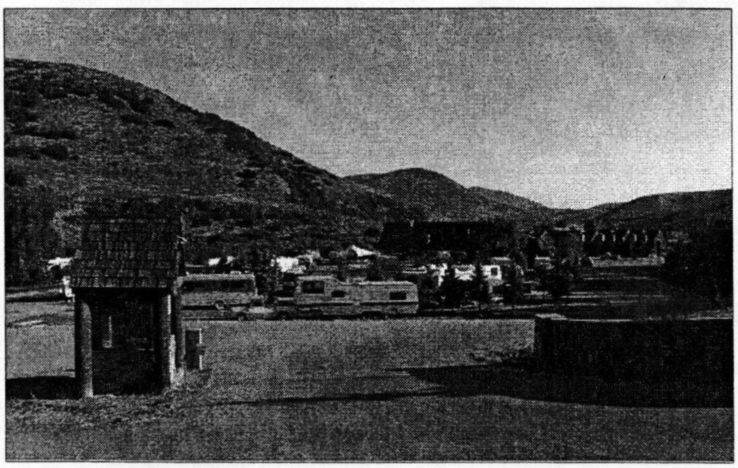


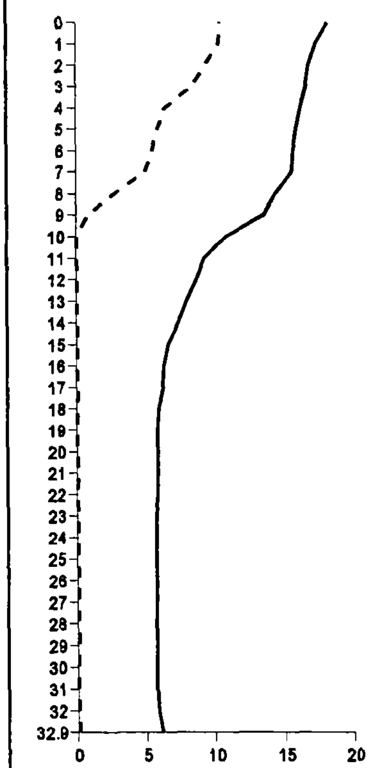
Figure 1.2 East Canyon Resort

1.2 Limnological Assessment

The water quality of East Canyon Reservoir is fair. It is considered to be hard with an average hardness concentration value of approximately 245 mg/L ($CaCO_3$)for the period 1992-97. The parameters that exceed State water quality standards for defined beneficial uses are phosphorus, temperature and dissolved oxygen. The average concentration of total phosphorus in the water column has consistently exceeded the State pollution indicator for phosphorus of 25 ug/L. For the period 1992-97 the average total phosphorus concentration in the water column of the Division of Water Quality (DWQ) data set is 117 ug/L. This high concentration is due primarily to high nutrient loadings from the watershed where a major municipal wastewater treatment plant discharges into East Canyon Creek. Other contributors include nonpoint sources of nutrients associated with agriculture, stormwater, residential, recreational and commercial development. In addition internal phosphorus loading occurs from lake sediments due to extensive anoxic conditions present in the reservoir. These high concentrations of nutrients stimulate the production of blue green algae and excessive algal production in general. This excessive production is directly tied to impaired water quality.

Figure 1.3 depicts a typical pattern for a dissolved oxygen/temperature profile of the water column near the dam obtained on September 1, 1992. The low dissolved oxygen concentrations as shown substantiate the fact that water quality impairments do exist. Concentrations dropped dramatically below the thermocline (9-10 meters) to virtually anoxic conditions. In addition summer surface water temperatures exceed the established criteria (20°C) for a cold water fishery. These factors (low dissolved oxygen and high surface temperatures) coupled together eliminate a very large portion of the reservoir as fishery habitat. Because of these impairments the reservoir and its watershed have been the focus of a Clean Lakes Phase I study.

According to the Utah Division of Wildlife Resources report, East Canyon Creek: Aquatic-Riparian Management Plan (1998), the fishery in East Canyon Reservoir has deteriorated as a result of poor water quality. A more complete discussion of the fishery status in the stream and reservoir is given in the paper, "East Canyon Creek Fisheries Summary". Oxygen concentrations below 10 meters, drop to near zero during the mid to late summer period, and surface water temperatures may approach levels that



D	°C	pH	DO	Cond
0	18 2	8 8	10 5	645
1	17 3	8.7	10 4	647
2	16.8	8.7	9 4	650
3	16 6	8 6	8 5	652
4	16 2	8 3	6 4	661
5	15 9	8 3	5 9	664
6	15 7	8.2	5 5	667
7	15 6	8 2	5 0	669
8	14 4	7 9	2.7	683
9	13 6	7.8	0 8	697
10	10.9	7 7	0 0	718
11	9 3	7 6	0 0	721
12	8 7	7.6	0.1	726
13	8.0	7 6	0 0	728
14	7.4	7 6	0.1	727
15	6 6	7.6	0.1	730
16	6 3	7.6	0 1	732
17	6 2	7.6	0 1	731
18	5 9	7 6	0 1	733
19	5.8	7 6	0.1	734
20	5.8	7 6	0.1	734
21	5 8	7.6	0 1	734
22	5 8	7.6	0 1	734
23	5 7	7 6	0.1	735
24	5 7	7 6	0.1	736
25	5.7	7 5	0.1	735
26	5.7	7 5	0 1	735
27	5 7	7.5	0 1	735
28	5 7	7.5	0 1	736
29	5 7	7 5	0.1	736
30	5 7	7 5	0.1	736
31	5 7	7 5	0.1	736
32	5.8	7 5	0 1	737
32.9	6 1	7 5	0.1	740

Temp DO

Figure 1.3 Water column data

are lethal to many fish.

Throughout the productivity season algae, and organic debris at the bottom of the reservoir extract oxygen from the water column during respiration and decomposition which contribute to the loss of available habitat for fish. Anoxic conditions move upward in the water column and high temperatures move down into the water column.

During the period for which these conditions persist, trout are confined to a narrow band of water and smaller fish are subjected to greater predation. In addition to marginal temperature during the summer and low levels of dissolved oxygen concentrations, fish are stressed by factors related to crowding, competition for food, and increased susceptibility to anchor worm infection. Utah Division of Wildlife Resource's (DWR) fisheries summary attributes loss of two spring plants in 1990 and 1991 of fingerling rainbow trout (~ 300,000 fish each) to these conditions. These conditions are a result in part to the high productivity experienced in the reservoir stimulated by the high concentration of nutrients within the reservoir.

Elevated levels of nutrients stimulate large algae blooms in late summer and early fall. These algal blooms not only contribute to the loss of dissolved oxygen from the water column but also detracts from swimming and water skiing activities in the reservoir. Algal production can also have a negative impact on treatment of this water for municipal and industrial uses. To produce high quality culinary water additional treatment such as 'activated charcoal addition' or other 'pretreatments' may be required which add significantly to the costs of treating surface water for use. Current plans to pipe water from the reservoir back into the upper watershed for culinary purposes may need to address this issue.

Poor water quality conditions are indicated by the dramatic decline in the number of visitors to the state park in recent years.

According to DWR and DWQ fish kills have been reported in recent years. In late summer of 1994 a fish kill was observed in the south arm of the reservoir by the author during a routing monitoring trip. In addition to poor water quality conditions, the fish population is infected with the parasite, *Lernaea*. *Lernaea* is an anchorworm that causes lesions and sores on the external surface of fish. These conditions and the stress factors associated with water quality are responsible for the loss of fish at the reservoir.

The reservoir has populations of the following game fish: rainbow trout (Oncorhynchus mykiss), cutthroat trout (*Oncorhynchus clarki*) and some brown trout (*Salmo trutta*). Macrophytes are not typically present and therefore not a problem.

As observed during the study period the phytoplankton community is dominated by blue-green algae and diatoms that are indicative of eutrophic waters.

Water quality concerns that have been identified in East Canyon Reservoir include algal blooms, low dissolved oxygen concentrations coupled with high epilimnetic temperatures leading to periodic fish kills, low dissolved oxygen concentrations during winter ice coverage and outbreaks of anchorworm parasitism.

In order to better understand the reasons for impaired water quality and establish recommendations to improve water quality in the reservoir, further studies were needed to provide more limnological information, to identify and quantify pollutant loadings and establish watershed alternatives to address these concerns.

The primary purpose of this Phase I study was to obtain such essential information. The major objectives of this study are:

- to develop and implement a detailed water quality monitoring program for East Canyon Reservoir and its associated watershed;
- to investigate the current limnological conditions with the reservoir; and
- to develop alternatives for the restoration or protection of water quality in East Canyon Reservoir.

Field and laboratory monitoring of water quality in the reservoir and watershed was started in June 1991 and continued until June 1993. The data obtained during this period was deemed inadequate considering the potential ramifications on development of a total maximum daily load (TMDL) for phosphorus with the reservoir watershed and its effect on point sources dischargers. Therefore additional monitoring was conducted through a cooperative monitoring program between the Utah Division of Water Quality and the Snyderville Basin Wastewater Improvement District from 1994-97.

The objectives of the program were modified as follows:

- to review the historical water quality information,
- to identify and quantify pollution sources,
- to develop a nutrient budget for the reservoir,
- to assess the lake water quality and its trophic state,
- to determine nutrient loadings and implement the total maximum daily load (TMDL) process and partition nutrient loads and reductions for the restoration requirements for the lake and stream,
- to evaluate the loss of social, economic and recreational benefits resulting from problems associated with water quality,
- to develop a list of alternatives for restoration, and
- to assess the costs, benefits and feasibility of restoration.

The reservoir is a valuable freshwater resource. Recreation, wildlife, agriculture and culinary water supplies are the key defined beneficial uses of the reservoir. This Clean Lakes 314 Water Quality Study has been jointly funded by the Environmental Protection Agency, Utah Department of Environmental Quality, and Weber Basin Water Conservancy District. Additional support has been provided by Snyderville Basin wastewater treatment improvement district during the final study phase of this project.

2.0 BACKGROUND

Weber River water was first used by new settlers for irrigation about 1848. Water development was reasonably rapid, and by 1896 more than 100 canal companies had begun to divert water from the river or its tributaries and had established rights to all of the normal summer flow. The 3,850 acre-foot East Canyon reservoir, constructed by private interests in 1896, was one of the first storage reservoirs in the basin. It was enlarged to a capacity of 29,000 acre-feet in 1916.

Planning for the Weber Basin project, which included East Canyon Reservoir, started in 1942. A report issued July 1949 led to congressional authorization of the project by the Act of August 29, 1949 (63 Stat. 677). The first appropriation of construction funds was made July 9, 1952. A construction contract to enlarge East Canyon for the third time was awarded on April 6, 1964, and completed July 1966.

The Weber Basin Project Repayment Contract between the Bureau of Reclamation and the Weber Basin Water Conservancy District was signed on December 12, 1952. The contract established that the reimbursable construction cost of the project was to be repaid by the water users. The operation and maintenance of the East Canyon Reservoir rests with the Davis and Weber Counties Canal Company, with costs shared with the District as agreed to in Contract 14-06-400-3373 entitled *Contract among the United States, the Davis and Weber Counties Canal Company and the Weber Basin Conservancy District Relating to the Construction of the East Canyon Dam and Reservoir and the Operation and Maintenance Thereof.*

The contract gives the Canal Company the permanent right to an annual yield of 28,000 acre-feet of stored water in the reservoir. The United States, for the use of the Weber Basin Project, has the permanent right to the annual yield of storage over and above the 28,000 acre-feet. Within the storage pool there is 3,000 acre-feet of inactive capacity reserved for fishery conservation.

The Contract also gives the Canal Company the responsibility of operation and maintenance of the dam and reservoir for project purposes.

Upon completion of the dam, recreational development began around the reservoir, as designed by the National Park Service. In 1967 the basic recreational features were constructed by the Bureau of Reclamation, with culinary water and electricity added in 1969. In 1969 the State of Utah added a boat dock and vault toilets.

On June 1, 1967, Contract No. 14-06-400-4876, *An Agreement Between the United States of America and the Utah State Park and Recreation Commission Concerning the Administration and Development of Lands and Facilities at the Enlarged East Canyon Reservoir for Recreation Purpose* was signed, giving the State of Utah the administration of the recreational aspects of the reservoir area. This agreement was updated by Contract No. 14-06-400-6092 on June 27, 1974.

Physical Data Summary

Latitude:	40°46'06"
Longitude:	111°34'59"
Township:	2N
Range:	3E
Section:	10
Watershed area:	36,442 ha (90,047 a)
Elevation:	1739 m (5,705 ft.)
Max. Surface Area:	262 ha (648 a)
Max. Volume:	63,228,532 m (51,260 af)
Active Storage:	
Mean Depth:	31 m (102 ft)
Max. Depth:	59 m (195 ft)

Figure 2.1 Physical Data Summary

2.1 Public Access and Public Uses

All of the shoreline of the reservoir and the management area around the reservoir is accessible to the public for recreational uses identified by the state park, with some restrictions to the western shores. Visitors can access the reservoir from either Highway 65, which parallels the east shore, or by Highway 66, which parallels the northern shore. Also access to the south and west sides of the reservoir is provided by the southwest access road. East Canyon Reservoir is easily accessible to motorists via Highway 65 and 66 which have connections to Interstates 80 and 84. Figure 2.1 is a map of the reservoir watershed with indicators for various recreational opportunities associated with the reservoir.

The state designated beneficial use classifications for the reservoir include: (1C) culinary, (2A) recreational bathing (swimming), (2B) boating and similar recreation (excluding swimming), (3A) cold water game fish and organisms in their food chain and (4) agricultural uses.

East Canyon State Park Visitation

	June	July	August	September	October	November	December	Total
1982	74,151	60,876	55,941	2,250	2,982	1,998	420	235,323
1983	56,906	57,294	61,417	9,312	4,123	1,320	60	223,051
1984	83,967	71,596	67,095	10,456	3,332	1,060	440	279,539
1985	87,318	71,806	71,213	7,476	3,428	124	616	289,759
1986	93,612	74,172	63,296	7,824	3,528	2,112	1,720	312,224
1987	80,208	68,944	63,224	8,532	3,692	2,428		300,634
1988	21,324	25,496	13,389	4,864	6,016	1,260	668	116,398
1989	16,156	31,583	18,923	10,832	4,729	11,797	2,994	140,097
1990	40,390	38,429	23,057	4,455	2,929	1,550	787	189,279
1991	23,642	39,816	23,506	7,388	4,781	672	430	119,537
1992	25,716	18,763	13,170	7,318	1,176	676	252	108,395
1993	83,379	34,706	34,706	3,851	1,037	2,383	3,437	155,432
1994	12,733	36,795	27,321	7,318	1,085	875	1,039	152,035
1995	12,733	35,094	30,389	6,473	1,396	1,760	1,428	110,876
1996	33,376	36,795	18,763	5,467	1,085	787	738	110,106
1997	12,733	36,795						77,087

Table 1 East Canyon State Park Visitation Data

Table 1 summarized the visitation records at the East Canyon State Park adjacent to the reservoir. As indicated by the graph in figure 2.2, it is clearly evident that there is a declining trend of park visits at the state park.

Traditionally according to state park records fishing and boating are the primary recreational activities engaged in by visitors to the park. Strong arguments can be made that this decline is due in part to the reduction in water quality and its effect on the fishery. The number of visits to East Canyon Reservoir has fluctuated but from 1982 to 1987, visitations rose to above 300,000 users per year. Since then, use has declined significantly to about 111,000 users.

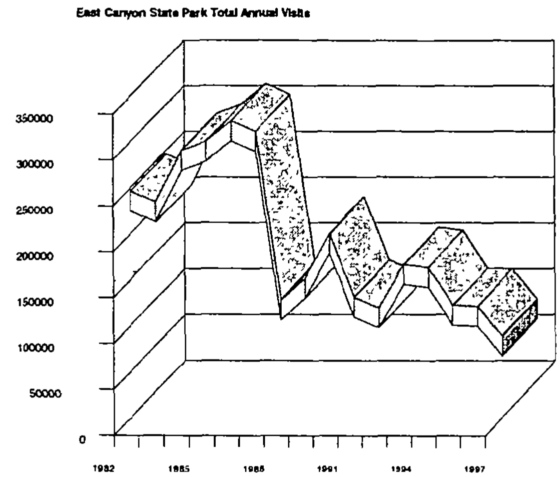


Figure 2.2 East Canyon State Park Annual Visitation Data

Fishing, which is the single most popular recreational activity at East Canyon Reservoir, has been adversely impacted by a decline in water quality. Trout are stressed by low dissolved oxygen concentration through the hypolimnion from mid-summer to early autumn. This condition resulted in a complete loss (100% mortality) of fingerling rainbow trout stocked in 1990 and 1991 as reported in DWR's fishery summary.

State Park Records show that nearly 98 percent of those who visit the reservoir area are Utah residents and almost all of those come from Salt Lake, Davis, Weber, Cache, Morgan, Tooele or Summit counties. The combined population of these counties is projected to reach 1,410,000 by the year 2000. With the accelerated growth and development in Park City and Summit County and the increased activity associated with the 2002 Winter Olympics there will need to be a major focus on protecting water quality and implementation of projects to restore or improve water quality throughout the watershed.

2.2 Watershed Description

East Canyon Reservoir is an impoundment of East Canyon Creek. The watershed as depicted in figure 2.3 drains the back side of the Wasatch Front, from behind Big Cottonwood Canyon to behind Emigration Canyon.

The area around the watershed is relatively dry compared to the areas closer to the Wasatch Front. Vegetation is mostly sage-grass, but there are areas of spruce-fir in sheltered, north facing slopes. Refer to Appendix A for a map of the vegetative communities of the watershed. Unlike the canyons that drain to the west, the scenery is not the lush forests most recreationalists hope to find in the mountains.

The watershed extends south and west from the reservoir. The highest elevations are along the Wasatch Front, with 10,000 foot ridge lines common at the south end of the watershed. The eastern border of the watershed is only slightly higher than the stream elevations in many areas. Like many areas behind the Wasatch Front, the divides between drainages are very low, with Parley's Summit, Snyderville basin to Park City, and Parley's Park all being major divides at low elevations. Silver Creek was once the headwaters of East Canyon Creek, but appears to have been diverted into the Weber Basin in recent geologic history. The Snyderville Basin is rapidly urbanizing, creating changes in water quality for this watershed. Nutrient and sediment loading within the watershed are major issues at the present time. Pollutant sources include urban runoff, golf courses, dairies and other cattle operations, construction and development sites, erosion and loss of riparian habitat, and discharge from the municipal wastewater treatment facility. These sources are the likely reasons for water quality problems at the reservoir. The East Canyon Technical Advisory Committee is attempting to bring about a coordinated effort to control sources of pollution and restore impaired water quality. Currently there is a spirit of cooperation by all parties associated with these problems.

East Canyon Reservoir Watershed General Features Map & STORET Monitor Locations

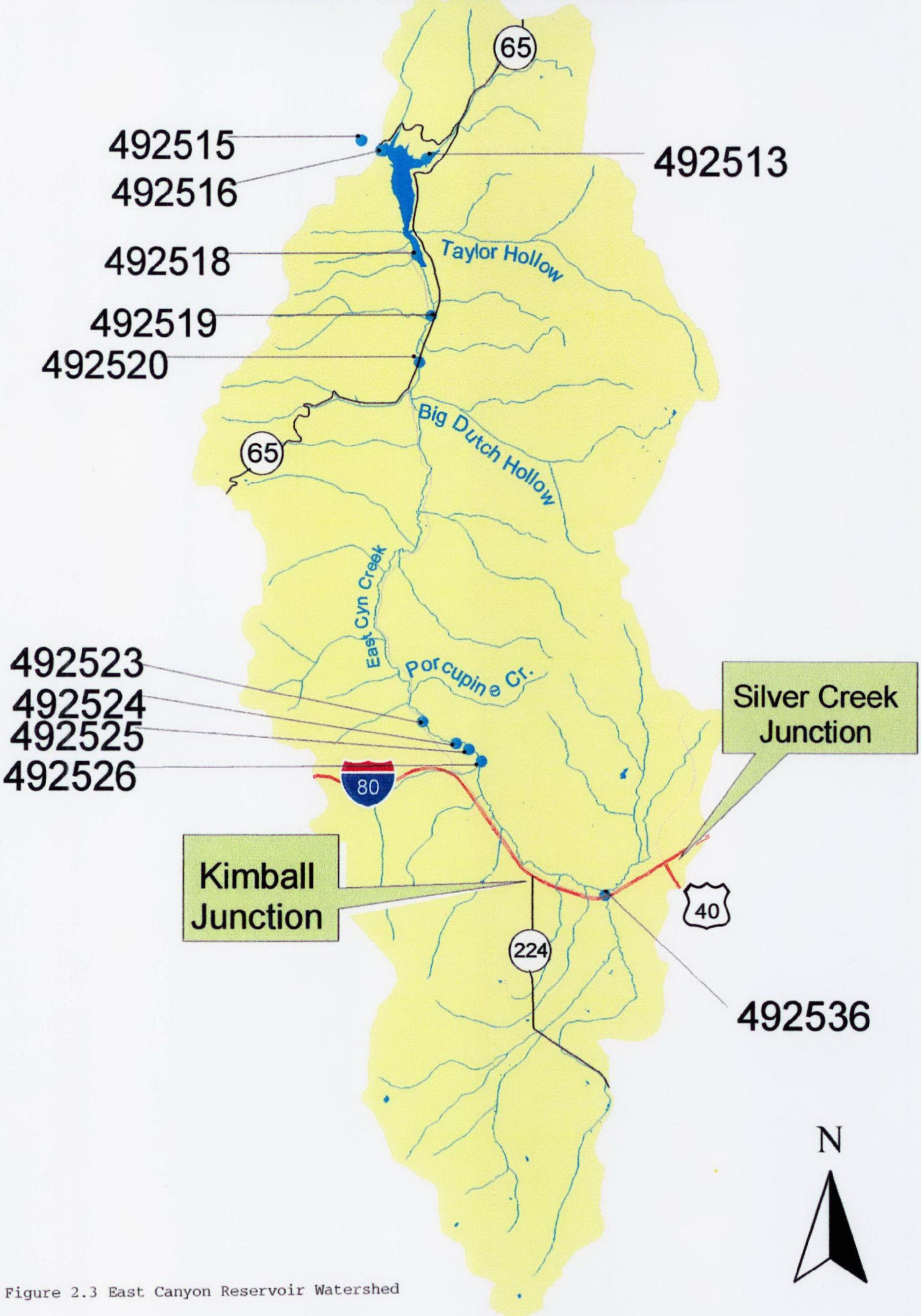


Figure 2.3 East Canyon Reservoir Watershed

The watershed high point is 2,753 m (9,034 ft) above sea level, thereby developing a complex slope of 9% to the reservoir. The average stream gradient above the reservoir is 4.2% (220 feet per mile). The inflows are East Canyon Creek, Dixie Hollow, Taylor Hollow, and Sawtooth Creek. The outflow is East Canyon Creek. The watershed is made up of high mountains, low mountains, and valleys.

The vegetation communities consist of pine, spruce-fir, oak-maple, alpine tundra, and sagebrush-grass. The watershed receives 41 - 102 cm (16 - 40 inches) of precipitation annually. The frost-free season around the reservoir is 80 - 100 days per year. Current land ownership identification in the watershed is represented in Appendix B.

Presently, all six square miles of Snyderville Basin, a relatively flat area of the upper part of the watershed, is under heavy development pressure. The watershed is almost entirely privately owned, leaving it susceptible to development

2.2.1 Soil and Geology

Soils and geology in the watershed area vary greatly from limestone-capped bedrock mountain peaks to fertile, loamy farmland to lush wetlands. Those formations and soil groups that affect water quality are generally the farmland soils near the streams. These soils are generally of the Broadhead and Henefer groups, characterized by good topsoil, greater than 60" depth to water table, CL classification, moderate permeability, and slight erosion hazard.

Although it is difficult to generalize in one short paragraph, the largest impact from the soils seems to come from streambank erosion and associated sediments and minerals washed into the stream from various construction oriented activities. Streambank erosion is exacerbated where vegetative cover is sparse. None of the surface soils except a limited amount in the upper watershed associated with the Park City formation appear to be high in natural minerals such as phosphorus. However, substantial amounts of precious metals have been located in the sub-surface soils in the Park City mining District area. For a more in-depth discussion of soils types, refer to the Natural Resource Conservation Service (NRCS)soil survey of the Park City Area. A new soil survey is currently underway and is expected to be completed by fall of 1999. Limited soils information is contained in Appendix C.

2.3 Basin Hydrology

Most of the inflow to East Canyon Reservoir comes from East Canyon Creek. The major sources of perennial flows in the basin are the Spiro Tunnel and the Snyderville Basin Wastewater Treatment Plant, while spring runoff from snow melt provides the greatest flow, primarily during April and May.

The mean annual precipitation in the East Canyon drainage is 26-37 inches per year, with 73 percent coming from snow during the period of October to April. During spring runoff East Canyon Creek flow increases from 15 cfs to 350 cfs. The East Canyon drainage basin contains 145 square miles and the following 10 small perennial streams: Kimball Creek, McLeod Creek, Spring Creek, Three Mile Creek, Two Mile Creek, Big Bear Hollow, Toll Creek, Schuster Creek, Big Dutch Hollow, and Little Dutch Hallow. Figure 2.3 shows the location of these various streams in the East Canyon Watershed.

A more extensive discussion of the basin hydrology is contained in the section (4) on watershed evaluation. The average flow at the East Canyon Creek near Morgan (USGS Station 10134500) for the period of record, 1938-1996 is 41,520 acre-feet per year. This station is approximately 2,500 feet downstream from the East Canyon Reservoir Dam.

2.4 Point Sources

There are two point sources in the watershed, the Snyderville Basin Wastewater Treatment Plant and Park City's Park avenue storm drain. The Snyderville Basin Wastewater Treatment Plant has been identified by the Division of Water Quality in their report, "Weber River Basin and Farmington Bay Area Stream Assessment(Toole, September, 1995) as a *significant* source of nutrient loading in East Canyon Creek. The Park Avenue storm drain is of lesser significance. No permit has been issued, nor is one pending for the storm drain although stormwater regulations are now being implemented in other areas of the state. The Utah State Division of Water Quality is assessing the need for a NPDES permit, and voluntary action for storm water in Park City.

The Snyderville Basin Wastewater Treatment Plant went on-line in 1980. It serves the Park City/Snyderville Basin area. The facility currently consists of an extended aeration air-activated sludge treatment process with ultraviolet disinfection. The physical plant consists of a bar screen and aerated grit chamber, an influent channel with a weir and equipped with ultrasonic continuous recording equipment and a second influent line equipped with an in-line mag meter, one oxidation ditch and secondary clarifier, two primary clarifiers, one activated sludge aeration basin, two secondary clarifiers, four shallow bed filters with automatic (and manual) backwash, flow paced ultraviolet light disinfection, two aerobic sludge holding tanks, two solids centrifuges, and a mechanical post-aerator basin. The facility was placed in service in 1980 with a design capacity of 1.3 MGD.

In July of 1996 a bioreactor side (oxidation ditch and secondary clarifier) of 1.5 MGD capacity was added voluntarily to the plant operations. One of the primary purposes for this upgrade was to incorporate into their treatment process the ability to reduce nutrients, primarily phosphorus, as much as possible. The plant has a combined current capacity of 2.8 MGD. The existing population equivalent (estimate due to the large influx of population during the recreational ski season) is estimated to be near 22,600 with an expectation of near 28,000 by the year 2003. Data summarized by Snyderville Basin SID prior to May, 1997 indicate that the influent organic loading was 2,504 lbs/day for five-day BOD, and 2,879 lbs/day for TSS.

Effluent limitations imposed on this facility are contained in Utah Pollutant Discharge Elimination System (UPDES) permit number UT0020001. In general there are limitations imposed for ammonia, carbonaceous biochemical oxygen demand, dissolved oxygen, total suspended solids, fecal and total coliforms, pH, and oil and grease. A summary of these limitations is include in Table 2.

The Utah Division of Water Quality has defined new permit limits effective May 1, 1999. Total phosphorus is a new parameter under consideration for inclusion as a limit in a possible reopener of the permit. A current recommended limit has been purposed at 0.05 mg/L or 2.085 pounds per day, whichever value is the most stringent, but negotiation with Snyderville Basin District are underway to define criteria needed in the permit to protect water quality.

Effluent Limitations				
Parameter	30-day average	7-day average	Daily Minimum	Daily Maximum
$CBOD_5$ mg/L/% minimum removal	12/85	17		
TSS, mg/L/Minimum Removal %	25/85	35		
Fecal coliforms #/100 mL	200	250		
Total coliforms #/100 mL	2000	2500		
pH			6.5	9
DO, mg/L			6.0	
Oil and grease, mg/L				10
Ammonia as N, mg/L June-August December-February Other months	 2.0 2.9 2.3			 8.4 10.5 8.6

Table 2 Effluent limitations for Snyderville Basin, East Canyon Plant

2.5 Nonpoint Sources

Sources of pollution which may have an impact on reservoir water quality include: urban runoff; stream bank erosion; agricultural practices; urban and recreational development.

2.5.1 Urban Runoff

Urban runoff is defined as water that originates from urban areas developed for residential and business development within the watershed. It can result from improper irrigation, precipitation on hard surfaces such as asphalt, concrete, or rooftops during and after a rainstorm or as snow melt, or merely as erosion induced as water moves across soils lacking vegetation. As water travels across these types of surfaces, transport of nutrients, sediments, metals and other pollutants occurs.

In the Park City area some of this runoff is contained in a storm water drain system that eventually discharges directly into a live waterway. Where storm drain systems are not present runoff may be transported across a variety of surfaces prior to entering a live waterway. In some cases vegetative buffer strips may be present to reduce or control the movement of some pollutants into live waterways. However, in many areas development that is directly adjacent or near a live stream pollutants may enter a given waterway without any significant loss of sediment or nutrient load. These types of contributions of sediments and nutrients into the system can be a significant source of controllable nutrients and sediments.

Because of the uncertainties about the true significance of urban runoff as a contributor to receiving water quality problems, Congress made treatment of separate stormwater discharges ineligible for Federal funding when it enacted the Clean Water Act (CWA) in 1977. To obtain information that would help resolve these uncertainties, the Agency established the Nationwide Urban Runoff Program (NURP) in 1978. The program was designed as a 5 year effort to gather data to examine such issues as:

1. the quality characteristics of urban runoff,
2. the extent to which urban runoff is a significant contributor to water quality problems, and
3. the performance characteristics and the overall effectiveness and utility of management practices for the control of pollutant loads from urban runoff.

Conclusions from that project are contained in the document, "Results of the Nationwide Urban Runoff Program", produced by the Water Planning Division of U.S. Environmental Protection Agency (USEPA) in December, 1983. The remaining information contained in this section has been taken from that document.

As part of the project, 28 locations were identified to gather data related to urban runoff issues. One of those sites was in Salt Lake City, Utah. An early point in the discussion was the general agreement that urban runoff causes problems. Remedial costs may be high, but the benefits are obvious.

In order to characterize urban runoff, monitoring was conducted at 81 acceptable "loading sites" in 22 different cities and included more than 2300 separate storm events.

The event mean concentration (EMC), defined as the total constituent mass discharge divided by the total runoff volume, was chosen as the primary water quality statistic . Event mean concentrations were based on flow weighted composite samples for each event at each site in the accessible data base. EMCs were chosen as the primary water quality characteristic subjected to detailed analysis, even though it is recognized that mass loading characteristics of urban runoff (e.g., pounds/acre for specified time interval) is ultimately the relevant factor in many situations. The reason is that, unlike EMCs, mass loadings are very strongly influenced by the amount of precipitation and runoff, and estimates of typical annual mass loads will be biased by the size of monitored storm events. The most reliable basis for characterizing annual or seasonal mass loads is on the basis of EMC and site-specific rainfall/runoff characteristics.

The following conclusions were presented as characteristics of urban runoff and are summarized in Table 3:

1. Heavy metals (especially copper, lead and zinc) are by far the most prevalent priority pollutant constituents found in urban runoff. End of pipe concentrations exceed EPA ambient water quality criteria and drinking water standards in many instances. Some of the metals are present often enough and in high enough concentrations to be potential threats to beneficial uses. It should be noted that documentation of these exceedances do not necessarily imply that an actual violation of standards will exist in the receiving waters, but the enumeration of exceedances serves as a screening function to identify those heavy metals whose presence in urban runoff warrants high priority for further evaluation. Based upon the extensive NURP data set for total copper, lead, and zinc, the site median EMC values for the median urban site are: copper = 34 ug/l, lead = 144 ug/l and zinc = 160 ug/l. For the 90^{th} percentile urban

site the values are: copper = 93 ug/l, lead = 350 ug/l and zinc = 500 ug/l. These values are suggested to be appropriate for planning level screening analyses where data are not available.

2. The organic priority pollutants were detected less frequently and at lower concentrations than the heavy metals.
3. Coliform bacteria are present at high levels in urban runoff and can be expected to exceed EPA water quality criteria during and immediately after storm events in many surface waters, even those providing high degrees of dilutions. Fecal coliform counts in urban runoff are typically in the tens to hundreds of thousand per 100 mL during warm weather conditions, with the median for all sites being around 21,000/100 mL. During cold weather, fecal coliforms counts are more typically in the 1,000/100 mL range, which is the median for all sites.
4. Nutrients are generally present in urban runoff, but with a few individual site exceptions, concentrations do not appear to be high in comparison with other possible discharges to receiving water bodies. Median site EMC median concentrations in urban runoff were total phosphorus = 0.33 mg/l, soluble phosphorus = 0.12 mg/l, total kjeldahl nitrogen = 1.5 mg/l and NO2+3 as Nitrogen = 0.68 mg/l.
5. Oxygen demanding substances are present in urban runoff at concentrations approximate to those in secondary treatment plant discharges. If dissolved oxygen problems are present in receiving waters of interest, consideration of urban runoff controls as well as advanced waste treatment appears to be warranted. Urban runoff median site EMC median concentrations of 9 mg/l BOD5 and 65 mg/l COD are reflected in the NURP data, with 90th percentile site EMC median values being 15 mg/l BOD5 and 140 mg/l COD.
6. Total suspended solids concentrations in urban runoff are fairly high in comparison with treatment plant discharges. Urban runoff control is strongly indicated where water quality problems associated with TSS, including build-up of contaminated sediments, exist.

Constituent	**Event to Event Variability in EMC's (Coef Var)**	**Site Median EMC**	
		For Median Urban Site	**For 90th Percentile Urban Site**
TSS (mg/l)	1-2	100	300
BOD5 (mg/l)	0.5-1.0	9	15
COD (mg/l)	0.5-1.0	65	140
Total Phosphorus	0.5-1.0	0.33	0.70
Soluble Phosphorus	0.5-1.0	0.12	0.21
TKN (mg/l)	0.5-1.0	1.50	3.30
NO2+3 -N (mg/l)	0.5-1.0	0.68	1.75
Total copper	0.5-1.0	34	93
Total lead (ug/l)	0.5-1.0	144	350
Total zinc (ug/l)	0.5-1.0	160	500

Table 3 Water Quality characteristics of Urban Runoff

In general the effects of urban runoff on receiving water quality are highly site specific. They depend on the type, size, and hydrology of the waterbody; the urban runoff quantity and quality characteristics; the designated beneficial use; and the concentration levels of the specific pollutants that affect that use.

Although the EMC median concentrations values are appropriate for many applications (e.g., assessing water quality impacts in rivers and streams), when cumulative effects such as water quality impacts in lakes and comparisons with other sources on a long-term basis (e.g., annual or seasonal loads) are to be examined, the EMC mean concentration values should be used. These EMC mean concentrations and the values used in the load comparison to follow are listed in the following Table 4.

Constituent	Site Mean EMC		
	Median Urban Site	**90th Percentile Urban Site**	**Values Used in Load Comparison**
TSS (mg/l)	141 - 224	424 - 671	180 - 548
BOD5 (mg/l)	10 - 13	17 - 21	12 - 19
COD (mg/l)	73 - 92	157 - 198	82 - 178
Total Phosphorus	0.37 - 0.47	0.78 - 0.99	0.42 - 0.88
Soluble Phosphorus	0.13 - 0.17	0.23 - 0.30	0.15 - 0.28
TKN (mg/l)	1.68 - 2.12	3.69 - 4.67	1.90 - 4.18
NO2+3 -N (mg/l)	0.76 - 0.96	1.96 - 2.47	0.86 - 2.21
Total copper	38 - 48	104 - 132	43 - 118
Total lead (ug/l)	161 - 204	391 - 495	182 - 443
Total zinc (ug/l)	179 - 226	559 - 707	202 - 633

Table 4 EMC Mean Values used in Load Comparison

It is a straight forward procedure to calculate mean annual load estimates for urban runoff constituents on a Kg/Ha basis by assigning appropriate rainfall and runoff coefficient values and selecting EMC mean concentration values. A runoff coefficient (RV), defined as the ratio of runoff volume to rainfall volume, has been determined for each of the monitored storm events As with the EMCs, the runoff coefficient values at a particular site area, with relatively few exceptions, well characterized by a lognormal distribution. Typical values for mean runoff coefficient (based on NURP data) have been assigned for residential land use (Rv = 0.3), commercial land use (Rv = 0.8), and for an aggregate urban area which is assumed to have representative fractions of the total area in residential, commercial, and open uses (Rv = 0.35).

Some observations can be made from a general comparison made as part of the NURP study. One of the central points in source identification of pollutants is the determination of the relative magnitude of those contributing sources. A comparison of urban runoff to the general operation of a well run secondary treatment plant was investigated. The following assumptions were made:

- Effluent values used for the treatment plant were TSS = 25 mg/L, BOD5 = 15 mg/L, and total phosphorus = 8 mg/L;
- Urban runoff mean concentrations used were TSS = 180 mg/L, BOD5 = 12 mg/L,

total phosphorus = 0.4 mg/L for a typical situation and TSS ≈ 548 mg/L, BOD5 = 19 mg/L and total phosphorus = 0.88 mg/L for a worst case situation;

- A value of 0.35 was selected as a typical mean runoff coefficient; and
- An average population density of 10 person per acre (the average of the NURP sites) and a mean annual rainfall of 40 inches per year, urban runoff averages 104 gallons per day per capita which is also a reasonable estimate of sewage generation in an urban area.

Therefore, the ratio of mean pollutant concentrations of urban runoff and POTW effluents will also be the ratio (urban values/WWTP values) of their annual loads. Thus, we have;

TSS = 180/25 ≈ 7; BOD5 = 12/15 ≈ 0.8; and Total phosphorus = 0.4/8 ≈ 0.05
using typical urban runoff values, and;

TSS = 548/25 ≈ 22; BOD5 = 19/15 ≈ 1.3; and Total phosphorus = 0.88/8 ≈ 0.01
using worse case values.

These numbers suggest that annual loads from urban runoff are approximately one order of magnitude higher than those from a well run secondary treatment plant for TSS, an equal order of magnitude for BOD5, and an order of one magnitude less for total phosphorus.

If the hypothetical urban area just described were to go to advanced waste treatment and achieve an effluent quality of TSS = 10 mg/L, BOD5 = 5 mg/L and total phosphorus = 1 mg/L and **no urban runoff controls were instituted,** the mean annual load reductions to the receiving waters would be:

TSS = 25-10/180+25 ≈ 7%; BOD5 = 15-5/12+15 ≈ 37%; and Total phosphorus = 8-1/0.4+8 ≈ 83%
for the typical case, and;

TSS = 25-10/548+25 ≈ 3%; BOD5 = 15-5/19+15 ≈ 29%; and Total phosphorus = 8-1/0.88+8 ≈ 79%
for the worst case scenario.

On the other hand, if urban runoff controls that reduced TSS by 90%, BOD5 by 60%, and total phosphorus by 50% were instituted, (typical results from a well designed detention basin), the mean annual load reductions to the receiving waters would be:

TSS = 180-18/180+25 ≈ 79%; BOD5 = 12-7/12+15 ≈ 19%; and Total phosphorus = 0.4-0.2/0.4+8 ≈ 2%
for the typical case, and;

TSS = 548-55/548+25 ≈ 86%; BOD5 = 19-8/19+15 ≈ 32%; and Total phosphorus = 0.88-.44/0.58+8 ≈ 5%
for the worst case scenario.

Therefore if these pollutants are causing receiving water quality problems, consideration of urban runoff control appears warranted for TSS, both urban runoff control and advanced wastewater treatment might be considered for BOD5, and only advanced wastewater treatment might be effective for total phosphorus control under these scenarios.

It should be noted that local values for annual rainfall, runoff coefficient, or point source characterization that are different than those used in the illustration will of course change the results shown; although in most cases the changes would not be expected to cause a significant change in the general relationship. However, removal of phosphorus from all sources in a water quality impaired watershed is important. Reductions from sources other than a treatment plant with advanced wastewater treatment may be more economical and practical due to escalating costs associated with chemical removal of phosphorus to low concentrations. When attempting to reduce annual total phosphorus loadings due to cost constraints, it may be more beneficial to focus on reduction from other sources.

As a final perspective on urban runoff loads, Table 5 presents an estimate of annual urban runoff loads, expressed as Kg/Ha/year, for comparison with other data summaries of nonpoint source loads which state results in this manner. Load computations are based on site mean pollutant concentrations for the median urban site and on the specified values for annual rainfall and runoff coefficient.

Constituent	Site Mean Concentration mg/L	Residential Rv = 0.3	Commercial Rv = 0.8	Aggregate Rv = 0.35
TSS	180	550	1460	640
BOD5	12	36	98	43
COD	82	250	666	292
Total Phosphorus	0.42	1.3	3.4	1.5
Soluble Phosphorus	0.15	0.5	1.2	0.5
TKN	1.90	5.8	15.4	6.6
NO2+3 -N	0.86	2.6	7.0	3.6
Total copper	0.043	0.13	0.35	0.15
Total lead	0.182	0.55	1.48	0.65
Total zinc	0.202	0.62	1.64	0.72

Table 5 Estimate of Annual Urban Runoff Loads (Kg/Ha/year)

The annual load estimates which results are comparable to values and ranges reported in the literature. Remember the annual loads shown by Table 5 have been computed on the basis of a 40 inch annual rainfall volume. For urban areas in regions with higher or lower rainfall, theses loads estimates can be adjusted by factoring by the ration of local rainfall volume to the 40 inch volume used for the table provided the remaining variables remain constant.

