UPPER PROVO RIVER WATER QUALITY MANAGEMENT PLAN

FINAL

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I. TABLE OF CONTENTS

I. TABLE OF CONTENTS III

II. LIST OF FIGURES VI

III. LIST OF TABLES VIII

IV. EXECUTIVE SUMMARY 1

V. INTRODUCTION 8

VI. PHOSPHORUS CYCLE 9

VII. PROJECT AREA 10

A. CLIMATE 10

C. SOILS 10

D. DEMOGRAPHICS, LAND USE, AND RECREATION 12

E. HYDROLOGY 13

VIII. WATER QUALITY ISSUES IN HEBER VALLEY 14

A. CURRENT WATER USERS AND ACTIVITIES 14

B. CURRENT CONDITIONS 23

C. BENEFICIAL USE CLASSIFICATIONS 32

D. MONITORING RESULTS 35

E. DIVISION OF WATER QUALITY'S 303D LIST 39

F. BASIN WIDE WATER QUALITY PATTERNS 40

1. Flow, Total Phosphorus and Dissolved Total Phosphorus 40

2. DTP Sources and Consequences 50

3. Deer Creek Reservoir 50

4. Jordanelle and Deer Creek Interdependence 50

5. *Fish Hatcheries* ... *53*

6. *Groundwater* ... *53*

7. *Golf Course Management* ... *53*

IX. TMDL'S FOR PROVO RIVER BASIN ... 54

A. THE TMDL PROCESS ... 54

B. PUBLIC INVOLVEMENT ... 55

C. DEVELOPING TMDL'S FOR THE UPPER PROVO RIVER BASIN ... 55

1. *Contaminant Concentrations* ... *56*

2. *Flow* ... *56*

3. *TMDL Values* ... *59*

X. RECOMMENDATIONS FOR TARGETED SEGMENTS ... 65

A. POTENTIAL REDUCTION IN PHOSPHORUS LOADING ... 65

1. *Provo River above Jordanelle Reservoir* ... *65*

2. *Provo River below Jordanelle Reservoir* ... *65*

3. *Provo River above confluence with Snake Creek* ... *65*

4. *Provo River below Deer Creek Reservoir* ... *66*

5. *Snake Creek above confluence with Provo River* ... *66*

6. *Daniels Creek above Deer Creek Reservoir* ... *66*

7. *Main Creek above Deer Creek Dam* ... *67*

B. POTENTIAL PHOSPHORUS REDUCTIONS TO DEER CREEK RESERVOIR ... 67

C. FUTURE MONITORING ... 67

D. GENERAL RECOMMENDATIONS ... 68

E. OTHER APPLICABLE RECOMMENDATIONS FROM 1984 PLAN ... 69

1. No Municipal Phosphorus Discharge *69*

2. Private Developments *69*

3. Public Developments *70*

4. Amend County Zoning Ordinances *70*

5. Mayflower Tailings *70*

6. Public Education *70*

7. Continued Study and Funding *70*

8. Other Restoration Techniques *71*

XI. BIBLIOGRAPHY 72

II. LIST OF FIGURES

FIGURE 1 SOIL EROSION POTENTIAL. FROM "A GUIDE FOR EROSION AND SEDIMENT CONTROL, WASATCH COUNTY UTAH" (EROSION AND SEDIMENT)........ 12

FIGURE 2 TSS LOADING ALONG THE PROVO RIVER........ 24

FIGURE 3 OVERVIEW OF TSS LOADING DURING 1997........ 25

FIGURE 4 DISSOLVED OXYGEN LEVELS IN JORDANELLE RESERVOIR FOR 1997........ 27

FIGURE 5 JORDANELLE RESERVOIR TSI (1993-1997)........ 28

FIGURE 6 DEER CREEK RESERVOIR BOTTOM DO CONCENTRATIONS FOR 1997........ 29

FIGURE 7 DEER CREEK RESERVOIR TSI AND PROVO RIVER AVERAGE FLOW 1981-1997........ 29

FIGURE 8 FLOW WEIGHTED TOTAL PHOSPHORUS AND DISSOLVED TOTAL PHOSPHORUS CONCENTRATIONS INTO DEER CREEK RESERVOIR PLOTTED AGAINST AVERAGE FLOW INTO DEER CREEK RESERVOIR FOR FIVE YEARS FROM 1991-1995........ 41

FIGURE 9 FLOW WEIGHTED TOTAL PHOSPHORUS AND DISSOLVED TOTAL PHOSPHORUS CONCENTRATIONS INTO DEER CREEK RESERVOIR PLOTTED AGAINST AVERAGE FLOW INTO DEER CREEK RESERVOIR FOR FIVE YEARS FROM 1991-1995. THE IMPACT OF THE SLOW OPERATION ON TP CONCENTRATIONS IS CLEARLY SEEN...... 41

FIGURE 10 TP, DTP AND FLOW COMPARISON IN PROVO RIVER AT WOODLAND; 1991-1996........ 43

FIGURE 11 TP, DTP AND FLOW COMPARISON IN PROVO RIVER AT HAILSTONE; 1991-1996........ 43

FIGURE 12 TP, DTP AND FLOW COMPARISON IN PROVO RIVER AT JORDANELLE DAM; 1991-1996........ 44

FIGURE 13 TP, DTP AND FLOW COMPARISON IN PROVO RIVER AT MIDWAY; 1981-1988, 1991-1996........ 44

FIGURE 14 TP, DTP AND FLOW COMPARISON IN PROVO RIVER AT DEER CREEK DAM; 1991-1996........ 45

FIGURE 15 TP, DTP AND FLOW COMPARISON IN SNAKE CREEK; 1981-1988, 1991-1996........ 45

FIGURE 16 TP, DTP AND FLOW COMPARISON IN DANIELS CREEK; 1991-1996........ 46

FIGURE 17 TP, DTP AND FLOW COMPARISON IN MAIN CREEK; 1991-1996........ 46

FIGURE 18 TOTAL PHOSPHORUS LOADS INTO DEER CREEK RESERVOIR DURING 1995........ 48

FIGURE 19 DISSOLVED TOTAL PHOSPHORUS LOADS INTO DEER CREEK RESERVOIR, 1995. 49

FIGURE 20 TP AND DTP LOADING DURING THE 1995 WATER YEAR AT VARIOUS WATER QUALITY STATIONS ON THE PROVO RIVER. THE TWO RESERVOIRS REDUCED THE LOADING OF TOTAL PHOSPHORUS BUT INCREASED THE LOAD OF DISSOLVED PHOSPHORUS IN THEIR DISCHARGE. 52

FIGURE 21 TP AND DTP LOADING DURING THE 1996 WATER YEAR AT VARIOUS WATER QUALITY STATIONS ON THE PROVO RIVER. THE INCREASE IN DTP LOADS WAS LIMITED BELOW JORDANELLE RESERVOIR. THIS IS THOUGHT TO BE A RESULT OF THE OPERATION OF THE SLOW. 52

FIGURE 22 SUB WATERSHED BOUNDARIES AND TERMINUS LOCATIONS. 57

FIGURE 23 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS AT THE PROVO RIVER AT WOODLAND SITE. 61

FIGURE 24 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS AT THE PROVO RIVER BELOW AT HAILSTONE SITE. 61

FIGURE 25 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS AT THE PROVO RIVER BELOW JORDANELLE DAM SITE. 62

FIGURE 26 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS AT THE PROVO RIVER AT CHARLESTON SITE. 62

FIGURE 27 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS AT THE PROVO RIVER BELOW DEER CREEK DAM SITE. 63

FIGURE 28 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS IN SNAKE CREEK. 63

FIGURE 29 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS IN DANIELS CREEK.. 64

FIGURE 30 MONTHLY TOTAL PHOSPHORUS LOADS AND 1996 TOTAL PHOSPHORUS LOADS IN MAIN CREEK....... 64

III. LIST OF TABLES

TABLE 1 MONTHLY TOTAL PHOSPHORUS TMDL LOADS (KG/YR) FOR EACH STREAM SEGMENT IN THE UPPER PROVO RIVER BASIN. 1

TABLE 2 TP TMDL LOAD AND TP LOADS FOR STREAM SEGMENTS IN THE UPPER PROVO RIVER BASIN. 2

TABLE 3 POTENTIAL REDUCTIONS IN DEER CREEK LOADINGS 2

TABLE 4 SUMMARY OF TMDL REQUIRED CRITERIA CHECKLIST 3

TABLE 5 AVERAGE TP LOAD, TSI, FLOW, TP CONCENTRATION AND DTP CONCENTRATION INTO DEER CREEK RESERVOIR FOR FOUR FIVE YEAR SEGMENTS. 4

TABLE 6 HISTORICAL DATA OF PHOSPHORUS AND TSS LOADINGS 26

TABLE 7 BENEFICIAL USE WATER QUALITY CRITERIA FOR WATERS IN WASATCH COUNTY. 33

TABLE 8 BENEFICIAL USE WATER QUALITY CRITERIA FOR WATERS IN WASATCH COUNTY. 34

TABLE 9 JTAC MONITORING PLAN FOR FISCAL YEAR 1997-1998 36

TABLE 10 JTAC MONITORING PLAN FOR FISCAL YEAR 1998-1999 37

TABLE 11 EXCEEDANCE REPORT FOR THE PERIOD JANUARY 1, 1990 TO NOVEMBER 1, 1995 38

TABLE 12 STREAM SEGMENTS FOR WHICH MANAGEMENT STRATEGIES WILL BE DEVELOPED. 39

TABLE 13 STREAM SEGMENTS LISTED ON THE DWQ'S 303D LIST. 39

TABLE 14 AVERAGE TP LOAD, TSI, FLOW, TP CONCENTRATION AND DTP CONCENTRATION INTO DEER CREEK RESERVOIR FOR FOUR FIVE YEAR SEGMENTS. 50

TABLE 15 SUB WATERSHED NAMES AND TERMINUS LOCATIONS. 56

TABLE 16 SUMMARY OF FLOW STATISTICS FOR SUB WATERSHED STREAM SEGMENTS. 58

TABLE 17 TP TMDL LOAD AND 1995 TP LOADS FOR STREAM SEGMENTS IN THE UPPER PROVO RIVER BASIN. 59

TABLE 18 MONTHLY TOTAL PHOSPHORUS TMDL LOADS (KG/YR) FOR EACH STREAM SEGMENT IN THE UPPER PROVO RIVER BASIN. 59

TABLE 19 SUMMARY OF TMDL REQUIRED CRITERIA CHECKLIST 60

TABLE 20 ANTICIPATED REDUCTIONS IN TOTAL PHOSPHORUS DUE TO VARIOUS MANAGEMENT TECHNIQUES. 67

IV. EXECUTIVE SUMMARY

Most are aware of the vital role water plays in the development of the West where productivity and economy is largely tied to maintaining access to abundant high quality sources of water. One of Utah's best water resources, the Provo River, provides water for use by over a million Utahns for purposes such as drinking water, agricultural, industrial, and recreational uses, and many other uses. At the same time, the Provo River supports a delicate ecosystem of important species of wildlife.

Along the Provo River, Deer Creek and Jordanelle Reservoirs have helped make this water available for public and private use. These reservoirs are vital to the surrounding communities that depend on the Provo River as a resource. One of the challenges facing the reservoirs is the control of eutrophication, a natural process that occurs in lakes and reservoirs when an abundance of nutrients spurs algal growth. Excessive algal growth, unfortunately, can seriously deteriorate water quality causing taste and odor problems and increasing the costs of treatment. Therefore, the predominant water quality problem in the Upper Provo River Basin continues to be high Total phosphorus (TP) loads and concentrations, the limiting nutrient for algae. This was identified in the 1984 Water Quality Management Plan. A number of recommendations were made in that report which were designed to help improve the water quality of Deer Creek Reservoir and to protect the water quality of the then proposed and now operational Jordanelle Reservoir. Many of these recommendations have been implemented and great efforts have been made to achieve the goals expressed in this 1984 plan. However, still some of the loads and concentrations of TP entering the reservoir still remain above the pollution indicator concentrations identified in the 1984 plan.

In response to this disparity, a review of the management plan was commissioned. This, along with the EPA requirement of the calculation of Total Maximum Daily Load (TMDL) values for the stream segments in the Upper Provo River Basin, prompted the compilation of this report. The TMDLs for TP were calculated for five stream segments on the Provo River as well as three other stream segments on Snake Creek, Daniels Creek and Main Creek. Also, a TMDL was calculated for one point source, the Kamas Fish Hatchery.

The monthly TMDLs of TP (kg) that were calculated are shown in Table 1.

Table 1 Monthly Total Phosphorus TMDL loads (kg/yr) for each stream segment in the Upper Provo River Basin.

WATERSHED NAME	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Provo @ Woodland	220	192	184	178	163	218	570	2337	2277	743	359	241
Kamas Fish Hatchery	12.9	11.7	13.6	11.0	14.1	14.1	14.9	18.4	17.7	17.8	14.4	12.2
Provo @ Hailstone	257	277	275	263	260	344	903	3085	2847	783	308	234
Provo @ Jordanelle	303	294	303	303	284	303	524	2478	2099	1020	434	340
Provo @ Charleston	334	375	387	377	386	556	912	2143	1869	433	334	323
Provo @ Deer Creek	630	546	686	619	596	738	952	1815	2437	1513	1260	997
Snake Creek	155	150	142	134	126	151	144	168	180	142	127	127
Daniels Creek	18	11	11	11	11	14	39	186	107	31	30	20
Main Creek	47	47	54	55	95	123	210	156	51	25	24	30

The sum of these monthly TMDLs yields the yearly TMDLs, which are shown in the Table 2 with the six-year (1991-1996) flow weighted average (FWA) of TP loads.

Table 2 TP TMDL load and TP loads for stream segments in the Upper Provo River Basin.

Watershed Name	Sum of Monthly TMDL's TP - kg/yr	Six Year FWA TP Load - kg/yr
Provo @ Woodland	7,681	3,644
Kamas Fish Hatchery	173	322
Provo @ Hailstone	9,837	9,601
Provo @ Jordanelle	8,685	4,786
Provo @ Charleston	8,428	9,830
Provo @ Deer Creek	12,788	8,796
Snake Creek	1,747	1,828
Daniels Creek	488	1,753
Main Creek	916	1,431

Table 2 demonstrates that TP reductions are most needed in Main Creek, Daniels Creek and Snake Creek. Some of these reductions can be accomplished by ongoing projects outlined in Table 3 below.

Table 3 Potential Reductions in Deer Creek Loadings

Management Strategy	Responsibility	Potential Reduction
Additional Reductions with Operation of SLOW Tower at Jordanelle Reservoir	CUWCD & USBR	2,800 kg/yr
Water Efficiency and Daniel Replacement Projects	CUWCD	100 kg/yr
Provo River Restoration Project	URMCC	100 kg/yr
Tri-Valley Watershed Improvements	NRCS	300 kg/yr
Stormwater Management	Wasatch County	448 kg/yr
Total Potential Reductions		3,748 kg/yr

TMDLs are subject to eight required criteria given by the EPA. Table 4, as follows, outlines these requirements and discusses how each criterion is addressed in this plan.

Table 4 Summary of TMDL Required Criteria Checklist

Requirement	Comment
• TMDLs result in maintaining and attaining water quality standards	Since the CUWCDs Deer Creek Model validated the 0.04 mg/l TP as a good goal to improve water quality in Deer Creek. This concentration was incorporated into the TMDL calculations, meaning that reaching TMDL goals, in essence, should correspond with meeting the 0.04 mg/l goal as well.
• TMDLs have a quantified target or endpoint	Several endpoints could be used to determine our target. For this watershed a target has already been established by JTAC for the in-stream concentration of TP of 0.04 mg/l. This target is also tied into the calculation of the TMDLs, which act as a target in of itself. The TMDLs individually serve as a quantifying target load for each stream segment. Another basin-wide target has come from earlier reports on the watershed, which set the goal of 12,000 kg/year of TP discharge into Deer Creek Reservoir.
• TMDLs include a quantified pollutant reduction target, but this target can be expressed in any appropriate manner	This plan has set the TMDLs in terms of a mass loading per month; from which, a mass loading per year for each stream is also derived. The value of each TMDL indicates the level of reduction needed for each stream segment. Also, certain projects within the basin should reduce TP loading to Deer Creek Reservoir as described in Table 3.
• TMDLs must consider all significant sources of the stressor of concern	The analysis of data in this plan has identified the possible sources of phosphorus and the recommended actions have been given to control them.
• TMDLs are supported by an appropriate level of technical analysis	To determine the TMDLs, an analysis of phosphorus data and stream flows has been the major technique used to determine appropriate targets.
• TMDLs must contain a margin of safety and consider seasonality	A margin of safety of 20% has been incorporated into the TMDLs, mostly due to the difference between the state standard for TP concentration of 0.05 mg/l and the JTAC standard of 0.04 mg/l. The TMDLs are set as monthly loads which incorporates the seasonality of stream flows and phosphorus concentrations.
• TMDLs apportion responsibility for taking actions	This plan makes several recommendations that are likely to improve water quality conditions. Also, the plan identifies several phosphorus control actions and estimates the reduction of loading anticipated from these actions. In Table 3, certain reductions with parties responsible for reduction are outlined.
• TMDLs involve some level of public involvement or review	Since JTAC is comprised of several federal, state, local, and private entities, discussions within JTAC has helped facilitate public involvement and review. Also this plan has been reviewed and comments have been addressed by several agencies.