A review of best management practices (BMP's) for control effectiveness of urban runoff, indicates there is a strong preference for detention devices, street sweeping, and recharge devices as reflected by the control measures selected at the local level for detailed investigation. Interest was also shown in grass swales and wetlands. A discussion of these measures can be found in the NURP report.

2.5.2 Stream Bank Erosion

Stream bank erosion, the loss of sediments in direct proximity to waterways can be attributed to several factors. Typically the stability of streambanks is reduced due to an alteration or loss of the protective vegetative cover essential for stabilization of those soils comprising the bank structure. These unstable soils can then be eroded away by water movement or a variety of mechanical mechanisms.

Although there is no comprehensive quantitative study assessing the conditions of all of the stream channels in the watershed, it can be stated that there is a general agreement that one of the sources of sediment and total phosphorus to East Canyon Reservoir is the existence of unstable streambanks. Denuded streambanks do occur and areas of active erosion are present in the watershed. Refer to section 8.1.2 for a description of current streambank conditions.

2.5.3 Agriculture

Many of the activities associated with farming or ranching provide the potential for the movement of nutrients , salts, sediments or other pollutants into adjacent waterbodies. However, through utilization of good agronomic practices and appropriate best management practices (BMP's) these can be reduced or eliminated.

The quantity of phosphorus in agricultural runoff is influenced by 1) the amount of phosphorus in the soil, 2) topography, 3) vegetative cover, 4) quantity and duration of runoff, 5) land use, and 6) cropping practices. All though runoff from agricultural land has not been precisely quantified, it is presently contributing to the overall nutrient load to the reservoir and the implementation of BMP's could reduce the overall loading of total phosphorus into watershed waters.

Currently the proposed development of the 640 acre Leland Swaner Memorial Wetland, will remove approximately 640 acres from agriculture production. This will not only reduce agricultural impacts on water quality for this area, but enhance the treatment of some surface waters in this area of the watershed.

Data from this study and other studies indicated that the Osguthorpe Dairy was responsible for the transport of animal waste and surface wash from feeding areas directly into the stream. Currently this dairy operation is not an active dairy. Some animal wastes may still be present that could move into adjacent waterways during episodic precipitation events, but the inactivation of this dairy in the long term represents a significant decline of agricultural source of nonpoint source of pollution.

Through the urbanization of the Park City and Snyderville Basin, agriculture is giving way to housing, business and recreational developments. Even with the loss of many agricultural acres there are still agricultural activities in the watershed that will need to be addressed to reduce or eliminate identified sources of nutrients and sediments into existing waterways.

The Division of Water Quality is in the process of trying to identify and quantify existing nonpoint sources of pollutants in the watershed through a consulting firm. A major focus of their effort will be to ascertain the affect of conversion of agricultural lands into urban and recreational areas. The primary purpose is to develop and implement strategies to control or eliminate pollutants that might result as a result of this shift in land use in the watershed.

2.5.4 Urban Development

Urban development pertains to those activities that occur during the natural construction activities required as an area moves to a residential and business type setting. During this process it is only natural for soil to be disturbed and the potential for new sources of pollutants to occur unless active steps are taken to prevent the movement of materials into adjacent waterways.

During the past twenty years, Park City and much of the Snyderville Basin has had a steady increase in the number of recreational and permanent homes built, business properties developed, and recreation facilities (ski resorts, golf courses et.al.) developed. It is readily apparent that this trend will continue, if not escalate, for some time to come. Many of these developments have allowed runoff from their properties or sites of construction or other activities to discharge to the nearest drainage way or stream without adequate types of detention or sediment control.

Current planning efforts will need to be implemented to control the movement of sediments and nutrients from these types of sites through the implementation of best management practices which inhibit movement of such materials from construction sites. To assure adequate protection from contaminated runoff from these areas or sites a concerted effort with a focus on local planning and zoning ordinances with periodic inspections to assure compliance with ordinances will need to be implemented by local governmental entities.

3.0 WATER QUALITY MONITORING

3.1 Water Quality Monitoring Sites

Water Quality monitoring for this project was designed to determine nutrient loadings from the watershed and to establish the limnological conditions present in the reservoir. In addition significant emphasis was directed towards lake productivity and eutrophication. Monitoring sites are listed in Table 6 and referenced by location in figure 2.3.

3.2 Sampling Procedure

During the Clean Lakes Phase I study, sampling was conducted by personnel from the Utah Department of Environmental Quality and the Weber Basin Water Conservancy District. A Hydrolab was used to measure temperature, pH, dissolved oxygen and conductivity in the field.

All water samples obtained were "grab samples". Dissolved nutrients and

Site	Location	STORET Number	Station Number	Miles above Res.
L1	East Canyon Reservoir above dam	492516	WBWCD 01	0
L2	East Canyon Reservoir in east arm	492513	WBWCD 02	0
L3	East Canyon Reservoir in south arm	492518	WBWCD 03	0
S1	East Canyon Creek below East Canyon Reservoir	492515	WBWCD 01	-0.4
S2	East Canyon Creek above reservoir at USGS station	492519	WBWCD 02	0.2
S3	East Canyon Creek at U65 crossing	492520		0
S4	East Canyon Creek at bridge above Big Dutch	492521	WBWCD 03	0
S5	East Canyon Creek below Jeremy Ranch golf course	492523	WBWCD 04	0.5
S6	East Canyon Creek below Snyderville WWTP	492524		11.6
S7	Snyderville Basin WWTP	492525	SBWWTP	12.4
S8	East Canyon Creek above Snyderville WWTP	492526		12.4
S9	East Canyon Creek 2.8 miles above Snyderville WWTP		WBWCD 05	15.2
S10	Kimble Creek		WBWCD 06	17.7
S11	McLeod Creek below Park City		WBWCD 07	22.1
L=Lake S=Stream				

Table 6 Water Quality Monitoring Sites

chlorophyll-a samples were filtered with a peristaltic pump through a millipore filter (0.45μ). Chlorophyll-a samples were stored in a dark container and frozen prior to analysis. Unlike stream or effluent grab samples, lake samples were collected using a Van Dorn sampler at designated depths through the water column.

Water samples were refrigerated and transported to either the Utah State Department of Health Laboratory in Salt Lake City or the Weber Basin Water Conservancy District Laboratory located in Layton, Utah. Later during the extended phase of monitoring, personnel from Snyderville Basin wastewater improvement district participated in the collection of samples. They focused primarily on the collection of samples associated with their facility discharge. These samples were analyzed by a State certified lab or the State Health Laboratory and which followed established criteria established by the Division of Water Quality.

All sampling conducted by the Division of Water Quality was in accordance with procedures and methods outlined in their quality assurance and procedures manual.

3.3 Sampling Schedule

3.3.1 Monitoring

Although, the initial monitoring schedule for the Phase I diagnostic/feasibility study was to sample lake sites on a monthly basis from June 1991 through June 1993 and stream and effluent sites on a biweekly basis from March, 1992 through June, 1993, a review of the data shows that there really was insufficient data obtained to conclusively move forward with recommendations for restoration. Due to the potential impact to the wastewater treatment plant in the watershed, it was mutually agreed upon by the parties involved that more data be obtained for limnological assessment of the reservoir and an extension of time for the project be allowed to evaluate a new biological treatment process being implemented at the wastewater treatment plant be conducted.

An additional period of monitoring was established through a cooperative monitoring program with the Snyderville Basin Sewer Improvement District (SBSID). Additional sampling was extended through September, 1997, but only sites at or below 492526 were monitored. In addition to the original monitoring plan phytoplankton samples were schedule for collection on the reservoir to provide addition information to support the trophic state classification of the reservoir and a more rigorous and extensive monitoring plan was developed to assess the impact of new facilities at the wastewater treatment plant.

In an effort to assess the effectiveness of the biological process added in the treatment monitoring was schedule at the treatment plant to coincide with the stream monitoring. When the biological process came on line the monitoring schedule would increase in frequency to provide as much data as possible for an effective evaluation of the plant by SBSID staff.

3.4 Parameters Measured

3.4.1 Lake Sites

Field measurements

Temperature, Dissolved oxygen, pH, Specific Conductance, Secchi depth and/or photo extinction

Lab Analysis

Nutrients:
Total Phosphorus, Total filterable Phosphorus, Total Kjeldahl Nitrogen, Nitrate/Nitrite, and Ammonia as N

Metals:
Arsenic, Cadmium, Copper, Lead, Mercury, Silver, Manganese, Barium, Chromium, Iron, Selenium, and Zinc

Chemistry:
pH, Alkalinity, Volatile Suspended Solids, Residual Suspended Solids, Calcium, Potassium, Total Hardness, Magnesium, Sodium, Chloride Sulfate

Biological:
Chlorophyll-a, Macrophyte, Phytoplankton

3.4.2 Stream Sites

Field measurements
Temperature, Dissolved oxygen, pH, Specific Conductance

Lab Analysis

Nutrients:
Total Phosphorus, Total filterable Phosphorus, Total Kjeldahl Nitrogen, Nitrate/Nitrite, and Ammonia as N

Metals:
Arsenic, Cadmium, Copper, Lead, Mercury, Silver, Manganese, Barium, Chromium, Iron, Selenium, and Zinc

Chemistry:
pH, Alkalinity, Volatile Suspended Solids, Residual Suspended Solids, Calcium, Potassium, Total Hardness, Magnesium, Sodium, Chloride Sulfate

Biological:
Macrophyte

3.5 Laboratory Sites

All water quality analysis, except field parameters, were performed by either the Utah Department of Health Laboratory in Salt Lake City, Weber Basin Water Conservancy District Laboratory located in Layton, Utah, Snyderville Basin WWTP laboratory, or another certified laboratory under contract with Snyderville Basin WWTP. Field parameters were measured on-site with a Hydrolab.

3.6 Quality Assurance and Quality Control

Sample collection, quality control, and data storage for all water quality samples in this study were done in accordance with the State of Utah standards and procedures. For a complete review refer to the Division of Water Quality's quality assurance and procedures manual.

All laboratories are State-certified environmental laboratories and maintain an effective written Quality Assurance Plan to ensure that routinely generated analytical data are scientifically valid and are of known and acceptable precision and accuracy.

As part of the DWQ's routine quality assurance program, the validity of total phosphorus data for 1997 came into question. Through the combined efforts of DWQ staff and the Utah State Health Laboratory (USHL) all of the phosphorus data for the period in question was scrutinized utilizing a ridged set of quality assurance/quality control criteria. Only the data that met the established guidelines was utilized for our report. Erroneous data was deleted for the DWQ's database. Therefore it should be noted that summaries of the 1997 data set do not have as many data points as the previous three years (1994-96) of the extended study period.

4.0 WATERSHED EVALUATION

4.1 Hydrology

The watershed area of East Canyon Reservoir contains 145 square miles. This watershed produced an average annual water inflow to the reservoir of approximately 41,520 acre-feet according to USGS flow records for the period 1931 through 1996. For the period 1992 through 1997, annual water budgets varied substantially from the annual average flow as depicted in Table 7.

A very simplified water budget formula has been used in determining water budgets for the study period:

Total reservoir inflow *= Outflow + Change in reservoir storage + Precipitation + Groundwater - Evaporation*

The documented flows in the watershed include the outflow as gaged at the USGS station 10134500 (East Canyon Creek near Morgan, Ut), the change in reservoir storage as indicated from USGS station 10134000 (East Canyon Reservoir near Morgan, Ut), and estimates for precipitation, and evaporation. Groundwater and other inflow from minor streams are estimated as one variable.

Flow data above the Snyderville wastewater treatment plant (SBWWTP) was calculated using the USGS flow determinations at their station 10133895, East Canyon Creek above Big Bear Hollow near Park City, Utah, minus the reported flows from SBWWTP. Records from this station are present for the period late 1989 through early 1996. The average annual flow at the Big Bear Hollow station from 1989 through early 1996 is 23,210 acre-feet. The approximate average annual flow for the same period for East Canyon Creek above the treatment plant is estimated at 22,295 acre-feet. This value was estimated by subtracting from the average annual flow at Big Bear Hollow from the average annual discharge from the treatment plant. It should be noted that the average total flow into East Canyon Reservoir for the same period is 33,134 acre-feet on a calendar year basis which is approximately 80 per cent of the long term average annual flow to the reservoir. An estimated long-term flow of 27,869 acre-feet per year will be used later in determining annual loads above the wastewater treatment plant. This value was determined by calculating 80% of the long-term flow rate above the reservoir and should be used for planning purposes only.

The total water stored in the reservoir is based primarily on the USGS flow records for the reservoir and the discharge from the reservoir. The reservoir station is an record of the acre-feet of water present in the reservoir and associated changes in the storage over time. The stream station (Morgan site) located approximately 2,500 feet downstream from the reservoir is an active station for the period of record 1931 to current date.

As indicated in Table 1 total inflow to the reservoir was determined by adding to the flow data from the stream station, 10134500, any change in storage volume in the reservoir for a given time period. For calculations of total inflow it was assumed that precipitation was equal to evaporation and that groundwater recharge coupled with intermittent tributary flows adjacent to the reservoir are minimal or not significant enough to change the overall inflow value to the reservoir.

TIME	East Canyon Creek above WWTP 492526	Snyderville WWTP 492525	East Canyon Creek below WWTP 492524	Total Reservoir Inflow (M + CIS) 492519/20	East Canyon Creek near Morgan, Utah 492515	Retention Period	East Canyon Reservoir Change in Storage per Period
96/97				61,840	60,590	0.98	1,350
96	*33,379	2,051	*35,430	54,620	58,050	1.06	(3,430)
95/96			34,870	54,060	57,430	1.06	(3,370)
1995	39,335	1,795	41,130	59,900	48,230	0.81	11,670
94/95			40,690	57,930	47,770	0.82	10,160
1994	15,220	1,550	16,770	22,350	32,360	1.45	(10,040)
93/94			17,350	22,630	32,950	1.46	(10,320)
1993	31,909	1,771	33,680	47,410	27,350	0.58	20,060
92/93			31,830	46,240	26,690	0.58	19,550
1992	7,700	1,250	7,700	12,150	29,560	2.43	(17,410)
91/92			8,220	12,980	29,780	2.29	(16,800)
1991	17,999	1,111	19,110	25,350	13,560	0.53	11,790
90/91			18,890	24,590	13,200	0.54	11,390
1990	9,473	967	10,440	15,660	22,830	1.46	(7,170)
89/90			10,640	16,240	23,180	1.43	(6,940)
1989		922		28,640	25,270	0.88	3,370
88/89				28,300	25,470	0.90	2,830
1988		609		18,080	19,530	1.08	(1,450)
87/88				19,750	19,560	0.99	190
1987		1,336		31,230	40,620	1.30	(9,390)

Table 7 Water budget summary
* Estimated values based on previous year data

4.2 Metal Analysis

Arsenic, cadmium, copper, lead, mercury, silver, manganese, barium, chromium, iron, selenium, and zinc were evaluated at four stream sites in the watershed. The standards used for assessment were those associated with the 1C designation for culinary waters and 3A designation for a cold water fishery. The most stringent standard was used to determine impairment. In general average values throughout the watershed did not exceed the State water quality standards for defined beneficial uses. However there were two specific samples where it exceedances of the standards did occur. The cold water fishery standard for lead is 3.2 ug/L for the 4 day average, but 82 ug/L for the 1 hour average. At East Canyon Creek below East Canyon Reservoir there was a reported value of 5.0 ug/L

Date	Ar	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn	Al	Hg
East Canyon Creek below East Canyon Reservoir (492515)													
4/14/93	<5.0	100	<1.0	<5.0	<20.0	<30.0	<3.0	94	<5.0	<2.0	<20.0		<0.2
7/22/93	<5.0	82	<1.0	<5.0	<20.0	<30.0	<3.0	15	<2.0	<2.0	<30.0		<0.2
11/23/93	<5.0	78	<1.0	<5.0	<20.0	<20.0	<3.0	20	<1.0	<2.0	<30.0		<0.2
1/13/94	<5.0	110	1	<5.0	<20.0	82	<3.0	13	<1.0	<2.0	<30.0		<0.2
2/16/94	<5.0	92	<1.0	<5.0	<20.0	<20.0	<3.0	41	<1.0	<2.0	<30.0		<0.2
4/6/94	<5.0	91	<1.0	<5.0	<20.0	<20.0	<3.0	51	<1.0	<2.0	<30.0		<0.2
8/11/94	<5.0	90	<1.0	<5.0	<20.0	<20.0	5	37	<1.0	<2.0	<30.0	<30.0	<0.2
Mean		**92**						**39**					
Maximum	**<5.0**	**110**	**1**	**<5.0**	**<20.0**	**82**	**5**	**94**	**<5.0**	**<2.0**	**<30.0**	**<30.0**	**<0.2**
East Canyon Creek above East Canyon Reservoir at U65 (492520)													
6/24/92	<5.0	100	<1.0	<5.0	<20.0	<20.0	<5.0	18	<5.0	<2.0	<20.0		<0.2
8/6/92	<5.0	120	<1.0	<5.0	<20.0	<20.0	<5.0	43	<5.0	<2.0	<20.0		0.2
9/24/92	<5.0	120	<1.0	<5.0	<20.0	28	<5.0	61	<5.0	<2.0	<20.0		<0.2
11/5/92	<5.0	120	1	<5.0	<20.0	51	<5.0	76	<5.0	<2.0	<20.0		<0.2
1/20/93	<5.0	110	<1.0	<5.0	<20.0	28	<3.0	43	<5.0	<2.0	48		<0.2
4/1/93	<5.0	96	<1.0	<5.0	<20.0	54	<3.0	84	<5.0	<2.0	<20.0		<0.2
4/14/93	<5.0	99	<1.0	<5.0	<20.0	58	<3.0	77	<5.0	<2.0	<20.0		<0.2
7/22/93	<5.0	90	<1.0	<5.0	<20.0	<30.0	<3.0	25	<2.0	<2.0	<30.0		<0.2
11/23/93	<5.0	96	<1.0	<5.0	<20.0	<20.0	<3.0	21	<1.0	<2.0	<30.0		<0.2
1/13/94	<5.0	94	<1.0	<5.0	<20.0	<20.0	<3.0	17	<1.0	<2.0	<30.0		<0.2
2/16/94	<5.0	100	<1.0	<5.0	<20.0	<20.0	<3.0	20	<1.0	<2.0	<30.0		<0.2
4/6/94	<5.0	110	<1.0	<5.0	<20.0	<20.0	<3.0	63	<1.0	<2.0	<30.0		<0.2
8/11/94	5	110	<1.0	<5.0	<20.0	<20.0	<3.0	24	<1.0	<2.0	<30.0	<30.0	<0.2
8/1/96	<5.0	100	<1.0	<5.0	<12.0	123	<3.0	57	<1.0	<2.0	<30.0	80	<0.2
10/23/96	<5.0	110	<1.0	5.6	<12.0	<20.0	<3.0	25	<1.0	<2.0	<30.0	<30.0	<0.2
1/30/97	<5.0	110	<1.0	6.1	<12.0	<20.0	<3.0	72	<1.0	<2.0	<30.0	<30.0	<0.2
8/6/97	<5.0	100	<1.0	<5.0	<12.0	<20.0	<3.0	34	<1.0	<2.0	<30.0	<30.0	<0.2
10/21/97	<5.0	100	<1.0	<5.0	<12.0	29.4	<3.0	27	<1.0	<2.0	<30.0	<30.0	<0.2
Mean		**105**						**44**					
Maximum	**5**	**120**	**1**	**6.1**	**<20.0**	**123**	**<3.0**	**84**	**<5.0**	**<2.0**	**48**	**80**	**0.2**
East Canyon Creek below golf course (492523)													
4/15/93	<5.0	97	<1.0	<5.0	<20.0	<30.0	<3.0	67	<2.0	<2.0	44		<0.2
7/20/93	<5.0	83	<1.0	<5.0	<20.0	<30.0	<3.0	31	<2.0	<2.0	<30.0		<0.2
10/27/93	<5.0	78	<1.0	<5.0	<20.0	<20.0	<3.0	24	<1.0	<2.0	<30.0		<0.2
11/23/93	<5.0	87	<1.0	<5.0	<20.0	<20.0	<3.0	32	<1.0	<2.0	<30.0		<0.2
2/17/94	<5.0	85	<1.0	<5.0	<20.0	22	<3.0	50	1	<2.0	<30.0		<0.2
4/5/94	<5.0	110	<1.0	<5.0	<20.0	27	<3.0	91	<1.0	<2.0	<30.0		<0.2
Mean		**90**				**25**		**49**					
Maximum	**<5.0**	**110**	**<1.0**	**<5.0**	**<20.0**	**27**	**<3.0**	**91**	**1**	**<2.0**	**44**		**<0.2**
East Canyon Creek above Snyderville Wastewater Treatment Plant (492526)													
6/24/92	<5.0	59	<1.0	<5.0	<20.0	<20.0	<5.0	31	<5.0	<2.0	<20.0		<0.2
8/6/92	<5.0	77	<1.0	<5.0	<20.0	28	<5.0	170	<5.0	<2.0	<20.0		<0.2
9/24/92	<5.0	66	<1.0	<5.0	<20.0	<20.0	<5.0	68	<5.0	<2.0	<20.0		<0.2
11/5/92	<5.0	74	<1.0	<5.0	<20.0	<20.0	<5.0	34	<5.0	<2.0	<20.0		<0.2
7/22/93	<5.0	82	<1.0	<5.0	<20.0	<30.0	<3.0	15	<2.0	<2.0	<30.0		<0.2
11/23/93	<5.0	78	<1.0	<5.0	<20.0	<20.0	<3.0	20	<1.0	<2.0	<30.0		<0.2
1/21/93	<5.0	74	<1.0	<5.0	<20.0	22	<3.0	97	<5.0	<2.0	150		<0.2
4/1/93	<5.0	83	<1.0	<5.0	<20.0	63	<3.0	73	<5.0	<2.0	<20.0		<0.2
4/15/93	<5.0	75	<1.0	<5.0	<20.0	<30.0	<3.0	45	<2.0	<2.0	<30.0		<0.2
7/20/93	5	78	<1.0	<5.0	<20.0	<30.0	<3.0	24	<2.0	<2.0	<30.0		<0.2
10/27/93	<5.0	67	<1.0	<5.0	<20.0	22	<3.0	15	<1.0	<2.0	<30.0		<0.2
11/23/93	<5.0	77	<1.0	<5.0	<20.0	<20.0	<3.0	21	<1.0	<2.0	<30.0		<0.2
2/17/94	<5.0	68	<1.0	<5.0	<20.0	<20.0	<3.0	44	<1.0	<2.0	<30.0		<0.2
4/5/94	<5.0	94	<1.0	<5.0	<20.0	32	<3.0	77	<1.0	<2.0	<30.0		<0.2
Mean		**74**						**58**					
Maximum	**5**	**94**	**<1.0**	**<5.0**	**<20.0**	**63**	**<5.0**	**170**	**<5.0**	**<2.0**	**150**		**<0.2**

Table 8 Metal analysis for watershed stream sites (values in ug/L).

in August, 1994. Although this value exceeds the 4 day average it is well below the 1 hour value. This is near the minimum detectable limit (MDL) of 3.0 ug/L and all other samples were reported at less than the MDL. Since the average appears less than the standard it appears that no significant violation has occurred. The other parameter of concern is zinc which has a 4 day average standard of 110 ug/L with a 1 hour average of 120 ug/L. In January, 1993 a value of 150 ug/L was report. This site is East Canyon Creek above Snyderville Wastewater Treatment Plant. All of the other samples at this site were reported below the minimum detectible limit. It does not appear that this is a problem of concern using similar reasoning as related to the lead parameter violation. In general there appears to be no metal problems within the watershed and the data obtained is summarized in Table 8.

Fish, invertebrates, and crayfish were collected by Utah Department of Wildlife Resources in September of 1990 and submitted to the Bureau of Reclamation for trace element analysis. Sediment Samples were also collected and analyzed for trace elements and nutrients.

Fish tissue analysis by the USBR revealed only one large fish to have mercury levels anywhere near a standard. The fish analyzed had levels of 0.4 ppm, whereas the standard for commercial seafood is 1 ppm. Utah does not have an adopted standard. Refer to Table 9 for data.

The edible tissue fish portions in East Canyon were low in all trace elements that might be harmful for human consumption, with the possible exception of mercury in a single rainbow trout sample. This fish weighted 816 grams as compared to the mean for all rainbow collected of about 126 grams. The 816 gram rainbow had a weight wet (fresh weight) mercury concentration of .41 ppm in edible tissue (muscle fillet) and 0.53 ppm in a combination liver/kidney sample. The Food and Drug Administration (FDA) has established a standard of 1 ppm fresh weight for commercial fish.

Many States have adopted a lower standard than the FDA 1 ppm for fresh weight, particularly for expectant mothers and young children. The State of Utah has not adopted a more stringent standard for sport fisheries, and relies on the FDA standard. Because mercury can accumulate faster in tissues than the excretion rate, larger and older fish which are higher on the food chain do tend to accumulate higher concentrations in their tissues. In general the fish in East Canyon Reservoir are not considered to be toxic and have a lower range and average mercury content than canned tuna.

In addition this one larger fish also had higher selenium concentrations, but only in the liver/kidney and not in the edible tissue. Selenium is antagonistic to mercury toxicity and is an essential trace element. This value is well within permissible concentrations for human consumption.

The biological tissue data collected from organisms in East Canyon Reservoir do not have concentrations of trace elements that should warrant any public health advisories for human consumption based on Utah or FDA standards. The trace elements are well within normal ranges, and no health impairment or biological affects would be expected to the biota based on the samples collected in 1990.

4.3. Chemical Analysis

In general water quality within the watershed boundaries is characterized as 'good' when comparing general parameter constituents with state water quality

East Canyon Reservoir Fish Tissue Analysis											
Sample Description	MCG/G										
	As DW	As WW	Cd DW	Cd WW	Pb DW	Pb WW	Hg DW	Hg WW	Se DW	Se WW	% Water
1 Kokanee Whole Body	0 200	0.060	0 020	0 004	0 100	0 030	0.686	0 174	1.100	0.280	74 7
2. Kokanee Edible Tissue	0 200	0 050	0 010	0 002	0.100	0.020	0.674	0 162	0.620	0 150	76
3 Kokanee Liver	0.200	0.050	0 058	0 011	0 100	0.020	1 600	0.300	5.200	1 000	80.7
4 Kokanee Whole Body	0 400	0.200	0 020	0.007	0 010	0.040	0.600	0 224	0.740	0.280	62 6
5. Redside Shinner Whole Body	0 700	0.140	0 020	0.004	0 300	0.060	0 350	0.070	1 000	0.210	80
6 Redside Shinner Whole Body	0 590	0.150	0 043	0.011	0 100	0 030	0 400	0.100	1.100	0.280	73 9
7. Redside Shinner Whole Body	0 600	0 100	0 030	0 008	0 010	0.020	0 420	0.110	1.200	0 300	74 7
8 Redside Shinner Whole Body	0 760	0.210	0 055	0.015	0 300	0.070	0.400	0 110	1.000	0 290	72 3
9 Redside Shinner Whole Body	0 600	0.160	0 030	0.007	0 090	0.030	0 470	0 130	0 930	0 250	73.1
10. Trout Whole Body	0.500	0.100	0 034	0.008	0 090	0.020	0 450	0.100	1.200	0.260	77 3
11 Trout Edible Tissue	0 200	0.060	0 010	0.003	0.090	0.030	0 850	0 233	0.670	0.180	72.6
12 Trout Liver/Kidney	0.200	0.060	0.068	0.016	0 100	0 020	1.100	0.260	15.100	3 510	76.8
13 Trout Edible Tissue	0.200	0 050	0.010	0 003	0 100	0.020	0.670	0.132	1.000	0 200	80 3
14 Trout Liver/Kidney	0 700	0 100	0.058	0.010	0.200	0 030	0 470	0 082	5.700	0 990	82 5
15. Trout Whole Body	0.300	0 050	0.010	0.002	0.100	0.020	0 440	0 910	1.100	0 220	79.3
16 Trout Edible Tissue	0 300	0 070	0.010	0 002	0.100	0.020	0.594	0.133	1.500	0 330	77.6
17. Trout Liver/Kidney	0 100	0 200	0 032	0.007	0.100	0 020	0 520	0.107	4.700	0.970	79.4
18 Trout Whole Body	0 200	0.060	0 043	0.012	0 100	0.030	0 575	0 161	2.400	0.670	72
19. Trout Edible Tissue	0 300	0.080	0 010	0.002	0.100	0.020	1.700	0 410	1.600	0.400	75 3
20. Trout Liver/Kidney	0 300	0 070	0 130	0.003	0.100	0.020	2 300	0 530	13.000	3.000	77 3
21. Sucker Whole Body	0 780	0.120	0 070	0 010	0.380	0.055	0 130	0 019	2.300	0 340	85 3
22. Sucker Whole Body	0 600	0.180	0 037	0.011	0.200	0 050	0.088	0 265	0.890	0.270	69 7
23. Crayfish	1.700	0 490	0.038	0 011	0 680	0 020	0 160	0 047	0.770	0 220	71
24. Crayfish	2 300	0.060	0 088	0 023	0.940	0.240	0 062	0 016	0 900	0 230	74 1
25. Crayfish	2.300	0.410	0 057	0 010	0.740	0 130	0 036	0 006	1 100	0 200	82 4
26. Crayfish	1.800	0 540	0.079	0 024	0.760	0 240	0.120	0 035	0.700	0 220	69 6
MDL	0 02	0.02-3	0 1	0.00- 001	0.1	0.01-4	0 01-2	.001-5	0 1-3	0.01-6	
27 Benthic Invertebrate	15 000	1 700	1.200	0.140	49.000	5 700	0 076	0 009	1.030	0 160	88.3
28 Benthic Invertebrate	11 000	2 000	0.930	0 170	30.000	5 500	0 058	0.010	0 870	0.160	81.8
29 Benthic Invertebrate	10.000	3 200	1 400	0.430	39.000	12.000	0 054	0.017	0 580	0.180	68 6
30. Benthic Invertebrate	12.000	0 680	1.200	0.070	58.000	3.200	0 084	0.005	0.980	0.054	94.5
31. Benthic Invertebrate	17 000	1 100	1 100	0.073	44 000	2 900	0.059	0.004	1 200	0.078	93 4

Benthic invertebrate MDL 1-2 1-3 0.2 0 01-.006 4 1 0.01 0 0003- 002
Data provided by Jerry Miller, U.S. Bureau of Reclamation Samples collected on September 14, 1990

Table 9 Metal analysis of aquatic life in East Canyon Reservoir standards. Total alkalinity and hardness, total suspended solids, residual solids, total volatile solids, calcium, potassium, magnesium, chloride, sodium, and sulfate were evaluated. Table 10 summarizes the data obtained during the study period on an annual basis. None of these chemical parameters in the watershed exceeded the State water quality standards for East Canyon Creek's designated beneficial uses. The water quality at East Canyon Creek above East Canyon Reservoir at U65 station is considered to be hard to very hard with an average concentration of 298 mg/L with a maximum reported value of 377 mg/L for the period 1990 through 1997. The average alkalinity concentration is 197 mg/L with a range from 145 to 238 mg/L for the same period at this site. The effects of hardness on freshwater fish and other aquatic life appear to be related to those ions that comprise the hardness and not the hardness itself. In general the hardness and alkalinity concentrations and other parameters monitored for these waters don't constitute a problems for defined beneficial uses.

Date	Ca	Mg	K	Na	Cl	SO4	T. Alk	T. Hard	TSS	TVS	RSS
			MDL = 1						MDL = 3		MDL = 3
East Canyon Creek below East Canyon Reservoir (492515)											
4/14/93	80.0	19.0	2.4	55.0	84.9	82.7	193	278	20.0	6.0	14.0
4/29/93	65.0	13.0	1.6	27.0	58.0	50.1	145	216	12.0		
5/12/93	78.0	19.0	2.5	54.0	87.4	80.9	185	273	10.0	6.0	4.0
5/25/93	72.0	18.0	2.4	52.0	83.9	75.4	172	254	8.0	6.0	1.5
6/10/93	63.0	14.0	2.3	29.0	53.0	51.1	151	215	9.0	3.0	6.0
7/22/93	75.0	16.0	2.4	39.0	74.7	67.1	167	253	1.5	2.0	1.5
8/25/93	73.0	16.0	1.8	34.0	62.0	65.6	169	248	1.5	4.0	0.0
9/23/93	73.0	17.0	2.4	40.0	74.9	67.8	170	252	1.5	2.0	1.5
10/28/93	71.0	17.0	2.3	46.0	71.9	68.1	183	247	4.0	2.0	1.5
11/23/93	68.0	17.0	2.1	47.0	77.4	70.5	180	240	1.5	0.0	3.0
1/13/94	73.0	19.0	2.1	40.0	63.9	59.1	200	260	1.5	1.0	1.5
2/16/94	77.0	18.0	2.3	48.0	74.9	69.4	177	266	1.5	3.0	1.5
3/24/94	78.0	19.0	2.0	40.0	75.0	65.6	177	273	27.0	8.0	19.0
4/6/94	77.0	18.0	2.3	39.0	72.0	68.0	177	266	8.0	2.0	6.0
4/21/94	79.0	19.0	2.3	48.0	80.5	72.4	185	275	4.0	2.0	1.5
5/3/94	76.0	18.0	2.3	50.0	77.5	67.8	184	264	8.0	2.0	6.0
5/17/94	76.0	18.0	2.2	50.0	78.5	67.5	185	264	4.0	4.0	1.5
6/1/94	77.0	17.0	2.1	39.0	69.5	63.6	194	262	5.0	1.0	4.0
6/15/94	80.0	18.0	2.5	40.0	75.5	69.7	182	274	6.0	4.0	1.5
Mean	**74.0**	**17.0**	**2.2**	**43.0**	**73.4**	**67.5**	**178**	**257**	**7.1**	**3.2**	**4.2**
Maximum	**80.0**	**19.0**	**2.5**	**55.0**	**87.4**	**82.7**	**200**	**278**	**27.0**	**6.0**	**19.0**
Minimum	**63.0**	**13.0**	**1.6**	**27.0**	**53.0**	**51.1**	**145**	**215**	**1.5**	**0.0**	**0.0**
East Canyon Creek above East Canyon Reservoir at U65											
1/16/90	100.0	22.0	2.0	93.0	160.0	100.0	200	340	1.5		
2/15/90	110.0	22.0	2.0	94.0	160.5	110.0	216	365	1.5		
4/5/90	91.0	19.0	2.0	37.0	73.0	92.0	185	305	9.0		
5/17/90	84.0	20.0	1.0	33.0	62.0	84.0	171	292	10.0		
6/19/90	86.0	19.0	2.0	29.0	49.5	76.0	193	293	1.5		
9/11/90	87.0	18.0	2.0	28.0		59.0	231	291	12.0		
10/10/90	88.0	19.0	2.0	33.0	51.9	79.0	215	298	0.0		
12/11/90	98.0	21.0	3.0	40.0	65.9	92.0	216	331	3.0		

Date	Ca	Mg	K	Na	Cl	SO4	T. Alk	T. Hard	TSS	TVS	RSS
2/20/91	110.0	24.0	3.0	73.0	139.0	110.0	204	373	5.0		
5/8/91	68.0	13.0	2.0	32.0	67.4	47.0	147	223	41.0		
6/27/91	88.0	18.0	1.6	25.0	48.0	71.0	197	294	9.0		
8/8/91	89.0	20.0	2.4	29.0	48.2	80.0	206	304	1.5		
10/8/91	91.0	20.0	2.1	28.0	49.9	84.0	211	309	4.0		
11/26/91	100.0	22.0	2.2	52.0	107.5	94.0	213	340	1.5		
1/30/92	98.0	21.0	2.1	33.0	56.3	110.0	202	331	1.5		
3/19/92	100.0	22.0	2.3	42.0	83.5	100.0	202	340	4.0		
4/21/92	95.0	21.0	1.7	38.0	75.9	88.0	209	323	14.0		
6/24/92	87.0	17.0	2.1	29.0	51.9	54.1	223	287	3.0		
8/6/92	85.0	17.0	2.6	26.0	45.5	36.7	238	282	6.0		
9/24/92	87.0	18.0	2.5	32.0	55.4	51.2	238	291	1.5		
11/5/92	110.0	25.0	3.3	68.0	128.0	174.5	194	377	6.0		
1/20/93	110.0	24.0	2.7	89.0	159.5	162.0	204	373	4.0		
4/1/93	76.0	16.0	2.2	38.0	83.4	73.8	151	256	40.0		
4/14/93	82.0	17.0	1.7	40.0	83.0	74.2	164	275	19.0	5.0	14.0
4/29/93	78.0	18.0	2.4	54.0	86.1	80.8	186	269	8.0		
5/12/93	38.0	15.0	2.2	33.0	42.5	33.0	145	157	50.0	10.0	40.0
5/25/93	59.0	12.0	1.5	15.0	28.5	41.9	145	197	38.0	8.0	30.0
6/10/93	71.0	15.0	1.5	20.0	37.8	65.8	173	239	14.0	3.0	11.0
7/12/93									10.0	4.0	6.0
7/22/93	85.0	18.0	1.7	26.0	50.5	84.5	192	286	8.0	5.0	3.0
8/25/93	82.0	19.0	1.6	30.0	54.5	88.2	192	283	4.0	3.0	1.5
9/1/93									4.0	2.0	1.5
9/23/93	85.0	19.0	2.1	29.0	52.4	79.2	200	290	4.0	1.0	3.0
10/28/93	94.0	22.0	2.0	30.0	55.9	113.2	203	325	1.5	2.0	1.5
11/23/93	88.0	21.0	2.2	31.0	57.4	98.4	205	306	1.5	0.0	3.0
1/13/94	94.0	21.0	2.1	48.0	85.9	113.8	198	321	1.5	2.0	1.5
2/16/94	100.0	23.0	2.5	56.0	101.0	105.0	191	344	4.0	3.0	1.5
3/24/94	97.0	22.0	2.0	120.0	215.0	74.2	196	333	14.0	5.0	9.0
4/6/94	92.0	19.0	1.9	48.0	87.5	70.3	194	308	20.0	6.0	14.0
4/21/94	69.0	13.0	1.5	28.0	57.0	37.5	161	226	35.0	7.0	28.0
5/3/94	82.0	17.0	1.7	35.0	69.5	61.3	180	275	29.0	5.0	24.0
5/17/94	65.0	13.0	1.3	20.0	36.0	43.2	161	216	40.0	10.0	30.0
6/1/94	77.0	16.0	1.4	23.0	42.0	53.8	187	258	34.0	7.0	27.0
6/15/94	89.0	19.0	1.7	31.0	56.0	67.9	205	300	7.0	1.0	6.0
6/28/94									8.0	4.0	4.0
8/11/94	91.0	19.0	3.0	39.0	67.0	56.8	235	305	6.0		
10/26/95	90.0	21.0	2.1	33.0	60.5	115.9	194	311	4.0		
11/15/95									1.5	2.0	1.5
3/6/96	110.0	23.0	2.3	160.0	310.0	82.4	198	369	6.0		
4/18/96	72.4	15.2	1.5	44.1	89.0	50.3	169	243	30.0		
8/1/96	83.1	17.4	1.3	32.4	61.0	58.5	218	279	6.8		
9/10/96	94.0	19.3	2.9	42.0	72.0	69.2	225	314	8.0		
10/23/96	83.6	18.6	2.5	38.0	76.0	70.4	213	285	4.4		
12/3/96	96.3	20.9	2.6	58.1	115.0	74.7	212	326	21.6		
1/30/97	104.0	22.8	2.5	93.8	190.0	101.4	200	353	17.2		
7/10/97	83.2	19.1	2.2	31.7	57.5	57.3	200	286	8.4		
8/6/97	90.5	19.1	2.4	33.6	60.0	53.7	225	304	6.8		
10/21/97	86.9	20.8	2.3	40.1	73.0	75.0	213	302	13.2		

Date	Ca	Mg	K	Na	Cl	SO4	T. Alk	T. Hard	TSS	TVS	RSS
Mean	**88.0**	**19.1**	**2.1**	**44.1**	**82.1**	**79.3**	**197**	**298**	**11.5**	**4.3**	**11.9**
Maximum	**110.0**	**25.0**	**3.3**	**160.0**	**310.0**	**174.0**	**238**	**377**	**50.0**	**10.0**	**40.0**
Minimum	**38.0**	**12.0**	**1.0**	**15.0**	**28.5**	**33.0**	**145**	**157**	**1.5**	**0.0**	**1.5**
East Canyon Creek above Snyderville Wastewater Treatment Plant (492526)											
1/17/90	110.0	27.0	2.0	41.0	73.9	160.0	190	386	1.5		
4/5/90	87.0	22.0	2.0	25.0	54.3	120.0	154	308	9.0		
6/19/90	80.0	23.0	0.5	19.0	37.0	120.0	151	294	1.5		
9/6/90	86.0	26.0	2.0	20.0	0.0	140.0	160	322	1.5		
10/10/90	99.0	27.0	2.0	18.0	37.5	170.0	172	358	0.0		
12/11/90	100.0	26.0	2.0	20.0	42.0	150.0	188	357	1.5		
2/20/91	110.0	28.0	2.0	46.0	94.4	160.0	188	390	12.0		
5/8/91	73.0	17.0	1.7	26.0	50.3	81.0	139	252	14.0		
10/8/91	90.0	26.0	1.7	21.0	42.5	150.0	154	332	1.5		
11/26/91	97.0	26.0	2.0	41.0	73.0	150.0	190	349	4.0		
1/30/92	89.0	25.0	1.7	20.0	38.5	160.0	179	325	4.0		
3/18/92	100.0	26.0	1.7	25.0	54.7	150.0	180	357	13.0		
4/21/92	95.0	26.0	1.5	26.0	59.7	150.0	176	344	6.0		
6/24/92	72.0	23.0	1.5	25.0	54.9	115.0	141	274	5.0		
8/6/92	82.0	28.0	2.5	26.0	58.0	164.3	144	320	10.0		
9/24/92	80.0	25.0	1.8	21.0	44.9	166.6	131	303	4.0		
11/5/92	120.0	31.0	2.7	37.0	70.4	266.4	179	427	3.0		
1/21/93	120.0	29.0	1.9	43.0	83.0	219.7	176	419	15.0		
4/1/93	75.0	18.0	2.3	32.0	74.9	101.2	133	261	23.0		
4/15/93	81.0	20.0	1.8	31.0	68.5	125.0	136	284	15.0	5.0	10.0
4/28/93	77.0	19.0	1.8	26.0	57.5	97.7	142	270	7.0		
5/11/93	66.0	16.0	1.6	24.0	48.2	66.1	136	231	15.0	6.0	9.0
5/27/93	54.0	13.0	1.8	12.0	21.5	50.6	129	188	31.0		
6/9/93	72.0	17.0	1.0	15.0	29.5	81.1	159	250	1.5	3.0	1.5
7/20/93	89.0	21.0	1.0	18.0	47.5	134.4	178	309	6.0	2.0	4.0
8/24/93	82.0	23.0	1.3	20.0	44.9	143.3	157	299	1.5	3.0	1.5
9/22/93	87.0	25.0	1.7	21.0	47.0	158.8	164	320	1.5	0.0	3.0
10/27/93	99.0	25.0	1.7	21.0	42.5	166.4	175	350	1.5	2.0	1.5
11/23/93	97.0	26.0	1.9	34.0	65.9	162.1	180	349	1.5	0.0	3.0
1/13/94	100.0	26.0	1.6	26.0	52.4	198.1	175	357	1.5		
2/17/94	100.0	26.0	1.5	33.0	64.9	167.7	182	357	4.0	2.0	1.5
3/23/94	96.0	25.0	2.1	39.0	92.5	112.1	177	342	24.0	7.0	17.0
4/5/94	91.0	23.0	1.8	41.0	90.0	97.0	177	322	19.0	5.0	14.0
4/19/94	80.0	20.0	1.5	29.0	59.5	84.2	159	282	59.0	10.0	49.0
5/3/94	79.0	20.0	1.5	42.0	75.0	90.6	159	279	68.0	12.0	56.0
5/17/94	56.0	13.0	1.0	12.0	25.5	53.2	133	193	36.0	8.0	28.0
6/1/94	68.0	19.0	0.5	16.0	30.0	94.8	134	248	12.0	2.0	10.0
6/15/94	86.0	23.0	1.0	22.0	45.5	115.4	172	309	8.0	2.0	6.0
Mean	87.5	23.1	1.7	26.7	54.0	134.0	161.8	313.5	11.6	4.3	13.4
Maximum	120.0	31.0	2.7	43.0	94.4	266.4	190.0	418.0	68.0	12.0	56.0
Minimum	54.0	13.0	0.5	12.0	21.5	50.6	131.0	188.0	0.0	0.0	1.5

Table 10 Chemical Analysis

4.4 Total Suspended Solids Analysis

The annual total suspended solids loading for East Canyon Creek above the reservoir are shown in figure 4.1. The average annual amount of total suspended sediment reaching the reservoir in recent years (1995-97) is 5,529 tons. Assuming that the general nature of the suspended solids measured is in the category of silt-loam, which has a density of 1.15 grams/cubic centimeter (Soil Science, Principles and Practices, Hausenbuiller, 1975) it equates to approximately 3.5 acre-feet per year of material. These calculations of TSS do not include the bed load carried down the streams and therefore represents a conservative estimate of the volume of materials that are being deposited in the reservoir.