In addition to the TMDL determinations, this plan has reviewed of the condition of water quality in the Upper Provo River Basin and a number of observations have been made:

1. It appears that the measures taken to reduce the TP loads entering Deer Creek Reservoir are working. The average yearly TP loads have decreased from over 32,000 kg/yr during 1980-1984 to just over 19,000 kg/yr in 1995-1996. Over the same time frame, the Carlson Trophic State Index, a measure of the nutrient state of the lake, indicates a general trend from eutrophic to mesotrophic. It should be noted that average yearly flows into the reservoir have also decreased during this time period and the TP loadings and concentrations are significantly influenced by the amount of water that runs off the watershed in any particular year. The following table illustrates these reductions:

Table 5 Average TP Load, TSI, Flow, TP concentration and DTP Concentration into Deer Creek Reservoir for four five year segments.

Period	Average TP Load (kg/yr)	Trophic State Index	Average Annual Flow (cfs)	Average FWA TP Conc. (mg/l)	Average FWA DTP Conc. (mg/l)
1980-1984	32,817	53.99	335.5		
1985-1989	24,861	48.59	254.4	0.069	
1990-1994	19,628	44.86	191.8	0.065	0.0248
1995-1996	19,172	40.05	212.0	0.059	0.0255

The four-year grouping interval was selected to correlate the four years of unusually wet weather in the 1980's into one group.

2. Calculations show that the total phosphorus (TP) concentration is directly related to the amount of water flowing in the basin during a given water year. In fact, during the past five years, the TP concentration has varied almost directly with the flow. Conversely, the concentration of dissolved total phosphorus (DTP) appears to be independent of flow. These observations suggests that the majority of the total phosphorus coming into Deer Creek Reservoir is attached to the suspended solids that are washed off the land from overland flow due to stormwater and spring runoff. A look at the last six years of TP loading data shows that on average over 60% of the TP load enters Deer Creek Reservoir during the spring runoff season.
3. 1996 marked the first year that the Selective Level Outlet Works (SLOW) at Jordanelle Dam was operational. The first indications are that the SLOW was successful in reducing the TP and DTP loads being released from Jordanelle Reservoir. However, Jordanelle Reservoir continues to undergo changes in the limnological behavior of the water. It will take some time to accurately determine the response of the lake. These early results are encouraging and it is recommended that the SLOW operation should continue to be monitored and analyzed.
4. Deer Creek Reservoir continues to release a considerable amount of phosphorus into the Lower Provo River. This can be attributed to the fact that anoxic conditions help create a high DTP concentration at the bottom of the reservoir where the outlet for the dam is also located. The water being released from the reservoir therefore has a high concentration of phosphorus.

Because of these observations, a number of recommendations are made in this report:

1. The operation of the SLOW tower should be continued in accordance with the forthcoming SLOW operational plan. This will help to limit the amount of phosphorus, in dissolved and total form, from reaching Deer Creek Reservoir.
2. Programs that help to reduce erosion from the tributaries should be continued. This would include implementation of best management practices and erosion control efforts recommended in the Tri-valley report.

3. Policies should be developed and implemented which will limit pollutants from new developments. This will include construction runoff as well as storm runoff from the finished facilities.
4. JTAC should continue to monitor the effectiveness of the indicators we are currently using to assess the value of the water quality control programs that are currently in place.
5. A stormwater master plan for the Heber Valley should be developed. On average over 60% of the TP load entering Deer Creek Reservoir enters during the three months of the spring runoff and the majority of that load is attached to the suspended solids. This suggests that a series of strategically located stormwater detention basins could reduce the amount of total phosphorus entering the reservoir from tributary streams by about 25%. These settling basins could be located at the termini of the canals and ditches and would catch the runoff and prevent the suspended solids from reaching the tributary streams.
6. Another area which should be looked at more closely is the influence groundwater quality has on the reservoir. Ever year it is estimated that almost 15% of the phosphorus load entering Deer Creek Reservoir comes from the groundwater. However, this is a guess at best. The phosphorus concentration and volume of water entering the reservoir should be calculated. A series of monitoring wells should be established and a regular sampling schedule developed in order to more accurately assess the impact the groundwater has on the reservoir water quality.

In addition to these recommendations, the original water quality management plan that was prepared in 1984 by Sowby and Berg listed several recommended actions to reduce phosphorus loading. Many of these recommendations have already been implemented and therefore no longer apply to the watershed. The recommendations that still apply to the watershed have been included in this management plan to reinforce these important issues that have either not yet been addressed or only partially been addressed. They are as follows:

1. No Municipal Phosphorus Discharge

Require no-discharge, total containment or land application for all new future sewerage systems containing municipal wastes or domestic sewage effluents containing phosphorus for the entire Provo River drainage above Deer Creek Reservoir. This is now the case in the entire watershed with the construction of the Heber Valley Special Service District land application facility.

2. Private Developments

Require that any new private development be subject to regulations for control of runoff, pollutant control, and plan review similar to that required of Deer Valley and Mayflower Mountain Resorts. This means proper monitoring, feasibility studies, engineering evaluations, and signed agreements for compliance prior to construction.

3. Public Developments

Implement a process whereby any public development, be it state, federal or local, including recreational developments or facilities built around Deer Creek Reservoir or the proposed Jordanelle Reservoir, comply with the same requirements as for private developments. Also, continue the review process by State County Health Departments whereby proper sanitation facilities are constructed.

4. Amend County Zoning Ordinances

Require that zoning ordinances of Wasatch and Summit County be amended to prohibit runoff or discharges from animal concentration from entering any live stream or waterway that reaches Deer Creek Reservoir or the proposed Jordanelle Reservoir. A time limit should also be established for the elimination of all nonconforming uses to this amendment.

5. Mayflower Tailings

Upon construction of the Mayflower Mountain Resort, require the developers to include stabilization of the Mayflower tailings ponds in their plans. This should include preventing runoff or seepage of water from other polluted mines or mine dumps where water issues from the mine and runs over or through said dumps.

6. Public Education

Mount a public education campaign in cooperation with the Utah State Department of Agriculture, Soil Conservation Service, Soil Conservation Districts, etc. to control over-application of water and consequent runoff from farm lands, grazing lands, winter feeding operations, and pastures. This could mean encouraging sprinkler irrigation and implementing various practices to reduce the runoff from pasture and winter feeding operations. Also, the appropriate agency should be involved in assisting the farmers and ranchers with their plans for implementing BMPs in order to be eligible for certain types of federal assistance.

7. Continued Study and Funding

Continue the work and funding of the Deer Creek/Jordanelle Technical Team. There is need for continued effort in coordinating and reviewing plans of all agencies concerned with water quality monitoring, improvement, or enforcement. One additional task could be to conduct an aggressive educational campaign program on the need to reduce pollution in these streams and reservoirs. Funding for this effort should be supported by the following groups: Salt Lake City Metropolitan Water District, Central Utah Water Conservancy District, U. S. Bureau of Reclamation, State Department of Health, U. S. Environmental Protection Agency, and others.

8. Other Restoration Techniques

Continue to consider other restoration techniques or phosphorus reduction programs. There may be others that may have not yet proven cost-effective, been demonstrated as needed or conceived. There may still be other reductions achievable with little or no effort.

V. INTRODUCTION

The Water Quality Management Plan presented here has been produced in an effort to identify water quality problems in the Upper Provo River Basin and make recommendations to control and manage these problems. Specifically this document develops Total Maximum Daily Loads (TMDL) for various segments of the Provo River. These TMDL's form a baseline for continuing efforts by Wasatch County and the Jordanelle Technical Advisory Committee (JTAC) in meeting State water quality standards and "target" pollution indicator concentrations. Management plans for complying with the TMDL's and the State water quality standards are also presented. This document is not meant to replace water quality efforts currently in process but to supplement them.

The "Deer Creek Reservoir and Proposed Jordanelle Reservoir Water Quality Management Plan" (Sowby and Berg, 1984) was written in 1984 as a result of the environmental assessment for the then proposed Jordanelle Reservoir. The goal of the plan was to limit the amount of total phosphorus (TP) entering Deer Creek Reservoir. Specific goals included a reduction of 11,000 kg/yr of TP in the inflow to Deer Creek. Many of the suggestions developed in that plan have been adopted and the implementation reports written since the original plan documented an improvement in the water quality of Deer Creek Reservoir and its tributaries. The result is that the average annual TP load into Deer Creek Reservoir has been reduced from over 30,000 kg/yr in the early 1980's to approximately 20,000 kg/yr currently. However, there are still a few areas upstream of Deer Creek Reservoir, which consistently exhibit high TP concentrations. This document will detail additional activities, which will help protect the water quality in the watershed.

VI. PHOSPHORUS CYCLE

(Taken from WATERSHEDSS, North Carolina State University, http://h2osparc.wq.ncsu.edu/info/phos.html)

Phosphorus in freshwater and marine systems exists in either a particulate phase or a dissolved phase. Particulate matter includes living and dead plankton, precipitates of phosphorus, phosphorus adsorbed to particulates, and amorphous phosphorus. The dissolved phase includes inorganic phosphorus (generally in the soluble orthophosphate form), organic phosphorus excreted by organisms, and macromolecular colloidal phosphorus.

The organic and inorganic particulate and soluble forms of phosphorus undergo continuous transformations. The dissolved phosphorus (usually as orthophosphate) is assimilated by phytoplankton and altered to organic phosphorus. The phytoplankton are then ingested by detritivores or zooplankton. Over half of the organic phosphorus taken up by zooplankton is excreted as inorganic P. Continuing the cycle, the inorganic P is rapidly assimilated by phytoplankton (Smith, 1990; Holtan et al., 1988).

Lakes and reservoir sediments serve as phosphorus sinks. Phosphorus-containing particles settle to the substrate and are rapidly covered by sediment. Continuous accumulation of sediment will leave some phosphorus too deep within the substrate to be reintroduced to the water column. Thus, some phosphorus is removed permanently from biocirculation (Smith, 1990; Holtan et al., 1988).

A portion of the phosphorus in the substrate may be reintroduced to the water column. Phosphorus stored in the uppermost layers of the bottom sediments of lakes and reservoirs is subject to bioturbation by benthic invertebrates and chemical transformations by water chemistry changes. For example, the reducing conditions of a hypolimnion often experienced during the summer months may stimulate the release of phosphorus from the benthos. Recycling of phosphorus often stimulates blooms of phytoplankton. Because of this phenomenon, a reduction in phosphorus loading may not be effective in reducing algal blooms for a number of years (Maki et al., 1983).

The EPA water quality criteria state that phosphates should not exceed .05 mg/l if streams discharge into lakes or reservoirs, .025 mg/l within a lake or reservoir, and .1 mg/l in streams or flowing waters not discharging into lakes or reservoirs to control algal growth (USEPA, 1986). Surface waters that are maintained at .01 to .03 mg/l of total phosphorus tend to remain uncontaminated by algal blooms.

Land use and various activities within the watershed will have an effect on the water quality in the streams, rivers and reservoirs. In section VII, Water Quality Issues, current events and activities in the Provo River Watershed that are considered to potentially have an impact on water quality are briefly discussed.

VII. PROJECT AREA

A. Climate

The climate for the Provo River Basin varies from its headwaters in the Uintah Mountains to the Heber Valley. The average annual rainfall for the area is from 16 inches in Heber to 22 inches in the Uintah Mountains. However, most of the precipitation at the headwaters falls as snow. The peak runoff at higher elevations generally occurs in May as the snow melts. Average temperatures range from 29°C in the summer to 1°C in the winter. The frost-free period is from 27 to 129 days in Heber with an average frost-free period of 90 days.

B. Geology and Geomorphology

The Upper Provo Watershed includes part of the east side of the Central Wasatch Mountains and part of the western end of the Uintah Mountains. Elevations range from 5,400 feet at Deer Creek Reservoir to slightly over 10,000 feet on some of the watershed boundaries. The transitional area between the two mountain ranges includes the West Hills and the Rhodes Plateau, both of which formed from Tertiary volcanic activity.

Rocks in the Upper Provo Watershed range in age from Precambrian to Quaternary. To the south, in Main Creek and Daniel's Creek sub-watersheds, the rocks are mainly Pennsylvanian and Permian-aged limestones, sandstones, and quartzites of the Oquirrh Formation. These underlie and surround Quaternary-aged unconsolidated valley-fill deposits of Round Valley.

To the west and northwest, in Wasatch Mountain State Park, sedimentary and metasedimentary rocks of Precambrian through Triassic age occur, with the Weber Sandstone, Round Valley Limestone, and Park City Formation Predominant. Rocks in this area have been folded and faulted by the emplacement of several intrusive igneous stocks of Tertiary monzonite. The West Hills and Rhodes Plateau, which include the area extending from Jordanelle Reservoir to Lake Creek watershed in the southeast, are underlain by the Oligocene Keetley volcanics, primarily andesitic in composition. These cover the westward-dipping sedimentary beds of the western nose of the Uintah Mountains anticline. Pleistocene glacial tills cover the volcanic Uintah Mountains anticline. Pleistocene glacial tills cover the volcanic rocks in large parts of the Lake Creek watershed, and some areas mapped as landslide deposits in Lake Creek are probably glacial moraines.

Kamas Valley and Heber Valley contain unconsolidated Quaternary valley-fill deposits ranging from less than 100 feet to as much as 375 feet deep. They include fluvial deposits from the Provo River, alluvial-fan and debri-fan deposits along the valley walls, and gravel terraces near Kamas, possibly from glacial outwash. Near Midway, tufa deposits (from thermal springs) up to 100 feet thick interfinger with the valley-fill deposits and crop out as isolated circular hills on the landscape.

In the vast majority of the Upper Provo Watershed, bedrock is not exposed at the surface but is covered by either residuum from bedrock weathered in place, slope-wash (colluvial) deposits, or glacial deposits (tri-valley).

C. Soils

In general, soils in the Upper Provo Watershed is characterized by loamy textures. Soils in the high mountains (above 6800 feet) on the east, south, and west sides of the watershed are loams, gravelly loams, or cobbly loams derived from residuum, colluvium, or glacial till, and extend to a depth of five feet or more. They contain an average of 48 percent fines (silt plus clay), 39 percent sand, and 13 percent gravel in the surface horizon, usually the uppermost one and one half to five feet.

Soils on mountain slopes at lower elevations and on the plateau areas are clay loams, silt loams, sandy loams, or cobbly loams derived from sedimentary or volcanic rocks. They are one and one half to five feet deep and contain an average of 58 percent fines, 31 percent sand, and 11 percent gravel in the surface horizon.

The foothills and alluvial fans bordering the three main valleys are mainly cobbly loams, silt loams, or clay loams formed in residuum and alluvium from sedimentary rocks. They are generally greater than five feet deep and contain an average of 63 percent fines, 30 percent sand, and 7 percent gravel in the surface horizon.

Soils on stream terraces and in the valley bottoms are comprised of loams or gravelly loams to a depth of about three feet overlying sands or gravels. The surface horizons of these soils contain an average of 59 percent fines, 26 percent sand and 15 percent gravel.

The fine-grained texture of most of these soils means that a significant percentage of the material eroded from upland areas will ultimately become part of the sediment yield to the Provo River and the reservoirs. Most of the fine silt and clay derived from these loams will be delivered over time as suspended sediment in streamflow, and much of the sand will be carried in the bedload (tri-valley).

The erosion potential of soils in Heber Valley was computed for use in the erosion and sediment control manual for Wasatch County (Erosion and Sediment). The erosion potential is a combination of the erodibility of the soils, the slope of the terrain, the proximity to perennial and intermittent streams and the potential rainfall. A map of the soil erosion potential in Heber Valley is shown in Figure 1.

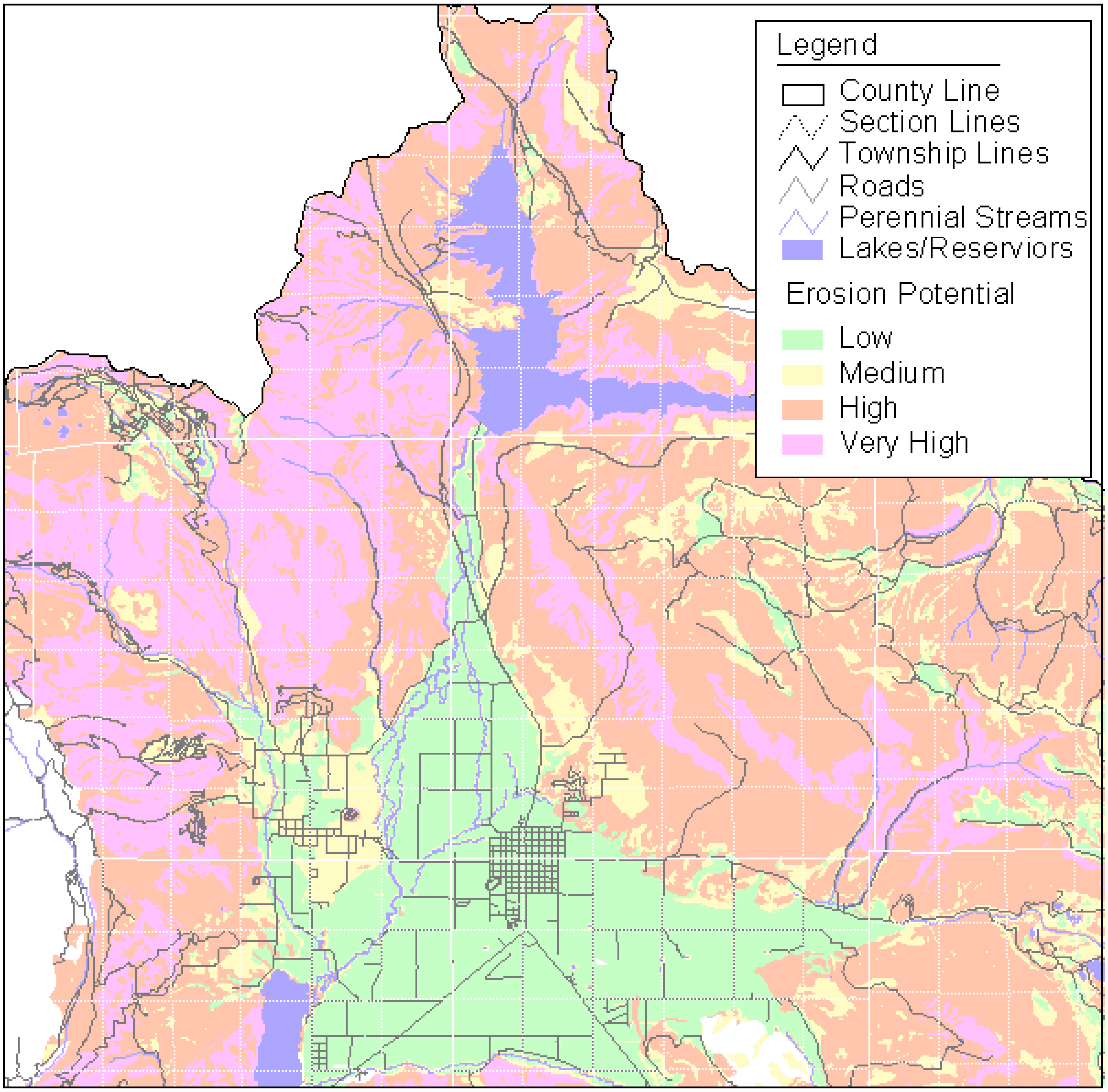

Figure 1 Soil Erosion Potential. From "A Guide for Erosion and Sediment Control, Wasatch County Utah" (Erosion and Sediment).

D. Demographics, Land Use, and Recreation

The Upper Provo River Basin is undergoing massive demographic changes as more people move into the area. The historically agricultural areas are rapidly turning into urban areas. The population of Heber was 4,782 in 1990 and is projected to be 5,991 by the year 2000. By the year 2010 the population is expected to be 6,888. However, these estimates do not reflect recent forces that are accelerating growth in the area such as the 2002 Olympics. With these factors added, the population growth is only expected to increase.

The federal government administers about 40 percent of the 324,600 acres of total land area in the Utah Lake Basin in Wasatch County. Federally administered land is under the jurisdiction of five agencies, the Forest Service, Bureau of Land Management, National Park

Service, U.S. Army and the Bureau of Reclamation. Private and State ownership of land in Wasatch County is approximately 158,100 acres and 35,100, respectively.

The largest recreational attraction in the area is the Wasatch Mountain State Park near Midway. The park has a number of campgrounds for overnight use but the primary attraction is its golf course. In the winter the park also attracts a number of snowmobilers. The total number of visitors to the park during 1995 was over 700,000.

Outside of the Heber Valley most of the human impact is due to recreation. The two large reservoirs in the basin draw the largest number of visitors to the area, but other sites draw visitors as well. In its inaugural year, Jordanelle Reservoir drew over 130,000 visitors. Deer Creek reservoir had over 290,000 visitors in 1995. In the upper areas of the Provo River, the land is regulated by the Wasatch-Cache National Forest. Data is not available for the number of people using the campgrounds in this area.

E. Hydrology

The Provo River Basin above Deer Creek Reservoir has been divided into nine hydrologic sub-basins. These sub-basins correspond to locations where water quality and water quantity data have been collected. Snow melt provides most of the runoff for these sub-basins and is the main hydrologic factor. Because of this, the spring runoff is one of the predominant factors in determining the water quality for the Provo River.

The Hydrology of the Provo River is significantly altered by the presence of two large water storage reservoirs. The recently completed Jordanelle Reservoir lies just north of Heber Valley. The reservoir started filling in 1989 and making initial deliveries in 1994. The operational capacity of the Jordanelle Reservoir is over 300,000 acre-feet of water. Deer Creek Reservoir lies just below the Heber Valley and has been in operation since the early 1950's. This reservoir holds 150,000 acre-feet of water.

As the water flows into the Heber Valley there are many diversions for irrigation. Almost 55,000 acre-feet of the water is diverted from the Provo for agricultural use each year. Water is also diverted from Daniels Creek, Snake Creek and Lake Creek.

In addition to the natural runoff of the Provo River basin, there are two transbasin diversions which import water into the basin above Jordanelle Reservoir. Water is diverted from the Weber River approximately three quarters of a mile east of Oakley and conveyed to a discharge point on the Provo River approximately four and one half miles northwest of Woodland. For the period 1961 through 1990, historical annual diversions near Oakley have averaged about 38,000 acre-feet and historical discharges to the Provo River from 1941 to 1990 have averaged about 35,000 acre-feet. More than 90 percent of the annual diversions occur during the period of April through July (Water Efficiency Study).

The second transbasin diversion diverts water from the Duchesne River into the Provo River, approximately 14 miles upstream of Woodland. Historical diversions for the period 1954 through 1984 have averaged about 23,900 acre-feet per year (Water Efficiency Study).

VIII. Water Quality Issues in Heber Valley

A. Current Water Users and Activities

Municipal

The Provo River is a major source of public drinking water for the growing areas in Salt Lake, Utah, Wasatch and Summit Counties. The Central Utah Water Conservancy District (CUWCD), the Salt Lake County Water Conservancy District (SLCWCD), the Metropolitan Water District of Salt Lake City (MWDSLC), Metropolitan Water District of Orem City (MWDO), and the Metropolitan Water District of Provo City (MWDP) all divert water into water treatment facilities from some point along the Provo River for culinary use. The preservation of good water quality is important to reduce the costs of expensive water treatment and improve the overall drinking water quality.

Agricultural

The Provo River is also a source of irrigation water for agricultural purposes. In Heber Valley, there are fourteen irrigation companies that have water rights to the Provo River. The Provo River Water Users Association (PRWUA) and several irrigation companies in Utah and Salt Lake Valleys also have water rights to much of the water contained in Deer Creek Reservoir.

Recreation and Fisheries

Jordanelle and Deer Creek Reservoirs along with the Provo River and its tributaries are a source of recreation for many. State Parks are located on Jordanelle and Deer Creek Reservoirs to provide basic services for the recreationists that visit. The reservoirs provide water skiing, swimming, boating, fishing and more. Jordanelle opened its waters to fishing in 1995. Deer Creek and Jordanelle Reservoirs along with the Provo River and its tributaries provide excellent fisheries for anglers.

JTAC "Keep Your Water Clean" Logo

A public information subcommittee of JTAC has developed a logo to convey the message that Deer Creek and Jordanelle Reservoirs are primarily storage reservoirs for drinking water. Additionally these reservoirs provide scenic and recreation opportunities and should therefore be protected from unnecessary pollution.

To distribute the logo and the concept to the public, litter bags and signs were distributed to the State Parks at both reservoirs. The litter bags were to be distributed at the entrances and the signs were to be posted around the parks. The costs of printing were distributed among eight state and local agencies, which contributed over

$20,000 of cash and in-kind support to this project. The bags and signs were delivered for the 1998 recreation season.

In addition, the State Division of Wildlife Resources published the logo with some explanation in the 1998 Fishing Proclamation and in the winter 1998 Wildlife Review. The State Division of Parks & Recreation printed the logo and explanation in the spring 1998 Discover. These efforts represent over $10,000 of in-kind contribution to the public education project from the Department of Natural Resources.

Currently, this public information campaign is being assessed and will be reevaluated by JTAC for 1999.

Tri-Valley Watershed Project

The Natural Resources Conservation Service (NRCS), through the United States Department of Agriculture's Small Watershed Program (PL-566), is assisting Wasatch Soil Conservation District and Wasatch County in planning a land treatment watershed. The plan addresses natural resource problems and opportunities within the 248,000 acre watershed.

Purposes of the Tri-Valley Watershed are water conservation, improved fish and wildlife habitat, and water quality. The on-farm irrigation systems will fulfill the purpose of water conservation and improved fish and wildlife habitat. The on-farm systems will receive a priority because conserved water will be used to enhance in-stream flows to benefit fish habitat. Some water quality improvements may also result from decreased surface runoff and decreased deep percolation.

The Tri-Valley Watershed Project received $500,000 federal cost-share funds from the Environmental Quality Improvement Program (EQIP) during 1998. These funds will be used to pay up to 65% of the cost of installing on-farm sprinkler systems, with a maximum cost-share grant not to exceed $500.00 per acre. Contracts were signed with 63 participants to use this money.

This year there is $500,000 of watershed cost-share funds and $250,000 of EQIP funds available for the on-farm sprinkler projects. NRCS calculates that these funds will almost complete the on-farm sprinkler conversion project.

In order to participate with the cost-share program, a Resource Management Plan must be developed by the participants. NRCS will assist with this plan by holding planning seminars. There is a seminar scheduled for February and June. Those interested in attending must pre-register with NRCS two days before the seminar.

Water Efficiency Project

Design of the Wasatch County Water Efficiency Project has been completed and Central Utah Water Conservancy District (CUWCD) advertised for construction bids. The project was awarded to Barnard Construction Company, Inc and received a Notice to Proceed on October 8, 1998. To date, the following work has been completed: the land acquisitions, some of the canal rehabilitation along Timpanogos Canal, excavation for the Timpanogos Regulating Pond, and began placement of filter material and drain lines in the pond

The project will be constructed over a three year period and will allow 1600 acres of land in the Heber Valley to be irrigated with sprinklers rather than the flood irrigation methods currently used. In addition, the project will allow the delivery of water to Daniel Irrigation Company as a replacement supply for water that they are diverting from the Strawberry River Basin. The Strawberry River flows will remain in the Strawberry Basin to improve fish and wildlife habitat, as required by the mitigation plan for the CUP's Strawberry Aqueduct and Collection System. A total of 23,000 acre feet of water will be used more efficiently in Heber Valley as a result of this project. Following construction, the Wasatch County Special Service Area #1 will operate and manage the system under contract to CUWCD. For more information contact Project Manager Karen Ricks at 801-226-7126.

Small Farm & Pasture Management Guide and Classes

The Wasatch Soil Conservation District recently published A Pasture & Hayland Management Guide: For Small Farms & Ranches in Wasatch County. The guide addresses planning, economics, water management, soil conservation, Best Management Practices and other important issues involved with agricultural lands. The District presents seminars to educate farmers and ranchers on use of the guide. The class is required for those farmers receiving government financial aid. Classes started in January 1998 when the guide was released.

Jordanelle Master Plan

Wasatch County has adopted the Jordanelle Basin Master Plan. Since the adoption of this plan, a Jordanelle Basin Overlay Zone has also been adopted, which will supplement existing county zoning regulations for lands within this overlay zone. These regulations will guide development within the Basin and provide the vision for what is to come.

Sewer, water lines, and water treatment plants are currently being constructed within the Jordanelle Special Service District to service developments within the Jordanelle Basin. Approximately 7,200 equivalent residential units have been approved. A fire station is also currently being constructed. Construction of some of the roads will begin this summer. It is anticipated that the Jordanelle Basin will grow rapidly within the next five years.

Deer Crest, located just west of the Mayflower Junction on U.S. 40, has already constructed and is operating ski lifts and ski runs in conjunction with Deer Valley. Infrastructure for this development is nearing completion. Wasatch County has issued three building permits for single family dwellings at Deer Crest. Future phases of approval may include commercial and multi-family structures.

Many other developments are submitting concept plans, with intentions of breaking ground within one to two years, including East Park, Pointe and Hollows, Hailstone Village, Staghorn/Elkhorn, Jordanelle View, and Deer Mountain. Other projects include Area C, Mayflower, and Jordanelle Heights, which have approved densities.

The eastern portion of the Basin, Area B, might also be developed into recreational areas and be included within the Jordanelle Overlay Zone. While no master plans have been approved yet for this area, development could occur soon or shortly after the development of the western side of the Jordanelle Basin.

Jordanelle Reservoir

Jordanelle Reservoir retains sediments and phosphorus which helps lowers total phosphorus concentrations in the Provo River and Deer Creek Reservoir below. The 1984 management plan called for the retention of 50% of all phosphorus originating in the Jordanelle Reservoir basin. The Selective Level Outlet Works (SLOW) on Jordanelle Dam was designed to assist in this goal by controlling the depth from which water is released from the reservoir.

Jordanelle Reservoir was filled for the first time in the summer of 1995 and SLOW functioned until November 1996 when additional construction began to improve the gate shaft lining. In August 1997 the SLOW tower was ready for operation again. Although the data available for analysis is limited to just a few years, it is believed that Jordanelle Reservoir has retained approximately 50% of its phosphorus inputs since 1994.

In November 1996, a blue-green algae bloom in Deer Creek Reservoir was observed by Charlie Thompson of the DWR. Jerry Miller, of the USBR, remembered observing a bloom on Jordanelle Reservoir in October 1996 that had been blown near the SLOW leading him to the conclusion that the bloom in Deer Creek was a result from part of the Jordanelle bloom being conveyed through the SLOW into the Provo River.

This occurrence may require that the Standard Operating Procedures for the SLOW be reviewed and revised. Jerry Miller is finishing "Jordanelle Dam Selective Outlet Works, Report and Operating Criteria" that analyzes the operation of the SLOW. The draft version of the report was released in 1998.

Jordanelle State Park

Camping, fishing, boating, hiking and other recreational activities are available at the two developed recreation sites of Jordanelle State Park. A third potential recreation site at the end of the North Arm, "Ross Creek" is still awaiting development funding.

The Rock Cliff Recreation Site is located at the east end of the reservoir and has accommodations which include a nature center, elevated boardwalk systems, modern restrooms with showers, group-use pavilions, 50 walk-in camping sites, and limited non-motorized trails.

The Hailstone Recreation Site and Jordanelle Reservoir opened its park gates and launch ramps at the end of June 1995. The 400 acre tract of land located on the west shore of the reservoir provides facilities for 180 camping units, individual powerboat and personal watercraft launching sites, 30 individual day use cabanas, beach house facility, 3 large group use pavilions, playgrounds, laundromats, visitor center and a convenience store / restaurant. The perimeter trail system opened in conjunction with the Hailstone facilities. The park now offers 13 miles of trails available for hiking, jogging, mountain biking, equestrian use, and cross-country skiing. A ten mile segment is planned for future development.

The Ross Creek site will be located on the east shore of the north arm of the reservoir. Limited day use access is planned for the summer of 1999 in the Ross Creek Area. No permanent facilities are being designed at present because of its limited use due to reservoir fluctuation, and because full development cannot proceed until a sewer system is developed and extended to this location.

Jordanelle Special Service District - Water System

Jordanelle Special Service District water system design (including waterlines, pump stations, intake structures, treatment plant, and storage tanks) began in 1997. Construction of some of the tanks and waterlines also began in 1997. Final design of the initial system needed to operate much of the Deer Crest area was substantially completed in 1998.