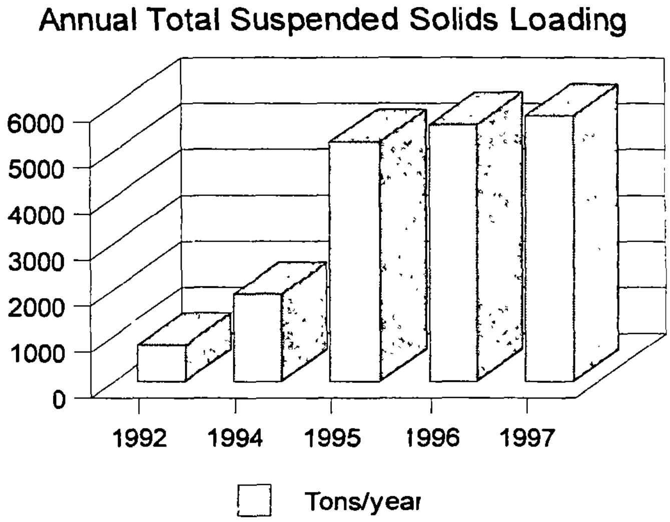


Figure 4.1 Annual TSS loadings at station above East Canyon Reservoir

There are several potential sources of this material which include; eroding streambanks, exposed soils associated with various constructions activities, urban runoff from impervious materials, recreational activities that have exposed soils making them vulnerable to erosion and winter recreational sites that have not provided adequate vegetative cover over disturbed soils.

4.5 Nutrient Analysis

The greatest impact on water quality is due to the high concentration of nutrients in watershed streams and East Canyon Reservoir. High concentrations of nutrients combined with low flows, limited riparian canopy and sediments from erosion are primarily responsible for high production of algae, macrophytes, and elevated water temperatures in watershed streams. Excessive nutrient loads are responsible for increased productivity and the water quality problems present in East Canyon Reservoir. A summary of the average annual nutrient data in the watershed tributaries is contained in Table 11. In addition, a complete set of the nutrient data used to make this summary is included in Appendix D.
Figure 4.2 and 4.3 represent annual average concentrations of total phosphorus for the period 1990-97 at tributary sites in the watershed. The most consistent data sets are for the years 1994-97. The data from the period 1990-93 has been compiled but it should be noted that it is not as extensive or consistent in frequency as the later data set. Therefore, our primary discussion will focus on the four year period of more intense monitoring. The data displayed at site 492519 for the years 1990-93 is the data from site 492520 for that period. These two sites are in close proximity to each other and the data is essentially the same.

Several observations can be made from a review of the nutrient summary:

1.) There has been a general decline in the concentration of total phosphorus

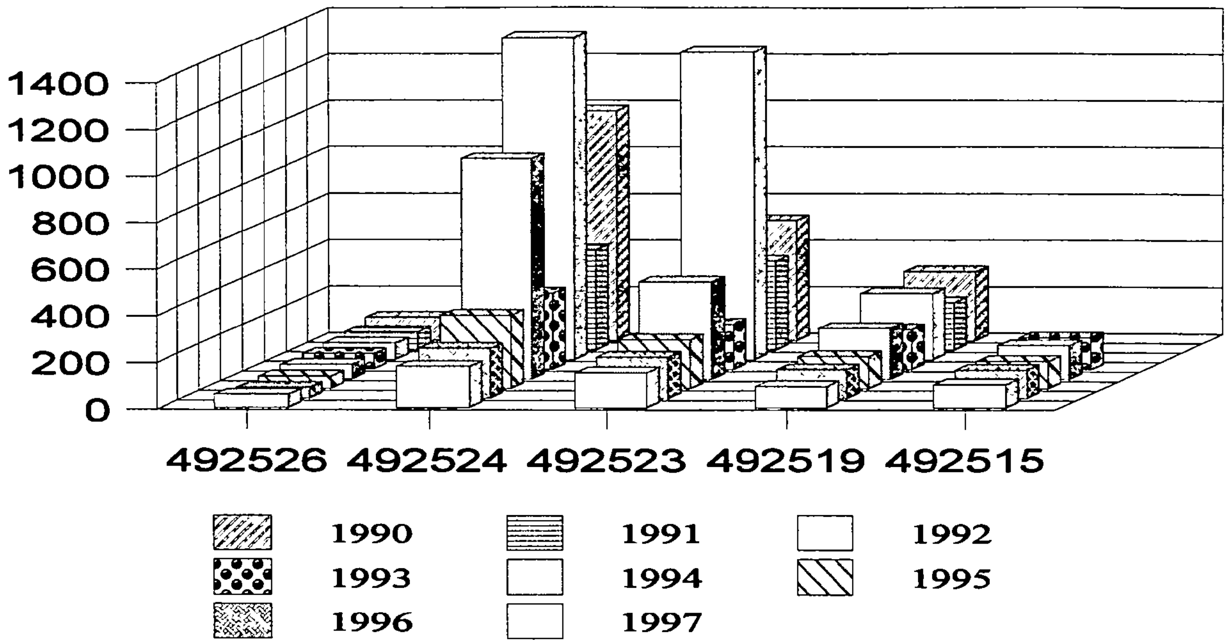


Figure 4.2 Total phosphorus concentrations (ug/L) at watershed tributary sites.

in recent years as is evident in comparing the 1990-93 data set with the 1994-97 data set depicted in figure 4.3. This general improvement is thought to be attributed to the elimination of some major agricultural nonpoint sources of organic wastes, primarily the Osguthorpe Dairy and improved efficiency for removal of total phosphorus from the Snyderville wastewater treatment plant with the voluntary addition of biological component;

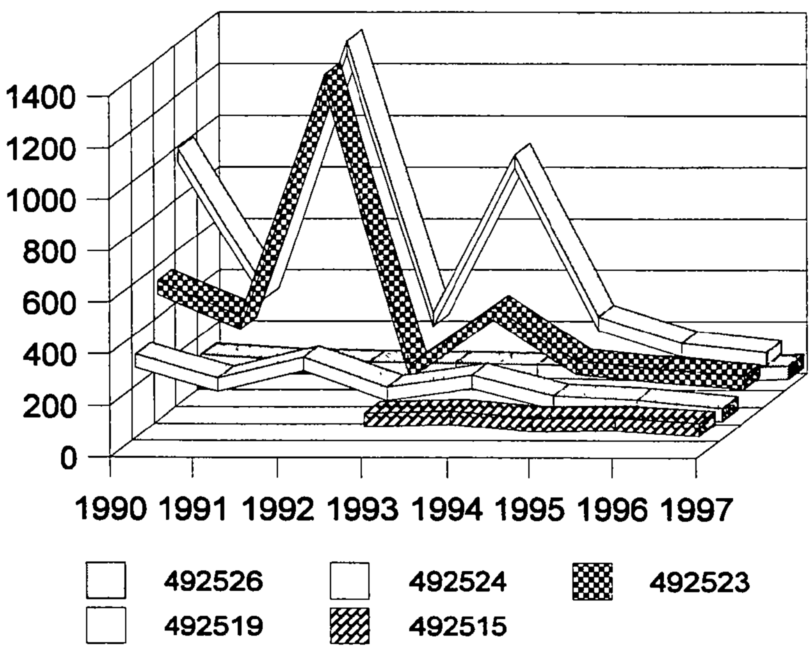


Figure 4.3 Total phosphorus concentrations (ug/L) at watershed tributary sites.

2.) As indicated by the data as observed at STORET station 492526 (East Canyon Creek above Snyderville WWTP) in figure 4.3, there has been a steady decline from 100 ug/L to 47 ug/L of total phosphorus.

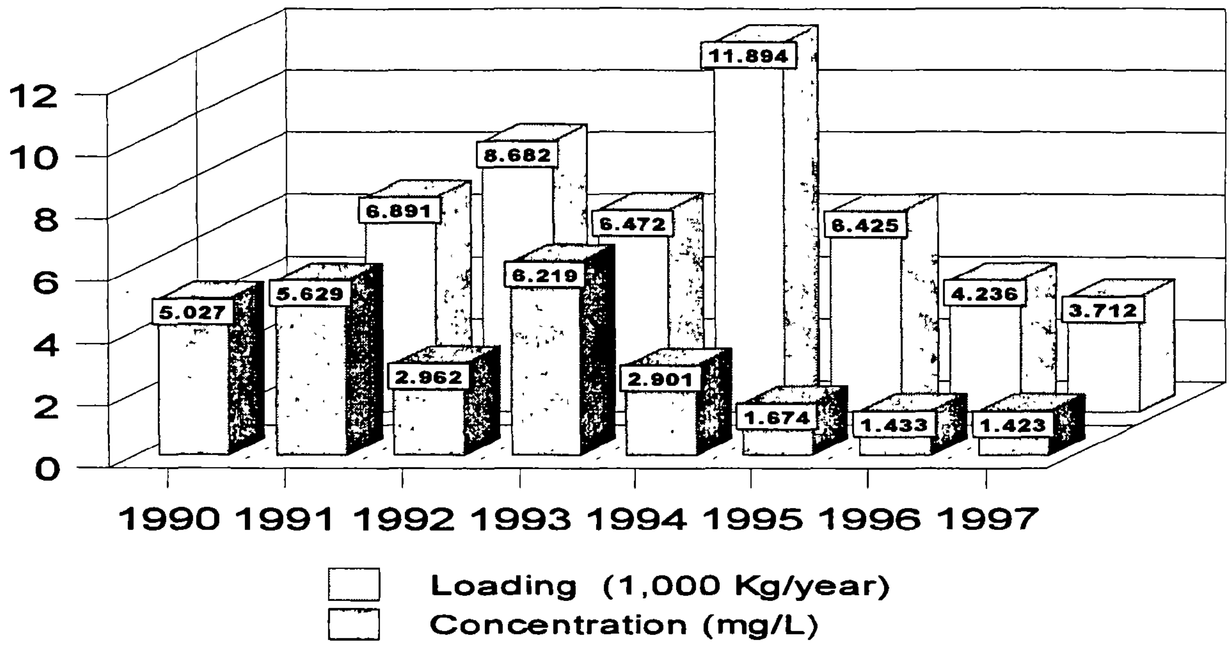


Figure 4.4 Average annual values for total phosphorus concentration and loads for Snyderville WWTP

Although it appears there has been an overall reduction in nonpoint sources of total phosphorus and other nutrients above this stream station, other nonpoint sources associated with new land uses have probably increased.;

3.) There is a major increase in the concentration of total phosphorus below the Snyderville Basin Wastewater Treatment Plant (SBWWTP). One of the major sources of nutrients in the watershed is this treatment plant. As is depicted in figure 4.4, there has been a decline in the concentration and loadings of total phosphorus discharged from the plant on an annual basis, but even with the addition of a biological process to remove phosphorus, the plant still is the most significant sources of controllable phosphorus in the watershed;

4.) There has been a declining trend in the concentration of total phosphorus in the stream as we move down the watershed towards the reservoir. This results as the phosphorus in the stream is removed through deposition of suspended materials and the uptake of phosphorus by plants as they grow. Eventually the majority of the phosphorus that is assimilated into the plant community or deposited in the loose sediments will flush to the reservoir. With the monitoring plan that was in place not all of this phosphorus can be accounted for through water analysis;

5.) Throughout the intensive period of study, data obtained has exceeded the pollution indicator value for total phosphorus of 0.05 mg/L in the stream and 0.025 mg/L in the lake. This is a strong indication that significant problems associated with the excessive amounts of nutrients in the system could develop. In fact, current impairment conditions for defined beneficial uses for the stream and lake are directly related to excessive production driven by excessive nutrients in the system.

4.5.1 Total Phosphorus Loadings

In order to understand the impact on productivity within the reservoir and to effectively establish goals for total phosphorus loading reduction, it is necessary to establish current levels of loadings related to existing water quality conditions and make reductions based on these relationships. Quarterly and annual loading rates for total phosphorus into East Canyon Reservoir have been determined and are summarized in Table 12. Included in Table 13 is a summary of annual loads at various points throughout the watershed based on annual water yields at those sites.

STORET	YEAR	Ammonia	TP	NO2/NO3	STORET	YEAR	Ammonia	TP	NO2/NO3
492515	1993	0.308	0.137	0.335	492523	1995	0.436	0.209	0.983
492515	1994	0.025	0.145	0.226	492523	1996	0.124	0.177	0.567
492515	1995	0.032	0.117	0.210	492523	1997	0.037	0.151	0.813
492515	1996	0.453	0.121	0.212	492524	1990	0.029	0.987	
492515	1997	0.039	0.101	0.215	492524	1991	0.044	0.431	0.925
492519	1994	0.025	0.218	0.437	492524	1992	0.048	1.385	3.499
492519	1995	0.041	0.139	0.461	492524	1993	0.025	0.328	1.945
492519	1996	0.049	0.124	0.252	492524	1994	0.041	0.945	3.656
492519	1997	0.035	0.093	0.334	492524	1995	0.046	0.313	1.403
492520	1990	0.025	0.298		492524	1996	0.157	0.213	0.669
492520	1991	0.045	0.207	0.522	492524	1997	0.088	0.177	0.772
492520	1992	0.030	0.286	0.667	492525	1991	0.067	5.027	15.987
492520	1993	0.043	0.172	0.658	492525	1992	0.111	5.629	16.722
492520	1994	0.025	0.174	0.575	492525	1993	0.050	2.962	12.423
492520	1995	0.025	0.130	0.460	492525	1994	0.064	6.219	11.884
492520	1996	0.043	0.120	0.280	492525	1995	0.231	2.901	10.663
492520	1997	0.035	0.096	0.245	492525	1996	1.434	1.674	4.510
492521	1995	0.034	0.161	0.667	492525	1997	0.134	1.423	4.490
492521	1996	0.067	0.150	0.411	492526	1990	0.025	0.100	
492521	1997	0.039	0.122	0.557	492526	1991	0.044	0.079	0.300
492523	1990	0.029	0.517		492526	1992	0.047	0.071	0.266
492523	1991	0.031	0.382	1.203	492526	1993	0.043	0.067	0.713
492523	1992	0.025	1.321	2.878	492526	1994	0.030	0.062	0.457
492523	1993	0.025	0.194	1.109	492526	1995	0.041	0.054	0.354
492523	1994	0.038	0.417	1.789	492526	1996	0.077	0.047	0.299
492523	1995	0.436	0.209	0.983	492526	1997	0.100	0.059	0.382

Table 11 Average annual concentrations of nutrient data at stream sites in the watershed

It is readily apparent that the annual loads can vary dependant upon the interval values for flows and the amount of water quality data available. Loads were calculated simplistically based on seasonal or annual concentration and flow averages. Comparing quarterly versus annual values in general indicate quarterly calculations yield lower annual load rates, but are within an acceptable range for planning purposes. It should be noted that the 1997 data set is limited because several water quality data points were removed after application of quality assurance procedures. This has resulted in a lower than average annual concentration value for total phosphorus, therefore perpetuating a lower annual phosphorus load. This is somewhat verified by the trend established that the total annual load is usually greater than the total quarterly annual loading and the calculations for 1997 show just the opposite relationship. Because of this, the data has been included in the tables but will not be used in accurately assessing conditions for 1997. It is recognized that annual loadings, reflect the limitation of the data in determining annual values. Specifically,

Total Phosphorus Loadings above East Canyon Reservoir					
Time Period	**Reservoir Outfall (AF)**	**Change in Storage (AF)**	**Ave QTR Flow (AF)**	**Ave QTR Conc. (mg/L)**	**QTR Loading (Kg/year)**
1994 1st QTR	2,695	4,770	7,465	0.242	2,229
1994 2st QTR	8,740	1,570	10,310	0.128	1,628
1994 3st QTR	19,690	(19,000)	690	0.022	19
1994 4st QTR	1,243	2,620	3,863	0.210	1,001
				Sum of the quarterly loadings	**4,877**
1994	**32,368**	**(10,040)**	**22,328**	**0.218**	**6,006**
1995 1st QTR	1,714	10,120	11,834	0.223	3,256
1995 2st QTR	22,780	10,560	33,340	0.091	3,743
1995 3st QTR	22,030	(13,140)	8,890	0.168	1,843
1995 4st QTR	1,703	4,130	5,833	0.130	936
				Sum of the quarterly loadings	**9,778**
1995	**48,227**	**11,670**	**59,897**	**0.139**	**10,273**
1996 1st QTR	16,665	(6,500)	10,165	0.173	2,170
1996 2st QTR	18,430	15,030	33,460	0.097	4,005
1996 3st QTR	20,640	(16,030)	4,610	0.159	904
1996 4st QTR	2,322	4,070	6,392	0.081	639
				Sum of the quarterly loadings	**7,718**
1996	**58,057**	**(3,430)**	**54,627**	**0.124**	**8,358**
1997 1st QTR	19,580	(6,510)	13,070	0.072	1,161
1997 2st QTR	17,660	18,610	36,270	0.102	4,565
1997 3st QTR	21,020	(14,820)	6,200	0.132	1,010
1997 4st QTR			0	0.090	0
				Sum of the quarterly loadings	**6,736**
1997	**58,260**	**(2,720)**	**55,540**	**0.093**	**6,373**
It should be noted the 1997 total phosphorus data is limited due to the elimination of a significant portion of the data due to quality assurance procedures for a major period of time during the year and the total annual flows are slightly different when computed on a quarterly basis. In addition total annual flows are slightly different than the annual flows shown in Table 4.					

Table 12 Annual and quarterly total phosphorus loadings above East Canyon Reservoir

STORET	YEAR	TP	ANNUAL FLOW	ANNUAL LOAD lbs/year	Kg/year		STORET	YEAR	TP	ANNUAL FLOW	ANNUAL LOAD lbs/year	Kg/year
492515	1993	0.137	27,350	10,177	4,616		492524	1990	0.987	10,440	28,029	12,714
492515	1994	0.145	32,360	12,763	32,360		492524	1991	0.431	19,110	22,404	10,163
492515	1995	0.117	48,230	0	6,963		492524	1992	1.385	7,700	29,009	13,158
492515	1996	0.121	58,057	19,109	8,668		492524	1993	0.328	33,680	30,004	13,610
492515	1997	0.101					492524	1994	0.945	16,770	43,108	19,554
	Long-term		41,520				492524	1995	0.313	41,130	35,018	15,884
							492524	1996	0.213	35,430	20,528	9,311
492519	1994	0.218	22,350	13,253	6,012		492524	1997	0.177			
492519	1995	0.139	59,900	22,648	10,273			1990-96		23,210		
492519	1996	0.124	54,620	18,423	8,357							
492519	1997	0.093					492525	1991	5.027	1,111	15,192	6,891
	Long-term	0.050	41,520	5,647	2,561		492525	1992	5.629	1,250	19,140	8,682
							492525	1993	2.962	1,771	14,269	6,472
492520	1990	0.298	15,660	12,694	5,758		492525	1994	6.219	1,550	26,221	11,894
492520	1991	0.207	25,350	14,274	6,475		492525	1995	2.901	1,795	14,165	6,425
492520	1992	0.286	12,150	9,452	4,288		492525	1996	1.674	2,051	9,339	4,236
492520	1993	0.172	47,410	22,181	10,061		492525	1997	1.423	2,114	8,183	3,712
492520	1994	0.174	22,350	10,578	4,798			Maximum		2,114		
492520	1995	0.130	59,900	21,182	9,608							
492520	1996	0.120	54,620	17,829	8,087		492526	1990	0.1	9,473	2,577	1,169
492520	1997	0.096					492526	1991	0.079	18,999	4,057	1,840
	Long-term		41,520				492526	1992	0.071	6,450	1,246	565
							492526	1993	0.067	31,909	5,815	2,638
492523	1990	0.517	10,440	14,682	6,660		492526	1994	0.062	15,220	2,567	1,164
492523	1991	0.382	19,110	19,857	9,007		492526	1995	0.054	39,335	5,778	2,621
492523	1992	1.321	7,700	27,668	12,550		492526	1996	0.047	33,379	4,267	1,936
492523	1993	0.194	33,680	17,773	8,062		492526	1997	0.059			
492523	1994	0.417	16,770	19,022	8,628			1990-96		18,310		
492523	1995	0.209	41,130	23,383	10,606							
492523	1996	0.177	35,430	17,058	7,738							
492523	1997	0.151										
	1990-96		23,210									

Table 13 Summary of annual total phosphorus loadings at watershed sites

monitoring strategies are not sufficient to assure that all of the sources of phosphorus are included in the annual loading rates. These might include the flushing of organic material and sediments accumulated in the stream during the productivity period or flushes from episodic events during the year.

Some general observations can be made from a review of Tables 12 and 13: (1) Although there is a reduction in the annual load from the Snyderville wastewater treatment plant (Station 492525), it still is a major source of phosphorus in the system; (2) Although the loading at the stream station above the treatment plant varies on an annual basis dependant upon the flow regime and concentration, it is apparent that there has been a decline during the last several years. Data for 1996 concentrations are at or near the pollution indicator value for total phosphorus in streams (0.050 mg/L); (3) Flow patterns are highly diverse through the course of time and in recent years both extremes have been observed; (4) Flows associated with SBWWTP have increased and are projected to continue to rise as land use shifts from current uses towards urbanization; (5) Loading at the stations above the reservoir (492519 or 492520) for total phosphorus has increased significantly over those at the station above SBWWTP (492526); (6) Annual loads from SBWWTP range from 51% to 198% of the loading to the reservoir; and (7) There is an inadequacy in the monitoring program to account for the flushing of nutrients from uptake into the stream flora or attached to sediments.

It is a recognized fact that the total phosphorus present in a given system moves downstream unless mechanisms are in place that physically impede its movement on a permanent basis or it is removed from the system by mechanisms that provide for the uptake and removal from the system. Therefore, in the discussion related to establishing pollutant reductions, it is essential to remember inputs of total phosphorus into the system at some point will reach the reservoir. Because the monitoring strategy isn't intensive enough to account for the 'flushing' of all materials, annual loading of total phosphorus as determined from water quality data and annual flows is conservative at best.

4.6 Biological Analysis

During the fall, spring, and summer of 1991-92 Bret Harvey of the Department of Zoology at Weber State University, reported to Weber Basin Water Quality Management Council on collected data for benthic invertebrates from five sites on East Canyon Creek. Sampling stations were identified as:

1. East Canyon Creek approximately 300 meters below East Canyon Dam;
2. East Canyon Creek 50 meters below the first road crossing above East Canyon Reservoir;
3. East Canyon Creek at Mormon Flat;
4. East Canyon Creek at the bridge below Jeremy Ranch golf course; and
5. Approximately 1 kilometer below Park City, as a reference station in relationship to the wastewater treatment plant above site 4.

Reported observations from the report included:

1. General physical conditions at the sampling stations reflect the disturbed nature of the watershed;
2. Riparian zones at stations 3 and 5 were noticeable barren, probably as a result of grazing;
3. At station 1 below the dam, anoxic sediments were extremely close to the surface of the substrate in both summer and fall and the organic material in summer benthic samples was so abundant that the samples were not effectively preserved in 90 percent ethanol and had to be discarded;
4. In general, the aquatic invertebrates from all stations were dominated by taxa with the highest "Tolerance Quotient: (TQ) which are recognized for their ability to withstand degraded environmental conditions indicative of low water quality
5. Where several taxa would be expected to be abundant in the absence of human disturbance, oligochaetes and nematodes dominated samples from stations 2, 3, and 4. ;
6. Predatory stoneflies such as members of the family Perlodidae and the perlid genus *Hesperoperla*, which are abundant in nearby streams were almost entirely absent;

7. Samples from station 1 revealed a noteworthy absence of Trichoptera in the filter-feeding family Hydropsychidae, one of the more common worldwide patterns in benthic assemblages present below impoundments. The outflow of East Canyon Reservoir is probably inappropriate for hydropsychids in terms of both water quality (low dissolved oxygen) and food quality (organic material dominated by bacteria and blue-green algae).;
8. It is safe to conclude that the benthic assemblages present at all stations sampled indicate considerable human impact, via both the abundance and diversity of tolerant taxa and the absence of less tolerant taxa which are common in other streams in northern Utah;
9. Virtually all of the taxa that are relatively common in northern Utah yet indicative of high water quality conditions are rare or absent from East Canyon Creek; and
10. The number of taxa present is relatively low compared to samples from streams in the region. There is a steadily decline in richness as we move downstream through the system.

4.7 Significant Pollutant Sources

4.7.1 Urban Runoff

Water quality data from urban runoff was not collected from storm drainage systems during the study. It is readily apparent from information gathered from the literature that urban areas do contribute significantly to the nutrient, organic and sediment loads into the streams and eventually to the reservoir. General observations indicate that storm water is collected throughout the urban area and in some cases is discharged directly into tributaries of East Canyon Creek.

A review specifically of USEPA's publication "Nationwide Urban Runoff Program (1983)", NURP, discussed earlier established that urban runoff has a significant total phosphorus load into waterways. This report represents data information obtained from over 2,300 rainfall events monitored at 22 project sites. Table 3 summarizes median event mean concentrations (EMC's) for median urban sites as: TSS = 100 mg/L; BOD5 = 9 mg/L; COD = 65 mg/L; total phosphorus = 0.33 mg/L; soluble phosphorus = 0.12 mg/L; TKN = 1.5 mg/L; total copper = 34 ug/L; total lead = 144 ug/L; and total zinc = 160 ug/L. Using statistical analyses EMC values were converted into a range of values that could be used to address inherent variability of the data.

Oberts in his paper "Influence of Snowmelt Dynamics on Stormwater Runoff Quality" which characterizes stormwater runoff in the St. Paul, Minnesota area indicates that the pollutants leached from snow packs can dramatically impact water quality. In this study it was determined that the flow weighted mean concentration of total phosphorus from snowmelt from storm sewers, open channels and creeks was 0.70 mg/L, 0.56 mg/L and 0.54 mg/L respectively. It is clearly evident that surface flush and snowmelt from urban areas does have the potential to impact water quality and therefore needs to be one of the elements that is targeted in developing an overall plan to address the control of phosphorus within this watershed.

Following the logic for estimating urban runoff contributions in section 2.5.1, and accepting the fact that Park City area exemplifies a runoff coefficient of 0.35 with an average annual rainfall of approximately 40 inches per year, it is expected to yield 1.5 Kg/Ha/year of total phosphorus and 640 Kg/Ha/year of total suspended solids. Table 14 represents current and projected

	Estimated Current Land Use			Projected Land Use		
Parameter	Residential	Commercial	Aggregate	Residential	Commercial	Aggregate
	365 Ha	200 Ha	565 Ha	1000 Ha	500 Ha	1500 Ha
Total Phosphorus (Kg/Ha/Yr)	1.3	3.4	1.5	1.3	3.4	1.5
Annual Load (Kg/Yr)	475	680	848	1,300	1,700	2,250
Annual Load (lbs/Yr)	215	308	384	590	771	1,020
Total Suspended Solids (Kg/Ha/Yr)	550	1,460	640	550	1,460	640
Annual Load (Kg/Yr)	200,750	292,000	361,600	550,000	730,000	960,000
Annual Load (Tons/yr)	221	322	399	606	805	1,058

Table 14 Current and projected loadings from urban runoff based on NURP data

loadings for these parameters based on current and estimated projected land uses in the watershed and these estimates of pollutant production based on the prior statistical analyses. It is important to note that there is expected to be a substantial increase in urban areas as agricultural lands are displaced with the increasing demands for development.

Estimates for the total phosphorus and total suspended solids loadings are based on values obtained in the literature for total phosphorus concentrations considering annual precipitation and land use data and should be used for planning purposes. Current land use information was developed using GIS interpretation of land use data available. The breakdown into residential and commercial areas is an estimated breakdown of the aggregate acreage. Future projections are strictly estimates which will need to be verified after the current study ascertains more accurate values. In addition these annual loads represent potential loads into the stream and reservoir. Not all of these potential load will actually enter a live waterway. It is evident that some control mechanism are already in place to eliminate or reduce the movement of these materials into waterways, but it is also essential that additional measures may be needed if significant loading of pollutants is occurring from the current sources or new sources created or developed as urban areas are increased.

4.7.2 Agriculture

Although water quality data has not identified any concentrated sources of agriculture runoff, a visual survey of the watershed has identified several areas of concern including:

1. Small detention basins associated with agricultural areas,
2. Livestock grazing in sensitive areas,
3. Areas where runoff moves sediments and nutrients to adjacent waterways,

4. Horse corals, stables, or feeding areas adjacent to streams, and
5. Historical practices or diversions have created some dysfunctional riparian areas or flood plains.

It should be noted that in recent history there has been a movement away from agricultural uses in the area towards commercial, residential and recreational areas. Along with this transition there has been a substantial reduction in historical nonpoint sources of pollution. These changes have resulted in the reduction of the amount of animal wastes produced and transported into the waterways. This is evident by the recent reduction in the annual average concentration of total phosphorus in East Canyon Creek above the Snyderville wastewater treatment plant. Although there are still best management practices (BMP's) that need to be implemented to negate or reduce total phosphorus loading from agriculture activities or restore dysfunctional areas, it is clearly evident that additional efforts will need to be directed towards those activities that have replaced the agricultural uses in the watershed. Currently there is an investigation being conducted by the DWQ to identify and quantify controllable nonpoint sources of total phosphorus for incorporation into a basin-wide TMDL.

4.7.3 Construction, Development and Recreation

One of the most significant potential sources of total phosphorus is from the movement of sediments from activities associated with the development of lands for urban needs including commercial, residential, transportation and recreational areas. It is imperative that all development in the watershed should only occur in conjunction with appropriate best management practices in place to protect and minimize the impacts to water quality in the watershed. As part of the clean lakes study we have not tried to quantify loadings from these distinct sources, but want to emphasize that they can be significant sources of sediments and nutrients where appropriate measures are not taken to eliminate the movement of pollutants from these sources. In addition there are several detention structures that could be modified to reduce significantly the movement of sediments downstream.

4.7.4 Snyderville Basin Wastewater Treatment Plant

The most significant controllable source of total phosphorus within the basin is from the Snyderville Basin Wastewater Treatment Plant. A review of the data contained in Table 13 for STORET stations 492526, 492525, and 492524 indicates there is a substantial increase in the total phosphorus loading from the stream station above the SBWWTP (492526) because of the discharge of the wastewater treatment plant (492525)to the station below the SBWWTP (492524). In 1995-96 annual total phosphorus loads from the plant have decreased to approximately 4,000 Kg/year because of additional treatment, but in 1994 a maximum of 11,894 Kg/year was determined.

SBWWTP is a permitee through the UPDES process. Through this regulated process the discharge of pollutants including total phosphorus can be controlled under the guidance of the Clean Water Act and other Utah State regulation. It is expected that at some point in time steps will be taken to incorporate limitations on the discharge of phosphorus through their waste waters.

5.0 RESERVOIR WATER QUALITY

5.1 Introduction

The overall water quality conditions in East Canyon Reservoir have deteriorated since 1980 as the result of increasing organic and nutrient loadings. The reservoir is exhibiting eutrophic symptoms, including oxygen depletion, high algal production with undesirable blue green species, and stresses on aquatic life.

Three trophic state water quality models (Vollenweider, Larsen-Mercier, and Carlson) will be discussed to verify that the lake is in an eutrophic state. Although there is not an exact agreement between the models, it is evident that conditions present in the reservoir are impairing defined beneficial uses of the reservoir.

Phytoplankton community diversity has been monitored since 1989. The dominate algae in the lake is *Aphanizominon*, which is indicative of poor water quality. There was enough *Aphanizominon* in the reservoir water in 1993 to form small windrows along the beaches as it was blown on to the shore. *Spirogyra* has been documented on the bottom near the shore as ice melts in the Spring and *Anabaena* and *Microcystis* are also present in the reservoir.

The fishery seems to be extremely stressed and barely holding the line. Oxygen levels on the bottom frequently are depleted to zero during several months, whereas a decade ago, there was still some oxygen there. It is not uncommon for oxygen to be almost totally depleted at a 10 meter depth as early as August. This is a dramatic change from the data reported in the "East Canyon Reservoir--Water Quality Assessment" (Merritt et.al., 1980). Their report noted that during the years of 1978 to 1979 the dissolved oxygen at the bottom of the reservoir rarely dropped below 4 mg/l. This includes summer months where averages were just below 4 mg/l. Analysis by Utah Division of Wildlife personnel indicate that there has been a degeneration of the fishery resource in the last decade. Due to a change in conditions in the reservoir, DWR has modified their stocking protocol to be able to provide the best possible cold water fishery that water quality conditions allow at this point in time. However it should be noted that DWR has been and still is planning to maintain these waters as a cold water fishery. Modifications of the management of this reservoir could occur if conditions do not improve or public demands require a higher quality of fishery at the reservoir.

5.2 Lake Processes

It is important in the overall understanding of the perceived conditions of waterbodies that we understand what constitutes productivity in a waterbody, the components involved, and the effect it has on individual lakes or reservoirs. Primary productivity deals with the rate at which algae and macrophytes fix or convert light, water, and carbon dioxide to sugar in plant cells. In addition the amount of plant material produced and remaining in the system is referred to as the primary production and is analogous to the standing crop or biomass of plants in a farmers's field. Photosynthesis normally is the dominant source of organic matter for the lakes's food web.

It is through the process of photosynthesis that molecular oxygen is produced. This is the primary source of dissolved oxygen in the water and of oxygen in the atmosphere. Oxygen is usually required to completely break down organic matter (molecules) and release their chemical energy. Plants and animals release this energy through a process called respiration. Its end products--energy, carbon dioxide, and water--are produced by the breakdown or organic molecules in the presence of oxygen.

Photosynthesis requires light in the production of organic matter by aquatic plants. It is restricted to the portion of the lake water column that is lighted, the photic zone. The thickness of the photic zone depends upon the transparency of the lake water and corresponds to the depth to which at least 1 percent of the surface light intensity penetrates. Transparency is dependent upon color, and the suspension of particulate matter, organic or inorganic.

When light is adequate for photosynthesis, the availability of nutrients often controls phytoplankton productivity. In the lake, differences between plant requirements for an element and its availability exert the most significant limit on lake productivity. Typically, phosphorus and nitrogen are the least available elements, and therefore they are the most likely to limit lake productivity.

Phosphorus in particular can often severely limit the biological productivity of a lake. The by-products of modern society, however, are rich sources of this element. Waste waters, fertilizers, agricultural drainage, detergents, and municipal sewage contain high concentrations of phosphorus, and if allowed to enter the lake, they can stimulate algal productivity. Such high productivity, however, may result in nuisance algal blooms, noxious tastes and odors, oxygen depletion in the water column, and undesirable fish kills during winter and summer.

Photosynthetic activity occurs primarily in two groups, algae and macrophytes (aquatic plants). It is essential here that each of these groups be discussed not only to help us in understanding lake productivity but also in understanding problems and solutions associated with these groups.

5.2.1 Algae

Algae are photosynthetic plants that contain chlorophyll and have a simple reproductive structure but do not have tissues that differentiate into true roots, stems, or leaves. They do however, grow in many forms. Some species are microscopic single cells; others grow as mass aggregates of cells (colonies) or in strands (filaments). Some even resemble plants growing on the lake bottom.

The algae are an important living component of lakes. They convert inorganic material to organic matter through photosynthesis; oxygenate the water through photosynthesis; serve as the essential base of the food chain; and affect the amount of light that penetrates into the water column.

Like most plants, algae require light, a supply of inorganic nutrients, and specific temperature ranges to grow and reproduce. Of these factors, it is usually the supply of nutrients that will dictate the amount of algal growth in a lake. In most lakes, increasing the supply of nutrients (especially phosphorus) in the water will usually result in a larger algal population.

There are a number of environmental factors that influence algal growth. The major factors include: (1) the amount of light that penetrates the water (determined by the intensity of sunlight, the amount of suspended material, and water color); (2) the availability of nutrients for algal uptake (determined both by source and removal mechanisms); (3) water temperature (regulated by climate, altitude, et cetera); (4) the physical removal of algae by sinking or flushing through an outflow; (5) grazing on the algal population by microscopic animals, fish, and other organisms; (6) parasitism by bacteria, fungi, and other microorganisms; and (7) competitive pressure from other aquatic plants for nutrients and sunlight.

It is a combination of these and other environmental factors that determines the type and quantity of algae found in lake. It is important to note, however, that these factors are always in a state of flux. This is because a multitude of events, including the change of seasons, development in the watershed, and rainstorms constantly create "new environments" in a lake.

Excessive growth of one or more species of algae is termed a bloom. Algal blooms, usually occurring in response to an increased supply of nutrients, are often a disturbing symptom of cultural eutrophication. A bloom of algae can give the water an unpleasant taste or odor, reduce clarity, and color the lake a vivid green, brown, yellow, or even red, depending on the species. Filamentous and colonial algae are especially troublesome because they can mass together to form scum or mats on the lake surface. These mats can drift and clog water intakes, foul beaches, and ruin many recreational opportunities.

5.2.2 Macrophytes

Aquatic plants have true roots, stems, and leaves. They, too, are a vital part of the biological community of a lake. Unfortunately, like algae, they can overpopulate and interfere with lake uses. Aquatic plants can be grouped into four categories; emergent plants, rooted floating-leaved plants, submergent plants and free-floating plants.

Emergent plants are rooted and have stems or leaves that rise well above the water surface. They grow in shallow water or on the immediate shoreline where water lies just below the land surface. They are generally not found in lake water over two feet deep.

Rooted floating-leaved plants have leaves that rest on, or slightly above, the water surface. These plants, whose leaves are commonly called lily pads or "bonnets," have long stalks that connect them to the lake bottom.

Submergent plants grow with all or most of their leaves and stems below the water surface. They may be rooted in the lake bottom or free-floating in the water. Most have long, thin flexible stems that are supported by the water. Most submergents flower above the surface.

Free-floating plants are found on the lake surface. Their root systems hang freely from the rest of the plant and are not connected to the lake bottom.

Through photosynthesis, aquatic plants convert inorganic material to organic matter and oxygenate the water. They provide food and cover for aquatic insects, crustaceans, snails, and fish. Aquatic plants are also a food source for many animals. In addition, waterfowl, muskrats, and other species use aquatic plants for homes and nests.

Aquatic plants are effective in breaking the force of waves and thus reduce shoreline erosion. Emergents serve to trap sediments, silt, and organic matter flowing off the watershed. Nutrients are also captured and utilized by aquatic plants, thus preventing them from reaching algae in the open portion of a lake.

There are many factors that affect aquatic plant growth including: the amount of light that penetrates into the water; the availability of nutrients in the water (for free-floating plants) and in the bottom sediments (for rooted plants); water and air temperature; the depth, composition, and extent of the bottom sediment; wave action and/or currents; and competition pressure from other aquatic plants for nutrients, sunlight, and growing space.

Excessive growth of aquatic plants is unsightly and can severely limit recreation. Submergents and rooted floating-leaf plants hinder swimmers, tangle fishing lines, and wrap around boat propellers. Fragments of these plants can break off and wash up on beaches and clog water intakes.