Jordanelle Special Service District - Sewer System

The Jordanelle Special Service District has continued with the design and construction of the sewer systems (including pump stations, main transmission lines, and emergency holding basins) needed to service the areas west and north of Jordanelle Reservoir. Individual collector mains are being constructed by each development.

Mayflower Resort

Mayflower Mountain Resort has been monitoring stream flows and water quality parameters in the McHenry Canyon drainage area since 1984, and reporting the results in an annual report to Wasatch County.

The Utah Division of Water Quality (DWQ) had issued a Ground Water Quality Discharge Permit for the stabilization of the three tailing ponds located adjacent to US Highway 40. This 5-year permit is scheduled expired in 1998, but because of failure by Mayflower to address a Notice of Violation (NOV) issued in 1996, DWQ did not renew the permit.

The NOV addressed the issue of stabilizing the tailing ponds. Plans and specifications have been prepared for the stabilization of the tailing ponds. The tailing ponds have not yet been capped because an economical source of random fill has not been obtained. Mayflower is presently attempting to identify an alternative source of random fill.

In the meantime, Mayflower has implemented interim storm water controls around the tailing ponds to control the migration of tailing material. The interim storm water controls consist of diversion channels and detention basins which are inspected, with DWQ oversight, twice a year and maintained as necessary. Biannual inspection reports are prepared and submitted to the DWQ identifying inspection observations and recommendations, and summarizing any maintenance performed on the interim storm water controls.

Wasatch County is working together with Mayflower to ensure that the hazardous site is contained before future developments occur in the area.

Soldier Hollow: 2002 Winter Olympics

In anticipation of the 2002 Winter Olympics, the SLOC selected Soldier Hollow as the site for all Cross-country, Biathlon, and Nordic combined events. The site is located on the southern end of Wasatch Mountain State Park and directly west of the northern tip of Deer Creek Reservoir. In order to facilitate hosting of these Olympic events it will be necessary to construct 23 kilometers of trail, a shooting range for small caliber rifles, a stadium area and a Competition Management facility. The venue is currently under design. It is anticipated that construction of most of the improvements will occur during the 1999 construction season.

In the fall of 1998 the first 5 kilometers of trail were constructed. The trails consist primarily of 5 to 11 meter wide trails bladed into the hillside, following existing contours. Drainage culverts were installed at drainage crossings and erosion control measures were incorporated to prevent erosion of the newly bladed areas into the existing waterways and streams. The trail areas will be re-seeded using a native seed mixture approved by the Division of Natural Resources (DNR).

Plans for the 1999 construction season will include the construction of the remaining 18 kilometers of trail; installation of a snow making system; installation of water, sewer, gas, electrical and telecommunications lines; and the construction of a shooting range and a Competition Management building. Bridges and culverts will be built to bridge streams and trail crossings. The design team has been working with the Army Corps of Engineers to obtain the necessary permits to allow construction of trails across existing wetlands and streams. It is anticipated that minor drainage channel improvements will need to be made to keep surface flows in drainage channels and away from the shooting range and stadium areas.

The majority of water flows through the venue site have traditionally come from irrigation canals. There are currently two irrigation ditches bringing flows to the site. The West Bench Ditch and the Epperson Ditch carry flows from the Midway Irrigation Company to service farm lands on the west side of the Heber Valley. Midway Irrigation Company will construct a new, winterized water line that will provide 8 ft3/sec of secondary water for snowmaking at the Olympic site and irrigation water for the future golf course. Currently, Midway Irrigation Company has completed a preliminary design for the aforementioned water line. The proposed 18-inch diameter waterline dead ends at the Cascade Springs Road. From this point, additional 2,200 feet of water line is needed to reach the Olympic stadium. Midway Irrigation Company estimates completion of this project in the Fall of 1999.

As part of the snow making system, a small holding pond will be constructed at the end of the Midway Irrigation Company pipeline. This pond will serve as a cooling pond for snow making and as a holding pond for irrigation of the proposed future golf course located just north of the Olympic venue.

With the completion of the Midway Irrigation piping, the West Bench Ditch will be abandoned and will serve only as a storm drainage collection ditch. The ditch has been breached just north of the main drainage channel running through the venue to prevent flows north of the drainage from contributing to the erosion potential along the newly constructed trails south of the drainage.

Overflows from the Midway Irrigation Piping will be allowed to flow through the Epperson to the main drainage just east of the stadium area, where they will join with natural flows running through an existing detention basin before flowing into Deer Creek Reservoir.

UPDES Permits

Three entities in the watershed have surface water discharge permits which are part of the Utah Pollutant Discharge Elimination System (UPDES) Permit program administered by the Division of Water Quality (DWQ). These are the Midway Fish Hatchery, Kamas Fish Hatchery, and United Park City Mines.

Midway Fish Hatchery

The UPDES permit was effective on March 1, 1995 and expires February 28, 2000. It specifically limits the total suspended solids (TSS) maximum concentration to 25 mg/l, TSS maximum daily loading to 1398 lbs/day, pH to a range of 6.5 to 9.0, and net increase of total phosphorus to 626 kg/yr. The permit requires the hatchery to monitor the influent springs and the effluent springs for the determination of net increase of total phosphorus. The results of the monitoring as reported in a monthly Discharge Monitoring Report (DMR) indicated that for 1997 the net increase of phosphorus measured was 320 kg and the TSS maximum daily loading was 570.8 kg/day.

Kamas Fish Hatchery

The Kamas Fish Hatchery, although smaller than the one at Midway, is planning to increase their fish production from 80,000 to 140,000 pounds per year. Reconstruction plans scheduled to begin this year will increase the capacity and efficiency of the hatchery. The new plans include concrete lining of the ponds and a string of settling ponds to reduce suspended solids in the effluent. Their current UPDES permit became effective March 1, 1995 and expires February 28, 2000. It was recently amended in August 1997 to allow for higher daily loads of TSS. The original limitations for TSS were a maximum 25 mg/l and 882 lbs/day. The new amended permit holds the maximum concentration of TSS at 25 mg/l, but allows the daily loading limit of TSS to increase to 1741 lbs/day.

The UPDES permit does not require phosphorus monitoring, however, to offset the potential for increased phosphorus discharges, the DWR has included settling ponds in the expansion plans that will contribute to reducing the amount of phosphorus loads that otherwise would have been discharged. The settling ponds at the Midway Fish Hatchery appear to have helped greatly to meet phosphorus limitations.

United Park City Mines

On the west side of Jordanelle Reservoir, the United Park City Mines discharges water from their treatment facilities at Keetley Station. This water originates from old mines in Park City that are drained through the Ontario #2 Drain Tunnel. The UPDES permit sets specific limitations on daily maximum concentrations of TSS, aluminum, copper, lead, mercury, zinc, oil and grease. Limitations are also placed on 30-day average concentrations of TSS, lead and mercury. The drain tunnel is not a significant source of phosphorus and phosphorus is not limited in the permit although JTAC monitors the effluent. The current permit was effective on August 1, 1997 and expires June 30, 2002.

Provo River Restoration Project

The goal of the Provo River Restoration Project (PRRP) is to restore the middle Provo River in the Heber Valley from below Jordanelle Dam to Deer Creek Reservoir. In many areas the river has been straightened due to development of agricultural lands and the construction of flood control levees. The Utah Reclamation Mitigation and Conservation Commission has proposed the PRRP to create a meandering river path with the purpose of restoring a more naturally functioning river system.

Existing levees would be set back to create a near natural flood plain that would allow for the river to change course naturally. Also important to the restoration, is the streamside vegetation that provides the necessary environment for healthy fisheries. Construction of side channels and ponds is also part of the proposed mitigation procedures for the improvement of fish habitat.

The first step in the project will begin with a pilot phase. A small section of the Provo River, near the bridge of US Highway 40, has been selected for this phase. Weather permitting, construction on this section will begin in March 1999 with the creation of side channels and expanded flood plan areas. The main channel will be realigned in the fall following the irrigation season. The CUWCD is cooperating by planning to rebuild the diversion facilities as part of the Wasatch County Water Efficiency Project.

The pilot project will be evaluated to determine its effectiveness. Lessons learned will be incorporated into restoring the rest of the river reach. The pilot phase will also help estimate the schedule, construction costs and available resources for the remainder of the project.

Groundwater Study

In 1995, the State Water Quality Board classified the aquifer in the Heber Valley as Class 1A pristine. From recommendations made in previous implementation reports, JTAC has been working with Wasatch County and the USGS to develop a groundwater monitoring plan. Fiscal year 1999 included cost-share funding for USGS to collect and analyze one sample from each of ten selected existing observation wells in the valley. This monitoring will help determine groundwater quality returning to Provo River and Deer Creek Reservoir, detect existing or future problems, and define trends in the groundwater. The samples were collected in August 1998 and will be analyzed by JTAC.

Deer Creek Resource Management Plan

The Deer Creek Resource Management Plan (RMP) insures water integrity as a principle source of water supply for the Wasatch Front area. It protects and maintains the purposes for which the Provo River Project was authorized by congress, as well as provides long term management direction information for prospective users as well as interested public.

It describes the activities necessary to achieve the desired future condition of the project, in the following decision areas:

1. Area-wide goals and objectives,
2. Area-wide management requirements,
3. Specific area management direction,
4. Lands suited or not suited for resource use and production, and
5. Monitoring and evaluation requirements.

The Deer Creek RMP was completed in 1998 and the environmental assessment was released for public comment. From public comments, the Bureau of Reclamation (USBR) has decided to go ahead with Alternative 1, the proposed alternative, but with a modification regarding the elimination of grazing on project lands. USBR has decided to allow grazing on project lands east of U.S. Highway 189, opposite side of the reservoir, with best management practices being implemented. Also, USBR has determined that the implementation of the proposed alternative should not require an environmental impact statement because of relatively low environmental impacts of the alternative.

Deer Creek State Park Renovations

Utah State Division of Parks and Recreation and the Bureau of Reclamation are jointly funding the $4.5 million renovation of recreation facilities at Deer Creek State Park. The first phase of the project is now complete with the development of Island Beach, Sailboat Beach, and a new park office.

The second phase of the project is currently under construction. This phase will develop the Rainbow Bay Day Use Area, Wallsberg Bay Overnight Group Use Area, a new campground, and also improve the maintenance area and Main Park launching ramp. These improvements should be complete by September 30, 1999.

The new developments of the second phase include construction an entrance station, modern restrooms, group pavilions, picnic shelters, docks, a new water system, and new campsites with and without full utility hookups.

Throughout the renovation, the State Park is ensuring that water quality is protected. New restrooms will require the construction of septic tanks and drain fields. These drain fields are being located at a minimum of 300 feet from the shoreline to prevent contaminated water from leaching into the reservoir.

And surface runoff containing oils and other contaminants that originate from asphalt roads and parking lots will not flow directly into the reservoir. Special catchments will allow for the contaminated water to be filtered before reaching Deer Creek.

Renovations will also place physical barriers such as rip rap to prevent motorized vehicles from accessing Deer Creek beaches and shoreline areas. New signs will be posted around the reservoir that prohibit dogs and other domestic pets from areas outside of campgrounds.

US-40 Highway Construction

The section of US-40 between the River Road/SR-32 intersection and Heber City is a two-lane facility with marginal shoulders. It was scheduled for reconstruction to a five-lane road in 1996 but funding was transferred to a higher priority project.

The existing road received an overlay in 1997 to preserve it until funding was again available. This section of US-40 is once again on-track for reconstruction and rehabilitation in 2000. The money will come from the Olympic funding. To realize the value of the overlay and reduce costs of the project, the concept has changed from total reconstruction to reconstruction and rehabilitation. The widening will be on the west side of US-40 and then an additional overlay over the existing road.

The completed project will be a five lane facility, two lanes in each direction, a permissive left turn lane and ten foot shoulders on both sides of the road. The project will include new drainage and irrigation culverts, some intersection improvements, and enhancement of a wetland mitigation site purchased for the 1996 project.

The concept change has required that the plans are redrawn and the contract package is prepared again. This work has commenced and will continue through the summer of 1999 with advertisement planned for September 1999 and construction work in 2000.

U-189 Highway Construction

Widening of US-189 in Provo Canyon from S Upper Falls to Wildwood that began in the spring of 1996 has continued through 1998. Most of the construction has been completed;

more specifically, the actual road in finished. Some smaller tasks, however, remain to finish up the project such as landscaping, painting, and wetlands mitigation.

The project has been plagued by problems during construction. On April 21, 1998, the Utah Water Quality Board issued a notice of violation to UDOT because of poor stormwater management. This citation occurred because of failure to notify the board about changes to the stormwater pollution prevention plan, and silt fencing that was uninstalled.

Also, in another violation, a 1000-foot section of the road encroached the 8-foot buffer zone for wetlands next to the Provo River, thus violating the wetlands permit issued by the U.S. Army Corps of Engineers. This incident required that the section be demolished and realigned outside of the 8-foot buffer. UDOT was fined $140,000 for the violation. Also, UDOT has been fined by the state Division of Water Quality for failing to channel construction site runoff away from the Provo River.

B. Current Conditions

The current conditions are based on the information from the 1998 Water Quality Implementation Report, which reported on the 1997 calendar year. The assessments made in this report were only based on TSS loadings because laboratory problems impaired the validity of phosphorus data in 1997. The findings are summarized here.

The Upper Provo River

Figure 2 and Figure 3 graphically shows the TSS loadings throughout the Provo River for 1997. Analysis of TSS loadings in the Provo River show that a significant amount of sediment increase in the 10-mile stretch between Woodland and Hailstone, which is typical each year.

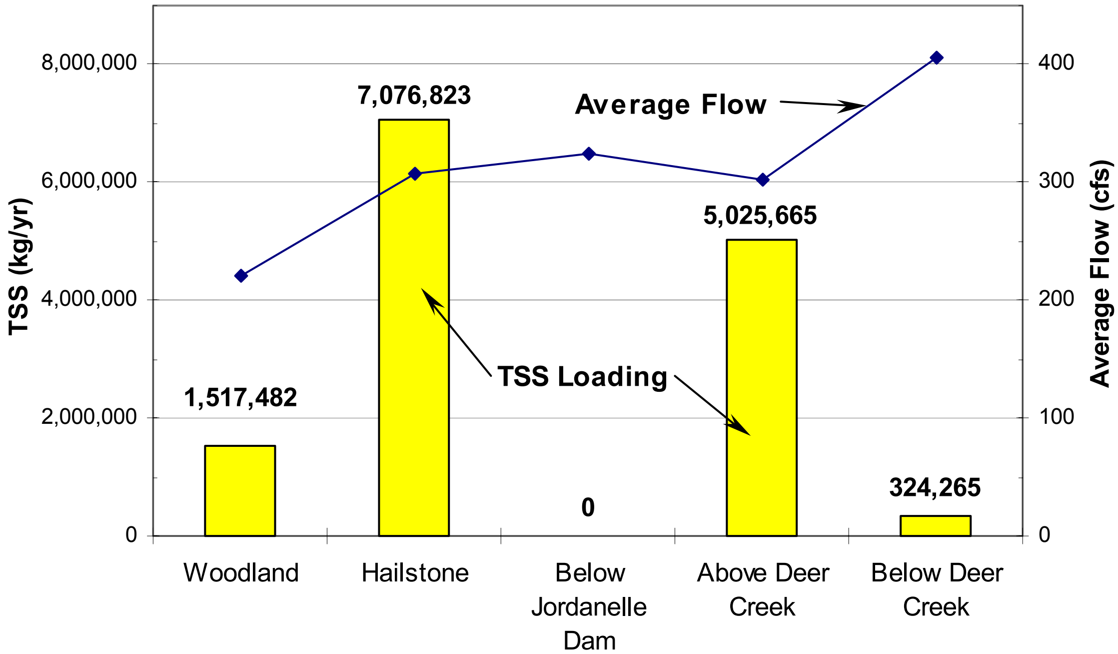

Figure 2 TSS Loading along the Provo River

The 1994 Tri-Valley Watershed Report from the Natural Resources Conservation Service (NRCS) identified several potential sediment sources in this area. These included natural soil conditions, vegetation type, channel gradient, and intense grazing. The TSS loading at Hailstone was low compared to previous years (see Table 6). The loading from the Weber-Provo Canal that discharges into the Provo River before it reaches Hailstone was also significantly lower than previous years.