For many species, fragmentation is also a form of reproduction. An overgrowth problem can quickly spread throughout a lake if boat propellers, harvesting operations, or other mechanical actions fragment the plants, allowing them to drift and settle in new areas of the lake.

Free-floating plants can collect in great numbers in bays and coves due to prevailing winds. Emergent plants can also be troublesome if they ruin lake views and make access to open water difficult. In addition, they create areas of quiet water where mosquitoes can reproduce.

From observations made during recent years macrophytes are very limited in East Canyon Reservoir and do not exhibit an impact on beneficial uses defined for the reservoir

5.2.3 In-lake Temperature & Dissolved Oxygen Profiles

Thermal stratification is an important process effecting productivity in northern lakes. Stratification causes surface and bottom waters to be separated by a narrow band of water called the metalimnion, characterized by rapidly changing temperature and densities called the thermocline. The density gradient change of the metalimnion acts as a physical barrier to the complete mixing of lake waters. In essence stratification inhibits or prevents the mixing of surface and bottom waters. Stratification occurs because the density (weight) of water changes depending on its temperature. Water is heaviest at about 39.2° F. Above and below this temperature water becomes lighter (less dense). In very shallow lakes, wind and wave forces along the surface are strong enough to mix the water throughout and prevent temperature stratification. In deeper lakes, however, stratification develops because the forces of temperature become greater than those of the wind.

As lakes continue to warm in the late spring, the temperature differences between the surface and deeper waters increase. Most U.S. lakes with a depth of 20 feet or more stratify into three temperature-defined layers during the summer season. The water in the upper layer (epilimnion) is warm, well lit, and circulates easily in response to wind action. In contrast, the deep layer (hypolimnion) is darker, colder, denser, and relatively stagnant. These two layers are separated by a transition zone (metalimnion) where temperatures change rapidly with depth. The metalimnion as discussed earlier functions as a barrier between the epilimnion and the hypolimnion. The magnitude of the temperature difference between the two layers defines how resistant they are to mixing. A large temperature difference means that the layers are stable and that it would take a great deal of wind energy to break down the stratification and mix the layers.

In the fall, chilly air temperatures cool the lake's surface. As the surface waters nears the temperature of 39.2° F it becomes denser (heavier). This chilled water is heavier than the water below and begins to sink towards the bottom. This process continues until waters in the upper layer have cooled to a point where they become the same temperature (and density) as the lower layer. At this time, the resistance to mixing is removed and the entire lake freely circulates in response to wind action. This action is known as fall overturn.

During winter the lake continues to cool. The colder water (32° F) "floats" on the top, and forms ice. This is why a lake doesn't freeze from the bottom up. The thermal gradient during the winter increases from top to bottom, the opposite of summertime gradients. As the weather moderates in the spring, the ice melts and the surfaces waters begin to warm above 32° F. As water temperatures rise towards 39.2° F, the surface water again becomes more dense and moves downward.

The equalization of the temperature gradient throughout the water column is facilitated by wind action. This process is called spring turnover. During this rather brief period of time most of the lake water is at the same temperature and in chemical equilibrium while surface waters mix freely with bottom waters.

East Canyon is a fairly deep reservoir with a maximum depth of approximately 60 meters. As indicated from lake monitoring the depth usually ranges from 30 to 55 meters during the year, making it subject to strong stratification. A review of the temperature and dissolved oxygen contained in Appendix E indicates that there is a significant dissolved oxygen depletion and elevated temperatures near the surface seriously limit available fishery habitat during the summer. It should be noted that these anoxic conditions increase the release of total phosphorus from the sediments into the water column.

5.2.4 Sedimentation and Nutrients

Nutrients primarily enter a lake from external and internal sources. Movement of total phosphorus is primarily through exportation of water, but atmospheric deposition and internal recycling from sediments can contribute significantly to the overall phosphorus load into the reservoir. This is graphically depicted in figure 5.1.

Internal phosphorus loading is associated with the process of decomposition. Decomposition of organic matter by bacteria is essential to lake ecosystems. Without decomposition, most material falling to the bottom would remain there and the lake would fill in. Decomposition speeds up the breakdown of matter and helps nutrients recycle back in to the system for reuse. Recycling of nutrients introduced into lakes is an important process. It not only involves the inputs of nutrients into the lake but involves changing the chemical form of nutrients already in the lake so that they may be utilized in the food web again. For example, plants take up inorganic nitrogen which animals cannot use and incorporate it in their tissues as organic nitrogen which animals can use. When animals die, nitrogen must be changed back to the inorganic form for plants or it will be lost to the system as a useful nutrient. This nutrient recycling is accomplished by biological (decomposition), chemical (oxidation), and physical (circulation) processes. Without recycling, many important nutrients such as phosphorus and nitrogen would become depleted and the productivity of many lakes would be drastically reduced.

Sedimentation is a process that greatly affects the ecosystem of lakes. The gradual filling-in of a lake is a natural process. Streams, storm water runoff, and other forms of moving water carry sand, silt, clays, organic matter, and other chemicals into the lake from the surrounding watershed. These materials settle out once they reach quieter waters. The rate of settling is dependent on the size of the particles, water velocity, density, and temperature. Not all sediment particles

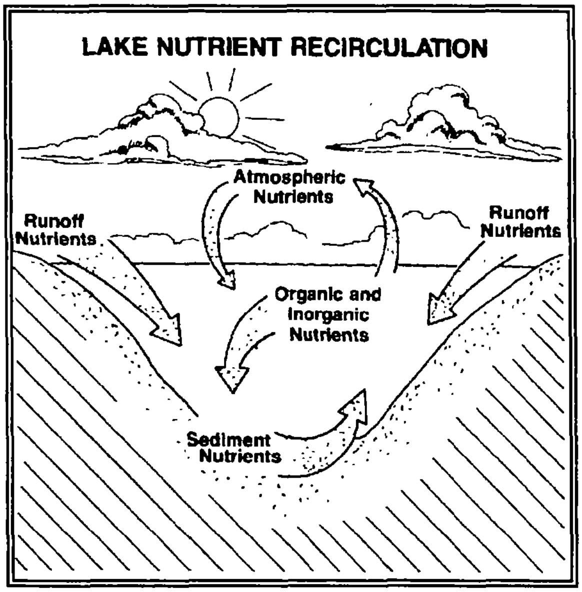


Figure 5.1 Cycling of nutrients in a lake is important factor in lake productivity.

quickly settle to the lake bottom. The lighter, siltier particles often stay suspended in the water column or settle so lightly on the bottom that they can be easily stirred up and re-suspended with even slight water motion. This causes the water to be turbid and brownish in appearance. Sediment blocks light from penetrating into the water column. It also interferes with the gills of fish and the breathing mechanism of other creatures.

The sediment input to a lake can be greatly accelerated by human development in the watershed. In general, the amount of material deposited in the lake is directly related to the use of watershed land. Activities that clear the land and expose soil to winds and rain (e.g., agriculture, logging, and site development) greatly increase the potential for erosion. These activities can significantly contribute to the sediment pollution of a lake unless erosion and runoff is carefully managed. The input of sediments to a lake makes the basin more shallow, with a corresponding loss of water volume. Thus, sedimentation affects navigation and recreational use and also creates more fertile growing space for plants because of increased nutrients and exposure to sunlight.

Sediment material from the watershed tends to fertilize aquatic plants and algae because phosphorus, nitrogen, and other essential nutrients are attached to incoming particles. If a large portion of the material is organic, dissolved oxygen can decrease as a result of respiration of decomposers breaking down the organic matter. Sedimentation also can ruin the lake bottom for aquatic insects, crustaceans, mussels, and other bottom-dwelling creatures. Most important, fish spawning beds are almost always negatively affected.

Oxygen depletion in the lower layer occurs "from the lake bottom up." This is because most decomposers live in or on the lake sediments. Through respiration, they will steadily consume oxygen. When oxygen is reduced to less than one part per million on the lake bottom, several chemical reactions occur within the sediments. Notably, the essential plant nutrient, phosphorus, is released from its association with sediment bound iron and moves freely into the overlying waters. The influx of phosphorus from the sediments under anaerobic conditions is referred to as the internal phosphorus loading. When stratification breaks down if present or as this phosphorus reaches the photic zone, this phosphorus can be used by algae and aquatic plants. This internal pulse of phosphorus can thus accelerate algal and aquatic plant problems associated with cultural eutrophication. Iron and manganese are also released from the sediments during anoxic (no oxygen) periods.

5.3 Water Chemistry

Water quality analysis for alkalinity, hardness, calcium, magnesium, chloride, and sulfate were conducted and in general the water quality for the reservoir as described previously is considered fair. The results of this analyses are shown in Table 15. The measured chemical parameters in East Canyon Reservoir water are all within State water quality standards and when compared with the data reported Merritt et.al. (1980) there are no significant changes except for sodium and chloride concentrations which have been reduced by approximately 50% from 33.8 mg/L and 64.3 mg/L to 17.7 mg/L and 30 mg/L respectively.

5.3.1 Total Phosphorus

Phosphorus is often the key nutrient in determining the quantity of algae in a lake or reservoir. Phosphorus is typically the least abundant element required for plant growth and commonly limits biological productivity in aquatic ecosystems. For eutrophication studies, total phosphorus is the single most important nutrient to identify in outgoing and incoming streams. Many lake management decisions will be made based on the total phosphorus load coming into a lake or reservoir.

In determining the nutrient limitation association with a specific waterbody it is necessary to determine the nitrogen/phosphorus (N:P) ratio. Specifically, the ratio of inorganic nitrogen (nitrate, nitrite, and ammonia) to total phosphorus needs to be calculated. A ratio value of less than 14 will be defined as nitrogen limited while those values of 14 or greater will be defined as phosphorus limited. Currently East Canyon Reservoir is not a phosphorus limited system, due in large part to excessive amounts of phosphorus in the lake. There will need to be a substantial reduction in phosphorus concentrations to shift the reservoir towards a phosphorus limited system.

When phosphorus acts as the limiting nutrient, it is readily apparent that increases of phosphorus to the lake may dramatically result in an increase in algal production. It is the magnitude of algal production that has a great impact on lake water quality and the aquatic life within the lake ecosystem. It is imperative to understand the relationship between phosphorus concentrations and water quality. Through the control of phosphorus loading, under this principle, one can influence the quality of water in a majority of waterbodies.

Total phosphorus as it relates to water quality standards is defined as an "indicator of pollution" and not a "standard". The numeric criteria limit associated with lake water quality has been established at 0.025 mg/L (25 micrograms per liter of water). This value is used as a criteria in assessing class 2A, 2B, 3A, and 3B waters. It is a widely recognized that these are the target values needed to put a reservoir into a moderate range of productivity.

Nutrient analysis of East Canyon Reservoir establishes that total phosphorus concentrations consistently well above this indicator value. Figure 5.2 represents the average total phosphorus concentration in the reservoir and the creek above the reservoir for the period 1992-97. The average annual concentration for the intensive monitoring period (1994-97) in the reservoir is 0.117 mg/L. It should be noted that the average concentration of total phosphorus from East Canyon Creek for the same period is 0.144 mg/L.

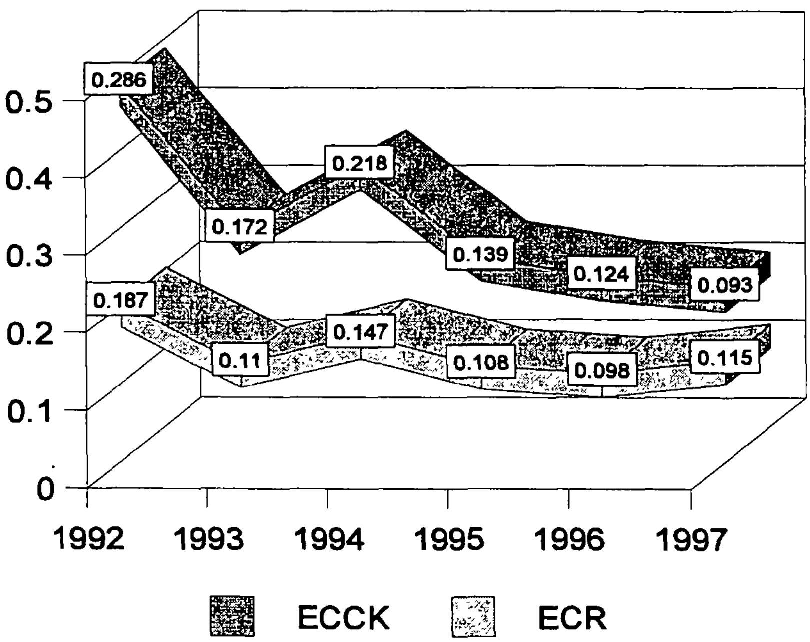


Figure 5.2 Annual total phosphorus concentration in East Canyon Reservoir and East Canyon Creek

Nutrient analysis of sediments collected in East Canyon Reservoir indicate that the water

Date	Calcium	Magnesium	Potassium	Sodium	Chloride	Sulfate	Alkalinity	Hardness
6/2/92	84	19	2.6	39	71.9	81.2	196	288
9/1/92	67	20	2.5	41	74.5	70.5	155	250
Average	**75.5**	**19.5**	**2.55**	**40**	**73.2**	**75.9**	**176**	**269**
7/12/93	65	14	1.8	25	47.5	52.2	154	220
9/1/93	66	15	1.8	27	50.5	58.8	152	226
Average	**65.5**	**14.5**	**1.8**	**26**	**49**	**55.5**	**153**	**223**
6/28/94	70	17	2.1	35	67.5	51.4	164	245
7/14/94	70	18	2.2	36	67.5	59.8	162	249
7/26/94	69	18	2.1	36	70	65.6	162	246
8/11/94	69	18	2.3	37	70	58.1	159	246
8/25/94	69	18	2.3	37	68.5	63.8	166	246
9/13/94	72	18	2.3	37	75	63.3	167	254
9/28/94	72	18	2.4	37	70.5	61.5	171	254
10/20/94	76	18	2.3	37	74	62.9	175	264
11/8/94	80	19	2.5	40	74	67.9	177	278
11/22/94	81	18	2.3	40	77	63.1	187	276
Average	**72.8**	**18**	**2.3**	**37.2**	**71.4**	**61.7**	**169**	**256**
1/31/95	81	19	2.6	40	75.5	66	179	280
4/4/95	78	19	2.4	46	88	65	174	273
4/20/95	81	19	2.3	46	91	66.5	175	280
5/3/95	83	19	2.3	46	89	63.9	172	285
5/16/95	77	17	2.2	43	85	62.5	171	262
5/30/95	73	16	2	38	78	58	166	248
6/13/95	70	15	1.9	33	64	50.3	166	236
7/3/95	68	15	1.8	30	60	52.5	164	231
7/11/95	69	15	1.6	28	54	48.2	169	234
7/27/95	70	15	1.6	27	50.5	60.5	169	236
8/10/95	69	16	1.6	27	48.5	54	172	238
8/22/95	68	16	1.6	27	49	56	156	236
9/7/95	66	16	1.7	27	49.5	58	159	231
9/26/95	67	16	1.7	28	54	56	164	233
10/26/95	69	17	1.7	30	57	62	166	242
11/15/95	72	17	1.8	32				
Average	**72.6**	**16.7**	**1.9**	**34.3**	**66.2**	**58.6**	**168**	**250**
2/14/96	77	18	2.2	38	71.5	60.5	187	266
3/6/96	73	17	2.2	35	69	57.8	184	252
4/4/96	72.2	16.7	2.4	39.6	73	65	175	249
4/30/96	72.1	14.7	1.4	41.8	70	52.1	172	240
5/29/96	68.1	13.5	1.85	30.3	62	41.2	164	226
6/12/96	60.2	13.3	1.5	29.1	58	46.2	144	205
7/9/96	64.2	13.9	1.3	27.5	52	40.7	159	217
7/23/96	66.1	14.6	1.3	29.2	54	46.5	161	225
8/7/96	68.7	15.3	1.67	29.1	54.5	49.7	166	234
8/23/96	71.4	15.1	1.5	30.2	56	52.1	171	240
9/10/96	72.3	15.7	1.9	29.8	55.5	49.9	175	245
9/26/96	69.8	15.4	1.9	29.5	58	45.6	172	238
10/8/96	69.4	16.4	2.3	40.4	74	37.4	179	241
11/5/96	73.2	16.8	3.12	32.9	64	50.6	179	252
Average	**69.8**	**15.5**	**1.9**	**33.0**	**62.3**	**49.7**	**171**	**238**
4/18/97	79.2	16.9	2.18	48.1	94.8	53.4	175	267
5/15/97	65.8	12.8	1.69	34	69	33.8	155	217
6/13/97	67.1	13.1	1.71	25.9	54.5	32.4	157	221
7/18/97	66.7	13.7	1.58	24.5	48.5	39	169	223
9/9/97	74.7	15.4	2	28.8	50.5	41.2	174	250
Average	**70.7**	**14.4**	**1.8**	**32.3**	**63.5**	**40.0**	**166**	**236**
Annual Ave	**71.2**	**16.4**	**2.0**	**33.8**	**64.3**	**56.9**	**167**	**245**

Table 15 Summary of chemical data (mg/L) for East Canyon Reservoir above dam site

soluble portion of the phosphorus was rather high. This supports the theory that internal phosphorus recycling in East Canyon Reservoir is an additional source of phosphorus into the lake increasing productivity and potentially delaying a response from reductions of external loading without further in lake treatments to reduce or eliminate this phosphorus source.

All nutrient parameters in East Canyon Reservoir were within State water quality standards except for phosphorus, which exceeded the pollution indicator criterion of 0.025 mg/l for its 3A classification. Phosphorus has exceeded this value significantly and consistently for an extended period of time.

5.4 Trophic Level Evaluation

The trophic state of a lake is a hybrid concept with no precise definition. Originally, trophic referred to nutrient status. Eutrophic water was water high in nutrients and by extension a eutrophic lake was a lake that contained eutrophic water. Later the concept of trophic state was applied to lakes rather than water, and its precise definition was lost. Now trophic state not only refers to the nutrient status of the water, but also to the biological production that occurs in the water and to the morphological characteristics of the lake basin itself. A eutrophic lake may not only be a lake with high levels of nutrients, but also a very shallow pond, full of rooted aquatic plants, that may or may not have high nutrient levels.

Lakes are typically divided into three trophic categories: oligotrophic, mesotrophic, and eutrophic. Other categories have been developed to account for anomalies within the system. In Utah we use the category *hypereutrophic* to describe lakes in the extreme eutrophic range. Lakes and reservoirs are categorized by various characteristics associated with each lake. An oligotrophic lake is typically a large deep lake with low nutrient enrichment, crystal clear waters and a rocky or sandy shoreline. Both planktonic and rooted plant growth are sparse, and the lake can support a cold water fishery. A eutrophic lake, on the other hand, is usually high in nutrient enrichment which may be shallower with a soft, mucky bottom. Algal blooms are common due to nutrient laden waters with reduced oxygen concentrations in the water column due to decomposition associated with the extensive algal blooms. Water clarity is reduced and the water often has a coloration. If deep enough to thermally stratify, the bottom waters are devoid of oxygen. Mesotrophic is an intermediate trophic state, displaying characteristics between the other two.

In evaluating the reservoir's trophic level, several approaches shown below were reviewed. The basic intent of review these models is to determine if there is an agreement at least to the trophic state of East Canyon Reservoir, and to identify a mechanism to establish endpoints based on any of these methods in determining a set of realistic goals to achieve a specific reduction in the trophic state of the reservoir.

5.4.1 Carlson Trophic State Index

The Carlson (1977) Trophic State Index (TSI) is intended to predict productivity of a lake, as indicated by three indicators: secchi depth, chlorophyll-a, and total phosphorus concentrations. Secchi depth measurements indicated transparency, chlorophyll-a indicates the amount of algal biomass, and total phosphorus indicates the nutrient availability to drive algae growth. Carlson assigned oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic ranges to each of these parameters. Utilizing the standard Carlson formulas, an annual average TSI Index value was determined for the reservoir. To determine the annual TSI values, the following procedure was used:

1 - An average annual TSI Index value for total phosphorus, secchi depth and chlorophyll-a was determined.

2 - The values from step one were then averaged to determine an overall TSI Index value for the reservoir.

3 - TSI values are compared to the following index values to determine current trophic state condition.

TSI Index value	< 40	Oligotrophic
TSI Index value	40 to 50	Mesotrophic
TSI Index value	50 to 60	Eutrophic
TSI Index value	> 60	Hypereutrophic

As indicated in Figure 5.3 the overall TSI values, an average of the value for total phosphorus, transparency, and chlorophyll-a, for the reservoir in recent years is consistently above the low range value of 50 for eutrophic status. It should be noted that the 1992-93 data set represents two monitoring periods in each year. The last 4 years is a better indication of existing condition in the reservoir.

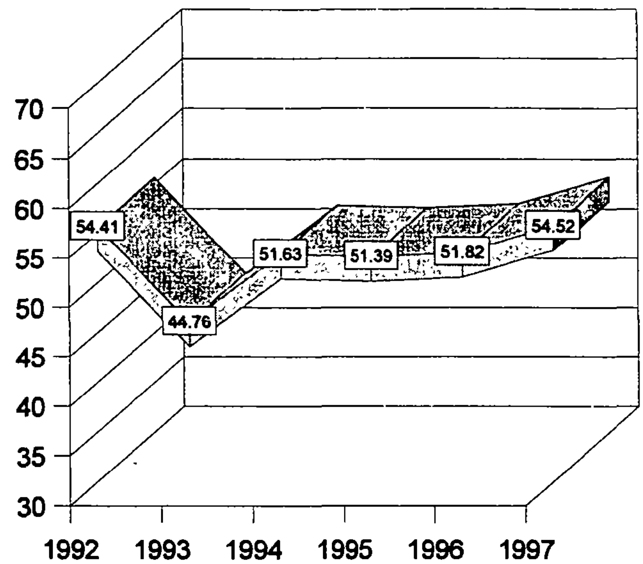


Figure 5.3 Average annual trophic state index values for East Canyon Reservoir

5.4.1.1 Transparency TSI

The transparency of water, or its ability to transmit light, is dependent mainly upon color and turbidity. An increase in color or suspended particles will reduce the depth which sunlight can penetrate in a lake and thus reduce clarity. The depth of light penetration in lakes, called the photic zone, is limited by water transparency. This is important because plants can only grow in the photic zone, therefore plant growth in lakes is controlled by the nature of the photic zone.

Secchi depth measurements, the indicator of transparency, were taken throughout the study period, but were more extensive during the period 1994-97. Secchi readings for the entire study period are shown in Table 16 along with other trophic state parameters values for the period of study. Depicted in figure 5.4 are the annual average TSI values for the various parameters used to assess the overall TSI values for the reservoir. Secchi readings are expressed in meters, chlorophyll-a in mg/L and surface total phosphorus concentrations in mg/L. The annual average transparency index values are reflective of mesotrophic conditions, however because of the interrelationship of these parameters it is important to determine the overall average trophic state value for all of the parameters to obtain a more precise indication of the trophic state.

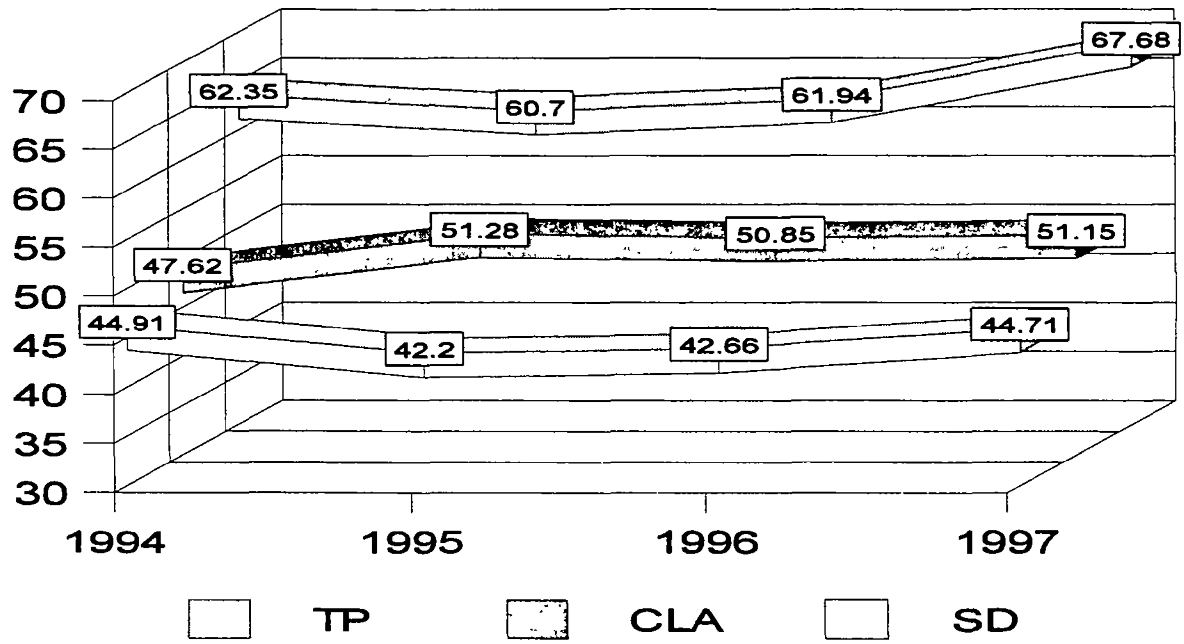


Figure 5.4 Average annual TSI values for total phosphorus, chlorophyll-a and transparency

5.4.1.2 Total Phosphorus TSI

Photosynthesis requires light in the production of organic matter by aquatic plants. It is restricted to the portion of the lake water column that is lighted, the photic zone. The thickness of the photic zone depends upon the transparency of the lake water and corresponds to the depth to which at least 1 percent of the surface light intensity penetrates. Transparency is dependent upon color, and the suspension of particulate matter, organic or inorganic.

When light is adequate for photosynthesis, the availability of nutrients often controls phytoplankton productivity. In the lake, differences between plant requirements for an element and its availability exert the most significant limit on lake productivity. Typically, phosphorus and nitrogen are the least available elements, and therefore they are the most likely to limit lake productivity.

Phosphorus in particular can often severely limit the biological productivity of a lake. The by-products of modern society, however, are rich sources of this element. Waste waters, fertilizers, agricultural drainage, detergents, and municipal sewage contain high concentrations of phosphorus, and if allowed to enter the lake, they can stimulate algal productivity. Such high productivity, however, may result in nuisance algal blooms, noxious tastes and odors, oxygen depletion in the water column, and undesirable fish kills during winter and summer. It should be noted that East Canyon Reservoir is not phosphorus limited at this time due to the relatively overabundance of total phosphorus present in the system. However, it is the recommendation of this report that phosphorus is the key parameter that needs to be targeted for reduction. Through this reduction process, it is anticipated that phosphorus will become the limiting factor on productivity in the reservoir.

Total phosphorus, which is the best indicator of potential algal growth, is a major focal point of our monitoring in the lake and watershed. It is apparent from reviewing figure 5.3 that total phosphorus concentrations would reflect in

Site	Date	Secchi	CLA	TP	Site	Date	Secchi	CLA	TP
492516	6/2/92	5	1	0.09	492518	8/22/95		20.6	0.02
492517	6/2/92	4.5	0.6	0.09	492513	9/7/95	2.6	10.3	0.02
492518	6/2/92	3.3	2.2	0.10	492516	9/7/95	3.1	4.4	0.01
492516	9/1/92	1	27.9	0.06	492518	9/7/95	3.4	6.7	0.01
492517	9/1/92	1.7	1.3	0.04	492513	9/26/95	3.3	8.8	0.01
492518	9/1/92	1	11.2	0.09	492516	9/26/95	3.8	6.8	0.00
Mean		**2.75**	**7.36**	**0.07**	492518	9/26/95	2.6	4.6	0.02
Maximum		**5**	**27.9**	**0.1**	492513	10/26/95	3.4	9.3	0.02
Minimum		**1**	**0.06**	**0.04**	492516	10/26/95	3.4	11.3	0.03
492516	7/12/93	4.8	1.1	0.01	492518	10/26/95	3.2	3.6	0.02
492517	7/12/93	4.4	2.7	0.02	492513	11/15/95	4.6	6.9	0.05
492518	7/12/93	3.9	3.8	0.02	492516	11/15/95	4.6	8.4	
492516	9/1/93	2	2.7	0.01	492518	11/15/95	4.2	1.4	0.05
492517	9/1/93	2	3.3	0.02	**Mean**		**3.44**	**8.23**	**0.05**
492518	9/1/93	1.8	4.5	0.03	**Maximum**		**4.6**	**39.5**	**0.13**
Mean		**3.15**	**3.01**	**0.01**	**Minimum**		**1.3**	**0.4**	**0.0**
Maximum		**4.8**	**4.5**	**0.03**	492516	2/14/96	5.6	2.3	0.1
Minimum		**1.8**	**1.1**	**0.01**	492516	3/6/96	5.6	12	0.09
492513	6/28/94	2.2	2.1	0.01	492513	4/4/96	1.9	21.6	0.12
492516	6/28/94	2	2.4	0.01	492516	4/4/96	1.6	38.3	0.13
492518	6/28/94	2	4.3	0.02	492518	4/4/96		10.3	0.14
492513	7/14/94	3	4.8	0.01	492513	4/30/96	2.3	17.9	0.07
492516	7/14/94	2.5	7.6	0.01	492516	4/30/96	2.5	20.5	0.07
492518	7/14/94	3	4.1	0.02	492518	4/30/96	2.3	14.8	0.06
492513	7/26/94	2.8	3.5	0.04	492513	5/29/96	3.2	2.1	0.04
492516	7/26/94	2.9	7.6	0.01	492516	5/29/96	2.5	12.7	0.04
492518	7/26/94	2.7		0.01	492518	5/29/96	2.9	7.7	0.04
492513	8/11/94	2.3	5	0.01	492516	6/12/96	3.9	0.4	0.01
492516	8/11/94	2.7	3.8	0.02	492513	6/27/96	5.5	2.1	0.16
492518	8/11/94	2.6	2.9	0.02	492516	6/27/96	5	2.8	
492513	8/25/94	1.6	3.4	0.06	492518	6/27/96	4	5	0.02
492516	8/25/94	2.1	4.1	0.04	492513	7/9/96	3.7	3.6	0.02
492518	8/25/94		4.1	0.03	492516	7/9/96	3.8	3.2	0.02
492513	9/13/94	1.5	9.2	0.05	492518	7/9/96	2.9	5	0.02
492516	9/13/94	2	10	0.03	492513	7/23/96	2.6	2.5	0.01
492518	9/13/94	2.7	5.8	0.04	492516	7/23/96	2.8	3.3	0.01
492513	9/28/94	1.5	8	0.03	492518	7/23/96	2.6	4.6	0.02
492516	9/28/94	1.7	6.7	0.03	492516	8/7/96	2.9	3.1	0.02
492518	9/28/94	1.4	8.8	0.04	492513	8/8/96	2.5	4.2	0.02
492513	10/20/94	5.6	2.7	0.07	492518	8/8/96	2.3	4.2	0.49
492516	10/20/94	5.8	1.8	0.07	492513	8/23/96	2.75	3.2	0.01
492518	10/20/94	3.6	4.3	0.07	492516	8/23/96	3.48	1.8	0.01

Site	Date	Secchi	CLA	TP	Site	Date	Secchi	CLA	TP
492513	11/8/94	4.8	8.4	0.10	492518	8/23/96	2.55	2 8	0.01
492516	11/8/94	5.4	4.1	0.12	492513	9/10/96	2.2	6.1	0.02
492518	11/8/94	4.4	6.2	0.10	492516	9/10/96	2.5	8.1	0.02
492513	11/22/94	4.5	11.3	0.15	492518	9/10/96	2	9.8	0.01
492516	11/22/94	4.6	4.8	0.19	492513	9/26/96	3.6	2 1	0.02
492518	11/22/94	4.4	12.6	0.14	492516	9/26/96	4	1.2	0.02
Mean		**3.04**	**5.66**	**0.05**	492518	9/26/96	3.6	2.6	0.02
Maximum		**5.8**	**12.6**	**0.19**	492513	10/8/96	4.5	3.3	0.00
Minimum		**1.3**	**1.8**	**0.01**	492516	10/8/96	3.95	23.2	0.00
492513	4/4/95	1.3	39 5	0.13	492518	10/8/96	3.9	7.8	0.00
492516	4/4/95	1.3	36	0.13	492513	11/5/96	4.1	5.5	0.05
492518	4/4/95	1.2	31.2	0.14	492516	11/5/96	4.3	7 5	0 08
492513	4/20/95	3.8	5.1	0.09	492518	11/5/96	4.3	18	0.06
492516	4/20/95		6.2	0.10	**Mean**		**3.33**	**7.87**	**0.05**
492518	4/20/95	3.6	6.6	0.10	**Maximum**		**5.6**	**38.3**	**0.49**
492513	5/3/95		2 6	0.09	**Minimum**		1.6	0.4	0.01
492516	5/3/95		10.5	0.09	492513	4/18/97	0.7	61.8	0.10
492518	5/3/95		2.5	0.10	492516	4/18/97	1	20.9	0.08
492513	5/16/95	5.5	2.2	0.08	492518	4/18/97	0.6	12.4	0.08
492516	5/16/95	3.6	3.9	0.07	492513	5/15/97	4.1	1.1	0.08
492518	5/16/95	2.2	2.8	0.07	492516	5/15/97	4.5	1.3	0.09
492513	5/30/95	4.5	1.6	0.06	492518	5/15/97	3.5	2.3	0 10
492516	5/30/95	4.9	0 4	0.06	492513	6/13/97	4.2	1.7	0.09
492518	5/30/95	5.2	2.1	0.06	492516	6/13/97	4.8	1.8	0.09
492513	6/13/95	4.1	6.1	0.04	492518	6/13/97	4	3.2	0.14
492516	6/13/95	4.7	5.1	0.05	492513	7/18/97	1.9	2.7	0.04
492518	6/13/95	4.4	1.8	0.05	492516	7/18/97	2.3	2.4	0.06
492513	7/3/95	3.2	1.9	0.03	492518	7/18/97	1.9	2.4	0.05
492516	7/3/95	3.9	2.8	0.03	492513	9/9/97		2.2	0.06
492518	7/3/95	2.2	3.8	0.03	492516	9/9/97	3.3	3	0.05
492513	7/11/95	3.9	2.9	0.02	492518	9/9/97	3.7	3.1	0.06
492516	7/11/95	3.9	4 1	0.01	**Mean**		**2.89**	**8.15**	**0.07**
492518	7/11/95	4.2	4 3	0.03	**Maximum**		**4.8**	**61.8**	**0.14**
492513	7/27/95	4	1.4	0.02	**Minimum**		**0.7**	**1.1**	**0.05**
492516	7/27/95	5	2						
492518	7/27/95		3.5	0.01					
492513	8/10/95	2	6.2	0.01					
492516	8/10/95	2.5	8.4	0.01					
492518	8/10/95	2	12.1	0.02					
492513	8/22/95		16.5	0.01					
492516	8/22/95	1.4	31.1	0.01					

Table 16 Trophic state index values for reservoir sites.

a significantly higher TSI value determination if that was the only parameter used in the evaluation.

5.4.1.3 Chlorophyll-a TSI

All three lake stations were monitored by the state for chlorophyll-a during the course of the intensive study period. Table 16 contains the data obtained during the study.

The average concentrations for the reservoir during the intensive study period was 5.67 mg/L, 8.23 mg/L, 7.88 mg/L and 8.15 mg/L for an annual average of 7.48 mg/L. The highest concentration measured was 61.8 mg/L on April 18, 1997. The Carlson index, as discussed earlier, gives trophic state values of 47.62, 51.28, 50.85 and 51.15 for the same respective years. A value greater than 50 indicates a eutrophic state.

5.4.2 Vollenweider's Model

Vollenweider's model for phosphorus loading diagram provides another way of evaluating the East Canyon Reservoir trophic level. Vollenweider (1968) developed equations and subsequently nutrient loading graphs in which the mean annual inflowing phosphorus concentration (ug/L) was plotted against the hydraulic retention time (years) where the residence time is lake volume/outflow.

A review of the hydraulic retention time for the reservoir indicates that the average for the years 1994-96 was 1.15 and for the last ten years 1.17. The model assigns trophic states to a reservoir with a retention period of ≈ 1.17 as: hypereutrophic with a total phosphorus inflow concentration greater than ≈ 130 ug/L; eutrophic with a total phosphorus inflow concentration greater than ≈ 50 ug/L; mesotrophic with a total phosphorus inflow concentration greater that ≈ 20 ug/L; and oligotrophic with a total phosphorus inflow concentration less than ≈ 20 ug/L.

Therefore during the intensive monitoring period (1994-96) the trophic state for the reservoir would be assigned as hypereutrophic based on the total inflow concentrations to the reservoir for the years 1994-96 as 218 ug/L, 139 ug/L, and 124 ug/L respectively.

5.4.3 Larsen Mercier Model

The Larsen Mercier model is similar to Vollenweider's. In this model, inflowing total phosphorus concentration is related to the phosphorus retention coefficient to the predicted trophic state in the lake or reservoir. Although the model works well for oligotrophic to meso-eutrophic waterbodies, eutrophic and hypereutrophic systems like East Canyon Reservoir have such an abundance of phosphorus that other factors play an increasingly significant role in limiting productivity at such a high level.

Phosphorus retention coefficients are calculated by subtracting the outflow phosphorus load from the inflow phosphorus load and dividing this difference by the inflow phosphorus load. It is assumed that an inflowing concentration of 10 ug/L is the point of separation between oligotrophic and mesotropic systems and 20 ug/L is the point of separation between mesotrophic and eutrophic or higher systems. A general model observation can be made that as the phosphorus retention coefficient increases these boundaries shift upward so that as the coefficient approaches the value 1 the inflowing concentration approaches 1000 ug/L as the point of separation between oligotrophic and mesotrophic systems.

This increase follows a logarithmic scale with a uniform straight line relationship until the coefficient values passes 0.4-0.5.

A review of data for the intensive study period indicate that the general phosphorus retention coefficient for the reservoir is near the lower end of the scale with a highest determined value of 0.32 and the lowest value of -.17 (indicates that more phosphorus left the system that year than enter the reservoir). It is clearly evident that the inflow concentrations to the reservoir for the years 1994-96 as 218 ug/L, 139 ug/L, and 124 ug/L respectively place the trophic state as well above the eutrophic border of approximately 20-30 ug/L for a given retention coefficient less than 0.32, the maximum found during the intensive study period.

The Larson Mercier curves are fit for a large number of common lakes. There is some indication from those who have studied the reservoir that East Canyon Reservoir differs from these typical lakes, hence the model gives a more eutrophic reading for lower phosphorus retention coefficients. It has been stated that these trophic states indicated by Larsen Mercier give higher than normal trophic readings, and for East Canyon Reservoir these levels should be reduced. However, because the plot of the inflowing phosphorus concentration against the phosphorus retention coefficients place the trophic status of the reservoir well into the eutrophic range, it does clearly indicate that the reservoir is indeed at least a eutrophic system.

5.5 Phytoplankon Community Dominance

As part of the intensive study phytoplankton samples were collected on the reservoir as part of the routine monitoring effort. Phytoplankton samples collected were representative of the water column to a depth of three times the transparency reading. The results of that sampling clearly indicate that the reservoir is dominated by blue-green algae. These algae are indicative of a highly eutrophic condition.

A review of the phytoplankton data obtained during the intensive study period (Table 17, 18, and 19) indicates that not only is the reservoir dominated by blue-green algae but there have been significant population densities of the most troublesome species present in the reservoir.

Blue-green algae, cyanobacteria, contribute to a wide variety of water quality problems in lakes worldwide. These problems range from aesthetic concerns to swimmers, the reduction in the filtration capacity and efficiency of water treatment facilities, the production of compounds responsible for unpleasant taste and odor in drinking water, creation of precursors (organic compounds) for the development of trihalomethanes (THM's) when chlorinated, to the production of compounds that are acutely toxic to animals, and likely also to humans.

Poisonings of animals occur when they drink water from ponds, dugouts and lakes contaminated with toxin producing blue-green algae. Reports of animal deaths are recorded in veterinary journals, community newspapers , personal memoirs and also in scientific journals. These animal poisonings include livestock (cattle, sheep), cats, dogs, deer, muskrats, waterfowl and shorebirds, and even a rhinoceros. Death can occur very quickly after the animals consume the contaminated water (in as little as a few minutes) (Kotak et.al., 1994).

Blue-green algae produces two classes of toxins: neurotoxins and hepato-(liver)-toxins. Neurotoxins are compounds which affect the nervous system after the toxin is ingested and, if ingested in sufficient concentrations, cause respiratory arrest in five to thirty minutes. Neurotoxins are produced primarily by species of *Anabaena*, although *Aphanizominon* as well. *Anabaena sp.* produces

Taxon	Relative Density (%) 6/28	7/14	7/26	8/11	8/25	Cell Volume (mm^3/liter) 6/28	7/14	7/26	8/11	8/25
Anabaena sp.	59.12	36.65	27.31			12.788	4.448	3.614		
Ankistrodesmus falcatus	0.02			0.10	0.04	0.004				0.004
Ankyra judayi	0.01					0.003				
Aphanizomenon flos-aquae			1.60	18.99				0.211	1.585	
Asterionella formosa			1.26	0.40				0.167	0.042	
Centric diatoms				0.08	0.23				0.007	0.023
Ceratium hirundinella		7.79	21.43	11.33	9.16		0.945	2.836	0.945	0.945
Chlamydomonas sp.	0.01					0.002				
Dinobryon divergens	3.22	0.40	1.85		0.12	0.697	0.049	0.245		0.012
Fragilaria crotonensis			7.56	5.49	3.23			1.001	0.458	0.334
Gloeocystis vesiculosa				0.13	0.11				0.011	0.011
Merismopedia glauca				0.60					0.050	
Microcystis aeruginosa				2.93					0.245	
Microcystis incerta	3.86			3.20	67.32	0.834			0.267	6.950
Oocystis sp.		1.65	1.89	3.10	1.45		0.200	0.250	0.259	0.150
Pandorina morum	1.03			18.65	4.31	0.222			1.557	0.445
Pennate diatoms	0.06	0.07	0.07	0.05	0.17	0.013	0.009	0.009	0.004	0.018
Phacotus sp.					13.46					1.390
Sphaerocystis schroeteri	31.10	50.39	36.97	31.65		6.728	6.120	4.893	2.641	
Stephanodiscus niagarae	0.82	2.93				0.178	0.356			
Unk. spherical chlorophyta	0.02	0.09				0.003	0.011			
Wislouchiella planktonica	0.72		0.07	3.70		0.156		0.009	0.309	

Table 17 Phytoplankton floras from East Canyon Reservoir for 1994

two neurotoxins termed anatoxin-a and anatoxin-a(s). These compounds are more toxic than dioxins, with LD50 value of 200 and 50ug/kg (measuring lethal dose that 50 percent of the test organism died), respectively, in mice. Accidental ingestion of the neurotoxins causes muscle tremors, staggering, gasping for breath, convulsions and can even cause death.