Figure 3 Overview of TSS Loading during 1997

Insert Figure 3 here

Table 6 Historical Data of Phosphorus and TSS Loadings

	1993*	1994*	1995*	1996*	1997**
Provo River at Woodland					
Average Flow (cfs)	336	134	301	239	**220**
Average T. Phosphorus (mg/l)	0.02	0.017	0.025	0.009	-
Average D. Phosphorus (mg/l)	-	-	0.009	0.004	-
Total Phosphorus Load (kg/yr)	6,118	2,122	6,878	2,033	-
D. Phosphorus Load (kg/yr)	-	-	2423	988	-
TSS Load (kg/yr)	7,693,845	1,716,324	10,334,714	2,486,544	**1,517,482**
Provo River at Hailstone					
Average Flow (cfs)	475	224	383	286	**308**
Average T. Phosphorus (mg/l)	0.052	0.038	0.04	0.022	-
Average D. Phosphorus (mg/l)	-	-	0.005	0.01	-
Total Phosphorus Load (kg/yr)	23,096	7,946	14,124	5,852	-
D. Phosphorus Load (kg/yr)	-	-	1754	2729	-
TSS Load (kg/yr)	15,266,237	8,245,837	14,552,043	5,595,323	**7,076,823**
Provo River below Jordanelle					
Average Flow (cfs)	324	137	232	234	**324**
Average T. Phosphorus (mg/l)	0.036	0.018	0.021	0.014	-
Average D. Phosphorus (mg/l)	-	-	0.018	0.013	-
Total Phosphorus Load (kg/yr)	10,824	2,259	4,638	3,072	-
D. Phosphorus Load (kg/yr)	-	-	3926	2872	-
TSS Load (kg/yr)	5,631,342	548,751	126,139	33,178	**0**
Provo River above Deer Creek					
Average Flow (cfs)	315	140	193	231	**303**
Average T. Phosphorus (mg/l)	0.072	0.04	0.063	0.04	-
Average D. Phosphorus (mg/l)	-	-	0.023	0.022	-
Total Phosphorus Load (kg/yr)	21,246	5,238	11,344	8,566	-
D. Phosphorus Load (kg/yr)	-	-	4207	4729	-
TSS Load (kg/yr)	6,758,591	942,721	4,696,854	2,455,059	**5,025,665**
Provo River below Deer Creek					
Average Flow (cfs)	324	206	248	318	**406**
Average T. Phosphorus (mg/l)	0.037	0.051	0.037	0.027	-
Average D. Phosphorus (mg/l)	-	-	0.031	0.021	-
Total Phosphorus Load (kg/yr)	11,109	9,843	8,593	8,002	-
D. Phosphorus Load (kg/yr)	-	-	7232	6081	-
TSS Load (kg/yr)	1,453,790	464,989	335,445	216,334	**324,265**
Main Creek above Deer Creek					
Average Flow (cfs)	23	9	31	20	**30**
Average T. Phosphorus (mg/l)	0.121	0.053	0.121	0.072	-
Average D. Phosphorus (mg/l)	-	-	0.031	0.043	-
Total Phosphorus Load (kg/yr)	2,552	455	3,437	1,306	-
D. Phosphorus Load (kg/yr)	-	-	896	779	-
TSS Load (kg/yr)	2,133,099	246,679	2,603,917	877,802	**3,727,492**
Daniels Creek above Deer Creek					
Average Flow (cfs)	24	10	19	14	**22**
Average T. Phosphorus (mg/l)	0.289	0.079	0.092	0.079	-
Average D. Phosphorus (mg/l)	-	-	0.04	0.048	-
Total Phosphorus Load (kg/yr)	6,504	705	1,627	1,047	-
D. Phosphorus Load (kg/yr)	-	-	712	633	-
TSS Load (kg/yr)	5,264,927	266,650	1,370,557	803,024	**1,801,933**
Snake Creek above Deer Creek					
Average Flow (cfs)	44	38	47	52	**48**
Average T. Phosphorus (mg/l)	0.056	0.058	0.063	0.042	-
Average D. Phosphorus (mg/l)	-	-	0.034	0.022	-
Total Phosphorus Load (kg/yr)	2,297	2,036	2,767	2,005	-
D. Phosphorus Load (kg/yr)	-	-	1482	1083	-
TSS Load (kg/yr)	169,959	446,084	537,857	539,966	**431,283**

* Water year ** Calendar year

Jordanelle Reservoir DO Analysis

From Figure 2 and 3, it is obvious that Jordanelle Reservoir retained the TSS. However, because of problems with the phosphorus data in 1997 it is unknown how much of the total phosphorus was retained in 1997. Jordanelle has been effective in past years at retaining approximately 50% of the total phosphorus input. The following figure shows the 1997 Dissolved Oxygen levels in the Jordanelle Reservoir.

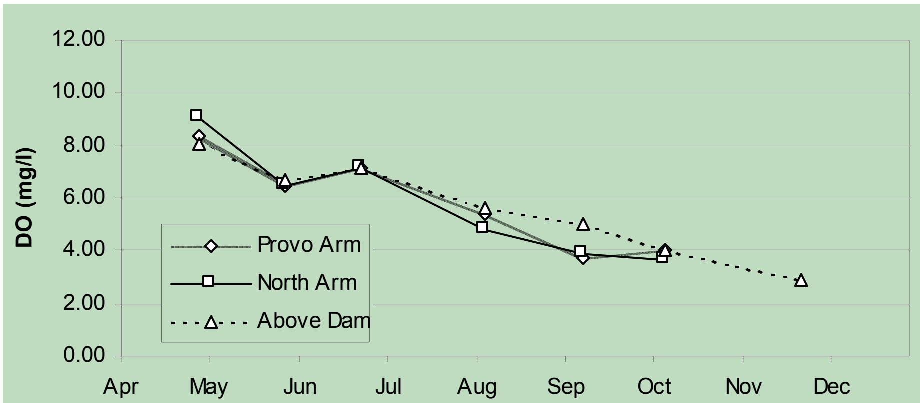

Figure 4 Dissolved Oxygen Levels in Jordanelle Reservoir for 1997

Figure 4 shows the reservoir bottom Dissolved Oxygen (DO) concentrations of the three monitoring locations. The Jordanelle Reservoir showed no instances of low DO concentrations below the state criteria of 2.0 mg/l; this is a great improvement from previous years. (In 1994 and 1995 late summer monitoring showed DO levels in the North Arm below 1.0 mg/l).

Jordanelle Reservoir Trophic State Index

The Carlson Trophic State Index (TSI) for Jordanelle Reservoir was calculated to be 47 which indicates a mesotrophic status. (eutrophic – high in plant nutrients, mesotrophic – healthy amount of nutrients, oligotrophic – low in plant nutrients). Figure 5 compares this value to previous years.

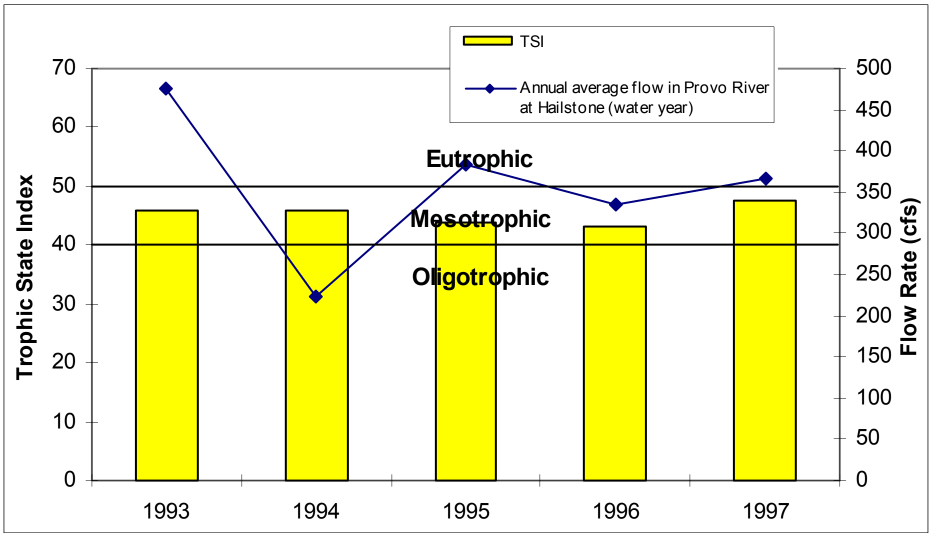

Figure 5 Jordanelle Reservoir TSI (1993-1997)

The figure shows that the 1997 TSI value is higher than normal. The reason for this increase may be due to the TSI method of calculation. The trophic value is related to a calculation using chlorophyll A, transparency depth and phosphorus concentrations. The phosphorus calculation was omitted due to unreliable phosphorus data in 1997 and may have raised the index value by 2 or 3 points, which may explain the increase from previous years.

Provo River through Heber Valley

The Provo River as discharged through the dam at Jordanelle Reservoir is essentially clear of TSS. In 1997, none of the samples recorded detectable traces of TSS (which can be seen from the loading chart in Figure 2). The Provo River increases in TSS load from the Jordanelle to the monitoring station above Deer Creek Reservoir by over 5,000,000 kg/yr. This loading is slightly above the average of past years. Typically there is a correlation between TSS loading and total phosphorus loading because phosphorus is usually tied into suspended particles. This may indicate that the 1997 phosphorus loading was also slightly higher than average.

Spring Creek yielded a contribution of 13% of the TSS load in the Provo River above Deer Creek. Snake Creek which discharges directly into Deer Creek Reservoir showed an average loading. In 1998 JTAC monitored the Heber Valley Flood Channel, which will help to identify other areas which contribute to the loading increases through the valley.

Deer Creek Reservoir DO Analysis

Deer Creek Reservoir continues to struggle with problems associated with eutrophication, especially with DO levels dropping to anoxic conditions in the bottom layer of the reservoir. Figure 6 below shows reservoir bottom DO concentrations of each monitoring location as well as the monitoring probe in the dam outlet (also at the bottom of the reservoir).

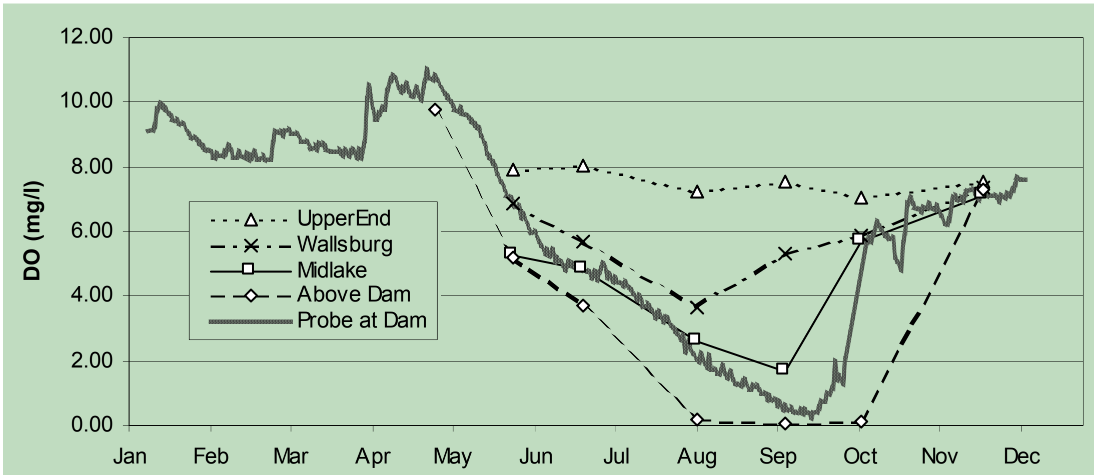

Figure 6 Deer Creek Reservoir bottom DO Concentrations for 1997

The graph demonstrates that during August, September, and part of October 1997, anoxic conditions existed in the reservoir at the lower depths in the reservoir near to the dam. These conditions are harmful to the fishery habitat in the reservoir. Low DO is also a prime factor in phosphorus release from sediments and can contribute to taste and odor problems in the water taken for culinary purposes. The low DO levels only occur at locations of sufficient depth for stratification.

Deer Creek Trophic State Index

The 1997 Carlson Trophic State Index for Deer Creek Reservoir was calculated to be 45, which indicates a mesotrophic status. Figure 7 below compares this value with historical TSI values.

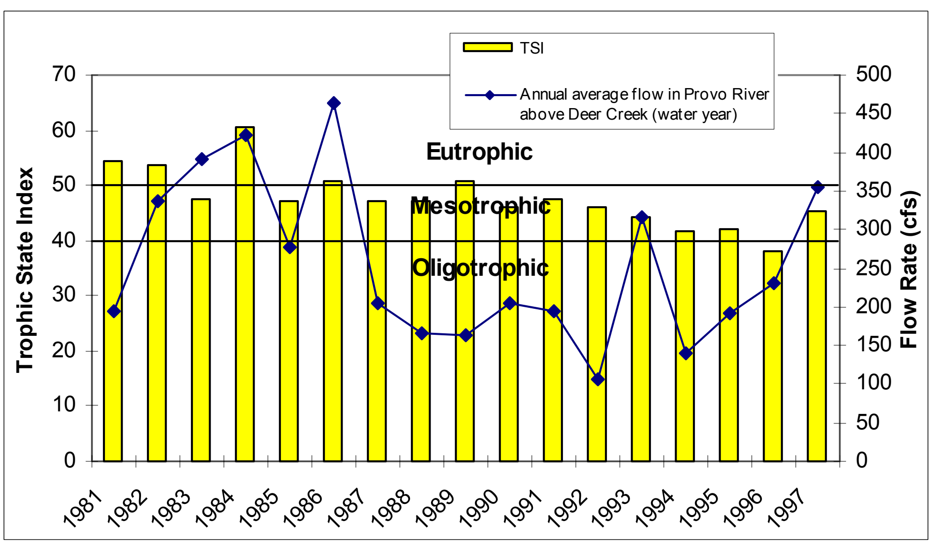

Figure 7 Deer Creek Reservoir TSI and Provo River Average Flow 1981-1997

There was a significant increase from the 1996 TSI value of 38. Again much of the increase may be partially associated with the lack of phosphorus data in the calculations as well as the increased runoff this year as compared with last year. In comparing the average flow with previous years, this year's runoff was similar to the runoff in 1982. Both 1982 and 1997 have approximately the same average flow and are preceded by a year with a lower average flow. Using this comparison, the improvement of Deer Creek Reservoir is apparent. In 1982 the reservoir was eutrophic with TSI of 54 whereas in 1997 the reservoir has established itself in the mesotrophic range.

Deer Creek Reservoir TSS Loading

The Provo River is the major source of TSS inflow to Deer Creek Reservoir. The Provo River accounted for 46% of the TSS loading discharged into Deer Creek in 1997. Main Creek also contributed a significant amount, accounting for 34% of the TSS loading. Daniels Creek and Snake Creek contributed 16% and 4% respectively. In Figure 6 below, a monthly distribution of the loading is shown.

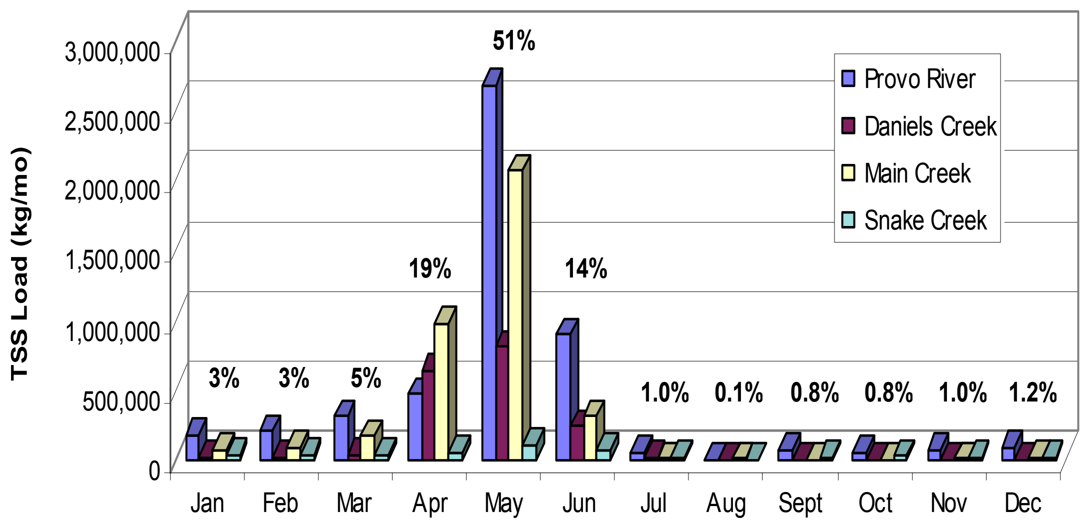

Figure 6. Monthly Distribution of TSS Loading into Deer Creek for 1997

The graph above indicates that most of the loading occurs during spring runoff when both stream flowrates and TSS concentrations are at maximums. During May, 51% of the annual TSS loading was discharged into Deer Creek, and 89% of the load inflowed during the combined spring runoff months March, April, May, June.

Recommendations

The Provo River System is a great resource, which benefits many people throughout the area. The programs made to improve the conditions in the Provo River are helping to sustain water quality. The recommendations provided herein are suggestions to further protect water quality in the Provo River, and Jordanelle and Deer Creek Reservoirs.

1. Jordanelle Reservoir – Management of Releases

The Jordanelle Reservoir has helped improve the water quality in the Provo River by retaining phosphorus rich sediments, regulating temperature of outlet water, and controlling dissolved phosphorus levels in outlet water. Many of these benefits are due to the Selective Level Outlet Works (SLOW) which is operated by the Bureau of Reclamation (USBR). The USBR is in the process of revising the Standard Operating Procedures of the SLOW to maximize its benefit.

2. Kamas Fish Hatchery

The Kamas Fish Hatchery is expanding its operation to almost double the output of fish. The expansion plans incorporate features such as settling ponds and concrete linings which will greatly aid in reducing TSS in the effluent. These features will help water quality as the fish operation expands. JTAC should continue to work with the DWQ to encourage phosphorus limits in the hatchery's UPDES permit.

3. Heber Valley – Storm Water Controls

In response to recommendations from previous years' implementation reports, JTAC and Wasatch County are currently completing the second year of a three year Storm Water Study in Heber Valley. The valley continues to experience increased urbanization which tends to increase natural storm runoff conditions. This study will identify potential sites for construction of new sedimentation basins intended to reduce eroded sediments in surface waters prior to entering Deer Creek Reservoir.

4. Agricultural – Non-Point Source Erosion

In coordination with the Tri-Valley Watershed Project, the Natural Resources Conservation Service (NRCS) has developed a guide for farmers and ranchers called *A Pasture & Hayland Management Guide: For Small Farms & Ranches in Wasatch County*. The guide addresses planning, economics, water management, soil conservation, and other important issues involved with agricultural lands. Best Management Practices are encouraged to reduce erosion and pollution entering into the local streams. The NRCS is offering free seminars to farmers interested in using the guide for management of their farms.

5. Soldier Hollow – Monitor Olympic Activities

Soldier Hollow has been selected for the biathlon and cross country events for the 2002 Winter Olympics. Construction of the needed Olympic facilities and surrounding developments have the potential to impact water quality in Deer Creek Reservoir. Wasatch County will be intimately involved in the planning and construction phases of this work.

6. Ordinances around Jordanelle

Heavy development is expected within the next 4-5 years in the Jordanelle area. Wasatch County is in the process of adopting county ordinances which will address the specific needs of the Jordanelle basin developments. These ordinances will address such water quality concerns as proper storm water management, sediment controls, erosion controls, revegetation, restoration and drainage.

C. Beneficial Use Classifications

The State of Utah classifies the water bodies in the state according to the *Beneficial Use* of that water. The water quality standards are different for each beneficial use category. A description of each *Beneficial Use* category found in Wasatch County is included below:

1. Class 1C: Protected for domestic purposes with prior treatment processes as required by Utah Department of Environmental Quality.
2. Class 2A: Protected for primary contact recreation such as swimming.
3. Class 2B: Protected for boating, water skiing and similar uses, excluding swimming.
4. Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
5. Class 4: Protected for agricultural uses including stock watering and irrigation of crops.

The Provo River and its tributaries have been placed by the State of Utah in the following beneficial use categories: 1C, 2B, 3A and 4. Deer Creek Reservoir has been classified as 1C, 2A, 2B, 3A and 4. The Jordanelle Reservoir has been classified as 1C, 2A, 3A, and 4.

Water quality standards are violated if the chronic or acute values are exceeded more than once in three years. The State of Utah water quality criteria for each different classification in the Upper Provo River Basin is summarized in Table 7 and Table 8:

Table 7 Beneficial Use Water Quality Criteria for waters in Wasatch County.

PARAMETER	CLASS 1C	CLASS 2A	CLASS 2B	CLASS 4
BACTERIOLOGICAL				
M.F. Total Coliforms	5000	1000	5000	
M.F. Fecal Coliforms	2000	200	200	
PHYSICAL				
Min. DO (mg/l)	5.5	5.5	5.5	
pH (Range)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
Turbidity Increase (NTU)		10	10	
METALS (soluble acid mg/l)				
Arsenic	0.05			0.1
Barium	1.0			
Cadmium	0.01			0.01
Chromium	0.05			0.10
Copper				0.2
Lead	0.05			0.1
Mercury	0.002			
Selenium	0.01			0.05
Silver	0.05			
INORGANICS (mg/l)				
Boron				0.75
Fluoride	1.4-2.4			
Nitrates as N	10			
TDS				1200
RADIOLOGICAL (pCi/l)				
Gross Alpha	15			15
Radium 226, 228	5			
Strontium 90	8			
Tritium	20000			
ORGANICS (µg/l)				
Chlorophenoxy Herbicides				
2,4-D	100			
2,4,5-TP	10			
Endrin	0.2			
Hexachlorocyclohexane (Lindane)	4			
Methoxychlor	100			
-Toxaphene	5			
POLLUTION INDICATORS				
Gross Beta (pCi/l)	50			50
BOD (mg/l)		5	5	5
Nitrate as N (mg/l)		4	4	
Phosphate as P (mg/l)		0.05	0.05	

Table 8 Beneficial Use Water Quality Criteria for waters in Wasatch County.

PARAMETER	CLASS 3A	
PHYSICAL		
DO (mg/l) - 30 Day Ave.	6.5	
DO (mg/l) - 7 Day Ave.	9.5/5.0	
DO (mg/l) - 1 Day Ave.	8.0/4.0	
Max. Temp (C)	20	
Max. Delta Temp (C)	2	
pH (Range)	6.5-9.0	
Turbidity Increase (NTU)	10	
METALS (soluble acid µg/l)	**4 DAY AVE.**	**1 HOUR AVE.**
Arsenic (Trivalent)	190	360
Cadmium	1.1	3.9
Chromium (Hexavalent)	11	16
Chromium (Trivalent)	210	1700
Copper	12	18
Cyanide (free)	5.2	22
Iron (Maximum)	1000	1000
Mercury	0.012	2.4
Nickel	160	1400
Selenium	5.0	20
Silver	0.12	4.1
Zinc	110	120
INORGANICS	**4 DAY AVE.**	**1 HOUR AVE.**
Chlorine (Total Residual)	0.011	0.019
Hydrogen Sulfide (Undissociated Max. µg/l)	2.0	NA
Phenol (Maximum)	0.01	NA
RADIOLOGICAL (pCi/l)		
Gross Alpha	15	
ORGANICS (µg/l)	**4 DAY AVE.**	**1 HOUR AVE.**
Aldrin (Maximum)	1.5	NA
Chlordane	0.0043	1.2
DDT and Metabolites	0.0010	0.55
Dieldrin	0.0019	1.25
Endosulfan	0.056	0.11
Endrin	0.0023	0.09
Guthion (Maximum)	0.01	NA
Heptachlor	0.0038	0.26
Mexachlorocyclohexane (Lindane)	0.08	1.0
Methoxychlor (Maximum)	0.03	NA
Mirex (Maximum)	0.001	NA
Parathion (Maximum)	0.04	NA
PCB's	0.014	2.0
Pentachlorophenol	13	20
Toxaphene	0.0002	0.73
POLLUTION INDICATORS		
Gross Beta (pCi/l)	50	
BOD (mg/l)	5	
Nitrate as N (mg/l)	4	
Phosphate as P (mg/l)	0.05	

D. Monitoring Results

Because of its importance as a drinking water source, there have been a number of long-term monitoring programs on the Provo River and its various tributaries. The Jordanelle Technical Advisory Committee (JTAC) has directed the Water Quality Monitoring Program since 1985 and the Division of Water Quality (DWQ) has the task of coordinating the yearly monitoring program. The DWQ provides field sheets to samplers, collects testing results, inputs testing results into the State database and provides final data to the Central Utah Water Conservancy District (CUWCD). The CUWCD, Mountainlands Association of Governments (MAG), and the US Bureau of Reclamation (USBR) gather samples in the field throughout the year.

During 1998, JTAC took nearly 600 samples from 46 locations for the purpose of water quality analysis. Tables 9 and 10 on the following pages list the 46 sites with their STORET number, descriptions, sampling frequency, sampling type, and the agency responsible to collect the sample.

The DWQ compiles an exceedence list for each water quality monitoring station. These lists identify how often the state water quality standards were exceeded during a specified period of time. For this report, exceedence reports for various water quality monitoring stations were obtained. These exceedence reports correspond to the period from January 1, 1990 to November 1, 1995 and are shown in Table 11.

Table 9 JTAC Monitoring Plan for Fiscal Year 1997-1998

Insert Table

Table 10 JTAC Monitoring Plan for Fiscal Year 1998-1999

Insert Table

Table 11 Exceedance report for the period January 1, 1990 to November 1, 1995

NAME	STORET #	PARAMETER	EXCEEDANCES	SAMPLES	PERCENTAGE
Provo R. ab Woodland	499840	pH, S.U.	3	79	3.8%
	499840	M.F. Total Coliforms	1	47	2.1%
	499840	Diss. Nitrate	1	11	9.1%
	499840	Total Phosphorus	4	81	4.9%
	499840	Cadmium	1	26	3.8%
	499840	Zinc	2	26	7.7%
	499840	T.D.S.	1	59	1.7%
Provo R. at Jordanelle @ US40	499733	M.F. Total Coliforms	1	47	2.1%
	499733	Total Phosphorus	11	81	13.6%
Provo R. ab Cnfl Snake Creek	591363	pH, S.U.	1	72	1.4%
	591363	M.F. Total Coliforms	1	41	2.4%
	591363	Total Phosphorus	29	72	40.3%
Snake Creek ab Cnfl Provo	591016	M.F. Total Coliforms	5	44	11.4%
	591016	Total Phosphorus	32	70	45.7%
Daniels Creek ab Deer Creek Res.	591352	M.F. Total Coliforms	7	39	17.9%
	591352	Total Phosphorus	61	63	96.8%
Provo R. blw Deer Creek Res.	591321	Min. DO (Class 1C, 5.5 mg/l)	15	68	22.1%
	591321	Min. DO (Class 3A, 6.5 mg/l)	18	68	26.5%
	591321	M.F. Total Coliforms	1	48	2.1%
	591321	Total Phosphorus	21	70	30.0%
Main Cr. ab Deer Creek Res.	591346	pH, S.U.	1	68	1.5%
	591346	M.F. Total Coliforms	2	41	4.9%
	591346	Total Phosphorus	46	69	66.7%
	591346	Min. DO (Class 3A, 6.5 mg/l)	2	67	3.0%

From Table 11, it is evident that the water quality parameter of greatest concern in the Upper Provo River Basin is phosphorus. It should be noted that the exceedances for phosphorus shown in Table 11 are based on the State criteria of 0.05 mg/l and not on the JTAC pollution indicator concentration of 0.04 mg/l. The State criteria for total phosphorus for lakes and reservoirs is 0.025 mg/l. The difficulties with phosphorus is especially evident in Daniels Creek, Snake Creek, Main Creek and the Provo River after it enters the Heber Valley. Although phosphorus is only an indicator contaminant, it is thought that dissolved phosphorus is the limiting nutrient in algae blooms in Deer Creek Reservoir. Algal blooms in the past have created taste and odor problems in water obtained from below Deer Creek Reservoir.

Low dissolved oxygen (DO) concentrations are a problem below Deer Creek Reservoir mainly because the outlet point for the reservoir is at the bottom where DO levels are low for part of the year. To date DO has not been a problem below Jordanelle Reservoir. However, results from the 1996 implementation report indicate that a significant DO problem is developing in Jordanelle Reservoir. The outlet structure at the bottom of the dam is designed to force re-aeration of the water to near saturation levels at any water release depth.

As shown in Table 11 on the previous page, there have been a few occurrences of exceedence of the Zinc and Cadmium concentrations at the Woodland site. However, these exceedences occurred in only 3 of 75 samples during the five year period from 1990 to 1995 or only 4% of the time. This occurrence rate was not high enough for the state to include these constituents in the 303D list, which is discussed below. Because of this it is felt that unless a more serious problem develops, these metals parameters should only be watched at this time.

The Provo River watershed has a number of unique segments with different flow as well as pollution characteristics. For this reason and so each segment could have a unique management scenario developed, the entire Upper Provo River Basin was divided into smaller sub basins. The terminus for each sub basin was selected such that water quality and water quantity data were available for an extended period of time. The sub basins are listed in Table 12 along with the water quality parameters for which management scenarios will be developed in this document.

Table 12 Stream segments for which management strategies will be developed.

NAME	PARAMETER
Provo R. ab Woodland	Total Phosphorus
Provo R. at Jordanelle @ US40	Total Phosphorus
Provo R. ab Cnfl Snake Creek	Total Phosphorus
Snake Creek ab Cnfl Provo	Total Phosphorus
Daniels Creek ab Deer Creek Res.	Total Phosphorus
Provo R. blw Deer Creek Res.	Min. DO (Class 1C, 5.5 mg/l)
	Min. DO (Class 3A, 6.5 mg/l)
	Total Phosphorus
Main Cr. ab Deer Creek Res.	Total Phosphorus

C. Division of Water Quality's 303D List

The DWQ is also responsible for determining areas of the watershed which are not supporting their beneficial use criterion. This list of non supporting streams is contained in the 303D report which is compiled every other year. The 303D list for Provo River Basin was updated in 1998. At that time, all stream segments in the upper Provo River Basin were taken off the 303D list. The stream segments that were taken off the 303D list are shown in Table 13. These stream segments were placed on the list for their exceedance of the phosphorus water quality criteria, but were delisted based on the change in State determination for phosphorus. As long as phosphorus is the only parameter exceeding water quality criteria, the State of Utah no longer considers the exceedance of the phosphorus criteria reason for listing a stream segment on the 303D list.

Table 13 Stream segments listed on the DWQ's 303D list.

NAME	SECTION
Main Creek	Lower six miles

Daniels Creek	Lower ten miles
Lower Charleston Canal	
Snake Creek	lower 4.3 miles
Spring Creek	

These stream segments still represent areas of greatest concern, and this management plan will focus on different strategies for these specific areas. However, some of the stream segments will be handled as groups. Because the Lower Charleston Canal runs into Daniels Creek prior to entry into Deer Creek Reservoir, this document will group Daniels Creek and the Lower Charleston Canal together. In addition, Spring Creek will not be handled separately but will be grouped with the Provo River in Heber Valley segment.

D. Basin Wide Water Quality Patterns

1. Flow, Total Phosphorus and Dissolved Total Phosphorus

The JTAC committee adopted the pollution indicator concentration of 0.04 mg/l total phosphorus as the target concentration as recommended by the 1984 Water Quality Management Plan. This level was introduced as a goal to help improve the water quality in Deer Creek Reservoir. However, because soluble phosphorus and not sedimentary phosphorus is more readily available for use as a food source by algae, it was determined that the interrelationship between total phosphorus and soluble phosphorus be investigated.

During the past 15 years the total phosphorus (TP) level has been tracked at various locations in the Provo River Basin. When the flow weighted average concentration of TP flowing into Deer Creek Reservoir is plotted versus the average flow into Deer Creek Reservoir for a given water year, it becomes evident that the TP concentrations varies directly with the average flow in the river (Figure 8). This is attributed to the greater amount of overland flow washing soil off the land surface and the stream channel erosion caused by increased flows during high water years. These flows carry the solids that contribute heavily to the Total Phosphorus concentration. However, when the dissolved component of the phosphorus load is plotted against flow it is evident that it does not vary directly with the flow from year to year. This is shown graphically in Figure 8. This suggests that dissolved total phosphorus (DTP) is entering water by a mechanism other than overland runoff. This also suggests that a separate management plan for reducing DTP may be necessary. During 1996 the operation of the SLOW at the Jordanelle Dam appears to have had a significant impact on the amount of TP concentrations in the water being released from Jordanelle Reservoir but no impact on the DTP concentrations. This is shown in Figure 9.