Hepatoxin poisonings are the most frequently reported cases of blue-green algal intoxication in the literature. Hepatotoxins were first reported to be produced by *Microcystis aeruginosa* and are, therefore, referred to as microcystins. Other species of blue-green algae, however, such as *Anabaena sp.* and *Oscillatoria sp.* also produce microcystins. Microcystins are small proteins that cause extensive liver hemorrhage when ingested. A lethal dose of microcystin will cause liver damage and death in two to twenty-four hours. More than 30 microcystins have been identified to date, with more being described each year. The most commonly occurring microcystin in Alberta, and likely in North

Taxon	Relative Density (%) 7/11	7/27	8/26	9/6	Cell Volume (mm^3/liter) 7/11	7/27	8/26	9/6
Aphanizomenon flos-aquae	8.87		28.21	43.94	0.106		4.859	10.247
Asterionella formosa	2.38				0.028			
Ceratium hirundinella			21.95	8.11			3.781	1.890
Chlamydomonas sp				0.02				0.004
Dinobryon divergens				0.16				0.037
Euglena sp.	3.45				0.041			
Fragilaria crotonensis			22.60	15.71			3.894	3.665
Melosira granulata var. angustissima		1.00	0.30			0.077	0.051	
Melosira granulata	13.73	2.13	0.32	0.23	0.163	0.163	0.054	0.054
Microcystis incerta				0.24				0.056
Oocystis gigas				0.14				0.033
Oocystis sp.	8.40	0.76	0.34	0.32	0.100	0.058	0.058	0.075
Pandorina morum		2.90	1.29	1.91		0.222	0.222	0.445
Pennate diatoms	2.29			0.12	0.027			0.027
Phacus sp.	2.33	3.26	2.42	0.83	0.028	0.250	0.417	0.195
Sphaerocystis schroeteri		68 93	15.33	22.65		5 282	2.641	5.282
Staurastrum gracil		4.72				0.361		
Stephanodiscus niagarae	44.82	16.25	7.23	2.29	0.534	1.245	1.245	0.534
Unk. Spherical chlorophyta		0.04	0.02			0.003	0.003	
Unk. Filamentous chlorophyta	13.73				0.163			

Table 18 Phytoplankton floras from East Canyon Reservoir for 1995

America, is microcystin-LR. It is also one of the most toxic of the microcystins, with an LD50 of 50ug/kg. Recent studies suggest that microcystin-LR is one of the most potent tumor promoters yet tested. Chronic exposure to low

levels of microcystins may increase the risk of liver tumors, so health agencies are now considering what levels of microcystins in drinking water would be necessary to pose a significant cancer risk. At present, primary liver cancer is relatively uncommon in North America.

Little information is available on the consequences of consuming low concentrations of microcystins over one's lifetime. The risk of long-term chronic exposure may exist as conventional water treatment practices such as flocculation, filtration and chlorination do not remove microcystins adequately from drinking water. Available data indicates that these processes remove between 10 and 30 percent of microcystin-LR while more sophisticated treatment involving activated carbon filtration or ozonization are much more effective, removing almost 100 percent of dissolved microcystin-LR from water.

In the study by Kotak et.al., it was concluded that the presence of

Microcystis aeruginosa in an algal sample generally assured that microcystin-LR would be present in detectable concentrations. There was a strong statistical correlation between the abundance of Microcystis aeruginosa and microcystin-LR ($r=.90$, $P<0.001$, $df=11$).

Taxon	Relative Density (%) 9/9	9/23	8/8	8/23	9/10	9/26	10/8	Cell Volume (mm^3/liter) 9/9	9/23	8/8	8/23	9/10	9/26	10/8
Anabaena spiroides var. crassa	18.83				0.97	11.48	54.64	1.168				0.106	0.778	12.45
Ankistrodesmus falcatus	0.14		0.10	0.10				0.009		0.004	0.004			
Aphanizomenon flos-aquae		4.90					31 05		0.634					7.078
Asterionella formosa	0.11	0.05	0.78	12.08	14 82	0.30	0.03	0.007	0.007	0.033	0.514	1.608	0 020	0.007
Botryococcus braunii		17.20							2.224					
Centric diatoms	0.13	0.12			0.07	0.23	0 10	0.008	0.016			0.008	0.016	0.023
Ceratium hirundinella		7.31		22.22	8.71	27.87			0.945		0.945	0.945	1.890	
Chlamydomonas sp.		0.40							0.051					
Coelastrum sp.						8.20							0.556	
Cosmarium sp.	1.26	0.60	1.81					0.07	0.07	0.07				
Dinobryon divergens	3.16	5.39	0.57	0.29		0.18	0.16	0.19	0.69	0.02	0.01		0.012	0.03
Fragilaria crotonensis		5.16	7.77	47.0	67.6	39.3	11.7		0.66	0.33	2.00	7.33	2.669	2.66
Melosira granulara var		0.40			0.47		0.22		0.05			0.05		0.05
Microcystis incerta	66.3	54.6	40.1			0.82		4.11	7.06	1.72			0.056	
Oocystis borgei	3.23							0.20						
Oocystis gigas			1.75	0.59	0.23	0.37				0.07	0.02	0.02	0.025	
Oocystis sp.	0.54	0.77	3.50	5.49	0.15		0.04	0.03	0.10	0.15	0.23	0.01		0.00
Pandorina morum			10.3	5.23		3.28	0.98			0.44	0.22		0.222	0.22
Pennate diatoms	0.07	0.14	0.21	1.46	0.08	0.07	0.04	0.00	0.01	0.00	0.06	0.00	0.004	0.00
Phacotus sp.			0.08	1.83	0.10	0.66	0.07			0.03	0.07	0.01	0.044	0.01
Quadrigula lacustris			25.9							1.11				
Sphaerocystis schroeteri					5.64							0.61		
Staurastrum gracile	5.83	2.80						0.36	0.36					
Stephanodiscus niagarae	0.27	0.13	5.83	3.53	1.08	7.13	0.88	0.01	0.01	0.25	0.15	0.11	0.484	0.200
Unk. spherical chlorophyta	0.09		0.52	0.13		0.08		0.006		0.022	0.006		0.006	

Table 19 Phytoplankton floras from East Canyon Reservoir for 1996

5.6 Reservoir Response

There are several factors that need to be considered as goals and objectives are established to improve water quality in this reservoir. Although the natural tendency is to want to see change in the water quality immediately, a more realistic long-term time frame is more appropriate in expecting water quality changes. After establishing goals, implementation of appropriate corrective action will take time. A monitoring program will need to be continued for the assessment of the effectiveness of the initial treatment alternatives and to establish if implementation of BMP's is achieving water quality endpoints or goals. If needed monitoring data may verify and direct correction action needed to accomplish water quality objectives.

To shorten the reservoir response time, treatment to inactivate the release of phosphorus from the sediments in the reservoir that have accumulated over an extended period of time may be a reasonable option. This treatment should not be implemented without first controlling the external sources of phosphorus into the reservoir to the extent feasible. This inactivation could be accomplished either by chemical treatment to inactivate the phosphorus in the sediments or by the elimination of anoxic conditions in the reservoir by breaking down the thermal stratification through the introduction of oxygen into the hypoliminion and disruption of the stratification by mechanical means.

Another treatment that could be effective on a long-term water quality in the reservoir is the breaching or removal of two previous dam structures in the reservoir.

Current plans are underway to import additional water into the basin. This plan would allow for an increase in the permanent population in the basin and probably expand recreational opportunities in the watershed to meet the needs of increased resident and nonresident populations. One proposal to import a minimum of 5,000 acre-feet of water back from East Canyon Reservoir could have a variety of impacts to water quality. Because of the complex nature of this proposal, a through review of the proposal should be conducted to assure no further degradation of water quality will occur in the stream or the reservoir.

East Canyon Reservoir is one of several reservoirs that is managed in part by Weber Basin Water Conservancy. As such the development of a water quantity management plan for all of the reservoirs under their jurisdiction can have a major impact on the water present in the reservoir at any given point in time. It should be noted that the management of these reservoirs for water rights downstream can have an impact on the water quality within any of the respective reservoirs according to representatives of the conservancy district.

6.0 RECREATION/SOCIO-ECONOMIC EVALUATION

Traditionally according to state park records fishing and boating are the primary recreational activities engaged in by visitors to the park. Strong arguments can be made that this decline is due in part to the reduction in water quality and its effect on the fishery. The number of visits to East Canyon Reservoir has fluctuated but from 1982 to 1987, visitations rose to above 300,000 users per year. Since then, use has declined significantly to about 111,000 users.

Fishing, which is the single most popular recreational activity at East Canyon Reservoir, has been adversely impacted by a decline in water quality. Trout are stressed by low dissolved oxygen concentration through the hypolimnion from mid-summer to early autumn. This condition resulted in a complete loss (100% mortality) of fingerling rainbow trout stocked in 1990 and 1991 as previously reported.

State Park Records show that nearly 98 percent of those who visit the reservoir area are Utah residents and almost all of those come from Salt Lake, Davis, Weber, Cache, Morgan, Tooele or Summit counties. The combined population of these counties is projected to reach 1,410,000 by the year 2000.
Most of the park's visitations occur between the months of April and September, with the heaviest use being May through August. Surveys conducted by Utah Division of Parks and Recreation indicate that the primary activities at East Canyon Reservoir in order of importance include; fishing, picnicking, camping, sightseeing, boating, and water skiing.

The impaired water quality in East Canyon Reservoir has the following economic impacts:

1. Increased cost for the treatment of reservoir waters for municipal and industrial uses.
2. Decrease in the tourist activity at the reservoir, affecting the State Park visitation and East Canyon Resort.
3. Loss of sales tax revenue to local agencies.
4. Stocking the reservoir with larger fish that have a better survival rate than the fingerling has increased the cost of maintaining a fishery in East Canyon Reservoir.
5. The 1991 U.S. Fish and Wildlife Service has estimated an economic loss in dollars per angler that would affect the fishery environment both in the community and reservoir. A value of $59.35 per angler would be lost if fishing were to cease. This includes logging, gas, and equipment among other things. Furthermore a overall community economic impact has been estimated at $122 per day. Using these figures one can estimate the loss of monies associated with a general decline in public use of this resource. Using Utah Division of Parks and Recreation use values there is a decline of 201,733 users days from the peak of 312,224 to the average users days for 1995-96 (110,491). If 25% of those days were dedicated to fishing ($59.35/day) a loss of $11,972,853.00 or an overall community economic impact of $24,611,426.00. Although these percentage values are estimates, it can readily be assumed that the decline in user days for this resource represents a significant economical impact to the area.

7.0 PUBLIC PARTICIPATION

At the beginning of the project a technical committee was organized and made up of the following State and Federal agencies and local interest groups. This committee has met on at least a bi-monthly basis to review the progress of the study and to provide valuable resources, and guidance towards completion of the study. This was an open meeting and public participation was encouraged. This committee was chaired by Richard Bojanowski of East Canyon Resort and Joan Patterson of Morgan County. Membership consisted of the following representatives:

East Canyon Resort
Utah Trout Foundation
High Country Fly Fishers
East Canyon Land Owners
Park City Development Board
910 Cattle Company
Morgan County Commission
Morgan County Planning Commission
U.S. Soil Conservation Service
Utah State Division of Wildlife Resources
Utah State Division of Parks and Recreation
Utah State Division of Water Resources
Utah State Department of Agriculture
Utah State Department of Environmental Quality
Summit City/County Health Department
Summit County Planning Commission
Summit County Commission
Park City
U.S. Bureau of Reclamation
Weber Basin Water Conservancy District
Snyderville Basin Sewer Improvement District
Mountainland Association of Governments
Weber/Morgan Health Department

During the period of intensive monitoring that was initiated after the preliminary clean lakes period of monitoring and evaluation, the East Canyon Technical Advisory Committee underwent a period of inactivity. Recently the group has been reorganized to provide oversight not only for the completion of the final clean lakes report but to provide input and direction into the development of a TMDL for designated impaired waterbodies and the development of a long range watershed plan focusing on water quality related issues and problems. They are also providing input with some oversight on projects that are planned or are being planned for development in the basin that might have an impact on water quality. The same basic representation has been solicited but the chairmanship for the committee has been under the Ray Loveless, Water Quality Director for Mountainlands Association of Governments.

8.0 EAST CANYON RESERVOIR WATERSHED TMDL DEVELOPMENT

East Canyon Reservoir is a valuable freshwater resource in Utah. Recreation, wildlife, agriculture, and water supply are key beneficial uses served by the lake. The area's value as a recreational resource is highlighted by over 300,000 user days at the state park surrounding the reservoir during peak use years in the 1980's and a significant number of visitors at East Canyon Resort at the south end of the reservoir. The fishery is the focal point of activity at the reservoir as shown by visitation records. Water from the reservoir is used primarily downstream for irrigation on downstream lands and for municipal and industrial purposes in the urban area of Davis and Weber Counties. The water is also used for recreation by users of the East Canyon Resort, other private property owners above the reservoir and users located along the Wasatch Front. Additional uses may develop with the anticipated movement of water from the reservoir back to the Park City area for snow making, culinary and other residential uses.

The objective of this program is to restore water quality for the defined beneficial uses. These include restoring the cold water fishery, protecting culinary water use by reducing the potential for taste and odor problems and protecting water-based recreation uses.

Findings reported in previous sections of this report indicate that an excessive total phosphorus load is currently entering the reservoir when viewed as to the trophic state of the reservoir. Evidence indicates that current phosphorus loadings support (eutrophic) excessive growth of algae and other aquatic plants and it is expected that a reduction in phosphorus loadings will reduce productivity. A review of past studies and current findings indicate that current loadings of available phosphorus are such that the reservoir is on the boundary between eutrophic and hyper-eutrophic condition and the reservoir has exhibited an increasing eutrophication trend in recent years. These eutrophic conditions are responsible for the beneficial use impairments observed in the reservoir.

Available evidence indicates that we could expect a favorable response to reductions of "phosphorus loadings" and thereby limit productivity, a leading cause of water quality impairments. EPA guidance for the development of TMDL's for impaired waterbodies requires the development of a strategy that will reduce or eliminate the stressors or pollutants that are responsible for the loss in beneficial uses for identified waters. Table 21 contains the major elements required for the development of a TMDL for an impaired waterbody or a Watershed Restoration Action Strategy (WRAS) with reference within this report to areas pertinent to those requirements.

Those waters currently defined in Utah's 303(d) list are East Canyon Reservoir and East Canyon Creek from East Canyon Reservoir to the headwaters. Figure 8.1 identifies the specific pollutant or stressor that has been linked to the impairment for specific defined beneficial uses of those listed waters.

Of the two pollutants identified it should be noted that total phosphorus is considered an 'indicator of pollution' as defined in Utah's "Standards of Quality for Waters of the State (R317-2, Utah Administrative Code)." Threshold values established for streams and lakes or reservoirs is 0.05 mg/L and 0.025 mg/L respectively. Numeric standards established for dissolved oxygen for Class 3A waters are:

30 Day Average	6.5 mg/L	
7 Day Average	Maximum 9.5 mg/L	Minimum 5.0 mg/L

1 Day Average Maximum 8.0 mg/L Minimum 4.0 mg/L

Through the assessment process defined by the Division of Water Quality in compliance with Section 305(b) of the Clean Water Act (CWA) additional information other than water quality data when available is used to validate exceedances of those pollution indicators in streams. Limited macroinvertebrate and diurnal dissolved oxygen data was available for the assessment of East Canyon Creek above the reservoir. The assessment process for lakes and reservoirs incorporates additional data and information in determining the impaired status of waters.

303(d) Identified Impaired Waterbodies		
Waterbody Description	**Specific Pollutant or Stressor**	**Impaired Beneficial Use**
East Canyon Creek from East Canyon Reservoir to the headwaters	Total Phosphorus, Dissolved oxygen	3A
East Canyon Reservoir	Total Phosphorus, dissolved oxygen	3A

Table 20 303(d) Identified Impaired Waterbodies

We recognize the validity of the pollution indicator for total phosphorus but additional endpoints will be defined to enhance our ability to evaluate the restoration of beneficial uses as defined by the State in their water quality standards. These additional endpoints will be associated with waterbody productivity, stream morphology, or the biological integrity of the stream, its corridor, or other ecological areas in the watershed.

Table 20 contains a summary of those endpoints for the impaired waters in the watershed. The linkage of these non-numerical standards to defined beneficial uses is supported by scientific studies that link these factors to those defined beneficial uses and to some of the existing violations of criteria associated with beneficial uses (eg. High algal production dominated by blue-green algae leads to low dissolved oxygen or anoxic conditions in reservoirs; lack of habitat and streambank stability leads to impaired fisheries).

8.1 TMDL Development and Allocation of Responsibility

The objective of establishing endpoints is to assure the restoration of impaired beneficial uses. Those waters defined as impaired from an empirical evaluation of available water quality data n-stream macroinvertebrate data coupled with observations from local constituents and water users in the watershed. There is some professional judgement associated with the definition of endpoints or targets established in this watershed, nevertheless, it is important to note that it is the intent of the stewards in this watershed that these endpoints be established based on our initial objective, the restoration of impaired beneficial uses.

The primary parameters of focus are total phosphorus, temperature (not a 303(d) listed parameter), and dissolved oxygen. Criteria associated with these parameters are defined in the Utah's "Standards of Quality for Waters of the State (R317-2, Utah Administrative Code)." Through the assessment process defined by the Division of Water Quality in compliance with Section 305(b) of the Clean Water Act (CWA) additional data when available is used to validate "exceedances" of those pollution indicators. Biological data presented in this

TMDL Endpoints for East Canyon Creek Watershed Impaired Waters				
Description	Waterbody Biota	Total Phosphorus concentration mg/L	Dissolved oxygen concentration mg/L	Miscellaneous Endpoints
East Canyon Creek and tributaries from East Canyon Reservoir to headwaters	Shift from organic enrichment and sediment tolerant macroinvertebrate to higher water quality species composition	≤0.05	Instantaneous dissolved oxygen concentration > 4.0 mg/L	Enhance or restore streambank stability in designated areas with accelerated streambank erosion. Implement DWR recommendations for stream corridor restorations of habitat and channel stabilization. Insure compliance with existing ordinances and develop additional ordinances for construction activities associated with recreation, residential or business development. Implement BMP's to reduce total phosphorus from urban runoff. "Fishery goals to be defined"
East Canyon Reservoir	Algal dominance not blue-green	In-lake concentration ≤.025; Inflow concentration of ≤0.05	Instantaneous water column average at dam site > 4.0 mg/L for > 50% of water column depth	Overall TSI value = 40-50.00; Annual loading equivalent to annual flow with 0.05 mg/L total phosphorus conc.

Table 21 TMDL Endpoints for East Canyon Creek Watershed Impaired Waters

report for some segments of East Canyon Creek and its tributaries, with additional criteria defined for the reservoirs in support of the conventional chemical assessment for those waters listed on the impaired waters listing, referred to as the 303(d) list.

The primary focus of restoration practices focuses on the reduction of total phosphorus within the system through control of those sources contributing excessive loadings: Snyderville Basin wastewater treatment plant (SBWWTP); urban runoff; development; recreation; agricultural related activities; and at risk riparian corridor conditions. The primary goal for the reservoir is to reduce total phosphorus loadings to the point where trophic state index values are in the mesotrophic range (40-50), shift the algal community dominance away from blue-green species composition, reduce temperature regimes in the epilimnion, and reduce anoxic conditions present in the hypolimnion.

In order to achieve this it is recommended that an annual loading to the reservoir be established based on an annual target concentration value of 0.05 mg/L for the waters flowing into the reservoir. This endpoint is equivalent to the established pollution indicator found in the states water quality standards which is based on scientific studies which support the biological effects associated with high levels of nutrients in aquatic systems and specifically on the modeling previously discussed supporting a shift in the trophic state status of the reservoir with a reduction of nutrient levels to this endpoint. A review of the average annual concentration for the intensive monitoring period (Section

5.3.1) indicates that the differential between inflowing concentrations to the reservoir and in-lake concentrations of total phosphorus to be 0.027 mg/L. This is basically the difference of the state pollution indicator values for a stream versus a lake. It is a good indication that if the inflowing stream concentration endpoint of 0.05 mg/L can be achieved that the in-lake concentration endpoint of 0.025 mg/L will also be achieved.

In addition when control of identified sources of total phosphorus is achieved, it is recommended that treatment of the sediments within the reservoir to reduce or eliminate internal loading of phosphorus be initiated. This could be accomplished either by chemical inactivation of the sediments or an ongoing program to entrain oxygen into the hypolimnetic portion of the reservoir. It is clearly evident that significant reduction in current phosphorus loadings will be required to achieve these goals.

Figure 8.3 summarizes loadings in recent years compared to what would have be expected through achieving target endpoint goals. This data is based on the phosphorus concentrations and annual flow rates as given in figure 8.2. Based on long-term annual flows into East Canyon Reservoir (41,520 acre-feet per year) and the target phosphorus concentration of 0.05 mg/L for inflowing water into the reservoir an annual target load for total phosphorus is 5,647 pounds (2,561 Kg/year). This target value will vary dependent upon the flow regime for any given water year. During 1994-96 as indicated in figure 8.3 there were two wet cycle years (1995-96) and one dry cycle year (1994). Target phosphorus loads range from 3,040 to 8,147 pounds per year. Actual data as determined in this reports indicates an excess each year from a low of 10,213 pounds during 1994 to a high of 14,501 pounds in 1995. The difference of these values represent the excess total phosphorus that must be removed from the system in order to restore beneficial uses.

During the same period the average annual concentration at the station above SBWWTP has been in a declining trend with concentrations levels in 1995-96 near the instream phosphorus concentration goal of 0.05 mg/L as referenced in Table 11 and observed in figure 4.2 and 4.3.

8.1.1 Snyderville Basin Wastewater Treatment Plant

The SBWWTP is the major contributor of total phosphorus into East Canyon Creek and Reservoir, even though significant reduction in total phosphorus loading has occurred in recent years. A summary of plant loadings is contained in Table 13. The highest loading occurred in 1994 with 26,221 pounds of phosphorus being discharged into East Canyon Creek. In 1996-97 loadings have been significantly reduced primarily due to the addition of a biological process for the removal of phosphorus. An average of 8,761 lbs/year was calculated for 1996-97. These

	ECC above Reservoir			ECC above WWTP			Snyderville WWTP			Project Annual Load		
Year	Flow ·(AF)	Conc. Mg/L	Load lbs/yr	Flow (AF)	Conc. Mg/L	Load lbs/yr	Flow (AF)	Conc. Mg/L	Load lbs/yr	Above Res	Above WWTP	WWTP
1994	22,350	0.218	13,253	15,220	0.062	2,567	1,550	6.219	26,221	3,040	2,070	211
1995	59,900	0.139	22,648	39,335	0.054	5,778	1,795	2.901	14,165	8,147	5,350	244
1996	54,620	0.124	18,423	33,379	0.047	4,267	2,051	1.674	9,339	7,429	4,540	279
1997							2,114	1.423	8,183			

Table 22 Loading calculations based on annual flow rates and concentrations

Comparison of Annual Total Phosphorus Loads (Based on projected TMDL Endpoints)					
Period	**Annual Flow ab Res (AF)**	**Above Res Lbs/yr**	**Above WWTP Lbs/yr**	**WWTP Lbs/yr**	**Below WWTP Lbs/yr**
Long-term	41,520	5,647	3,790	288	1,569
1994 w/TMDL	22,350	3,040	2,070	211	759
Actual	22,350	13,253	2,567	26,221	
Excess	(19,170)	10,213	497	26,010	
Long-term	41,520	5,647	3,790	288	1,569
1995 w/TMDL	59,900	8,147	5,350	244	2,553
Actual	59,900	22,648	5,778	14,165	
Excess	18,380	14,501	428	13,921	
Long-term	41,520	5,647	3,790	288	1,569
1996 w/TMDL	54,620	7,427	4,540	274	2,613
Actual	54,620	18,423	4,267	9,339	
Excess	13,100	10,996	(273)	9,065	

Long-term values are determined using long-term annual flow rates and TMDL endpoint concentrations
w/TMDL values are based on existing flows with TMDL endpoint concentrations
Actual values are determined using existing flow and concentration data
Excess values are the difference of "actual values minus w/TMDL values

Table 23 Comparative annual loadings based on defined TMDL endpoints

loadings represent a significant source of phosphorus that technological processes are available to remove. It is the recommendation of this report that given the current information available that a permit load limit should be incorporated into the plant UPDES discharge permit based on an average concentration of 0.05 mg/L for any given annual flow to be treated (2,114 acre-feet for 1997). This is also consistent with the fact that the stream concentrations has been near this target concentration value of 0.05 mg/L for the period 1995-96. This will ensure reaching the annual target loading for the reservoir. This will require the implementation of chemical treatment for the removal of phosphorus. There may be options available to treat other sources of phosphorus in lieu of achieving extremely low concentrations limits in this process. This is an area that will need to be explored as determinations are made to what can be achieved from chemical treatment based on cost feasibility.

Loadings will vary dependant upon the hydrologic regime for any given year, therefore, it is important to remember the relationship of concentration, flow, and annual loads in establishing target goals for various sources of total phosphorus. Specifically regarding point sources strategies will need to be developed to assure achieving annual loads into the reservoir.

It should be noted that efforts are underway with representatives of the SBWWTP to structure their permit to address targets or endpoints which adequately reduce phosphorus discharge from their operation. Issues that are currently being reviewed that may have an impact on these negotiations include:

1. Currently, investigations are underway to develop a watershed model that

will determine loading rates into East Canyon Reservoir needed to achieve defined reservoir endpoints and restore defined beneficial uses.

2. Based on best available technology(BAT)for chemical removal of phosphorus, can endpoints defined for the stream and reservoir be achieved? Should the focus of the endpoint be an annual or seasonal loading values or do we need to maintain some correlation to instream concentration of total phosphorus? What are the factors that will drive BAT in reducing loadings to the point of 'feasibility or cost effectiveness'? What discharge concentrations can be achieved under cost effective constraints? Is this an acceptable endpoint concentration or can reduction of other sources to which are more cost effective be controlled to offset proposed limitations needed on the wastewater plant? Are there other operation and maintenance issues (sludge removal) that may limit the reduction of total phosphorus concentrations in SBWWTP effluent? Can numerical limits be removed from the permit and placed in other documents that would assure efforts to achieve targets or endpoints while allowing flexibility in the permitting process for non-compliance to ridged numerical limits?

3. What are the controllable nonpoint sources of total phosphorus and what is the expected total phosphorus loading reduction?

4. Can a mechanism be developed in the permitting process for SBWWTP that could potentially be an incentive based approach to the implementation of nonpoint source control of total phosphorus?

5. What are the limitations on the stream related to flow regimes that may be impacting defined beneficial uses and are they more restrictive than nutrient related impairments?

6. Are there existing data limitations that preclude the development of a basin wide TMDL for all sources related to the impairment?

Studies, modeling, and experience with other reservoirs in the area (Deer Creek Reservoir) supports the supposition that as the loading to the reservoir is reduced and the trophic status moves into the mesotrophic range (TSI Index of 40-50), there will also be a shift in the algal dominance away from the blue-green species currently present.

Anoxic conditions present in the reservoir are directly related to the decomposition of organic materials discharged into the lake via the stream, and the demand from high production of algae. The algae can exhibit an immediate demand during the diurnal cycle or a long-term effect from the decomposition of algae at the sediment layer of the reservoir. A reduction of algae biomass present in the reservoir will have an impact on the dissolved oxygen concentration in the reservoir. Acute fish kills associated with low dissolved oxygen conditions during the diurnal cycle due to high algal biomass can be eliminated as productivity in the reservoir is controlled. Oxygen demand for decomposition can be reduced with the reduction of organic material being deposited in the reservoir.

8.1.2 Riparian Corridor/Stream Restoration

Low dissolved oxygen concentrations at night in the streams where heavy macrophyte and algal communities are present can be reduced with the reduction of biomass which is present due to the high concentrations of nutrients, low flows, and lack of shading.

One component that needs to be evaluated is the affect that lack of shading might be exhibiting on the temperature regimes and the plant biomass of the stream. The 0.05 mg/L total phosphorus concentration in the stream may be sufficient to control plant biomass, if additional shading can be obtained through the development of more diversified riparian community with emphasis on developing a 'herbaceous canopy' (woody streambank vegetation) associated with the stream corridor. We recommend the implementation of a demonstration project which can be monitored and evaluated to obtain this needed information. There are limited studies that suggest that these levels of total phosphorus may not be adequate, but because there are so many variables associated with stream ecology, site specific information will need to be developed to provide long-term endpoints that will assure water quality protection for defined beneficial uses in East Canyon Creek.

An increase in stream canopy may also produce lower temperature regimes in the reservoir.

The Utah Division of Wildlife Resources produced a document, "East Canyon Creek Aquatic-Riparian Management Plan" (June, 1998) describing management strategies needed in the riparian zones to support potential sport fisheries. In their report East Canyon Creek was segmented into five sections for planning purposes. The following is a description and summary of restoration plans for those sections above East Canyon Reservoir:

1. Section 3, East Canyon Creek from East Canyon Reservoir to Summit County boundary (about 5.5 miles).

   A. "Beaver ponds are numerous in the upper part of the section. However, increased siltation, thick macrophyte beds, and increased filamentous algae growth have occurred as a result of reduced flows and nutrient loading from urban growth in the Snyderville basin. Mid-summer water temperatures and dissolved oxygen concentrations often approach lethal limits for salmonids. Some natural adaptation in channel morphology has resulted from changes in creek flows and nutrient levels. The width:depth ratio of the channel has improved (narrowed and deepened) and additional vegetation has helped stabilize some eroding banks. However, recovery rate is slow, and nonexistent in much of the reach. Habitat improvements including grazing management and bank stabilization are needed at the following locations: 1) downstream portion of the McFarlane Ranch - needs an estimated 23 rock barbs, riparian fencing, bank sloping and transplants and replanting with native woody vegetation; 2) upstream portion of McFarlane Ranch - requires riparian fencing, bank sloping, replanting, and placement of approximately 28 rock barbs; 3) Schuster Creek/Mormon Flat area (approximately ½ mile of stream) - estimate 24 rock barbs and many transplants/plantings of woody vegetation. These habitat improvements will decrease siltation, minimize solar heating, and provide more pool habitat for adult fish.

2. Section 4, East Canyon Creek from Summit County to Interstate 80 (about 10 miles).

   B. Habitat restoration is needed in Section 4. Historical livestock grazing and recent urban development have degraded channel morphology, riparian habitat, and water quality. Efforts to restore instream habitat without increasing flows would probably be unsuccessful. Similar to Section 3, some natural adaptation in channel morphology has resulted from changes in creek flows and nutrient levels. The width:depth ratio of the channel has improved and additional vegetation has helped stabilize some eroding banks. However, recover rate is slow, and nonexistent in much of the reach. Habitat improvements including grazing management and bank stabilization are needed at the following locations: 1) Bear Hollow; bank sloping, about 35 rock barbs, and willow plantings are recommended throughout a ½ mile reach; 2) Summit Self Storage to Hidden Haven Campground; 23 rock barbs and willow plantings throughout a 3/4 mile reach; and 3) above Hidden Haven Campground; undetermined bank stabilization.

3. Section 5, Mouth of Kimball Creek/McLoed Creek at I-80 to headwaters (about 4 miles).

    C. Additional public access, stream restoration, and enhanced flows are needed. Access and potential easements and stable summer flow rates are of primary concern. Kimball Creek/McLeod Creek is relatively stable and contains good fish habitat. The upper portion (McLeod Creek) was recently renovated and trout habitat was enhanced. Public access to restored sections is secured".

In addition to DWR's assessment is should be noted that there have been diversions of some of the smaller streams (eg. Thayne Creek) in the upper watershed to enhance development opportunities. Several smaller streams run through residential areas with frequent small, shallow ponds present that may be increasing water temperatures in the system.

8.1.3 Urban Runoff

To control urban runoff, it is recommended that sediment or stormwater detention ponds or wetland enhancement areas be considered at significant sources of urban runoff including the following locations:

1) At the end of the Park Avenue stormwater drain at a location north of the intersection of Park Avenue and Kearns Blvd., east of highway U224.

2) On the drainage ditch leaving the Park Meadows area near highway U224 south of Meadows Drive.

3) On the west side of U224 south of Meadows Drive so as to capture and detain waters from the Thanes Canyon drainage.

4) At a location on the east side of highway U224 between Meadows Drive and Park Avenue.

5) Other minor stormwater control facilities in the Summit County area including erosion control during construction.

These small sediment basins need to also have a plan for periodic cleaning and maintenance. If properly constructed and maintained, some phosphorus laden sediments, debris, gravel, and salts from roadways can be prevented from entering the stream.

8.1.4 Development/Construction

It is obvious with all of the development associated with urbanization, recreation, and the 2002 Winter Olympics that a renewed effort be undertaken to control the movement of sediments and nutrients from construction sites. These sites with disturbed soils can be a significant source of pollutants of concern. It is the recommendation of this report that compliance to the storm water permitting process and existing planning and zoning regulation be attained. In addition if new ordinances or regulations are needed to prevent the movement of sediments or phosphorus into the waterways of this watershed, then appropriate agencies with jurisdictional oversight should as expeditiously as possible develop regulations or policies to achieve this goal. This oversight might also include the development of bans on detergents with phosphorus, street sweeping, guidance on fertilizer application for residential use, fertilizer management plans for golf courses or other activities or other activities that could reduce the contribution of total phosphorus into the waters of the watershed.

Several sites have been identified where emphasis might be directed to reduce or control the movement of sediments or phosphorus from areas that may be defined as urban but are directly related to development activities or conditions conducive to the movement of pollutants from on-site into waterways. They include but are not limited to the following sites:

1. Area east of K-Mart/Smiths Food & Drug Store (and proposed Boyer Development directly east of this area) and south of I-80 in this expanding commercial development zone.
2. The area west of highway 224 and south of the UDOT maintenance shed.
3. Lower Willow Draw area west of highway 224.
4. The area of expanding residential/commercial development in the lower to mid-elevation watershed north and east of Silver Springs and Ranch Place subdivisions on drainages associated with Willow Draw and Spring Creek.
5. The Toll Canyon Creek area near I-80/Jeremy Ranch exit just west of the Jeremy Ranch Elementary School.
6. The Red Pine and White Pine drainages.
7. The small drainages originating from within the Pinebrook Subdivisions. Potential areas include the area just south of Kilby Road/South frontange road of I-80 between Kimball Junction and Jeremy Ranch exits.
8. Broad Meadow in the southwest portion of Silver Creek Estates prior to the confluence with East Canyon Creek (North of I-80, west of Silver Creek Junction.

8.1.5 Lead Agencies for Implementation, Monitoring, Maintenance, and Evaluation

The Utah Division of Water Quality will take the lead in conjunction with the East Canyon Steering Committee, the local planning entity, and other designated agency that have jurisdictional involvement for planning, program implementation, or policy development for oversight for implementation and post-implementation activities.

All water quality monitoring will be done by the DWQ or designated representatives under guidelines and policies established through the divisions quality assurance protocols.

Implementation projects will be under the direction of those agencies or groups that may be sponsoring projects. Nonpoint sources projects may be funded from several sources including: Nonpoint Source Program (CWA, Section 319), DWR Habitat Program, NRCS Environmental Programs (eg. EQIP), private funding or others conservation groups or funding sources. All of the project work will be coordinated under the oversight of the local watershed planning group and the DWQ to assure that projects specifically address the recommendations of the watershed restoration plan. Maintenance of project BMP's will be defined and incorporated into agreements with private property owners and project administrative agencies.

Overall evaluation of achievement of defined beneficial uses will be under the lead of the DWQ in cooperation with the local water quality planning committee and representatives of stewards within the watershed.

Currently funding for voluntary efforts to control nonpoint sources will be primarily from available federal programs to address nonpoint source problems or environmental restoration programs, available habitat restoration funds through Utah's DWR, or other available public and private funds to do restoration work. In addition on private lands, expenditure of funds from land owners may be required to match other funding sources. Funding for the control of point sources will be the responsibility of those discharges under permit requirements from Utah's DWQ.

8.2 Monitoring and Evaluation

An ongoing monitoring plan to assess water chemistry related to defined endpoints needs to be implemented and maintained throughout the implementation phase to evaluate the effectiveness of BMP's in reducing total phosphorus and evaluation of other endpoints related to these reductions. This monitoring will also serve as the margin of safety required in the TMDL process to assure that endpoint achievement meets the goal of restoring defined beneficial uses. If attainment of beneficial uses does not result from implementation of restoration measures, then additional endpoints need to be established to assure achievement of water quality goals.

The monitoring plan will establish water quality sites for the stream and reservoir to track water quality changes for specific defined targets or endpoints. Additional biological monitoring will be conducted to ascertain algal composition, macroinvertebrate composition of diversity, and status of the fishery. As implementation occurs in the riparian corridor habitat diversity and stream morphology will be assessed and evaluated to track effectiveness of implemented restoration practices.

TMDL/WRAS Element	**Reservoir TMDL/WRAS**	**East Canyon Creek TMDL/WRAS**
Description of water quality standards applicable (beneficial uses, narrative, numeric or antidegradation)	YES, refer to Section 2.1; 2.2; 5.3.1 and 9.0	Same as Reservoir TMDL reference
Defined quantifiable endpoint	Refer to 8.0	Same as reservoir TMDL reference
A quantified pollution reduction target	Refer to 8.1	Same as reservoir TMDL reference
All significant sources of pollutants need to be addressed	YES, refer to 4.6	Same as reservoir TMDL reference

Defined appropriate level of technical analysis	YES, refer to 5.4-5.6	Applied best available profession judgement with additional studies for further evaluation.
Defined margin of safety	YES, refer to 8.2	Same as reservoir TMDL reference
An apportion of responsibility for taking actions	YES, refer to 8.1	Same as reservoir TMDL reference
Public involvement	YES, refer to 7.0	Same as reservoir TMDL reference
Identification of measurable environmental and programmatic goals	YES, refer to 8.1	Same as reservoir TMDL reference
Restoration measures to achieve resource goals	YES, refer to 8.1	Same as reservoir TMDL reference
Schedule for implementation of restoration measures	YES, refer to 8.1	Same as reservoir TMDL reference
Identification of lead agencies to oversee implementation, monitoring, maintenance, and evaluation	YES, refer to 8.1.5, 8.2	Same as reservoir TMDL reference
Monitoring and evaluation plan developed	YES, refer to 8.2	Same as reservoir TMDL reference
Funding plans identified for implementation and maintenance	YES, refer to 8.1.5	Same as reservoir TMDL reference

Table 24 Required elements for TMDL or WRAS development

9.0 REFERENCES

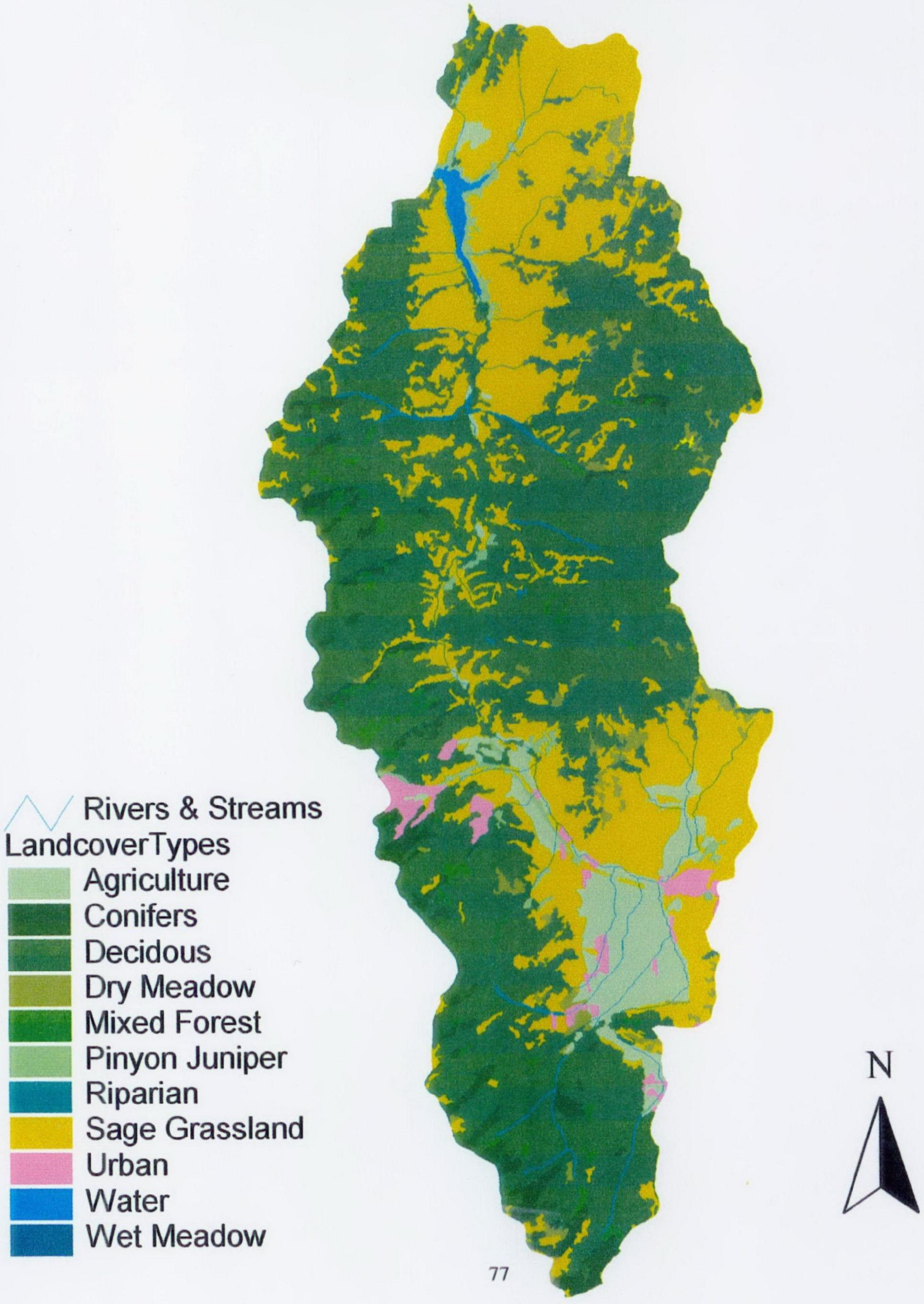
1. Chu, Fun Sun, 1994. Algal Toxins in Drinking Water? Research in Wisconsin, Lakeline, North American Lake Management Society (NALMS).
2. Harvey, Bret, 1994. Report to the Weber Basin Water Quality Management Council, "Biological Assessment of East Canyon Creek", Department of Zoology, Weber State University.
3. Judd, Harry Lewis, 1997. Utah's Lakes and Reservoirs: Inventory and Classification of Utah's Priority Lakes and Reservoirs. Utah Division of Water Quality.
4. Kotak, Brian G., et.al., 1994. Bleu-Green Algal Toxins in Drinking Water Supplies-Research in Alberta, Lakeline, North American Lake Management Society (NALMS).
5. Merritt, LaVere, B. et.al., 1980. East Canyon Reservoir: Water Quality Assessment, Eyring Research Institute, Inc., Provo, Ut.
6. Miller, Jerry, 1994. "Mercury and Selenium in East Canyon Reservoir Biological Fish Tissue Samples", U.S. Bureau of Reclamation.
7. Mountainland Association of Governments, 1980. East Canyon Reservoir Water Quality Assessment.
8. Northern Region, Utah Division of Wildlife Resources, 1998. East Canyon Creek: Aquatic-Riparian Management Plan.
9. Simpson, J. T. 1991. Volunteer Lake Monitoring: A Methods Manual, EPA 440/4-91-002.
10. Utah Division of Wildlife Resources. East Canyon Creek Fisheries Summary. (Contact: William (Bill) Bradwisch, DNR/DWR Aquatic Section, SLC, Ut.)