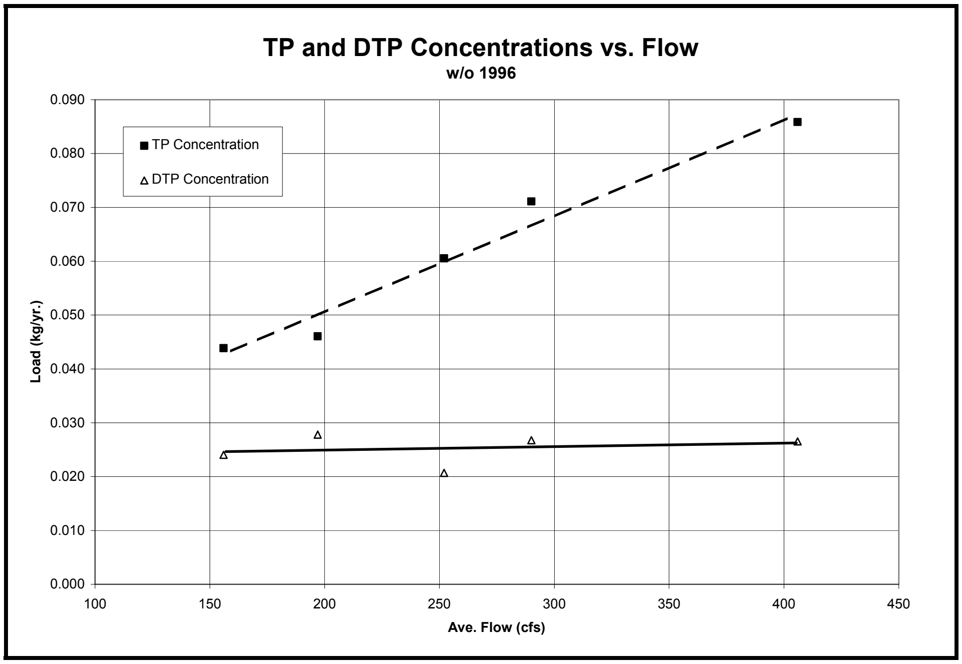

Figure 8 *Flow Weighted Total Phosphorus And Dissolved Total Phosphorus Concentrations Into Deer Creek Reservoir Plotted Against Average Flow Into Deer Creek Reservoir For Five Years From 1991-1995.*

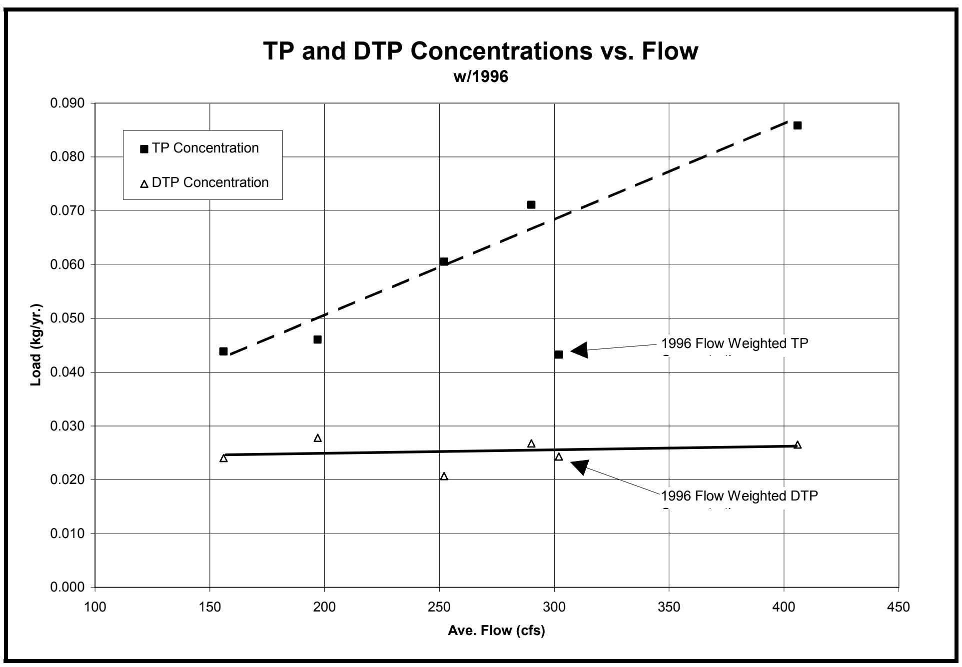

Figure 9 *Flow Weighted Total Phosphorus And Dissolved Total Phosphorus Concentrations Into Deer Creek Reservoir Plotted Against Average Flow Into Deer Creek Reservoir For*

Five Years From 1991-1995. The Impact Of The SLOW Operation On TP Concentrations Is Clearly Seen.

Figure 10 through Figure 17 show the TP and DTP concentrations versus average flow at the water quality stations in the Upper Provo River Basin. Before 1991 orthophosphate concentrations were collected at some sites rather than DTP. After 1991 all sites collected DTP concentrations. Therefore for those graphs showing data previous to 1991, the DTP concentrations are actually the orthophosphate concentrations.

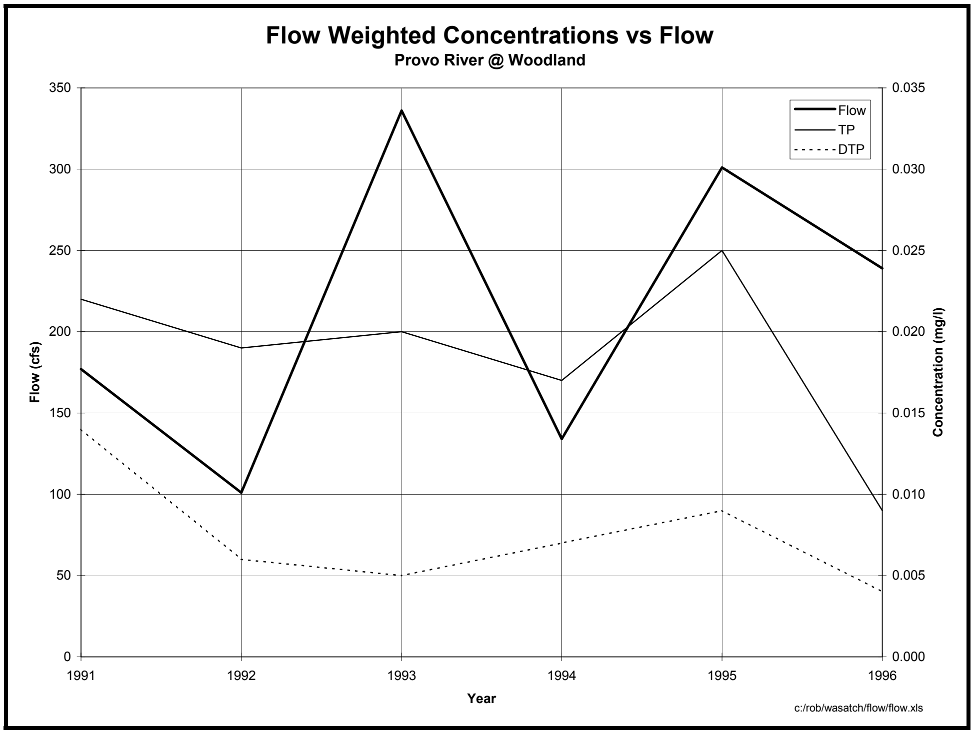

Figure 10 TP, DTP and Flow comparison in Provo River at Woodland; 1991-1996 .

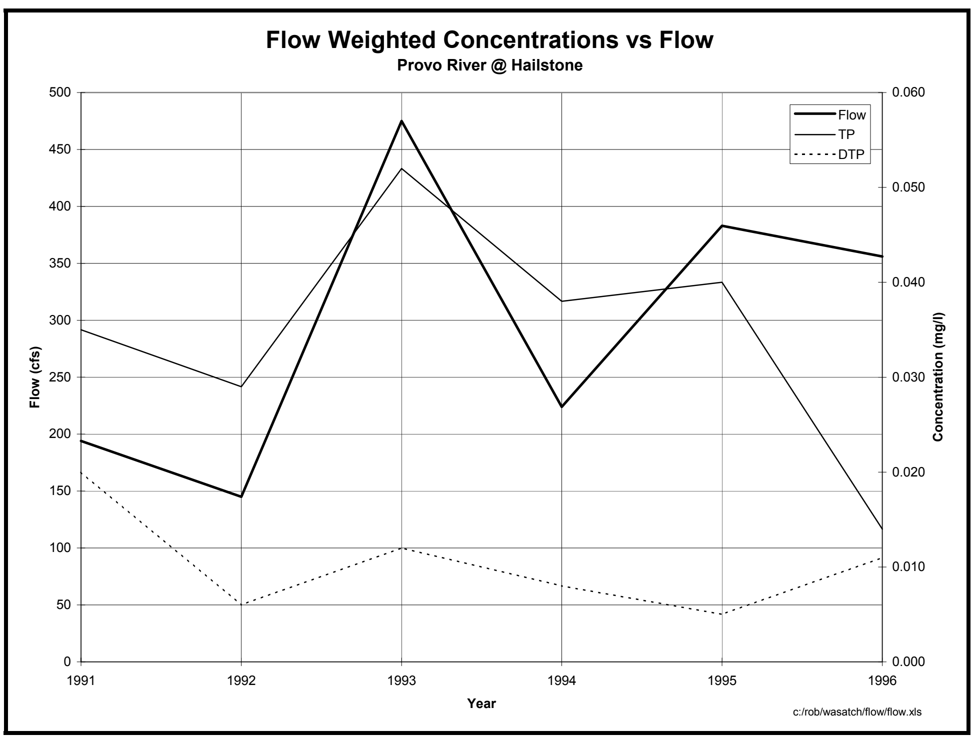

Figure 11 TP, DTP and Flow comparison in Provo River at Hailstone; 1991-1996.

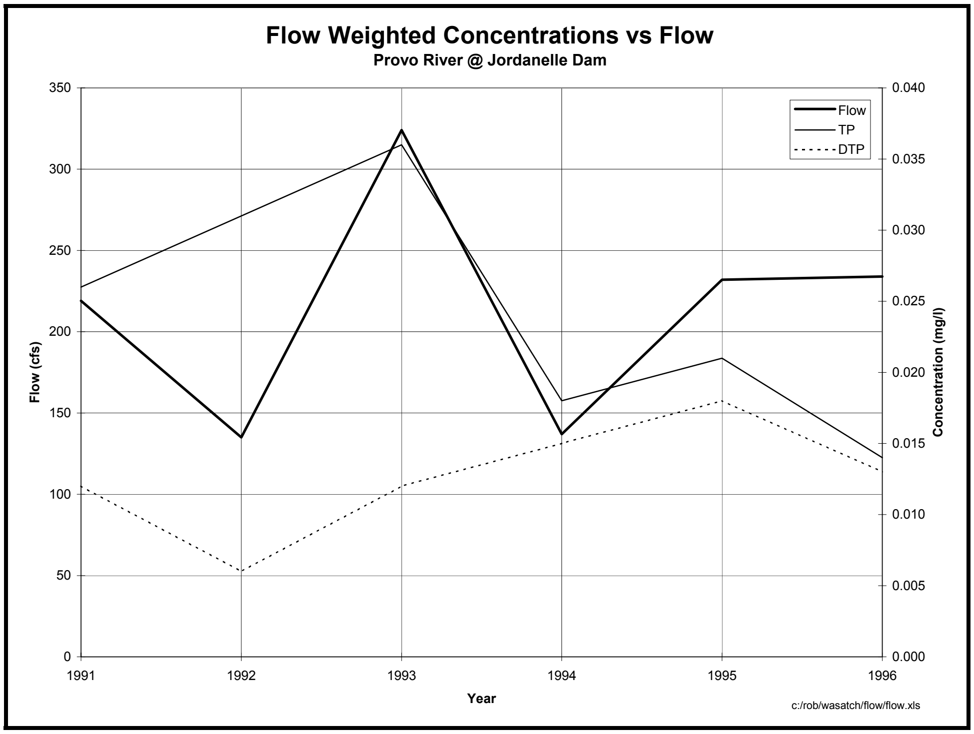

Figure 12 TP, DTP and Flow comparison in Provo River at Jordanelle Dam; 1991-1996.

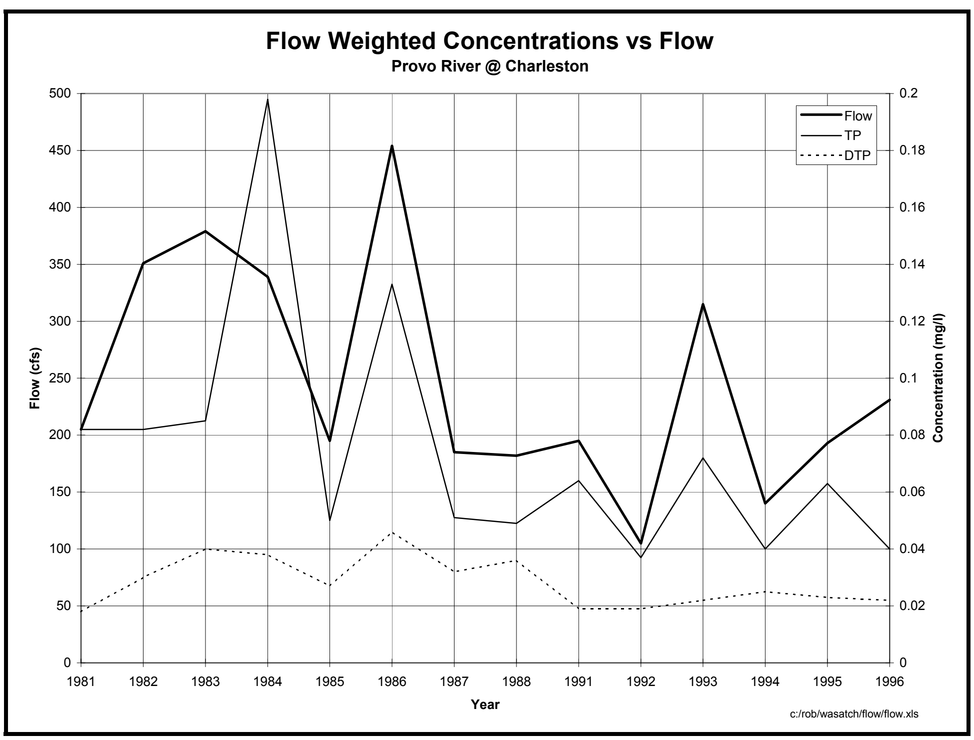

Figure 13 TP, DTP and Flow comparison in Provo River at Midway; 1981-1988, 1991-1996.

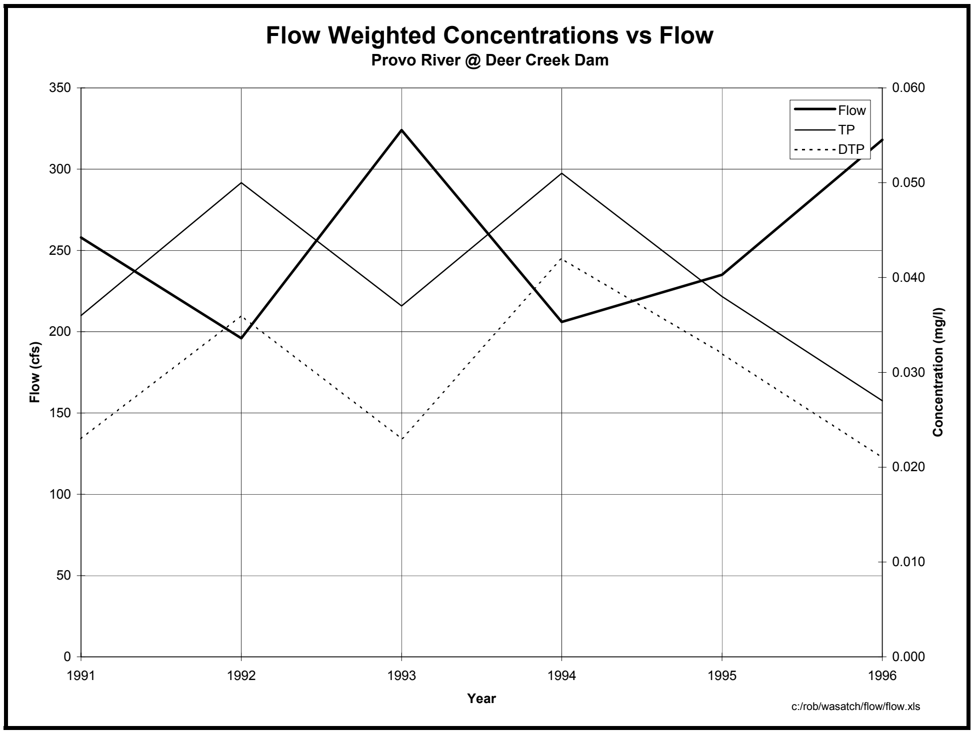

Figure 14 TP, DTP and Flow comparison in Provo River at Deer Creek Dam; 1991-1996.