APPENDIX A

Land Cover Designation

Land Cover		
	Acres	Percent of total
Deciduous	48,406	53.76
Sage Grassland	26,557	29.49
Agriculture	4,896	5.44
Conifers	3,240	3.60
Dry Meadow	1,952	2.17
Urban	1,396	1.55
Mixed Forest	1,295	1.44
Pinyon Juniper	1,168	1.30
Riparian	707	0.79
Water	405	0.45
Wet Meadow	23	0.03

East Canyon Reservoir Watershed
Generalized Land Cover Map

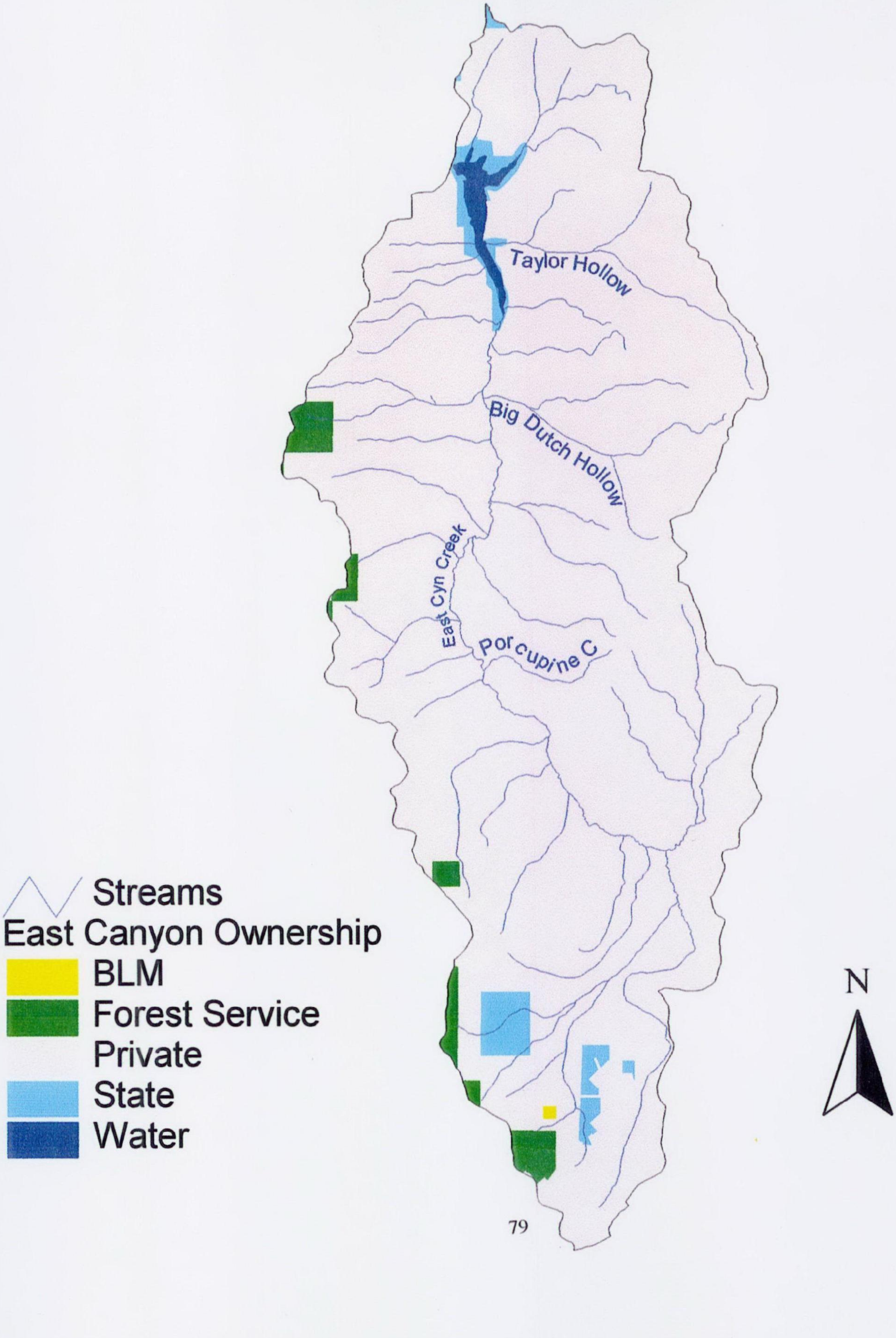


APPENDIX B

Land Use Designation

Ownership		
	Acres	Percent of total
Private	85,475	94.92
State	2,138	2.37
USFS	1,744	1.94
Water	649	0.72
BLM	39	0.04

East Canyon Reservoir Watershed
Generalized Ownership Map

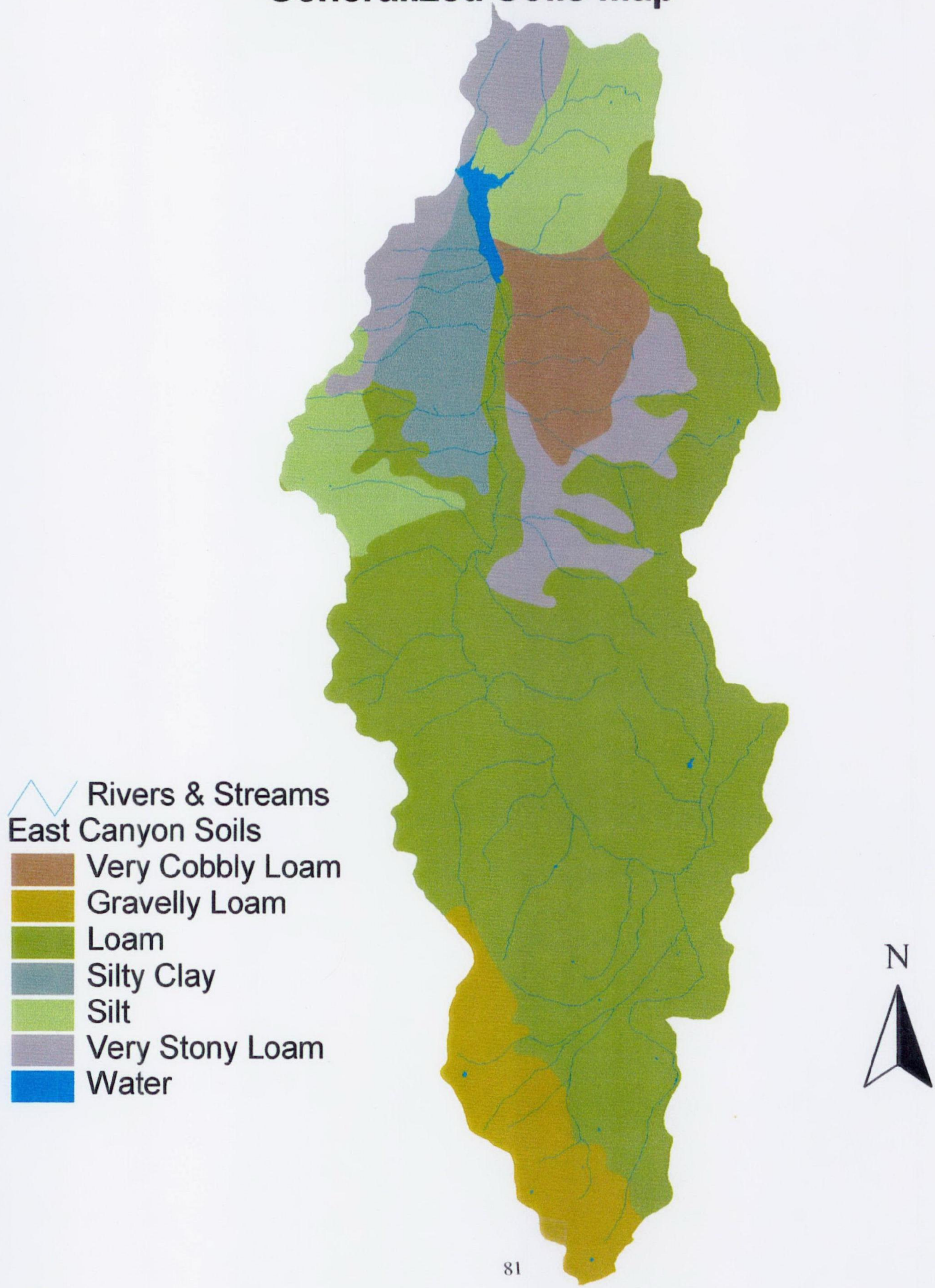


APPENDIX C

Soils Designation

Soils		
	Acres	Percent of total
Loam	53367	59.27
Silty Loam	9613	10.68
Very Stony Loam	9585	10.64
Gravelly Loam	6664	7.40
Very Cobbly Loam	5467	6.07
Silty Clay	4964	5.51
Water	388	0.43

East Canyon Reservoir Watershed Generalized Soils Map



APPENDIX D

Nutrient Data

(All stream and lake data is expressed in mg/L)

STORET	Date	NH3-N	TP	DNO2/3
492515	4/14/93	0.025	0.168	0.650
492515	4/29/93	0.025	0.092	0.072
492515	5/12/93	0.025	0.134	0.527
492515	5/25/93	0.025	0.123	0.398
492515	6/10/93	0.025	0.079	0.098
492515	7/22/93	0.083	0.141	0.339
492515	8/25/93	0.025	0.146	0.351
492515	9/23/93	0.025	0.168	0.314
492515	10/28/93	0.025	0.155	0.240
492515	11/23/93	0.025	0.162	0.361
492515	1/13/94	0.025	0.107	0.363
492515	2/16/94	0.025	0.142	0.312
492515	3/24/94	0.025	0.178	0.342
492515	4/6/94	0.025	0.140	0.182
492515	4/21/94	0.025	0.134	0.418
492515	5/3/94	0.025	0.125	0.305
492515	5/17/94	0.025	0.087	0.308
492515	6/1/94	0.025	0.054	0.036
492515	6/15/94	0.025	0.172	0.241
492515	7/14/94	0.025	0.140	0.263
492515	7/26/94	0.025	0.123	0.010
492515	8/11/94	0.025	0.146	0.184
492515	8/25/94	0.025	0.181	0.117
492515	9/13/94	0.025	0.121	0.102
492515	9/28/94	0.025	0.233	0.176
492515	10/20/94	0.025	0.189	0.208
492515	11/8/94	0.025	0.201	0.360
492515	11/22/94	0.025	0.139	0.140
492515	1/31/95	0.025	0.153	0.366
492515	2/28/95	0.030	0.122	0.383
492515	4/4/95	0.025	0.136	0.174
492515	4/20/95	0.025	0.122	0.120
492515	5/3/95	0.025	0.124	0.300
492515	5/16/95	0.025	0.118	0.260
492515	5/30/95	0.025	0.136	0.220
492515	6/13/95	0.025	0.110	0.240
492515	6/29/95	0.025	0.040	0.050
492515	7/11/95	0.025	0.030	0.020
492515	7/27/95	0.025	0.020	0.030
492515	8/10/95	0.025	0.140	0.300
492515	8/22/95	0.025	0.120	0.200
492515	9/6/95	0.056	0.130	0.210
492515	9/26/95	0.101	0.210	0.270
492515	10/26/95	0.025	0.130	0.160
492515	11/15/95	0.025	0.150	0.270
492515	2/14/96	0.081	0.110	0.040
492515	2/23/96	0.060	0.110	0.060
492515	3/6/96	0.057	0.120	0.210
492515	3/21/96	0.066	0.140	0.230
492515	4/4/96	0.055	0.130	0.090
492515	4/18/96	0.051	0.110	0.070
492515	4/30/96	0.025	0.080	0.040
492515	5/16/96	0.025	0.130	0.300
492515	5/29/96	0.058	0.130	0.340
492515	6/12/96	0.052	0.070	0.150
492515	6/27/96	0.025	0.080	0.180
492515	7/1/96	0.071	0.100	0.250
492515	7/23/96	0.025	0.080	0.200
492515	8/8/96	0.025	0.108	0.220
492515	8/23/96	0.025	0.090	0.240
492515	9/10/96	0.053	0.110	0.180
492515	9/26/96	0.056	0.133	0.270
492515	10/8/96	0.106	0.212	0.270
492515	10/23/96	0.025	0.247	0.320
492515	11/5/96	0.025	0.142	0.230
492515	11/21/96	0.025	0.153	0.350
492515	12/3/96	0.025	0.098	0.320
492515	12/17/96	0.025	0.102	0.310
492515	1/15/97	0.060	0.236	0.060
492515	1/30/97	0.050	0.072	0.240
492515	2/14/97	0.087	0.059	0.090
492515	3/4/97	0.025	0.057	0.180
492515	3/25/97	0.025	0.107	0.280
492515	4/4/97	0.025	0.104	0.340
492515	4/18/97	0.051	0.111	0.130
492515	5/2/97	0.025	0.065	0.220
492515	5/15/97	0.053	0.138	0.260
492515	5/30/97	0.025	0.183	0.260
492515	6/13/97	0.072	0.113	0.100
492515	6/26/97	0.051	0.088	0.160
492515	7/18/97	0.025	0.088	0.260
492515	8/6/97	0.025	0.108	0.280
492515	8/15/97	0.057	0.145	0.050
492515	8/28/97	0.025	0.198	0.210
492515	9/9/97	0.025	0.114	0.290
492515	9/25/97	0.025	0.212	0.390
492515	10/10/97	0.025	0.186	0.350
492515	10/21/97	0.060	0.474	0.360
492515	12/4/97	0.050	0.093	0.330
492519	7/14/94	0.025	0.158	0.010
492519	7/26/94	0.025	0.209	0.154
492519	8/11/94	0.025	0.254	0.528
492519	8/25/94	0.025	0.280	0.359
492519	9/13/94	0.025	0.226	0.320
492519	9/28/94	0.025	0.204	0.642
492519	10/20/94	0.025	0.150	0.247
492519	11/8/94	0.025	0.296	0.953
492519	11/22/94	0.025	0.185	0.718

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492519	1/31/95	0.025	0.272	1.553
492519	2/28/95	0.030	0.181	0.764
492519	4/4/95	0.025	0.128	0.586
492519	4/20/95	0.025	0.053	0.110
492519	5/3/95	0.049	0.116	0.320
492519	5/16/95	0.025	0.107	0.290
492519	5/30/95	0.090	0.084	0.150
492519	6/13/95	0.025	0.080	0.050
492519	6/29/95	0.081	0.070	0.070
492519	7/11/95	0.060	0.130	0.400
492519	7/27/95	0.025	0.140	0.420
492519	8/10/95	0.025	0.140	0.390
492519	8/22/95	0.050	0.180	0.700
492519	9/6/95	0.069	0.230	0.580
492519	9/26/95	0.025	0.190	0.630
492519	11/15/95	0.025	0.130	0.360
492519	2/14/96	0.025	0.140	0.650
492519	2/23/96	0.146	0.160	0.630
492519	3/6/96	0.060	0.200	0.900
492519	3/21/96	0.071	0.190	0.500
492519	4/4/96	0.065	0.160	0.120
492519	4/18/96	0.050	0.090	0.360
492519	4/30/96	0.025	0.070	0.290
492519	5/16/96	0.025	0.010	0.170
492519	5/29/96	0.050	0.070	0.210
492519	6/16/96	0.052	0.130	0.200
492519	6/27/96	0.089	0.150	0.340
492519	7/1/96	0.025	0.180	0.180
492519	7/23/96	0.052	0.190	0.030
492519	8/8/96	0.025	0.148	0.010
492519	8/23/96	0.025	0.120	0.010
492519	9/10/96	0.025	0.130	0.010
492519	9/26/96	0.050	0.187	0.010
492519	10/8/96	0.095	0.168	0.010
492519	10/23/96	0.025	0.075	0.070
492519	11/5/96	0.025	0.072	0.130
492519	11/21/96	0.053	0.034	0.190
492519	12/17/96	0.025	0.057	0.530
492519	1/15/97	0.055		1.090
492519	1/30/97	0.025	0.070	0.550
492519	2/14/97	0.025	0.040	0.500
492519	3/4/97	0.025	0.035	0.610
492519	3/25/97	0.025	0.144	0.770
492519	4/4/97	0.025	0.102	0.440
492519	4/18/97	0.025		0.250
492519	5/2/97	0.025		0.320
492519	5/15/97	0.025		0.180
492519	5/30/97	0.025		0.150
492519	6/13/97	0.067		0.200
492519	6/26/97	0.055		0.210

STORET	Date	NH3-N	TP	DNO2/3
492519	7/18/97	0.025		0.040
492519	8/6/97	0.069	0.152	0.010
492519	8/15/97	0.058	0.111	0.230
492519	8/28/97	0.025		0.010
492519	9/9/97	0.058		0.020
492519	9/25/97	0.025		0.060
492519	10/10/97	0.025		0.310
492519	10/21/97	0.025		0.360
492519	12/4/97	0.025	0.090	0.700
492520	1/16/90	0.025	0.371	
492520	2/15/90	0.025	0.239	
492520	4/5/90	0.025	0.232	
492520	5/17/90	0.025	0.198	
492520	6/19/90	0.025	0.214	
492520	9/11/90	0.025		
492520	10/10/90	0.025	0.370	
492520	12/11/90	0.025	0.460	
492520	2/20/91	0.025	0.250	1.184
492520	5/8/91	0.025	0.164	0.287
492520	6/27/91	0.060	0.166	0.324
492520	8/8/91	0.110	0.272	0.323
492520	10/8/91	0.025	0.194	0.196
492520	11/26/91	0.025	0.158	0.817
492520	1/30/92	0.025	0.404	0.959
492520	3/19/92	0.025	0.374	1.335
492520	4/21/92	0.060	0.281	0.555
492520	6/24/92	0.025	0.241	0.100
492520	8/6/92	0.025	0.274	0.082
492520	9/24/92	0.025	0.214	0.810
492520	11/5/92	0.025	0.213	0.828
492520	1/20/93	0.250	0.420	1.627
492520	4/1/93	0.025	0.182	1.047
492520	4/14/93	0.025	0.112	0.613
492520	4/29/93	0.025	0.159	0.620
492520	5/12/93	0.025	0.126	0.387
492520	5/25/93	0.025	0.107	0.236
492520	6/10/93	0.025	0.087	0.259
492520	7/12/93	0.025	0.161	0.635
492520	7/22/93	0.053	0.168	0.874
492520	8/25/93	0.025	0.188	0.575
492520	9/1/93	0.025	0.168	0.206
492520	9/23/93	0.025	0.168	0.260
492520	10/28/93	0.025	0.192	0.789
492520	11/23/93	0.025	0.167	1.083
492520	1/13/94	0.025	0.263	1.372
492520	2/16/94	0.025	0.321	1.461

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492520	3/24/94	0.025	0 142	0.523
492520	4/6/94	0.025	0.149	0.441
492520	4/21/94	0 025	0 128	0 287
492520	5/3/94	0 025	0.128	0 273
492520	5/17/94	0.025	0.013	0.347
492520	6/1/94	0 025	0.181	0 390
492520	6/15/94	0.025	0.143	0 265
492520	6/28/94	0.025	0.152	0.202
492520	8/11/94	0 025	0.289	0.768
492520	10/26/95	0.025	0 130	0.540
492520	11/15/95	0 025	0.130	0.380
492520	3/6/96	0.055	0 180	0 880
492520	4/18/96	0.050	0.100	0.350
492520	8/1/96	0.025	0 180	0 030
492520	9/10/96	0.025	0 130	0 010
492520	10/23/96	0.025	0 075	0 070
492520	12/3/96	0.078	0.055	0.340
492520	1/30/97	0 025	0.077	0.530
492520	7/10/97	0.025	0.072	0 030
492520	8/6/97	0.065	0.140	0 010
492520	10/21/97	0.025	0.227	0.410
492521	11/22/94	0 025	0.372	1.473
492521	1/31/95	0 025	0 322	1 501
492521	2/28/95	0.030	0 194	0 954
492521	4/4/95	0.025	0 118	0.661
492521	4/20/95	0.025	0 067	0.250
492521	5/3/95	0.069	0.171	0.420
492521	5/16/95	0.025	0.096	0.340
492521	5/30/95	0 025	0.083	0.210
492521	6/13/95	0 025	0.080	0.070
492521	6/29/95	0 025	0 070	0 110
492521	8/10/95	0 058	0.230	1.080
492521	8/22/95	0.056	0.300	1.400
492521	10/26/95	0.025	0.170	0 840
492521	11/15/95	0.025	0 190	0.830
492521	3/6/96	0.100	0.240	1 170
492521	3/21/96	0.080	0 200	0 720
492521	4/30/96	0.025	0 090	0.340
492521	5/16/96	0.025	0.010	0.210
492521	5/29/96	0.025	0.070	0.430
492521	6/16/96	0.025	0.120	0.390
492521	6/27/96	0.091	0.160	0.450
492521	8/8/96	0.025	0.525	0 030
492521	8/23/96	0.025	0.110	0 030
492521	9/10/96	0.025	0 220	0 110
492521	10/8/96	0 087	0 261	0.040

STORET	Date	NH3-N	TP	DNO2/3
492521	10/23/96	0.025	0 071	0.460
492521	11/21/96	0 201	0.028	0.330
492521	12/3/96	0 176	0 066	0.480
492521	12/17/96	0.069	0.082	0 980
492521	1/15/97	0 066	0.177	1.540
492521	1/30/97	0 025	0.087	0.880
492521	2/14/97	0 025	0.073	1.130
492521	3/25/97	0 025	0.146	0 990
492521	4/4/97	0.054	0 098	0.550
492521	4/18/97	0.062	0.130	0.290
492521	5/2/97	0.025	0.053	0.360
492521	5/15/97	0.025	0.186	0 170
492521	5/30/97	0.025	0.117	0 220
492521	6/13/97	0.059	0.093	0 270
492521	6/26/97	0.025	0.125	0.270
492521	7/18/97	0 068	0.146	0.130
492521	8/6/97	0.062	0 210	0.120
492521	8/28/97	0 025	0 318	0.130
492521	9/9/97	0.070	0.207	0 180
492521	9/25/97	0.025	0 416	0.500
492521	10/10/97	0 025	0 465	1.200
492521	10/21/97	0 025	0 246	0 750
492521	12/4/97	0.025	0.112	0.910
492523	1/17/90	0 025	0 466	
492523	1/25/90	0 025		
492523	4/5/90	0.025	0.210	
492523	6/19/90	0.025	0 397	
492523	8/29/90	0 050		
492523	9/6/90	0 025	0.699	
492523	9/27/90			
492523	10/10/90	0 025	0.760	
492523	12/11/90	0.050	0.570	
492523	2/20/91	0.050	0.697	3 301
492523	2/21/91	0.050		
492523	5/8/91	0.025	0.134	0 480
492523	8/7/91	0.080		
492523	8/27/91		0.341	
492523	9/19/91	0.025		
492523	10/8/91	0.025	0 524	0.032
492523	11/26/91	0.025	0.212	1.000
492523	1/30/92	0.025	0 629	1 765
492523	2/13/92	0 025		2.443
492523	3/18/92	0.025	0.363	1.397
492523	4/21/92	0 025	0.530	1.566
492523	6/23/92	0 025	2.913	4.696
492523	8/6/92	0 025	2 869	5 478
492523	9/24/92	0.025	1 398	3 728

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492523	11/5/92	0.025	0 544	1.954
492523	1/21/93	0.025	0.568	2 573
492523	4/1/93	0 025	0.166	1.369
492523	4/15/93	0.025	0.110	1.009
492523	4/28/93	0 025	0 076	0.656
492523	5/11/93	0.025	0 128	0 731
492523	5/27/93	0.025	0.082	0 351
492523	6/9/93	0.025	0.072	0.614
492523	7/20/93	0.025	0.177	1 160
492523	8/24/93	0.025	0.197	0 961
492523	9/22/93	0.025	0 270	1 042
492523	10/27/93	0 025	0.243	1.227
492523	11/23/93	0.025	0.244	1 613
492523	1/13/94	0.025	0.268	1 507
492523	2/17/94	0 025	0.677	2 728
492523	3/23/94	0.025	0 272	0 996
492523	4/5/94	0 025	0.058	
492523	4/19/94	0.025	0 131	0 632
492523	5/3/94	0 025	0.173	0.587
492523	5/17/94	0 025	0 131	0.510
492523	6/1/94	0.025	0 149	0.578
492523	6/15/94	0 025	0.179	0 761
492523	6/28/94	0.025	0 390	2 164
492523	7/14/94	0.025	0.397	1 551
492523	7/26/94	0.025	0.686	0.127
492523	8/9/94	0.276	1 314	5.636
492523	8/25/94	0.025	0 623	2 428
492523	9/13/94	0.025	0.928	4 894
492523	9/28/94	0.025	0.554	2.920
492523	10/20/94	0 025	0.350	1.909
492523	11/8/94	0.025	0.325	1 224
492523	11/22/94	0 025	0.486	1.678
492523	12/30/94	0 025	0.255	1.160
492523	1/12/95	0.025	0.569	2 762
492523	1/31/95	0.025	0.319	1 561
492523	2/15/95	0.025	0.346	1.703
492523	2/28/95	0.030	0 190	1.107
492523	3/8/95	0.025	0.263	1.330
492523	3/24/95	0 025	0.110	1.086
492523	4/4/95	0.025	0.123	0 926
492523	4/20/95	0.025	0 106	0.680
492523	5/3/95	0.025	0.130	0 550
492523	5/16/95	0.025	0.126	0.420
492523	5/30/95	0.025	0.063	0 330
492523	6/15/95	0.025	0 100	0.130
492523	6/29/95	0 025	0 060	0.200
492523	7/11/95	0 079	0.120	0.560
492523	7/25/95	0.154	0 160	0 880
492523	8/8/95	0.025	0.360	1 430

STORET	Date	NH3-N	TP	DNO2/3
492523	8/22/95	0 064	0.200	1.000
492523	9/5/95	0.125	0.260	0.900
492523	9/19/95	0 025	0 290	1.330
492523	10/3/95	0 025	0.200	1.030
492523	10/17/95	0.025	0.150	0.640
492523	10/31/95	0.025	0.170	0 660
492523	11/14/95	0.025	0.180	0 730
492523	11/21/95	0.025	0.260	1.060
492523	11/28/95	0 025	0.230	0 830
492523	12/12/95	0 051	0.210	1 110
492523	12/26/95	0.174	0.360	1.590
492523	1/9/96	0.097	0 260	1 200
492523	1/23/96	0 114	0 260	1.220
492523	2/6/96	0.142	0.340	1.230
492523	2/20/96	0 209	0 540	1.190
492523	3/5/96	0.099	0 270	1 190
492523	3/6/96	0.102	0.320	1.520
492523	3/19/96	0 114	0.140	0.980
492523	4/2/96	0 103	0.220	0.520
492523	4/16/96	0.056	0 090	0 590
492523	4/30/96	0.025	0 080	0.480
492523	5/14/96	0 025	0 100	0.380
492523	5/28/96	0 025	0.090	0.500
492523	6/11/96	0 025	0.120	0.490
492523	6/25/96	0.025	0.170	0.610
492523	7/9/96	0 110	0 180	0 500
492523	7/23/96	0.062	0.210	0 290
492523	8/1/96	0.088	0 330	0 090
492523	8/6/96	0 025	0.194	0.100
492523	8/21/96	0 025	0.100	0.180
492523	8/27/96	0.025	0.110	0.120
492523	9/3/96	0.066	0 170	0 210
492523	9/10/96	0.056	0 130	0.120
492523	9/17/96	0 025	0.140	0.320
492523	9/24/96	0 072	0.430	0.180
492523	10/1/96	0 071	0.174	0.200
492523	10/8/96	0 085	0.213	0.130
492523	10/15/96	0.057	0 214	0.200
492523	10/22/96	0 064	0.137	0.290
492523	10/23/96	0 025	0 106	0.560
492523	10/29/96	0 025	0.086	0.440
492523	11/5/96	0 025	0.099	0.330
492523	11/12/96	1.120	0 069	0.280
492523	11/19/96	0 391	0.053	0.420
492523	11/26/96	0 390	0.049	0.340
492523	12/3/96	0.170	0.065	0.570
492523	12/3/96	0.096	0.094	0.520
492523	12/10/96	0.069	0 088	0.370
492523	12/17/96	0 113	0 036	1 320
492523	12/27/96	0 301	0 221	0 980

STORET	Date	NH3-N	TP	DNO2/3
492523	12/31/96	0.243	0.371	1.520
492523	1/14/97	0.025	0.186	1.420
492523	1/28/97	0.053	0.087	1.130
492523	1/30/97	0.056	0.073	0.420
492523	2/11/97	0.025	0.278	1.170
492523	2/25/97	0.025	0.344	2.700
492523	3/11/97	0.025	0.151	1.020
492523	3/25/97	0.025	0.137	1.010
492523	4/8/97	0.025	0.070	0.650
492523	4/22/97	0.065	0.088	0.480
492523	5/6/97	0.025	0.100	0.540
492523	5/14/97	0.025	0.126	0.290
492523	5/20/97	0.025	0.138	0.240
492523	6/3/97	0.025	0.137	0.230
492523	6/17/97	0.025	0.036	0.340
492523	7/1/97	0.025	0.270	0.220
492523	7/15/97	0.025	0.290	0.180
492523	7/29/97	0.062	0.224	0.290
492523	8/6/97	0.025	0.247	0.180
492523	8/12/97	0.051	0.288	0.290
492523	8/26/97	0.025	0.243	0.300
492523	9/9/97	0.064	0.284	3.230
492523	9/23/97	0.025	0.287	0.410
492523	10/7/97	0.025	0.338	1.230
492523	10/21/97	0.025	0.489	0.300
492523	10/21/97	0.025	0.179	0.760
492523	11/4/97	0.025	0.117	1.040
492523	11/18/97	0.026	0.205	1.080
492523	12/2/97	0.025	0.226	0.990
492523	12/16/97	0.125	0.120	1.610
492523	12/30/97	0.075	0.044	0.650
492524	1/17/90	0.025	1.074	
492524	1/25/90	0.025		
492524	4/5/90	0.025	0.225	
492524	6/19/90	0.025	0.387	
492524	9/6/90	0.025	2.097	
492524	10/10/90	0.025	1.180	
492524	12/11/90	0.050	0.960	
492524	2/20/91	0.100	0.471	1.898
492524	5/8/91	0.025	0.132	0.471
492524	10/8/91	0.025	0.770	0.054
492524	11/26/91	0.025	0.350	1.275
492524	1/30/92	0.070	1.418	3.051
492524	2/13/92	0.110		2.135
492524	3/18/92	0.050	0.360	1.237
492524	4/21/92	0.055	0.674	2.184
492524	6/24/92	0.025	1.513	4.171
492524	8/6/92	0.025	3.947	9.593

STORET	Date	NH3-N	TP	DNO2/3
492524	9/25/92	0.025	1.305	3.688
492524	11/5/92	0.025	0.480	1.933
492524	1/21/93	0.025	0.914	4.150
492524	4/1/93	0.025	0.169	1.494
492524	4/15/93	0.025	0.112	1.288
492524	4/28/93	0.025	0.115	0.846
492524	6/28/94	0.025	0.460	2.155
492524	7/14/94	0.025	0.972	4.305
492524	7/26/94	0.025	1.597	1.993
492524	8/9/94	0.066	1.551	6.527
492524	8/25/94	0.054	1.222	5.469
492524	9/13/94	0.025	1.580	6.024
492524	9/28/94	0.025	0.888	4.848
492524	10/20/94	0.025	0.404	2.097
492524	11/8/94	0.025	0.465	1.768
492524	11/22/94	0.025	0.826	2.722
492524	12/30/94	0.133	0.431	2.307
492524	1/12/95	0.025	0.377	
492524	1/31/95	0.025	0.563	2.641
492524	2/15/95	0.025	0.665	3.329
492524	2/28/95	0.030	0.250	1.367
492524	3/8/95	0.162	0.305	1.399
492524	3/24/95	0.025	0.135	1.253
492524	4/4/95	0.025	0.150	0.968
492524	4/20/95	0.025	0.124	0.790
492524	5/3/95	0.025	0.123	0.520
492524	5/16/95	0.025	0.249	0.610
492524	5/30/95	0.025	0.067	0.300
492524	6/15/95	0.025	0.060	0.200
492524	6/29/95	0.025	0.060	0.220
492524	7/11/95	0.050	0.120	0.650
492524	7/25/95	0.025	0.180	0.890
492524	8/8/95	0.050	0.370	1.990
492524	8/22/95	0.062	0.340	1.700
492524	9/5/95	0.186	0.400	1.500
492524	9/19/95	0.025	0.340	1.860
492524	10/3/95	0.066	0.530	2.510
492524	10/17/95	0.025	0.450	2.030
492524	10/31/95	0.025	0.570	1.690
492524	11/14/95	0.025	0.240	1.190
492524	11/28/95	0.025	0.310	0.950
492524	12/12/95	0.058	0.360	1.800
492524	12/26/95	0.100	0.790	2.730
492524	1/9/96	0.086	0.430	2.000
492524	1/23/96	0.088	0.390	1.630
492524	2/6/96	0.121	0.450	1.610
492524	2/20/96	0.202	0.380	0.920

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492524	3/6/96	0.088	0 410	1.810
492524	3/19/96	0.099	0 240	1.070
492524	4/2/96	0.090	0 220	0.480
492524	4/16/96	0 052	0.090	0.580
492524	4/30/96	0.025	0.070	0.390
492524	5/14/96	0.025	0.100	0 320
492524	5/28/96	0.025	0.100	0 560
492524	6/11/96	0 025	0.190	1.040
492524	6/25/96	0.025	0 250	0 790
492524	7/9/96	0.122	0 330	0.650
492524	7/23/96	0.076	0.390	0.350
492524	8/6/96	0.025	0.190	0.220
492524	8/21/96	0 025	0.110	0 270
492524	8/27/96	0 025	0.070	0.130
492524	9/3/96	0.065	0 200	0.310
492524	9/10/96	0 052	0.120	0.160
492524	9/17/96	0 025	0.120	1 030
492524	9/24/96	0 077	0.570	0 200
492524	10/1/96	0 080	0.156	0 190
492524	10/8/96	0.025	0.317	0 220
492524	10/15/96	0 025	0 223	0.870
492524	10/22/96	0.025	0.081	0.320
492524	10/29/96	0.025	0.038	0 360
492524	11/5/96	0 025	0.106	0.410
492524	11/12/96	1.730	0 071	0.250
492524	11/19/96	0.351	0 040	0.480
492524	11/26/96	0.980	0 091	0.380
492524	12/3/96	0.082	0.053	0.510
492524	12/10/96	0.052	0 065	0 340
492524	12/17/96	0.154	0.242	0.630
492524	12/27/96	0.370	0 283	1.130
492524	12/31/96	0.275	0 491	1.470
492524	1/14/97	0.025	0.194	1 560
492524	1/28/97	0.056	0 076	1.100
492524	2/11/97	0.025	0 207	0.960
492524	2/25/97	0 148	0.255	1.180
492524	3/11/97	0.025	0.138	0 910
492524	3/25/97	0.025	0 137	1.080
492524	4/8/97	0.025	0 078	0.720
492524	4/22/97	0.062	0.129	0.570
492524	5/6/97	0.025	0.104	0.480
492524	5/20/97	0.025	0.305	0 180
492524	6/3/97	0.025	0.065	0.230
492524	6/17/97	0.025	0.175	0.250
492524	7/1/97	0.025	0 195	0.260
492524	7/15/97	0.025	0 086	0.180
492524	7/29/97	0 061	0.218	0 260
492524	8/12/97	0 025	0.332	0.340
492524	8/26/97	0.025	0.309	0.350
492524	9/9/97	0.084	0.326	0.090
492524	9/23/97	0.025	0 275	0 350

STORET	Date	NH3-N	TP	DNO2/3
492524	10/7/97	0 025	0 386	1.720
492524	10/21/97	0.025	0 963	1.710
492524	11/4/97	0.025	0.155	0.910
492524	11/18/97	0.025	0.198	0 650
492524	12/2/97	0.025	0.123	0 830
492524	12/16/97	0.152	0 300	2.280
492524	12/30/97	1.260	0.380	0.910
492525	2/20/91	0.050	5.312	
492525	2/21/91	0 130		
492525	5/8/91	0.025	2 189	
492525	8/7/91	0.120		
492525	9/19/91	0 090		15 560
492525	10/8/91	0 090	6 428	
492525	11/26/91	0.025	6 177	16.414
492525	1/30/92	0.025	5.992	11.992
492525	2/13/92	0 710		15 734
492525	3/18/92	0 025	4.937	16 236
492525	4/21/92	0.025	5 664	16.229
492525	6/24/92	0.025	6.260	19.034
492525	8/6/92	0 025	5.814	17 787
492525	9/24/92	0.025	5 639	16.837
492525	11/5/92	0.025	5.096	19.924
492525	1/21/93	0 252	5.511	18 824
492525	4/1/93	0.025	1 368	7.918
492525	4/15/93	0.025	2.077	10.083
492525	4/28/93	0.057	2.327	10 050
492525	5/11/93	0.025	1 280	4.975
492525	5/27/93	0.025	1.192	7.391
492525	6/9/93	0.025	1.770	7.899
492525	7/20/93	0.025	3.584	14.546
492525	8/24/93	0.025	3.268	16 534
492525	9/22/93	0.069	4.145	13 004
492525	10/27/93	0.025	5.191	18.470
492525	11/23/93	0.025	3.828	19.387
492525	1/13/94	0.025	4.909	18 341
492525	2/17/94	0 175	4 238	0.556
492525	3/23/94	0 025	22 320	5.703
492525	4/5/94	0 025		5.455
492525	4/19/94	0.025	3.065	7.670
492525	6/15/94	0.025	3.504	14.661
492525	8/9/94	0 132	4 131	19.681
492525	9/20/94	0.025	3.320	21.426
492525	11/15/94	0.025	4.103	13.500
492525	12/30/94	0.154	6 383	11.850
492525	1/12/95	0 025	4.174	
492525	2/15/95	0.025	3.172	15 695

STORET	Date	NH3-N	TP	DNO2/3
492525	3/8/95	2.200	3.535	9.602
492525	3/24/95	0.135	1.457	5.829
492525	4/4/95	0.025	2.616	7.599
492525	4/20/95	0.433	2.330	7.550
492525	5/3/95	0.025	1.786	7.130
492525	5/16/95	0.025	2.984	9.150
492525	5/30/95	0.025	2.068	6.650
492525	6/15/95	0.025	1.040	6.200
492525	6/29/95	0.025	1.350	5.800
492525	7/11/95	0.050	2.570	10.130
492525	7/25/95	0.025	2.570	13.660
492525	8/8/95	0.050	3.450	18.040
492525	8/22/95	0.071	3.270	18.200
492525	9/5/95	1.800	3.900	10.400
492525	9/19/95	0.103	3.710	17.370
492525	10/3/95	0.094	3.940	16.680
492525	10/17/95	0.025	3.530	15.220
492525	10/31/95	0.025	3.070	10.590
492525	11/14/95	0.052	2.770	8.440
492525	11/21/95	0.163	4.200	10.100
492525	11/28/95	0.057	3.180	6.080
492525	12/12/95	0.067	2.940	9.140
492525	1/9/96	0.083	3.180	10.780
492525	1/23/96	0.690	3.040	9.990
492525	2/1/96	0.445	4.220	12.160
492525	2/6/96	0.133	3.540	9.940
492525	2/20/96	0.654	4.230	9.950
492525	3/5/96	2.050	3.290	1.570
492525	3/6/96	0.064	1.960	12.050
492525	3/19/96	0.080	2.240	7.300
492525	4/2/96	0.025	1.380	4.940
492525	4/16/96	0.107	1.170	6.110
492525	4/17/96	0.025	1.090	5.930
492525	4/30/96	0.065	1.650	6.040
492525	5/14/96	0.863	1.630	5.530
492525	5/28/96	0.058	2.140	9.330
492525	6/11/96	0.025	3.460	20.060
492525	6/25/96	0.025	3.080	9.060
492525	7/9/96	0.104	3.320	5.200
492525	7/23/96	28.200	2.900	2.700
492525	8/1/96	0.069	2.960	0.950
492525	8/6/96	0.068	0.980	0.850
492525	8/21/96	0.025	0.270	0.810
492525	8/27/96	0.025	0.230	0.560
492525	9/3/96	0.073	0.300	0.790
492525	9/10/96	0.067	0.140	0.740
492525	9/17/96	0.025	0.540	0.760
492525	9/24/96	0.095	2.930	0.810
492525	10/1/96	0.053	0.396	0.720
492525	10/15/96	0.020	0.923	0.050
492525	10/22/96	0.025	0.672	0.790

STORET	Date	NH3-N	TP	DNO2/3
492525	10/22/96	0.025	0.415	0.760
492525	10/29/96	0.025	0.186	0.970
492525	11/5/96	0.103	0.229	1.270
492525	11/12/96	11.300	0.704	0.760
492525	11/19/96			1.280
492525	11/26/96	4.420	0.289	0.600
492525	12/3/96	0.365	0.236	0.910
492525	12/4/96	0.157	0.245	0.760
492525	12/10/96			0.500
492525	12/27/96	2.440	1.760	4.370
492525	1/14/97	0.209	1.152	6.810
492525	1/28/97	0.055	0.800	6.430
492525	1/30/97	0.050	0.508	4.270
492525	2/11/97	0.025	1.139	6.450
492525	2/25/97	0.742	1.500	4.730
492525	3/11/97	0.950	0.884	0.400
492525	3/25/97	0.089	0.970	5.410
492525	3/25/97	0.173	1.079	4.840
492525	4/8/97			0.310
492525	4/22/97	0.076	4.054	4.760
492525	5/6/97	0.025	1.275	4.470
492525	5/14/97	0.025	1.562	3.930
492525	5/20/97	0.051	1.427	3.280
492525	6/3/97	0.025	1.234	4.330
492525	6/17/97	0.025	2.393	4.790
492525	7/1/97	0.025	1.573	1.110
492525	7/10/97	0.070	0.279	0.970
492525	7/15/97	0.025	0.784	1.550
492525	7/29/97	0.054	1.798	2.790
492525	8/6/97	0.025	1.190	3.080
492525	8/12/97	0.053	0.385	1.610
492525	8/26/97	0.025	1.636	2.090
492525	9/9/97	0.122	1.466	0.290
492525	9/23/97	0.025	1.963	1.560
492525	9/25/97	0.025	3.310	4.240
492525	10/7/97	0.064	1.907	12.360
492525	10/21/97	0.096	2.868	9.150
492525	10/21/97	0.064	0.936	8.440
492525	11/4/97	0.025	0.527	6.510
492525	12/11/97	0.050	0.930	9.450
492525	12/16/97	0.765	1.470	8.780
492526	1/17/90	0.025	0.041	
492526	1/25/90	0.025		
492526	4/5/90	0.025	0.011	
492526	6/11/90		0.262	
492526	6/19/90	0.025	0.051	
492526	8/29/90	0.060		
492526	9/6/90	0.025	0.126	
492526	9/27/90			

STORET	Date	NH3-N	TP	DNO2/3
492526	10/10/90	0.025	0.070	
492526	12/11/90	0.025	0.040	
492526	2/20/91	0.100	0.113	0.578
492526	2/21/91	0.130		
492526	5/8/91	0.025	0.096	0.176
492526	8/7/91	0.080		
492526	9/19/91	0.420		
492526	10/8/91	0.025	0.050	0.152
492526	11/26/91	0.025	0.055	0.294
492526	1/30/92	0.090	0.090	0.626
492526	2/13/92	0.025		0.535
492526	3/18/92	0.025	0.036	0.204
492526	4/21/92	0.062	0.068	0.159
492526	6/24/92	0.025	0.099	0.010
492526	8/6/92	0.098	0.104	0.010
492526	9/24/92	0.025	0.080	0.010
492526	11/5/92	0.025	0.020	0.572
492526	1/21/93	0.025	0.048	0.661
492526	4/1/93	0.025	0.099	1.200
492526	4/15/93	0.025	0.029	0.659
492526	4/28/93	0.025	0.035	0.530
492526	5/11/93	0.025	0.094	0.722
492526	5/27/93	0.235	0.091	0.179
492526	6/9/93	0.025	0.022	0.386
492526	7/20/93	0.025	0.259	0.739
492526	8/24/93	0.025	0.019	0.316
492526	9/22/93	0.025	0.017	0.272
492526	10/27/93	0.025	0.074	0.283
492526	11/23/93	0.025	0.021	2.606
492526	1/13/94	0.025	0.076	0.659
492526	2/17/94	0.025	0.046	0.636
492526	3/23/94	0.092	0.086	0.791
492526	4/5/94	0.025	0.032	0.031
492526	4/19/94	0.025	0.093	0.030
492526	5/3/94	0.025	0.125	0.303
492526	5/17/94	0.025	0.069	0.241
492526	6/1/94	0.025	0.038	0.040
492526	6/15/94	0.025	0.028	0.010
492526	6/28/94	0.025	0.034	0.091
492526	7/14/94	0.051	0.071	0.010
492526	7/26/94	0.025	0.059	4.929
492526	8/9/94	0.025	0.089	0.275
492526	8/25/94	0.025	0.048	0.010
492526	9/13/94	0.025	0.028	0.010
492526	9/28/94	0.025	0.019	0.010
492526	10/20/94	0.025	0.230	0.224
492526	11/8/94	0.025	0.025	0.010
492526	11/22/94	0.025	0.029	0.410

STORET	Date	NH3-N	TP	DNO2/3
492526	12/30/94	0.025	0.015	0.423
492526	1/12/95	0.025	0.058	
492526	1/31/95	0.025	0.027	0.310
492526	2/15/95	0.025	0.065	0.398
492526	2/28/95	0.030	0.059	0.526
492526	3/8/95	0.025	0.087	0.534
492526	3/24/95	0.025	0.080	0.877
492526	4/4/95	0.025	0.054	0.465
492526	4/20/95	0.025	0.038	0.510
492526	5/3/95	0.025	0.108	0.900
492526	5/16/95	0.025	0.178	0.190
492526	5/30/95	0.025	0.060	0.120
492526	6/15/95	0.025	0.050	0.030
492526	6/29/95	0.025	0.040	0.110
492526	7/11/95	0.025	0.080	0.660
492526	7/25/95	0.271	0.040	0.250
492526	8/8/95	0.025	0.030	0.180
492526	8/22/95	0.058	0.160	0.100
492526	9/5/95	0.025	0.030	0.100
492526	9/19/95	0.025	0.030	0.130
492526	10/3/95	0.025	0.030	0.240
492526	10/17/95	0.025	0.005	0.070
492526	10/31/95	0.025	0.020	0.140
492526	11/14/95	0.025	0.020	0.290
492526	11/21/95	0.052	0.030	0.280
492526	11/28/95	0.057	0.020	0.370
492526	12/12/95	0.057	0.030	0.690
492526	12/26/95	0.079	0.030	0.730
492526	1/9/96	0.073	0.050	0.310
492526	1/23/96	0.085	0.040	0.560
492526	2/1/96	0.117	0.050	0.590
492526	2/6/96	0.122	0.050	0.480
492526	2/20/96	0.160	0.220	0.420
492526	3/5/96	0.113	0.100	0.470
492526	3/6/96	0.080	0.010	0.580
492526	3/19/96	0.097	0.070	0.500
492526	4/2/96	0.918	0.180	0.430
492526	4/16/96	0.025	0.040	0.550
492526	4/30/96	0.025	0.050	0.320
492526	5/14/96	0.056	0.060	0.280
492526	5/28/96	0.025	0.040	0.340
492526	6/11/96	0.025	0.050	0.010
492526	6/25/96	0.025	0.030	0.280
492526	7/9/96	0.108	0.060	0.280
492526	7/23/96	0.098	0.050	0.090
492526	8/1/96	0.140	0.040	0.010
492526	8/6/96	0.025	0.038	0.130
492526	8/21/96	0.025	0.010	0.110
492526	8/27/96	0.025	0.010	0.220

STORET	Date	NH3-N	TP	DNO2/3
492526	9/3/96	0.025	0.010	0.230
492526	9/10/96	0.062	0.040	0.040
492526	9/17/96	0.025	0.040	0.190
492526	9/24/96	0.055	0.005	0.110
492526	10/1/96	0.077	0.100	0.010
492526	10/8/96	0.061	0.005	0.040
492526	10/15/96	0.025	0.018	0.050
492526	10/22/96	0.025	0.025	0.230
492526	10/22/96	0.025	0.037	0.260
492526	10/29/96	0.025	0.011	0.280
492526	11/5/96	0.025	0.039	0.260
492526	11/12/96	0.056	0.012	0.170
492526	11/19/96	0.025	0.032	0.300
492526	11/26/96	0.025	0.005	0.320
492526	12/3/96	0.062	0.026	0.450
492526	12/4/96	0.056	0.029	0.750
492526	12/10/96	0.025	0.077	0.310
492526	12/17/96	0.025	0.067	0.420
492526	12/27/96	0.051	0.056	0.500
492526	12/31/96	0.025	0.060	0.370
492526	1/14/97	0.025	0.013	0.460
492526	1/28/97	0.025	0.016	0.490
492526	1/30/97	0.025	0.129	1.110
492526	2/11/97	0.025	0.055	0.400
492526	2/25/97	0.025	0.021	0.440
492526	3/11/97	0.025	0.080	0.400
492526	3/25/97	0.025	0.086	0.860
492526	4/8/97	0.025	0.005	0.500
492526	4/22/97	0.025	0.096	0.410
492526	5/6/97	0.025	0.102	0.290
492526	5/14/97	0.025	0.115	0.230
492526	5/20/97	0.025	0.104	0.200
492526	6/3/97	0.025	0.096	0.170
492526	6/17/97	0.025	0.336	0.280
492526	7/1/97	0.025	0.060	0.400
492526	7/15/97	0.025	0.143	0.090
492526	7/29/97	0.025	0.060	0.070
492526	8/6/97	0.025	0.043	0.010
492526	8/12/97	0.025	0.075	0.130
492526	8/26/97	0.025	0.056	0.060
492526	9/9/97	0.025	0.154	2.040
492526	9/23/97	0.025	0.119	0.160
492526	10/7/97	0.058	0.490	0.160
492526	10/21/97	0.025	0.533	0.400
492526	10/21/97	0.058	0.198	0.010
492526	11/4/97	0.025	0.094	0.220
492526	11/18/97	0.025	0.081	0.260
492526	12/2/97	0.052	0.014	0.350
492526	12/16/97	0.066	0.030	0.500
492526	12/30/97	2.170	0.484	0.360

STORET	Type	Date	NH3-N	T P	DNO2/3
492513	21	6/28/94	0.025	0.018	0.010
492513	29	6/28/94	0.058	0.233	0.303
492513	21	7/14/94	0.025	0.015	0.010
492513	29	7/14/94	0.025	0.202	0.352
492513	21	7/26/94	0.025	0.048	0.338
492513	29	7/26/94	0.025	0.020	0.010
492513	21	8/11/94	0.025	0.012	0.010
492513	29	8/11/94	0.025	0.213	0.295
492513	21	8/25/94	0.025	0.067	0.010
492513	29	8/25/94	0.080	0.263	0.118
492513	21	9/13/94	0.025	0.051	0.010
492513	29	9/13/94	0.061	0.239	0.134
492513	21	9/28/94	0.025	0.037	0.010
492513	29	9/28/94	0.125	0.269	0.010
492513	21	10/20/94	0.025	0.076	0.010
492513	29	10/20/94	0.174	0.281	0.010
492513	21	11/8/94	0.025	0.106	0.010
492513	29	11/8/94	0.025	0.109	0.010
492513	21	11/22/94	0.071	0.151	0.010
492513	29	11/22/94	0.069	0.148	0.010
492513	21	4/4/95	0.025	0.133	0.073
492513	29	4/4/95	0.025	0.143	0.261
492513	21	4/20/95	0.041	0.095	0.080
492513	29	4/20/95	0.025	0.192	0.380
492513	21	5/3/95	0.025	0.090	0.100
492513	29	5/3/95	0.025	0.102	0.160
492513	21	5/16/95	0.070	0.083	0.010
492513	29	5/16/95	0.080	0.124	0.300
492513	21	5/30/95	0.025	0.062	0.110
492513	29	5/30/95	0.025	0.153	0.320
492513	21	6/13/95	0.025	0.040	0.040
492513	29	6/13/95	0.025	0.170	0.400
492513	21	7/3/95	0.025	0.030	0.010
492513	29	7/3/95	0.058	0.110	0.270
492513	21	7/11/95	0.025	0.020	0.010
492513	29	7/11/95	0.050	0.180	0.410
492513	21	7/27/95	0.025	0.020	0.010
492513	29	7/27/95	0.025	0.190	0.440
492513	21	8/10/95	0.025	0.010	0.010
492513	29	8/10/95	0.025	0.180	0.390
492513	21	8/22/95	0.025	0.010	0.010
492513	29	8/22/95	0.025	0.080	0.200
492513	21	9/7/95	0.025	0.020	0.010
492513	29	9/7/95	0.090	0.210	0.420
492513	21	9/26/95	0.025	0.010	0.010
492513	29	9/26/95	0.104	0.240	0.340
492513	21	10/26/95	0.025	0.020	0.010
492513	29	10/26/95	0.025	0.010	0.010
492513	21	11/15/95	0.025	0.050	0.010
492513	29	11/15/95	0.025	0.080	0.020
492513	21	4/4/96	0.025	0.120	0.090
492513	29	4/4/96	0.058	0.120	0.160
492513	21	4/30/96	0.025	0.070	0.080
492513	29	4/30/96	0.067	0.210	0.290
492513	21	5/29/96	0.053	0.040	0.070
492513	29	5/29/96	0.092	0.150	0.330
492513	21	6/27/96	0.084	0.160	0.010
492513	29	6/27/96	0.052	0.010	0.330
492513	21	7/9/96	0.053	0.020	0.010
492513	29	7/9/96	0.025	0.030	0.010
492513	21	7/23/96	0.025	0.010	0.010
492513	29	7/23/96	0.052	0.170	0.410
492513	21	8/8/96	0.025	0.021	0.010
492513	29	8/8/96	0.025	0.095	0.260
492513	21	8/23/96	0.025	0.010	0.010
492513	29	8/23/96	0.025	0.170	0.370
492513	21	9/10/96	0.060	0.020	0.010
492513	29	9/10/96	0.066	0.190	0.340
492513	21	9/26/96	0.058	0.022	0.010
492513	29	9/26/96	0.056	0.024	0.010
492513	21	10/8/96	0.079	0.005	0.010
492513	29	10/8/96	0.076	0.166	0.150
492513	21	11/5/96	0.025	0.055	0.020
492513	29	11/5/96	0.025	0.060	0.040
492513	21	4/18/97	0.025	0.105	0.010
492513	29	4/18/97	0.025	0.086	0.160
492513	21	5/15/97	0.155	0.082	0.030
492513	29	5/15/97	0.130	0.123	0.140
492513	21	6/13/97	0.073	0.095	0.020
492513	29	6/13/97	0.139	0.105	0.150
492513	21	7/18/97	0.025	0.048	0.010
492513	29	7/18/97	0.065	0.144	0.330
492513	21	9/9/97	0.053	0.063	0.010
492513	29	9/9/97	0.052	0.145	0.340
492516	21	6/2/92	0.025	0.091	0.010
492516	23	6/2/92	0.025	0.093	0.010
492516	27	6/2/92	0.025	0.174	0.235
492516	29	6/2/92	0.262	0.344	0.256
492516	21	9/1/92	0.025	0.063	0.010
492516	23	9/1/92	0.098	0.171	0.010
492516	27	9/1/92	0.342	0.378	0.010
492516	29	9/1/92	0.346	0.391	0.010
492516	21	7/12/93	0.025	0.016	0.010
492516	23	7/12/93	0.025	0.032	0.044
492516	27	7/12/93	0.025	0.064	0.139
492516	29	7/12/93	0.121	0.270	0.595
492516	21	9/1/93	0.025	0.017	0.010
492516	23	9/1/93	0.025	0.019	0.010
492516	27	9/1/93	0.025	0.104	0.332
492516	29	9/1/93	0.240	0.284	0.705
492516	21	6/28/94	0.025	0.019	0.010
492516	23	6/28/94	0.025	0.066	0.010
492516	27	6/28/94	0.025	0.155	0.280
492516	29	6/28/94	0.107	0.289	0.178

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492516	21	7/14/94	0.025	0.013	0.010
492516	23	7/14/94	0.025	0.033	0.010
492516	27	7/14/94	0.025	0.029	0.010
492516	29	7/14/94	0.341	0.298	0.010
492516	21	7/26/94	0.025	0.017	0.010
492516	23	7/26/94	0.025	0.019	0.010
492516	27	7/26/94	0.025	0.146	0.265
492516	29	7/26/94	0.025	0.280	0.252
492516	21	8/11/94	0.025	0.021	0.010
492516	23	8/11/94	0.025	0.021	0.010
492516	27	8/11/94	0.025	0.183	0.395
492516	29	8/11/94	0.298	0.299	0.010
492516	21	8/25/94	0.025	0.046	0.045
492516	23	8/25/94	0.025	0.032	0.010
492516	27	8/25/94	0.025	0.211	0.284
492516	29	8/25/94	0.025	0.222	0.257
492516	21	9/13/94	0.025	0.034	0.010
492516	23	9/13/94	0.025	0.031	0.045
492516	27	9/13/94	0.025	0.176	0.150
492516	29	9/13/94	0.284	0.327	0.010
492516	21	9/28/94	0.025	0.037	0.026
492516	23	9/28/94	0.057	0.186	0.045
492516	27	9/28/94	0.077	0.214	0.083
492516	29	9/28/94	0.383	0.336	0.010
492516	21	10/20/94	0.025	0.075	0.010
492516	23	10/20/94	0.122	0.222	0.010
492516	27	10/20/94	0.167	0.281	0.010
492516	29	10/20/94	0.447	0.383	0.010
492516	21	11/8/94	0.051	0.120	0.010
492516	23	11/8/94	0.025	0.115	0.010
492516	27	11/8/94	0.101	0.158	0.010
492516	29	11/8/94	0.493	0.387	0.010
492516	21	11/22/94	0.163	0.196	0.010
492516	23	11/22/94	0.121	0.182	0.010
492516	27	11/22/94	0.110	0.166	0.010
492516	29	11/22/94	0.170	0.208	0.454
492516	21	1/31/95	0.025	0.143	0.010
492516	23	1/31/95	0.025	0.153	0.038
492516	27	1/31/95	0.065	0.171	0.098
492516	29	1/31/95	0.141	0.232	0.145
492516	21	4/4/95	0.025	0.136	0.287
492516	23	4/4/95	0.025	0.132	0.120
492516	27	4/4/95	0.025	0.135	0.251
492516	29	4/4/95	0.063	0.149	0.201
492516	21	4/20/95	0.037	0.106	0.050
492516	23	4/20/95	0.044	0.102	0.070
492516	27	4/20/95	0.034	0.123	0.190
492516	29	4/20/95	0.025	0.180	0.450
492516	21	5/3/95	0.076	0.094	0.060
492516	23	5/3/95	0.287	0.093	0.090
492516	27	5/3/95	0.025	0.121	0.250
492516	29	5/3/95	0.025	0.167	0.380

STORET	Type	Date	NH3-N	T P	DNO2/3
492516	21	5/16/95	0.025	0.077	0.100
492516	23	5/16/95	0.060	0.083	0.090
492516	27	5/16/95	0.070	0.099	0.140
492516	29	5/16/95	0.050	0.178	0.410
492516	21	5/30/95	0.025	0.062	0.100
492516	23	5/30/95	0.025	0.064	0.100
492516	27	5/30/95	0.070	0.090	0.150
492516	29	5/30/95	0.090	0.236	0.410
492516	21	6/13/95	0.025	0.050	0.040
492516	23	6/13/95	0.025	0.050	0.020
492516	27	6/13/95	0.050	0.060	0.120
492516	29	6/13/95	0.070	0.210	0.470
492516	21	7/3/95	0.025	0.030	0.010
492516	23	7/3/95	0.025	0.020	0.010
492516	27	7/3/95	0.025	0.040	0.010
492516	29	7/3/95	0.050	0.230	0.510
492516	21	7/11/95	0.025	0.010	0.010
492516	23	7/11/95	0.025	0.030	0.010
492516	27	7/11/95	0.025	0.140	0.040
492516	29	7/11/95	0.062	0.210	0.460
492516	21	7/27/95	0.025		0.010
492516	23	7/27/95	0.025	0.010	0.010
492516	27	7/27/95	0.025	0.090	0.210
492516	29	7/27/95	0.025	0.220	0.510
492516	21	8/10/95	0.025	0.010	0.010
492516	23	8/10/95	0.025	0.010	0.010
492516	27	8/10/95	0.050	0.060	0.100
492516	29	8/10/95	0.122	0.220	0.390
492516	21	8/22/95	0.025	0.010	0.010
492516	23	8/22/95	0.025	0.010	0.010
492516	27	8/22/95	0.025	0.120	0.200
492516	29	8/22/95	0.203	0.250	0.200
492516	21	9/7/95	0.025	0.010	0.010
492516	23	9/7/95	0.025	0.010	0.460
492516	27	9/7/95	0.025	0.160	0.010
492516	21	9/26/95	0.025	0.005	0.020
492516	23	9/26/95	0.025	0.010	0.050
492516	27	9/26/95	0.025	0.140	0.410
492516	29	9/26/95	0.261	0.240	0.100
492516	21	10/26/95	0.025	0.030	0.010
492516	23	10/26/95	0.025	0.100	0.050
492516	27	10/26/95	0.025	0.170	0.290
492516	29	10/26/95	0.522	0.330	0.010
492516	23	11/15/95	0.025	0.040	0.010
492516	27	11/15/95	0.246	0.250	0.050
492516	29	11/15/95	0.588	0.350	0.010
492516	21	2/14/96	0.067	0.100	0.020
492516	23	2/14/96	0.057	0.100	0.040
492516	27	2/14/96	0.120	0.120	0.020
492516	29	2/14/96	0.185	0.140	0.080
492516	21	3/6/96	0.076	0.090	0.020

STORET	Type	Date	NH3-N	T P	DNO2/3
492516	23	3/6/96	0 052	0 090	0.050
492516	27	3/6/96	0.099	0.120	0.140
492516	29	3/6/96	0.241	0.160	0.200
492516	21	4/4/96	0.025	0 130	0.140
492516	23	4/4/96	0.068	0 120	0.440
492516	27	4/4/96	0 114	0 130	0.250
492516	29	4/4/96	0.299	0 200	0.200
492516	21	4/30/96	0 025	0.070	0 010
492516	23	4/30/96	0.025	0.080	0.010
492516	27	4/30/96	0 025	0 100	0 170
492516	29	4/30/96	0.063	0.170	0 380
492516	21	5/29/96	0.025	0 040	0.040
492516	23	5/29/96	0.025	0.050	0.030
492516	27	5/29/96	0.126	0.070	0 130
492516	29	5/29/96	0 084	0 130	0 370
492516	21	6/12/96	0.025	0 010	0 010
492516	27	6/16/96	0.025	0.030	0 010
492516	29	6/16/96	0 060	0.200	0.430
492516	23	6/27/96	0 025	0 010	0 010
492516	27	6/27/96	0.025	0.020	0 010
492516	29	6/27/96	0 128	0.220	0.390
492516	21	7/9/96	0.025	0.020	0.010
492516	23	7/9/96	0.097	0 020	0 010
492516	27	7/9/96	0.099	0 020	0 020
492516	29	7/9/96	0.073	0.170	0.410
492516	21	7/23/96	0.025	0.010	0.010
492516	23	7/23/96	0.025	0 010	0 010
492516	27	7/23/96	0.025	0 140	0.410
492516	29	7/23/96	0 133	0.200	0.490
492516	21	8/7/96	0 025	0.020	0.010
492516	23	8/8/96	0.025	0.020	0.010
492516	27	8/8/96	0 025	0 053	0 080
492516	29	8/8/96	0 150	0.022	0 420
492516	21	8/23/96	0 060	0.010	0.010
492516	23	8/23/96	0.025	0.010	0.030
492516	27	8/23/96	0 025	0 150	0.460
492516	29	8/23/96	0 174	0.250	0 360
492516	21	9/10/96	0 025	0.020	0 010
492516	23	9/10/96	0.025	0.020	0.010
492516	27	9/10/96	0.025	0.090	0.280
492516	29	9/10/96	0.246	0 230	0.280
492516	21	9/26/96	0 053	0 024	0 010
492516	23	9/26/96	0 025	0.024	0 010
492516	27	9/26/96	0.025	0.032	0.040
492516	29	9/26/96	0.106	0.192	0.400
492516	21	10/8/96	0.025	0 005	0.010
492516	23	10/8/96	0 025	0.023	0 010
492516	27	10/8/96	0 025	0.190	0 360
492516	29	10/8/96	0.249	0.291	0.240
492516	21	11/5/96	0.025	0.084	0.150
492516	23	11/5/96	0.025	0.074	0.030
492516	27	11/5/96	0 025	0.076	0.030

STORET	Type	Date	NH3-N	T P	DNO2/3
492516	29	11/5/96	0 229	0.275	0.140
492516	21	4/18/97	0.025	0 081	0.020
492516	23	4/18/97	0 025	0 082	0.210
492516	27	4/18/97	0.025	0.115	0.430
492516	29	4/18/97	0.025	0.119	0.450
492516	21	5/15/97	0 141	0 091	0.010
492516	23	5/15/97	0.137	0.085	0.030
492516	27	5/15/97	0 058	0 110	0 100
492516	29	5/15/97	0 051	0.169	0 440
492516	21	6/13/97	0 025	0 090	0.030
492516	23	6/13/97	0.025	0.088	0.060
492516	27	6/13/97	0.079	0 065	0.120
492516	29	6/13/97	0 192	0 274	0 380
492516	21	7/18/97	0 025	0 065	0 010
492516	23	7/18/97	0 065	0.040	0 030
492516	27	7/18/97	0 060	0 121	0 250
492516	29	7/18/97	0.025	0 194	0.400
492516	21	9/9/97	0 025	0 059	0 010
492516	23	9/9/97	0 025	0 081	0.040
492516	27	9/9/97	0.025	0.130	0.450
492516	29	9/9/97	0.025	0.206	0 460
492517	21	6/2/92	0 025	0.093	0.010
492517	29	6/2/92	0 096	0 282	0 465
492517	21	9/1/92	0 025	0.044	0.010
492517	29	9/1/92	0.168	0.321	0.010
492517	21	7/12/93	0.025	0 022	
492517	29	7/12/93	0.060	0.239	0.719
492517	21	9/1/93	0.025	0 024	0 039
492517	29	9/1/93	0 127	0 254	0 435
492518	21	6/2/92	0.025	0 105	0.010
492518	29	6/2/92	0 025	0 165	0.132
492518	21	9/1/92	0.025	0.094	0.010
492518	21	7/12/93	0.025	0.024	0 010
492518	29	7/12/93	0 051	0 233	0 584
492518	21	9/1/93	0.025	0.035	0.010
492518	29	9/1/93	0.055	0.129	0.280
492518	21	6/28/94	0.025	0.026	0 010
492518	29	6/28/94	0.025	0.221	0.350
492518	21	7/14/94	0.025	0.024	0.010
492518	29	7/14/94	0 025	0.475	0 350
492518	21	7/26/94	0.025	0.018	0.261
492518	29	7/26/94	0 025	0.252	0.010
492518	21	8/11/94	0.025	0 024	0.010
492518	29	8/11/94	0.079	0.234	0.194
492518	21	8/25/94	0.025	0.030	0.010
492518	29	8/25/94	0.098	0.287	0.096
492518	21	9/13/94	0.025	0.042	0.052
492518	29	9/13/94	0.085	0.244	0.010
492518	21	9/28/94	0 025	0 047	0.010
492518	29	9/28/94	0 153	0.343	0 010
492518	21	10/20/94	0 025	0.078	0.010

STORET	Type	Date	NH3-N	T P	DNO2/3
492518	29	10/20/94	0.025	0.134	0.031
492518	21	11/8/94	0.025	0.107	0.010
492518	29	11/8/94	0.025	0.119	0.010
492518	21	11/22/94	0.060	0.142	0.010
492518	29	11/22/94	0.059	0.150	0.010
492518	21	4/4/95	0.025	0.145	0.209
492518	29	4/4/95	0.068	0.193	0.320
492518	21	4/20/95	0.029	0.106	0.030
492518	29	4/20/95	0.041	0.154	0.280
492518	21	5/3/95	0.025	0.103	0.100
492518	29	5/3/95	0.025	0.127	0.170
492518	21	5/16/95	0.025	0.075	0.130
492518	29	5/16/95	0.050	0.157	0.210
492518	21	5/30/95	0.025	0.065	0.110
492518	29	5/30/95	0.025	0.187	0.130
492518	21	6/13/95	0.025	0.050	0.030
492518	29	6/13/95	1.500	0.160	0.330
492518	21	7/3/95	0.025	0.030	0.010
492518	21	7/11/95	0.025	0.030	0.010
492518	29	7/11/95	0.074	0.210	0.430
492518	21	7/27/95	0.025	0.010	0.010
492518	29	7/27/95	0.025	0.110	0.210
492518	21	8/10/95	0.025	0.020	0.010
492518	29	8/10/95	0.025	0.190	0.420
492518	21	8/22/95	0.025	0.020	0.010
492518	29	8/22/95	0.025	0.140	0.300
492518	29	9/6/95	0.082	0.230	0.430
492518	21	9/7/95	0.025	0.010	0.010
492518	21	9/26/95	0.025	0.020	0.010
492518	29	9/26/95	0.124	0.270	0.260
492518	21	10/26/95	0.025	0.020	0.010
492518	29	10/26/95	0.025	0.110	0.110
492518	21	11/15/95	0.025	0.050	0.010
492518	29	11/15/95	0.079	0.090	0.050
492518	21	4/4/96	0.085	0.140	0.310
492518	29	4/4/96	0.063	0.120	0.210
492518	21	4/30/96	0.025	0.060	0.010
492518	29	4/30/96	0.025	0.110	0.210
492518	21	5/29/96	0.025	0.040	0.050
492518	29	5/29/96	0.076	0.130	0.310
492518	29	6/16/96	0.059	0.170	0.380
492518	21	6/27/96	0.025	0.020	0.020
492518	29	6/27/96	0.114	0.070	0.060
492518	21	7/9/96	0.054	0.020	0.010
492518	29	7/9/96	0.069	0.160	0.320
492518	21	7/23/96	0.025	0.020	0.010
492518	29	7/23/96	0.025	0.190	0.430
492518	21	8/8/96	0.025	0.498	0.010
492518	29	8/8/96	0.052	0.191	0.420
492518	21	8/23/96	0.025	0.010	0.030
492518	29	8/23/96	0.060	0.240	0.470
492518	21	9/10/96	0.055	0.010	0.010

STORET	Type	Date	NH3-N	T P	DNO2/3
492518	29	9/10/96	0.090	0.230	0.340
492518	21	9/26/96	0.053	0.020	0.010
492518	29	9/26/96	0.134	0.204	0.250
492518	21	10/8/96	0.074	0.005	0.010
492518	29	10/8/96	0.175	0.298	0.240
492518	21	11/5/96	0.025	0.062	0.030
492518	29	11/5/96	0.025	0.057	0.020
492518	21	4/18/97	0.025	0.080	0.200
492518	29	4/18/97	0.025	0.083	0.290
492518	21	5/15/97	0.096	0.102	0.070
492518	29	5/15/97	0.088	0.160	0.280
492518	21	6/13/97	0.089	0.148	0.060
492518	29	6/13/97	0.084	0.319	0.370
492518	21	7/18/97	0.025	0.055	0.010
492518	29	7/18/97	0.081	0.156	0.340
492518	21	9/9/97	0.061	0.064	0.010
492518	29	9/9/97	0.074	0.166	0.420

APPENDIX E

Dissolved Oxygen/Temperature Profiles

APPENDIX E

WATER COLUMN PROFILES

Column Sequence: Depth (meters), Temperature (C), pH, Dissolved oxygen (mg/L), and Conductivity (umhos)

EAST CANYON RESERVOIR
07/12/93

0 0	19 1	8.5	7 8	531
1 0	19 0	8.5	7.8	535
2 0	18 6	8 5	7.7	536
3 0	18.3	8 5	7.5	536
4 0	17.5	8 5	7.0	541
5 0	16.8	8 4	6.5	546
6 0	15.9	8 3	6 0	549
7 0	15.2	8 3	5 6	554
8 0	13 0	8.1	4.7	559
9 0	11.1	8 0	4 5	578
10 0	10.4	7 9	4 6	583
11.0	9.8	7 9	4 8	596
12.0	9 1	7.9	4.8	618
13 0	8.6	7.8	4.8	636
14 0	8 2	7.8	4.6	643
15 0	7.6	7 7	4.4	658
16.0	7.0	7 6	3 8	685
17.0	6.6	7.6	3 5	694
18.0	6.3	7.5	3.2	702
19.0	6.1	7.5	3.1	710
20 0	6 0	7.5	2.9	708
21 0	5.9	7 5	2 8	720
22 0	5.6	7 4	2 5	736
23.0	5 5	7.4	2 3	726
24 0	5 4	7.4	2.2	744
25 0	5.3	7 4	2.2	831
26 0	5.3	7.4	2.1	732
27 0	5.2	7 4	2.1	730
28 0	5.1	7.4	2.1	760
29.0	5 0	7.4	1.9	750
30 0	4.9	7 4	1 9	753
31 0	4.8	7.4	1 9	753
32.0	4.8	7 4	1.8	753
34 0	4.5	7.3	0.8	765
36.0	4.3	7 3	0.8	782
38.0	4.2	7 3	0 4	780
40.0	4 1	7.3	0 2	777
45.0	4.0	7.3	0 1	780
50.0	4 0	7.3	0 1	780
52 0	4 0	7.3	0.0	793

EAST CANYON RESERVOIR
06/28/94

0 0	20.6	8.5	8 5	620
1 0	20 1	8 6	8.5	622
2 0	19.8	8 6	8.4	621
3.0	19 6	8 6	8.3	624
4 0	19.3	8 6	8.1	623
5 0	19.0	8.6	7 5	626
6.0	15 9	8 5	5 4	648
7 0	15 5	8.4	5 1	647
8.0	14 5	8.3	4 6	657
9.0	13.2	8.2	4.2	650
10 0	11.9	8 2	4.1	659
11.0	10.6	8.1	3 9	660
12.0	9 3	8 0	3.5	667
13 0	7 6	7 9	2.9	686
14 0	7 2	7.8	2.6	697
15.0	6 5	7.8	2.3	703
16 0	6.2	7.7	2 2	707
17 0	6.0	7.7	2 1	710
18 0	5.9	7.7	1 9	712
19 0	5 8	7 7	1 7	715
20 0	5.7	7.7	1 7	719
21 0	5 7	7 7	1 7	723
22.0	5 6	7 7	1 6	720
23 0	5 5	7 7	1.6	716
24.0	5 5	7 7	1.6	715
25.0	5 4	7.6	1.5	715
26 0	5 3	7.6	1.5	716
27 0	5 3	7 6	1 4	719
28 0	5 2	7.6	1.4	722
29 0	5.2	7.6	1.2	724
30 0	5 1	7 3	1.0	726
31 0	5 0	7.6	0.8	722
32.0	5 0	7 7	0 6	729
33.0	4 9	7 5	0.4	731
34.0	4 2	7 5	0.2	733
35 0	4 7	7 5	0.1	734
36 0	4.7	7.5	0.1	734
37 0	4.6	7.5	0 1	735
38 0	4 6	7.5	0 1	735
39 0	4 5	7.5	0 1	736
40 0	4 5	7 5	0.1	736
41.0	4.5	7 5	0 1	738
42.0	4 5	7 5	0 1	740
43 0	4 4	7 5	0 1	742
44 0	4 4	7 5	0 1	744
45 0	4.4	7 5	0.1	745
46 0	4.4	7.5	0 1	745
49 0	4.3	7.5	0.1	747
50 0	4.3	7.5	0 1	748
50 2	4 3	7.5	0.1	749

EAST CANYON RESERVOIR
06/28/94

EAST CANYON RESERVOIR
07/26/94

0 0	20 9	8.6	8.3	633
1 0	20 8	8.6	7.6	635
2 0	20 8	8.6	7 6	634
3.0	20 8	8 6	7 6	637
4.0	20 8	8 6	7 6	632
5.0	20.8	8 6	7 4	633
6.0	20 8	8 6	7 6	632
7.0	20 8	8 6	7 6	637
8 0	19.0	8 3	4 0	647
9 0	15 8	8.0	2.7	657
10.0	13 1	7.9	1.8	675
11 0	10 1	7.8	1.8	701
12 0	8 1	7 8	1.5	712
13.0	6 8	7.7	1.5	121
14 0	6.3	7 7	1 4	731
16.0	6 0	7 6	0 9	732
18 0	5 7	7.6	1.4	731
20 0	5 6	7.6	0.8	736
24.0	5 4	7.6	3.9	736
28 0	5.3	7.5	4 0	747
32 0	5 0	7 5	4.5	739
36 0	4 8	7 6	0 6	766
38.7	4.7	7 5	0.3	764

EAST CANYON RESERVOIR
08/11/94

0.0	20.1	8.3	7.8	616
1 0	20 1	8 3	7 8	614
2 0	20 9	8.3	7 8	616
3.0	20 8	8 3	7 8	608
4 0	20.8	8.3	7 8	614
5.0	20 8	8.3	7.8	614
6.0	20.8	8 4	7 8	616
7.0	20 8	8 3	7.8	620
8.0	18 1	7 7	1.2	630
9.0	15.0	7 6	0 4	640
10 0	12.0	7 6	0 3	649
11 0	11 0	7 6	0.3	660
12 0	8 3	7 5	0 3	662
13 0	7 0	7 5	0.3	672
14.0	6 6	7 4	0 4	670
15.0	6 3	7.4	0 4	676
16.0	6 1	7 4	0 3	672
17.0	6 1	7 4	0 2	672
18.0	6 0	7 4	0 1	673
19 0	5 9	7.4	0 1	674
20.0	5 7	7.4	0 2	673
22.0	5 7	7 4	0 2	675
24 0	5.5	7.4	0.1	677
26 0	5.2	7 4	0 1	651
28 0	5 2	7 4	0 1	681
30.0	5.0	7 4	0 1	685
32.0	4 9	7 4	0 1	687
34.0	4.8	7.4	0 1	689
36.0	4 8	7 4	0 0	691
38.0	4 7	7.4	0 0	691
40.0	4 7	7.4	0 0	693
42.0	4 6	7.3	0 0	694
44 0	4.6	7.3	0.0	694
46 0	4.6	7.3	0 0	695
47 0	4.6	7 3	0 0	695

EAST CANYON RESERVOIR
09/13/94

0 0	17.3	9 0	7 5	617
1.0	17 3	9.0	7 4	621
2.0	17 3	9.0	7 3	619
3 0	17 3	9 0	7.3	619
4 0	17 3	9 0	7.3	621
6.0	17 3	9 0	7 2	622
7 0	17 3	8 9	6.2	630
8 0	13 8	8 3	1 0	642
9.0	11.3	8.2	0.7	646
10 0	9 9	8.2	0.4	647
11 0	8.7	8.2	0.4	660
12 0	8.2	8 2	0 4	660
13 0	7.6	8 2	0 3	665
14 0	7 4	8 2	0.3	661
16.0	7.1	8 2	0 3	666
18 0	6.6	8 2	0 3	669
20.0	6.2	8.2	0 3	665
24 0	5 7	8 2	0 3	672
28 0	5 4	8 2	0.3	673
32 0	5 2	8 1	0.3	677
36 0	5 1	8 1	0.2	670
40 0	5 0	8.1	0.3	680
41.5	5.1	8 1	0.2	686

EAST CANYON RESERVOIR
11/08/94

0 0	7 3	8 1	7.5	656
2 0	7.3	8 1	7 4	657
4 0	7.3	8 2	7 5	656
6 0	7.3	8.2	7 5	656
8 0	7 3	8.2	7.5	656
10 0	7 3	8 1	7.3	659
12 0	7 3	8 1	6.7	659
14 0	7.2	8 0	5 8	662
16.0	7 1	7.9	4 2	672
20 0	6.9	7 8	2 3	674
24 0	6 8	7.7	0.9	672
28 0	6 7	7.6	0.4	674
32 0	6 6	7 6	0.4	678
36.0	6 2	7 6	0.4	678

EAST CANYON RESERVOIR
11/22/94

0 0	5.1	7.8	7 2	685
1.0	5.1	7.8	7 2	683
2 0	5.1	7.8	7.2	685
4 0	5.1	7.8	7 4	680
6.0	5.1	7 8	7 4	686
8.0	5.1	7 8	7 4	687
10 0	5.1	7 8	7.4	689
12.0	5.1	7.8	7.4	689
14 0	5.1	7.8	7 4	692
16 0	5.1	7.8	7.4	682
18 0	5.1	7.8	7.7	698
20 0	5.1	7.8	.7.9	700
22 0	5 0	7.9	8.0	687
24.0	5 1	7.9	8.1	689
26 0	5 0	7 9	8 2	666
28.0	5 0	7 9	8 1	687
30.0	5 0	7 9	8 2	680
34 0	5 0	7 9	8 2	672
38 0	5.0	7.8	7 5	692
41.3	4.8	7.9	8 5	690

EAST CANYON RESERVOIR
04/04/95

0.0	5.1	7 6	9 6	728
1.0	5.1	8.1	9 4	726
2.0	5.1	8 1	9 4	726
3 0	5.1	8.1	9 4	727
4.0	5.1	8 1	9 4	727
5 0	5.0	8 1	9 4	728
6 0	5 0	8 1	9 4	727
7 0	5 0	8 1	9.3	728
8 0	5 0	8 1	9 3	727
9 0	5 0	8.1	9.3	727
10 0	4.9	8 1	9.2	728
11.0	4.9	8 1	9.2	727
12 0	4.9	8.1	9 1	727
13.0	4 9	8.1	9.0	727
14 0	4 9	8 1	9.0	726
15.0	4 8	8 1	9 0	727
16 0	4.8	8 1	8 8	728
17 0	4.8	8 1	8 7	727
18.0	4.6	8.0	8.5	727
19 0	4 4	7 9	8.0	733
20 0	4 4	7.9	7.8	740
21 0	4.3	7.8	7.4	744
22.0	4 3	7.8	7 3	744
23.0	4.3	7 8	7 2	746
24.0	4 3	7 8	7 2	744
25.0	4 2	7 8	7.1	748
26.0	4 2	7 8	7 0	752
27 0	4.1	7 8	6 8	752
28 0	4.1	7 7	6 7	752
29.0	4.0	7 7	6 6	758
30.0	4.0	7 7	6 5	761
31.0	3 9	7.7	6.3	772
32 0	3 8	7 7	6.0	776
33 0	3.7	7 7	5 9	781
34 0	3.6	7.6	5 7	786
35.0	3.6	7.6	5 6	789
36 0	3.6	7.6	5 5	789
37.0	3.6	7.6	5 4	790
38 0	3.5	7.6	5 3	791
39.0	3 5	7 6	5 3	791
40.0	3 5	7 6	5.2	793
41.0	3 5	7 6	5.2	795
42 0	3 5	7 6	5 1	793
43 0	3 5	7 6	5 0	795
44 0	3.5	7.6	5.0	794
45 0	3.5	7 6	5.0	795

EAST CANYON RESERVOIR
04/04/95

0 0	6.7	8.5	10 6	741
1 0	6 7	8.5	10 3	741
2 0	6 4	8.5	10 3	738
3.0	6 4	8.5	10.2	737
4.0	5 8	8.5	10.2	735
5 0	5.8	8 4	10.1	733
6.0	5 9	8 4	10.0	731
7.0	5 9	8 4	10 0	731
8.0	5.8	8 4	10 0	732
9 0	5.5	8.3	9 6	737
10 0	4 9	8.2	8 9	739
11 0	5 0	8.2	8 8	739
12 0	4 8	8 2	8 6	747
13 0	4.5	8 1	8.4	747
14 0	4.4	8 1	8 0	751
15.0	4.3	8 0	7.8	752
16 0	4 3	8 0	7 6	754
17 0	4 2	8 0	7 5	753
18.0	4 1	7.9	7.3	756
19 0	4 0	7 9	7.0	758
20 0	4.0	7.9	6 9	762
21.0	4 0	7.9	6 8	763
22 0	4.0	7 9	6.8	762
23 0	4 0	7 9	6.7	763

EAST CANYON RESERVOIR
04/04/95

0 0	5 8	8 2	10.8	719
1.0	5 8	8 3	10.6	724
2 0	5 8	8 2	10.5	726
3.0	3 7	8 2	10.5	726
4.0	5 7	8.2	10.2	726
5 0	5 4	8 2	10.1	725
6 0	5.4	8 2	9.9	727
7 0	5.2	8.2	9.8	726
8 0	5.2	8.2	9.6	727
9.0	5.1	8.2	9.5	727
10.0	5.0	8.1	9.4	726
11 0	5 0	8.1	9 3	728
12.0	4.9	8.1	9 2	728
13 0	4.9	8.1	9.2	729
14 0	4.8	8.1	8 9	729
15 0	4 9	8.1	8 8	728
16 0	4 6	8 0	8 7	731
17 0	4.6	8 0	8 4	739
18.0	4.4	8 0	8 0	740
19 0	4 4	7 9	7.9	740
20.0	4 4	7 9	7.6	743

EAST CANYON RESERVOIR
05/18/95

0 0	11 4	8 6	9.8	675
1 0	11 2	8 6	9 4	676
2.0	11.1	8.6	9.2	673
3 0	11 1	8 6	9 0	676
4 0	11.0	8 6	9.1	673
5.0	11.0	8 6	9.3	673
6.0	11.0	8 6	9.0	673
7 0	11 0	8.6	8 9	672
8.0	11.0	8.6	9.1	670
9.0	10.8	8.6	8 9	673
10 0	10.7	8 6	8 7	678
11 0	10.6	8 6	8 7	675
12 0	9.0	8.5	8.0	683
13 0	8 5	8.5	8 0	692
14 0	7.9	8 4	7.7	709
15.0	7.4	8.4	7 6	720
16 0	6 9	8 3	7.6	725
17.0	6.5	8.3	7.2	732
18.0	6 1	8.2	6 9	736
19.0	5.9	8 2	6.8	745
20 0	5 7	8 2	6.6	745
21 0	5 7	8 2	6.4	745
22 0	5 6	8 1	6.4	735
23 0	5.4	8 1	6.2	745
24 0	5.3	8 1	6.1	735
25 0	5.3	8 1	5.9	746
26 0	5 3	8 1	5.9	735
27.0	5 1	8 1	5.9	742
28.0	5 1	8 0	5 7	744
29.0	5 0	8 0	5.6	750
30.0	4 9	8 0	5.1	749
31.0	4 8	7.9	4 9	750
32.0	4 8	7 9	4.8	759
33.0	4 7	7 9	4.7	759
34.0	4 7	7.9	4 6	758
35.0	4 7	7.9	4 4	764
36.0	4 7	7.9	4 3	761
37.0	4.6	7.9	4 2	761
38.0	4 6	7.9	4 1	759
39.0	4 6	7 9	4 0	758
40.0	4 6	7.9	4 0	759
41.0	4 6	7.9	4 0	760
42.0	4.6	7.9	4 0	760
43.0	4 6	7 9	4 0	761
44.0	4.5	7 9	3 9	761
45.0	4 5	7.9	3 9	761
46.0	4 5	7.9	3 8	761
47 0	4 5	7.8	3 7	762
49.0	4.5	7.8	3 6	762
50.4	4.5	7 8	2 8	764

EAST CANYON RESERVOIR
05/18/95

0.0	10.5	8.5	9 0	626
1.0	10.5	8.5	9 0	623
2 0	10.4	8 5	9.0	620
3 0	10.4	8 5	9 0	613
4 0	10.3	8 5	9 0	615
5.0	10.0	8 5	8 8	629
6.0	9 6	8.5	8 8	668
7.0	9.0	8 5	8 6	638
8 0	8.7	8 4	8.4	638
9.0	8 6	8 4	8 2	658
10 0	8.1	8.4	7 9	673
11 0	8.0	8 3	7 7	675
12 0	7.9	8 3	7 6	675
13 0	7.7	8 3	7 1	677
14.0	7.5	8 2	6 8	690
14 5	7.3	8.2	6.3	695

EAST CANYON RESERVOIR
05/18/95

0.0	11 6	8 6	9 1	667
1 0	11 4	8 6	9 1	669
2 0	11.3	8 6	8 8	672
3 0	11.3	8 6	9.1	669
4 0	11.3	8 6	8 9	669
5.0	11 2	8 6	8.9	669
6 0	11 0	8.6	8.9	666
7.0	10 8	8 6	8.8	673
8 0	10 6	8 8	8 9	672
9 0	10 3	8 6	8.7	680
10 0	10 1	8 5	8 7	676
11 0	9 7	8 5	8.3	681
12.0	9.0	8 5	8.1	683
13.0	8 7	8 4	7.8	685
14.0	8.3	8 4	7.7	691
15.0	8.1	8 4	7.5	692
16.0	7.7	8 3	7.1	708
17 0	7 5	8 3	7.0	711
18.0	7.3	8 2	6.9	711
19 0	7 0	8.2	6 6	717
20 0	6.6	8 2	6.4	727
21.0	6 5	8 1	6 3	728
22 0	6 2	8 1	6 1	734
22.2	6 0	8.1	5.3	740

EAST CANYON RESERVOIR
05/30/95

0.0	12.9	8.3	8 8	592
1.0	12.8	8 4	8 6	588
2.0	12.5	8 4	8 7	586
3.0	12 3	8 4	8.6	587
4 0	12 2	8.4	8 6	593
5 0	12 1	8.4	8.8	594
6 0	11.2	8 3	8.9	565
7 0	10.9	8 3	8 6	580
8 0	10.2	8 2	8 4	557
9 0	9.9	8 2	8 6	567
10 0	9 7	8 2	8 8	569
11 0	9.6	8 2	9 3	574
12.0	9.3	8 2	8 3	572
14.0	8.5	8 1	8.0	607
16.0	7 7	8.0	7 6	650
18.0	6.9	7 9	6.7	675
20.0	6 6	7.9	6.4	679
22.0	6 1	7.8	6.2	699
24.0	5.6	7.8	5.7	706

EAST CANYON RESERVOIR
05/30/95

0 0	13.0	8.4	9 5	612
1.0	12.7	8 4	9.1	612
2 0	12.4	8 4	9 0	615
3 0	12 1	8 4	9 1	617
4.0	11 9	8.4	9 2	616
5 0	11 8	8 4	9.2	616
6 0	11 7	8 4	9 0	615
7.0	11 7	8.4	8.9	616
8.0	11 6	8.4	8 9	617
9 0	11.5	8.4	8.9	619
10.0	11 3	8.3	8.7	616
11.0	10.5	8 2	8 8	604
12.0	9 6	8.2	7.9	619
13.0	8 8	8.2	7 5	656
14.0	7 5	8.1	6 8	684
15.0	7 1	8.0	6.7	690
16.0	7 1	8.0	6.7	690
17.0	6 5	7.9	6 4	694
18.2	6 3	7 9	6.3	700

EAST CANYON RESERVOIR
05/30/95

0.0	13.6	8 8	8.8	625
1.0	12.7	8 7	8.8	621
2 0	12 3	8.6	8.8	622
3.0	12.2	8.6	8 8	621
4.0	12.2	8.6	8.7	618
5.0	12.0	8 5	8.7	616
6.0	12.0	8 5	8 7	619
7.0	12.0	8 5	8 7	622
8.0	11 9	8.5	8.7	622
9.0	11.8	8.5	8 6	627
10.0	11 5	8.5	8 4	632
11 0	10 7	8.4	8 0	618
12 0	9 9	8.3	8 0	622

13 0	9 0	8 3	8 0	648
14 0	8 6	8.3	7 8	653
15 0	7.8	8.2	7 7	679
16.0	7 6	8.1	7.4	681
17.0	7 2	8 1	7 4	690
18.0	6.9	8 1	7.2	694
19 0	6.7	8 0	7 3	699
20.0	6.6	8.0	7 1	698
21.0	6.4	8 0	7 1	701
22.0	6.3	8 0	7 5	700
23.0	6.1	7.9	7 5	701
24 0	6.0	7.9	6 9	704
25.0	5.9	7 9	6 7	707
26 0	5.6	7 8	6 6	708
27.0	5 4	7.8	6 3	709
28 0	5 4	7.8	6.3	709
29 0	5 3	7.7	5 7	710
30 0	5 0	7 7	5 7	710
31 0	5.2	7.7	5 5	709
32 0	5 2	7 7	5.5	709
33.0	5 1	7 7	5.5	713
34.0	5 1	7.7	5 5	713
35.0	5.0	7.7	5 2	713
36 0	5 0	7.7	5 2	713
37 0	5 0	7 6	5.0	713
38.0	5.0	7 6	5 0	713
39 0	5 0	7 6	4.8	713
40 0	5 0	7 6	4 8	713
41.0	4 9	7 6	4.8	713
42.0	4 9	7.6	4.8	713
43.0	4 9	7 6	4 6	714
44.0	4 9	7 6	4 6	714
45 0	4 9	7.6	4 5	712
46 0	4.9	7.6	4 5	712
49.0	4.8	7.6	4.0	714
51 0	4 8	7.6	4 0	713
52 0	4 8	7 6	3 8	710

EAST CANYON RESERVOIR
08/22/95

0.0	19.7	8.2	9.7	583
1.0	19.7	8.2	9.7	585
2.0	19 7	8 2	9.9	585
3.0	19 7	8.2	9.6	587
4 0	19 7	8.2	9 3	585
5 0	19 7	8.2	9 4	589
6 0	19 2	8.2	8 9	590
7.0	18.9	8 1	8 4	599
8 0	17.9	8.1	7.2	601
9.0	16 9	8 1	6.4	609
10.0	15 0	8 0	5.5	608
11.0	13.8	7.9	4 8	609
12.0	11 0	8.0	4 7	630
13.0	9.3	7.9	4.6	680
14 0	8.8	7 7	4 4	682
15.0	8.4	7.7	4.2	694
16.0	8.0	7 6	4.1	703
17 0	8 0	7 6	4.0	711
18.0	7 7	7.5	4 0	711
19.0	7 7	7 5	4 0	715
20.0	7 4	7.5	3 9	722
21.0	7 3	7.5	4.0	725
22.0	7.1	7 5	4.0	727
23 0	7.0	7 5	4 0	727

EAST CANYON RESERVOIR
08/22/95

0.0	20 6	8.3	8.8	575
1.0	20.6	8 3	8 8	575
2 0	20 6	8.3	8 8	575
3.0	20 3	8.4	8.7	575
4.0	20.9	8 4	8.7	576
5.0	20 1	8 3	8 0	580
6.0	19 7	8.3	7 6	583
7.0	19 5	8.3	7.0	583
8.0	17.8	8 0	4.6	600
9 0	16.3	7 8	3 5	596
10 0	14 6	7.7	2 9	591
11.0	12 9	7.7	2.7	593
12 0	11 6	7 6	2.7	605
13.0	10.4	7 6	3 0	634
14 0	9 5	7 6	3 1	655
15.0	9 3	7 5	3 1	666
16.0	8 9	7.5	3 1	674
17.0	8 5	7 5	3 1	695
18 0	8 0	7 5	3 1	695
19 0	7.9	7 4	3 0	700
20.0	7.8	7 4	3 0	703
21.0	7 5	7.4	2 9	708
22 0	7 5	7 4	2.8	710
23.0	7 5	7 4	2 8	713
24 0	7 4	7.4	2.7	716
25.0	7.3	7 4	2 6	715
26.0	7 3	7.4	2.5	718
27.0	7 0	7 3	2 4	723
28 0	6 9	7 3	2 4	723
29 0	6 9	7 3	2 3	725
30 0	6.7	7.3	2 0	730
31.0	6.5	7.3	1.9	736
32.0	6 4	7 3	1 9	740
33 0	6 3	7.2	1 2	743
34 0	6 2	7 2	1 2	746
35 0	6 0	7 2	1 0	747
36 0	6 0	7.2	1 0	749
37.0	6.0	7.2	1.0	750
38.0	6 0	7.2	1.0	750
40.0	5 9	7 0	0 8	752
41.0	5 9	7 0	0 8	752
42 0	5 9	7 0	0 8	752
43 0	5.8	7.0	0 8	751
44.0	5.8	7.0	0.8	749
45.0	5.8	7 0	0.8	753
46.0	5 8	7 0	0 8	755
47 0	5.8	7 0	0 8	754
48.0	5.8	7 0	0.8	754
49 0	5 8	7.0	0 8	753
50.5	5 8	7 0	0.8	753

EAST CANYON RESERVOIR
08/22/95

0.0	20 6	8.1	10 5	578
1 0	20 6	8 1	10 5	578
2 0	20 6	8.2	10 5	580
3 0	20 5	8 2	10.5	583
4 0	20.4	8.2	10 2	588
5.0	19.9	8 1	9 6	589
6 0	19 6	8 2	9 3	592
7.0	19 1	8 1	8 7	599
8 0	18.6	8 1	7.7	603
9 0	16.0	8 1	6 3	604
10 0	14 6	8 0	5 2	601
11 0	13 7	7 9	5 0	601
12.0	12 0	7.9	4.9	619
13 0	11.2	7 8	4.8	625
14 0	11 2	7 7	4 6	624

EAST CANYON RESERVOIR
10/26/95

0.0	9 8	8 6	13 6	615
1.0	9.9	8 6	12 3	629
2 0	9.9	8 7	12.2	630
3 0	9 9	8.7	12.5	629
4 0	9 8	8.7	12 6	618
5.0	9 8	8.7	12 6	619
6 0	9 8	8 7	12 1	630
7 0	9 8	8 7	12 1	630
8 0	9 8	8.7	12 1	630
9 0	9 8	8.7	12 1	629
10.0	9.8	8 7	12 4	618
11.0	9.8	8 7	12 6	617
12 0	9 5	8 8	8.7	635
13.0	9 0	8.8	8 7	635
14.0	8.8	8.7	8 7	684
15 0	8.5	8 2	8.4	700
16.0	7 9	8 2	8 1	710
17.4	7 9	8.2	7.8	728

EAST CANYON RESERVOIR
10/26/95

0 0	9 8	8.6	14 0	625
1.0	9 8	8 7	14 8	618
2.0	9.8	8 7	14 1	632
3.0	9 8	8.7	14 1	630
4 0	9 8	8.7	14.0	630
5 0	9 8	8 7	14 4	630
6.0	9.8	8 7	13 7	632
7 0	9 8	8.7	13 7	632
8 0	9 7	8.7	13 6	632
9.0	9 7	8 7	13 6	632
10 9	0 7	8 7	13.2	632
11.0	9.7	8.7	13.1	632
12.0	9.6	8.7	13 5	632
13 0	9 4	8.6	13 4	632
14 0	9 0	8 5	12 9	645
15.0	8 8	8 4	11.5	663
16 0	8 4	8 0	11.3	677
17.0	8.1	8 1	10 9	677
19 3	7 8	8.1	9 8	730

EAST CANYON RESERVOIR
10/26/95

0 0	10 2	8.6	12 9	658
1 0	10 1	8.6	12 6	644
2.0	10 0	8 6	12.0	642
3.0	10.0	8.6	12 0	635
4 0	9 9	8.6	12 0	635
5 0	9 9	8 0	13.2	648
6 0	9 9	8 6	13 2	646
7.0	9.8	8 6	13.2	646
8.0	9.9	8.6	13 3	647
9 0	9.8	8 6	13 1	647
10 0	9 8	8 6	13 0	640
11.0	9.8	8 6	13 2	648
12.0	9 8	8.6	13 2	648
13 0	9 8	8 6	13.1	646
14 0	9 7	8 4	13 2	652
15 0	9 6	8.3	13 2	666
16 0	9 0	8.0	10 5	715
17 0	8 1	7.8	9 2	739
18 0	7.9	7 8	8.9	737
19.0	7 7	7 8	9 2	737
20 0	7.6	7.7	9 4	736
21 0	7 5	7 7	9 4	736
22.0	7.4	7.7	9 4	741
23 0	7.4	7.7	9 4	741
24 0	7.2	7 7	9.3	746
25 0	7 2	7.6	9.3	741
26 0	7 0	7 6	9 3	746
27.0	7 0	7 6	9 4	750
28.0	6.8	7 6	9 5	760
29 0	6 7	7.6	9 7	768
30.0	6 4	7 6	9 7	768
31.0	6 4	7 6	9 7	768
32 0	6.4	7.6	9 7	768
33 0	6.4	7 5	9.7	768
34.0	6.2	7.6	10 0	770
35.0	6.0	7 6	9 9	777
36 0	6.0	7 6	9 9	771
37.0	5 9	7.6	9.7	772
38 0	5 9	7.6	9 7	772
39.0	5.9	7.6	9 7	772
40 0	5.9	7.5	10 0	772
41 0	5.9	7.5	10 0	771
42.0	5 9	7 5	10.1	770
43.0	5 9	7 5	10 2	769
44 0	5 9	7 5	10.5	768
45 0	5.9	7 5	10.5	769
46 0	5 9	7 5	10 5	770
47 0	5.9	7.5	10.5	771

EAST CANYON RESERVOIR
04/30/96

0.0	8 1	8 7	13.0	657
1 0	7.8	8.7	12 2	657
2.0	7.8	8.7	12.1	658
3.0	7.8	8.7	11.9	659
4.0	7.8	8.7	11 8	658
5.0	7 8	8 7	11.7	659
6 0	7.7	8.7	11.6	659
7.0	7.7	8.7	11.6	659
8.0	7 7	8 7	11 6	659
9 0	7 6	8 7	11 5	661
10.0	7.2	8.6	11.2	668
11.0	6.4	8.5	9.7	686
12 0	5 5	8 4	8 9	701
13.0	5.4	8.3	8 0	704
14.0	5 1	8 3	8.0	704
15 0	5.0	8.2	7 5	712
16 0	5 0	8 2	7 4	712
17.0	4 9	8.2	7 4	715
18.0	4.8	8.2	7.3	718
19 0	4 8	8 2	7.1	721
20 0	4 8	8 2	7.0	723
22 0	4 6	8 1	6 8	728
24 0	4.5	8.1	6 6	732
26.0	4 4	8.1	6 4	739
28.0	4 3	8 1	6.1	742

30.0	4.1	8.0	5.8	751
35.0	4.0	8.0	5.3	758
40.0	3.9	8.0	5.1	762
41.0	3.8	8.0	4.9	768
42.0	3.8	8.0	4.8	767
43.0	3.8	8.0	4.8	765
44.0	3.8	8.0	4.8	767
45.0	3.8	8.0	4.8	768
46.0	3.8	8.0	4.8	768
46.2	3.8	7.9	4.6	768

EAST CANYON RESERVOIR
04/30/96

0.0	9.2	8.8	12.7	605
1.0	9.1	8.8	12.1	607
2.0	8.8	8.8	11.7	615
3.0	8.4	8.8	11.7	632
4.0	8.3	8.8	11.5	640
6.0	8.1	8.8	11.5	649
7.0	7.8	8.8	11.3	654
8.0	7.6	8.8	11.1	652
10.0	6.2	8.8	10.7	682
11.0	5.3	8.7	9.1	713
12.0	5.0	8.7	8.1	721
13.0	4.6	8.7	7.4	737
15.0	4.5	8.6	6.9	737
16.0	4.4	8.6	6.6	748
17.0	4.3	8.5	6.3	747
21.1	4.2	8.3	5.5	751

EAST CANYON RESERVOIR
04/30/96

0.0	9.2	8.8	12.5	640
1.0	8.8	8.8	12.5	647
2.0	8.4	8.8	12.5	649
3.0	8.3	8.8	12.4	650
5.0	8.1	8.5	12.1	652
6.0	8.0	8.8	11.9	655
7.0	7.7	8.8	11.6	659
9.0	7.1	8.7	11.2	672
10.0	6.8	8.7	10.5	674
11.0	6.3	8.7	9.9	687
13.0	5.8	8.7	7.3	701
14.0	5.5	8.6	8.6	707
15.0	5.4	8.6	8.1	709
17.0	4.6	8.5	7.4	736
19.4	4.3	8.5	6.3	746

EAST CANYON RESERVOIR
04/30/96

0.0	9.2	8.8	12.5	640
1.0	8.8	8.8	12.5	647
2.0	8.4	8.8	12.5	649
3.0	8.3	8.8	12.4	650
5.0	8.1	8.5	12.1	652
6.0	8.0	8.8	11.9	655
7.0	7.7	8.8	11.6	659
9.0	7.1	8.7	11.2	672
10.0	6.8	8.7	10.5	674
11.0	6.3	8.7	9.9	687
13.0	5.8	8.7	7.3	701
147.0	5.5	8.6	8.6	707
15.0	5.4	8.6	8.1	709
17.0	4.6	8.5	7.4	736
19.4	4.3	8.5	6.3	746

EAST CANYON RESERVOIR
06/12/96

0.0	20.2	8.8	9.7	534
1.0	19.3	8.8	9.8	536
2.1	19.0	8.8	9.8	533
3.1	18.5	8.8	9.9	536
4.0	17.9	8.9	10.2	537
5.0	15.2	8.9	10.9	545
6.0	14.5	9.0	11.6	556
7.1	13.7	8.9	10.6	562
7.9	13.0	8.9	10.0	568
9.0	12.4	8.8	8.7	574
10.0	12.0	8.7	7.8	576
11.1	11.5	8.6	7.2	580
12.1	10.7	8.5	6.6	589
13.0	10.5	8.5	6.4	591
14.0	10.2	8.5	6.3	598
15.0	6.5	8.4	5.3	711
16.1	6.4	8.4	5.2	717
17.0	6.5	8.3	5.1	712
18.0	6.2	8.3	5.0	721
19.0	6.1	8.3	4.9	722
20.2	5.8	8.3	4.9	729
21.0	5.8	8.2	4.9	729
22.0	5.6	8.2	4.9	735
23.1	5.5	8.2	4.9	738
24.0	5.5	8.2	4.9	739
24.9	5.3	8.2	4.9	744
25.7	5.0	8.2	4.9	752

EAST CANYON RESERVOIR
06/12/96

0.1	21.2	8.8	9.2	539
1.1	20.4	8.8	9.3	539
2.0	20.0	8.8	9.4	539
1.8	19.8	8.8	9.3	540
4.0	17.3	8.9	12.2	538
5.0	15.2	9.1	13.1	551
6.2	14.0	9.1	12.9	563
7.0	12.8	9.0	11.4	576
8.0	12.3	8.8	8.1	579
9.0	12.0	8.7	7.6	579
10.0	11.6	8.6	7.1	581
11.0	11.3	8.5	6.7	581
12.1	10.9	8.5	6.6	585
13.0	10.6	8.5	6.4	590
14.1	10.3	8.5	6.5	592
15.0	10.1	8.4	6.4	599
16.1	9.6	8.4	6.1	613
17.0	8.2	8.3	5.6	659
17.9	7.2	8.3	5.5	696
19.0	6.4	8.3	5.3	718
20.0	6.1	8.3	5.2	726
21.0	6.1	8.3	5.1	725
22.1	5.9	8.2	5.1	730
23.0	5.8	8.2	5.0	733
24.0	5.7	8.2	5.0	734
25.0	5.6	8.2	4.9	737
26.1	5.5	8.2	4.9	737
26.8	5.5	8.2	4.8	739

EAST CANYON RESERVOIR
06/12/96

0.1	20.5	9.0	10.1	535
1.0	19.5	9.0	10.3	536
1.9	19.3	9.0	10.2	538
3.0	19.2	9.0	10.2	538
4.0	15.7	9.2	12.6	552
5.1	13.7	9.3	12.8	569
6.0	13.0	9.1	10.0	573
7.1	12.3	8.9	8.1	576
8.1	12.1	8.8	7.7	579
9.1	11.7	8.7	7.2	579
10.0	10.4	8.6	6.9	580
11.1	10.5	8.6	6.7	589
12.2	10.4	8.6	6.7	591
13.0	10.2	8.6	6.7	595
14.0	9.7	8.6	6.7	607
15.0	9.1	8.6	6.7	629
16.0	8.7	8.6	6.6	643
17.0	8.4	8.5	6.6	656
18.0	7.8	8.5	6.6	678
19.0	7.1	8.5	6.6	702
20.0	6.6	8.5	6.5	713
21.0	6.2	8.5	6.4	721
21.9	6.3	8.5	6.6	724
23.1	6.0	8.5	6.5	727
24.0	5.9	8.5	6.4	728
25.0	5.8	8.5	6.3	729
26.0	5.7	8.4	6.2	733
27.1	5.6	8.4	6.0	734
28.1	5.5	8.4	6.0	735
29.4	5.4	8.4	6.1	737
29.9	5.3	8.4	6.0	740
32.1	5.2	8.3	5.7	746
34.1	5.0	8.3	5.4	751
36.0	4.8	8.2	5.0	761
38.2	4.6	8.2	4.5	767
40.1	8.2	8.2	4.2	768
42.1	8.2	8.2	4.1	768
43.8	4.6	8.3	4.2	770
46.0	4.5	8.2	4.0	770
48.0	4.4	8.2	4.0	771
49.9	4.4	8.1	3.8	771
51.9	4.4	8.1	3.6	773
52.4	4.4	8.1	3.0	774

EAST CANYON RESERVOIR
06/27/96

0.0	18.4	8.8	8.7	526
1.0	18.4	8.8	8.6	526
2.1	18.3	8.8	8.6	527
2.1	18.3	8.8	8.6	525
3.0	18.2	8.8	8.5	526
4.0	18.2	8.8	8.4	527
5.1	18.1	8.8	8.3	526
6.0	17.7	8.8	8.0	536
7.0	15.6	8.6	7.5	574
8.0	13.4	8.5	5.9	572
9.1	12.1	8.3	5.2	564
10.0	11.1	8.2	4.4	572
11.0	10.4	8.1	4.2	584
11.2	10.5	8.1	4.1	584

EAST CANYON RESERVOIR
06/27/96

0.0	19.1	8.7	8.4	522
1.0	19.1	8.7	8.3	523
2.1	19.1	8.7	8.2	523
3.0	19.0	8.8	8.2	523
4.0	18.9	8.8	8.2	524
5.0	18.7	8.8	8.2	525
6.1	17.8	8.7	8.1	530
7.0	15.5	8.7	8.2	545
8.0	14.2	8.6	8.1	547
8.9	13.4	8.5	7.8	551
10.0	12.5	8.4	7.4	558
11.0	11.9	8.3	5.9	559
12.0	11.1	8.2	4.9	566
13.1	10.4	8.1	4.5	574
14.0	10.0	8.1	4.4	591
15.0	9.5	8.1	4.5	592
16.0	9.3	8.0	4.3	600
17.0	8.5	8.0	4.1	622
18.0	7.5	7.9	4.0	654
19.0	6.8	7.9	3.9	675
20.1	6.6	7.9	3.8	679
21.0	6.4	7.8	3.8	683
22.0	6.3	7.8	3.7	686
23.0	6.2	7.8	3.7	688
23.9	6.1	7.8	3.7	690
25.0	5.8	7.8	3.6	698

EAST CANYON RESERVOIR
06/27/96

0.0	19.3	8.3	8.3	526
1.0	19.3	8.6	8.1	524
2.0	19.3	8.6	8.2	523
3.0	19.2	8.7	8.1	523
4.0	19.2	8.7	8.1	523
5.0	19.0	8.7	8.1	524
5.9	17.7	8.7	8.1	530
7.0	14.5	8.6	8.8	548
7.0	14.3	8.5	8.9	547
8.0	13.2	8.4	7.5	550
9.0	12.7	8.3	7.1	553
10.0	12.4	8.3	6.2	554
11.0	11.9	8.2	5.1	555
13.0	11.0	8.0	4.6	557
14.0	10.0	8.0	4.5	578
15.0	9.4	7.9	4.6	599
16.0	8.8	7.9	4.7	618
17.0	8.2	7.9	4.7	641
18.0	7.6	7.9	4.8	656
19.0	7.2	7.8	4.8	668
20.0	6.8	7.8	4.7	678
21.0	6.5	7.8	4.5	683
22.0	6.3	7.8	4.4	687
23.1	6.2	7.7	4.3	689
24.0	6.2	7.7	4.3	691
25.0	6.0	7.7	4.5	694
26.0	5.7	7.7	4.6	702
27.0	5.5	7.7	4.7	706
28.0	5.3	7.7	4.5	710
29.1	5.3	7.7	4.2	712
30.0	5.2	7.6	3.9	715
31.0	5.1	7.6	3.8	717
32.0	5.0	7.6	3.6	721
33.0	4.9	7.6	3.3	722

34.0	4.9	7.6	3.2	724
35.0	4.8	7.6	3.0	724
36.0	4.8	7.5	2.8	727
37.0	4.8	7.5	2.7	728
38.0	4.7	7.5	2.7	728
39.0	4.7	7.5	2.6	730
40.0	4.7	7.5	2.4	729
41.0	4.7	7.5	2.4	730
42.0	4.7	7.5	2.2	731
43.0	4.7	7.5	2.1	730
44.0	4.7	7.5	2.1	731
45.0	4.7	7.5	2.0	731
46.1	4.7	7.5	1.9	731
48.0	4.6	7.5	1.8	732
51.0	4.6	7.5	1.3	732
52.7	4.6	7.5	0.9	735

EAST CANYON RESERVOIR
07/09/96

0.0	22.6	8.8	7.3	554
1.1	22.4	8.7	7.3	556
2.0	22.1	8.7	7.3	556
3.0	21.9	8.7	7.4	557
4.0	20.7	8.7	7.5	560
5.0	18.9	8.6	7.6	572
6.0	18.1	8.6	7.3	574
7.0	16.1	8.4	7.1	585
8.0	14.4	8.3	6.6	591
10.0	12.6	8.1	5.4	596
11.0	11.9	8.0	4.7	599
12.0	11.1	7.9	4.4	604
13.0	10.8	7.9	4.3	609
14.0	9.9	7.8	4.1	625
17.0	9.6	7.8	4.0	678
19.0	7.3	7.8	3.9	719
23.1	6.4	7.7	3.9	732

EAST CANYON RESERVOIR
07/09/96

0.0	22.0	8.6	7.2	555
1.0	21.9	8.6	7.1	555
2.0	21.9	8.6	6.9	555
3.0	21.8	8.6	7.0	555
4.0	21.8	8.6	6.9	555
5.0	20.0	8.6	6.7	561
6.0	17.2	8.4	6.4	581
7.0	15.9	8.3	6.1	582
8.1	14.7	8.2	5.6	589
9.0	13.7	8.1	5.0	587
10.0	12.1	7.9	3.6	594
11.0	11.4	7.8	3.2	596
12.0	10.7	7.8	3.2	605
13.0	10.3	7.7	3.3	615
14.0	9.5	7.7	3.4	634
15.0	8.8	7.7	3.4	655
16.0	8.1	7.7	3.5	681
17.0	7.7	7.7	3.5	693
18.0	7.2	7.7	3.4	710
19.0	7.0	7.6	3.4	714
20.0	6.8	7.6	3.4	721
21.0	6.7	7.6	3.3	722
22.0	6.5	7.6	3.3	726
23.0	6.4	7.6	3.3	728
24.0	6.2	7.6	3.2	731
25.0	6.2	7.6	3.2	733
26.0	6.1	7.6	3.2	735
27.0	6.0	7.6	3.3	738
28.1	5.9	7.6	3.3	740
29.0	5.8	7.6	3.2	743
29.9	5.7	7.6	3.2	744
31.0	5.7	7.6	3.2	745
32.0	5.7	7.6	3.0	746
33.0	5.7	7.6	3.0	747
34.0	5.6	7.6	3.0	748
35.0	5.5	7.6	2.8	753
36.0	5.3	7.5	2.8	757
37.0	5.2	7.5	2.5	753
38.0	5.2	7.5	2.5	762
39.1	5.0	7.5	2.3	766
41.0	5.0	7.5	2.8	767
42.0	4.9	7.5	2.4	769
42.9	4.8	7.5	1.8	773

EAST CANYON RESERVOIR
08/08/96

0.6	13.9	8.6		651

EAST CANYON RESERVOIR
08/08/96

0.0	20.3	8.5		572
1.0	20.3	8.6		575
1.9	20.3	8.6		577
3.0	20.1	8.6		578
4.0	20.1	8.6		577
5.0	20.1	8.6		577
6.0	19.9	8.6		577
7.0	19.6	8.6		586
7.9	18.2	8.4		603
9.0	17.0	8.2		611
10.0	15.8	8.2		606
11.1	14.2	8.2		605
12.0	12.3	8.2		621
13.0	11.2	8.2		627
14.1	10.0	8.2		645
14.8	9.4	8.1		650
15.9	7.8	8.1		691
17.2	7.2	8.1		705
18.2	7.1	8.0		704
19.1	6.9	8.0		710
20.0	6.6	8.0		716

EAST CANYON RESERVOIR
08/08/96

0.1	20.0	8.6	7.3	574
1.0	19.9	8.7	7.3	575
2.0	19.9	8.7	7.3	576
3.0	19.9	8.7	7.0	574
4.0	19.9	8.7	7.1	574
5.0	19.9	8.7	7.1	575
6.1	19.8	8.7	7.1	575
7.0	19.8	8.7	7.2	575
8.2	19.8	8.7	7.3	575
9.0	19.7	8.6	7.3	575
10.0	15.8	8.2	3.6	611
11.0	13.3	8.2	2.7	604
12.0	10.7	8.4	2.3	620
13.0	9.7	8.3	2.3	640
14.0	8.4	8.3	2.4	669
15.0	8.0	8.2	2.5	682
16.0	7.6	8.2	2.5	692
17.1	7.2	8.2	2.6	702
18.0	7.1	8.2	2.6	706
19.1	6.9	8.1	2.5	709
20.0	6.8	8.2	2.5	711
21.0	6.8	8.1	2.4	714
22.1	6.6	8.1	2.5	712
23.0	6.6	8.1	2.5	713
24.0	6.5	8.1	2.3	716
25.1	6.4	8.0	2.3	719
26.1	6.3	8.0	2.3	721
27.0	6.2	8.0	2.3	724
28.0	6.2	8.0	2.2	724
29.0	6.1	8.0	2.2	728
30.0	6.0	8.0	2.2	729
30.9	5.8	8.0	2.0	735
32.1	5.7	8.0	1.9	738
33.0	5.6	8.0	1.7	741
34.1	5.5	8.0	1.5	741
35.0	5.5	8.0	1.4	745
36.0	5.3	7.9	1.1	749
37.0	5.3	7.9	0.8	750
38.1	5.2	7.9	0.6	751
39.0	5.2	7.9	0.5	752
40.1	5.2	7.9	0.4	753
41.0	5.1	7.9	0.4	756
42.1	5.0	7.9	0.3	760
42.9	5.0	7.9	0.3	760
44.0	5.0	7.9	0.3	760
44.9	5.0	7.9	0.3	761
45.8	5.0	7.9	0.3	762

EAST CANYON RESERVOIR
08/08/96

0.0	20.3	8.5	7.5	572
1.0	20.3			

EAST CANYON RESERVOIR
08/08/96

0.0	20.4	8.7		571
1.2	20.4	8.6		573
2.0	20.2	8.6		574
3.0	20.1	8.6		575
4.1	20.1	8.6		575
5.0	20.1	8.6		576
6.0	20.0	8.6		576
7.1	19.9	8.5		579
8.0	19.8	8.5		578
9.0	19.1	8.3		588
10.0	15.7	8.1		596
11.0	12.0	8.2		608
12.1	10.7	8.4		618
13.0	9.8	8.4		634
14.2	9.0	8.3		649
14.9	8.2	8.3		673
15.5	8.1	8.2		680

EAST CANYON RESERVOIR
08/23/96

0.0	19.7	8.7	7.9	556
1.0	19.6	8.6	7.9	555
2.0	19.5	8.6	7.9	555
3.0	19.5	8.6	7.9	558
4.0	19.4	8.6	7.9	562
5.0	19.4	8.6	7.9	553
6.0	19.4	8.6	7.9	553
7.0	19.3	8.6	7.9	554
8.0	19.3	8.6	7.9	557
9.0	17.2	8.1	2.7	575
10.0	15.5	8.0	1.2	583
11.0	12.1	7.9	0.8	592
12.0	10.2	7.9	1.2	612
13.0	8.4	7.8	1.7	652
14.0	8.0	7.8	1.8	647
15.0	7.5	7.7	1.8	668
16.0	7.2	7.7	1.7	682
17.0	7.0	7.7	1.7	680
18.0	6.8	7.7	1.8	675
19.0	6.7	7.7	1.6	690
20.0	6.6	7.6	1.5	699
21.0	6.6	7.6	1.6	693
22.0	6.5	7.6	1.7	696
23.0	6.5	7.6	1.6	698
24.0	6.4	7.6	1.6	698
25.0	6.2	7.6	1.5	683
30.0	5.8	7.5	1.1	688
35.0	5.3	7.5	0.1	732
40.0	5.0	7.5	0.1	746
45.0	4.9	7.5	0.1	722
47.4	4.8	7.4	0.1	737

EAST CANYON RESERVOIR
08/23/96

0.0	19.9	8.6	7.8	558
1.0	19.9	8.5	7.8	561
2.0	19.7	8.5	7.6	563
3.0	19.5	8.5	7.6	565
4.0	19.5	8.5	7.5	557
5.0	19.5	8.5	7.5	566
6.0	19.4	8.5	7.3	560
7.1	19.3	8.5	7.1	558
8.0	19.2	8.5	6.9	564
9.0	18.9	8.4	5.1	575
10.0	14.6	8.1	1.2	606
10.9	11.8	7.9	0.4	607
12.0	9.9	7.8	0.6	618
13.0	9.2	7.7	0.7	620
14.0	8.5	7.6	0.9	647
15.0	8.2	7.6	0.7	656
17.9	7.3	7.6	3.8	669

EAST CANYON RESERVOIR
08/23/96

0.0	20.0	8.6	8.0	550
1.0	19.9	8.5	8.0	552
2.0	19.8	8.5	7.9	554
3.0	19.5	8.5	7.8	557
3.9	19.5	8.5	7.7	558
5.1	19.4	8.5	7.6	559
6.0	19.4	8.5	7.3	559
7.0	19.1	8.5	6.5	564
8.0	18.5	8.3	4.8	574
9.0	17.1	8.1	3.2	580
10.0	15.5	7.9	1.6	583
11.0	13.1	7.8	0.6	596

12 0	11 5	7 7	0.4	623
12.9	10.2	7.7	0 3	617
14 0	9 2	7 6	0 5	652
15.0	8.8	7 6	0 4	635
20 0	6 7	7.5	0 1	677
22 0	3.4	7 5	0 2	676

EAST CANYON RESERVOIR
08/28/96

0.1	22.0	8 8	8.2	562
1.0	21.8	8.7	7.9	561
2 0	21 6	8.7	8 3	560
3.0	21.5	8 7	8 4	560
3 9	21 3	8.7	8 6	559
5.0	20 0	8 7	8 7	564
5.2	20 0	8 7	8 6	564
6.1	18.5	8 5	8.4	593
7.0	17.3	8 3	7 9	601
8 0	16 0	8 3	7 6	599
9 0	13 9	8 2	7.1	600
10.0	12 5	8 0	6.0	602
11 0	11.6	8.0	5.9	605
12 0	11 1	8.0	5.2	611
13.1	10 4	7 9	4 6	623
14.0	9 5	7.8	4 3	644
15 0	9 0	7.8	4 0	657
16 1	8 0	7 8	3.7	683
17 0	7 6	7 8	3 5	690
18 0	7 2	7 7	3.3	709
23 0	7 1	7 7	3.1	717
27.1	5.9	7.7	2.6	747