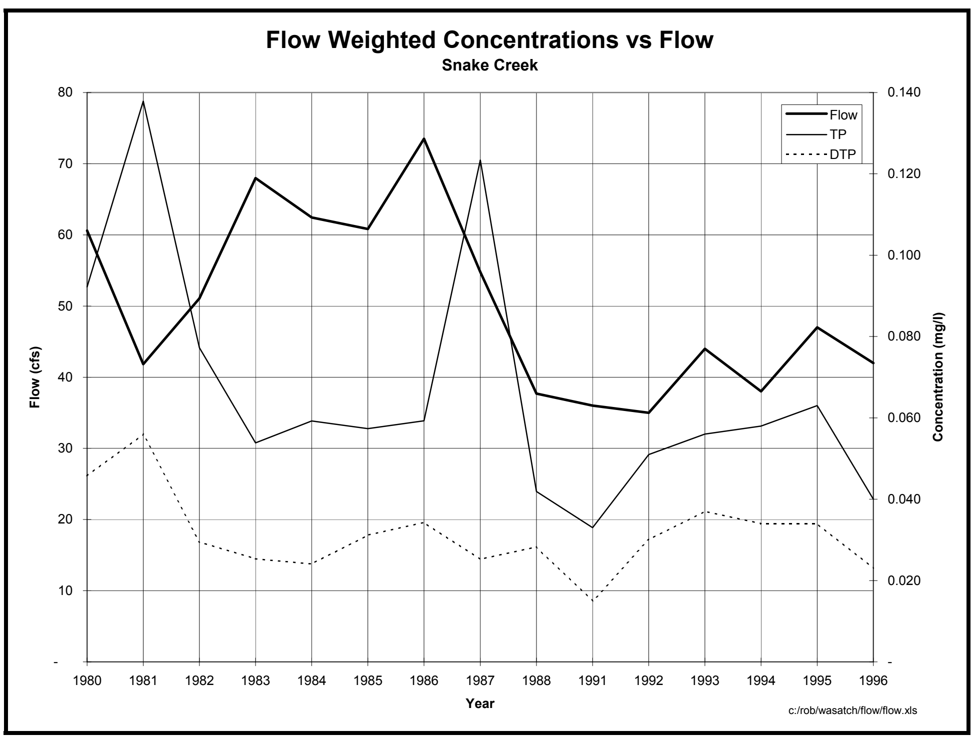

Figure 15 TP, DTP and Flow comparison in Snake Creek; 1981-1988, 1991-1996.

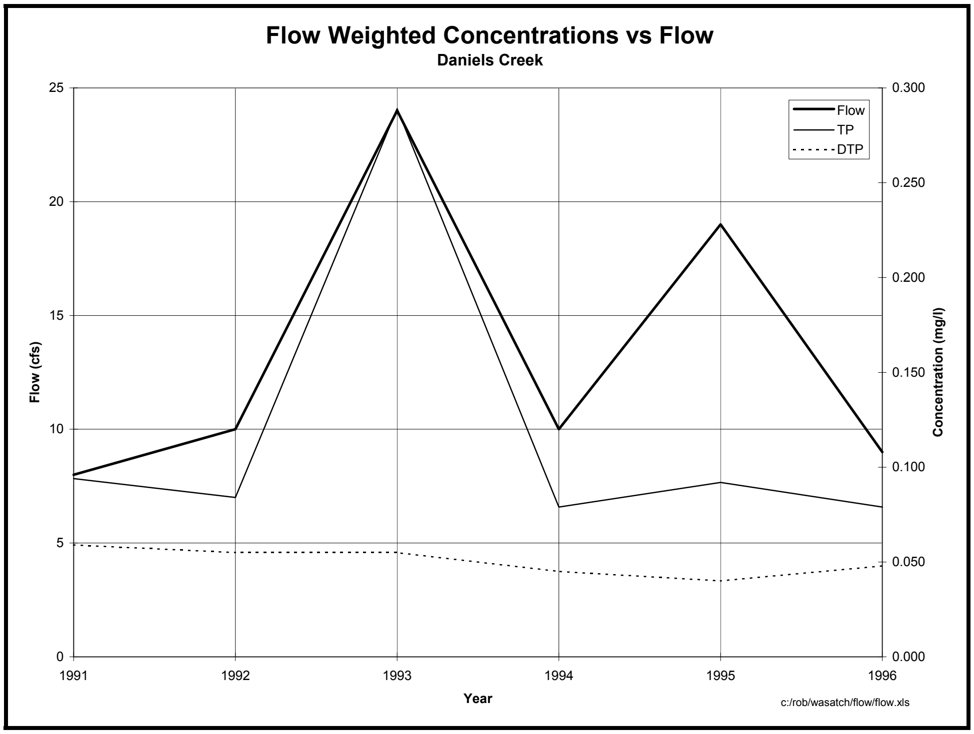

Figure 16 TP, DTP and Flow comparison in Daniels Creek; 1991-1996.

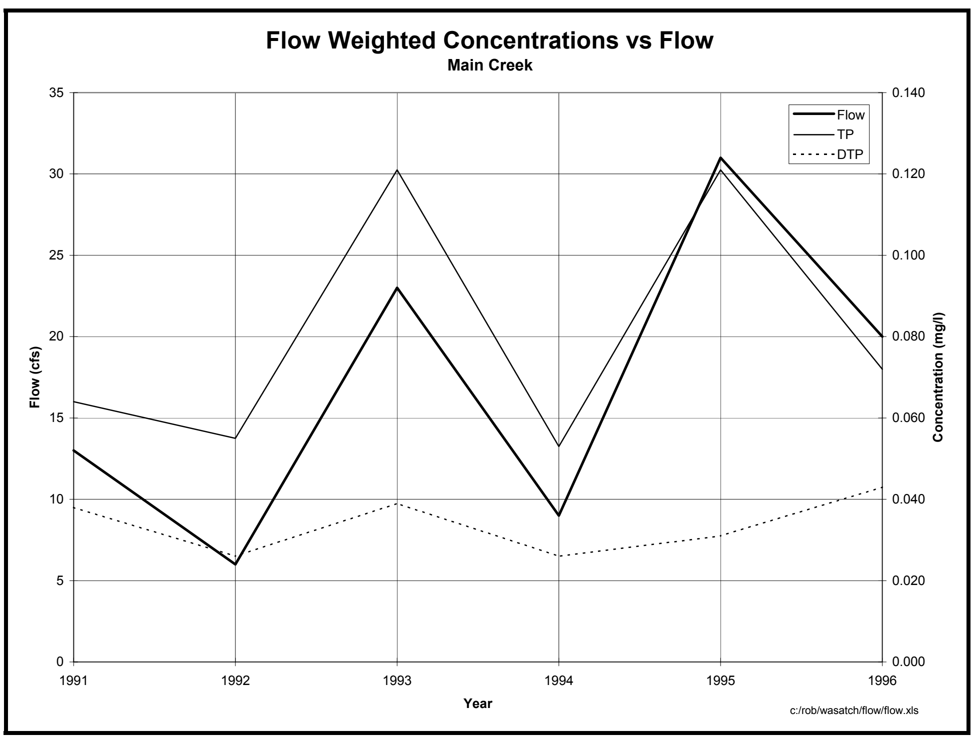

Figure 17 TP, DTP and Flow comparison in Main Creek; 1991-1996.

In observing Figure 10 through Figure 17, two conclusions can be drawn:

1. TP Concentration varies with flow, higher flows translate into higher concentrations.

2. DTP Concentration remains fairly constant, higher flows do not directly translate into higher concentrations.

3. Exceptions

    - Snake Creek - The effluent from the Midway Fish Hatchery appears to influence the phosphorus amounts in Snake Creek.

    - Below Deer Creek and Jordanelle Dams - Anoxic conditions in the reservoir drive a separate phosphorus cycle.

Another interesting item discovered through the monitoring program is that majority of the TP that flows into the reservoir does so during the three months of the spring runoff. Figure 18 shows the TP entering Deer Creek from the Provo River, Snake Creek, Main Creek and Daniels Creek during the 1995 water year. Approximately 75% of the TP enters Deer Creek Reservoir during the three runoff months. In contrast, 60% of the DTP enters the reservoir during these same three months (See Figure 19). Because approximately 66% of the total flow into Deer Creek Reservoir occurs during this runoff period, the high loading of TP is due to higher flows as well as higher concentrations. This analysis suggests the amount of total phosphorus entering the reservoir is directly connected to the amount of phosphorus laden sediments that are washed off the ground during high water years. It also suggests that efforts to control this total phosphorus load may not significantly influence the amount of DTP entering the reservoir.

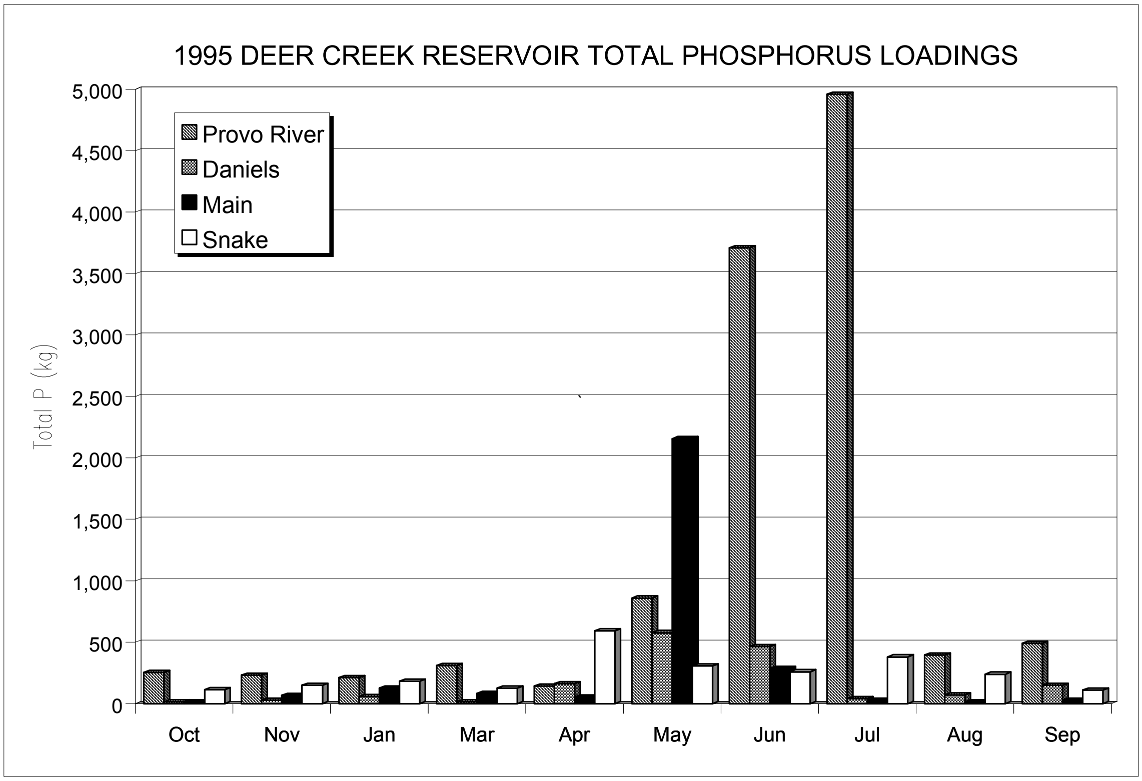

Figure 18 Total Phosphorus Loads into Deer Creek Reservoir during 1995.

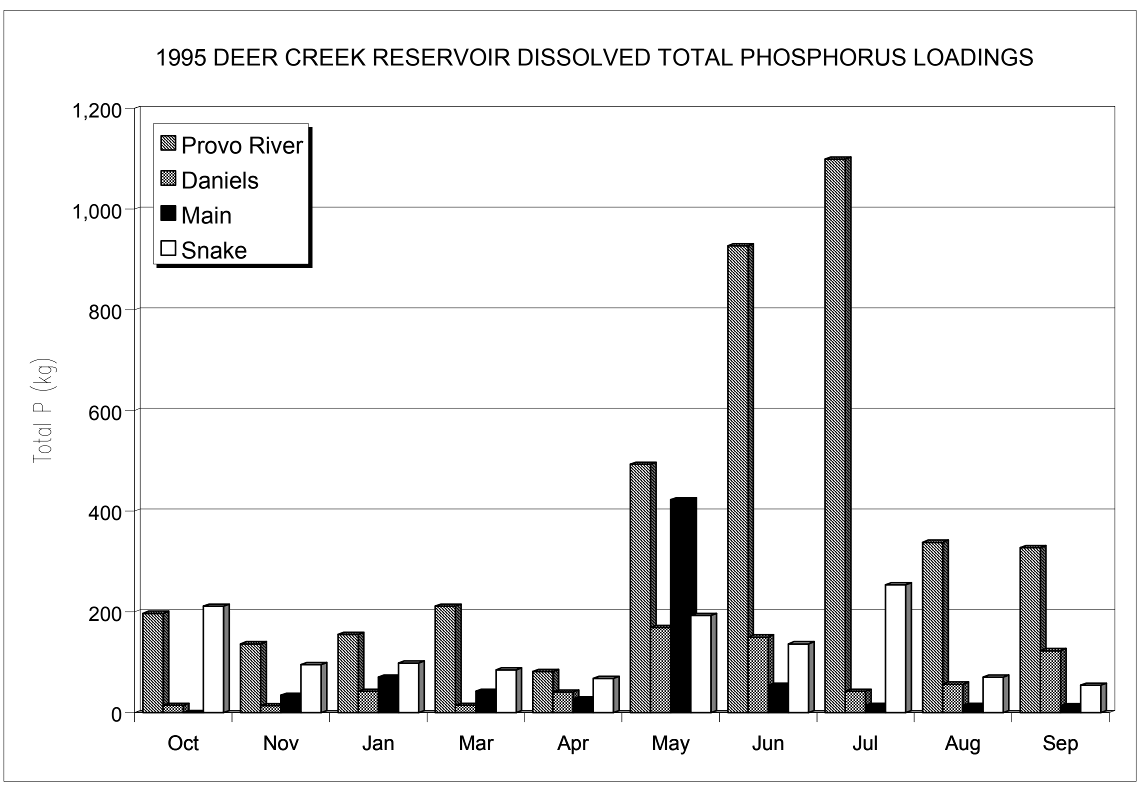

Figure 19 Dissolved Total Phosphorus Loads into Deer Creek Reservoir, 1995.

2. DTP Sources and Consequences

Some of the possible sources for DTP in the Provo River and it's tributaries include the following:

1. A high phosphorus content in the soils that creates a higher phosphorus equilibrium state in the water stream.
2. The effluent from the Kamas and Midway Fish Hatcheries.
3. The natural benthic processes that exist in lakes and streams whereby DTP is discharged from water with low dissolved oxygen.
4. The influence of animal and human wastes.
5. Urban runoff
6. Construction activities
7. Recreation
8. Septic tanks

3. Deer Creek Reservoir

It appears that the measures taken to reduce the TP loads entering Deer Creek Reservoir are working. The average yearly TP loads have decreased from over 32,000 kg/yr during the time period of 1980-1984 to just over 19,000 kg/yr. During the same period, the Carlson Trophic State Index, a measure of the nutrient state of the lake, indicates a general trend from eutrophic to mesotrophic. It should be noted that average yearly flows into the reservoir have also decreased during this time period and the TP loadings and concentrations are significantly influenced by the amount of water that runs off the watershed in any particular year. These reductions are illustrated in Table 14.

Table 14 Average TP Load, TSI, Flow, TP concentration and DTP Concentration into Deer Creek Reservoir for four five year segments.

Period	Average TP Load (kg/yr)	Trophic State Index	Average Annual Flow (cfs)	Average FWA TP Conc. (mg/l)	Average FWA DTP Conc. (mg/l)
1980-1984	32,817	53.99	335.5		
1985-1989	24,861	48.59	254.4	0.069	
1990-1994	19,628	44.86	191.8	0.065	0.0248
1995-1996	19,172	40.05	212.0	0.059	0.0255

4. Jordanelle and Deer Creek Interdependence

There is the potential for increase DTP inflow into Deer Creek Reservoir because of the increase in the DTP concentration in the outflow from Jordanelle Reservoir. During 1995 there was an increase of 2100 kg of DTP from Hailstone to below

Jordanelle dam. (Figure 20) This suggests that a low DO condition at the bottom of the reservoir may be causing DTP production in Jordanelle Reservoir also. This could have an overall detrimental influence to the water quality in Deer Creek Reservoir.

During 1996, the Selective Level Outlet Works (SLOW) at Jordanelle Dam was operational for the first time. Initial indications were that the operation of the SLOW helped to limit the amount of phosphorus being released into the Provo River below the dam. During 1996 there was only a 146 kg increase in DTP loads. However, it is too early to tell if the decrease was due to the SLOW or other factors. The study of the influence of the SLOW on DTP release below Jordanelle Reservoir should be continued.

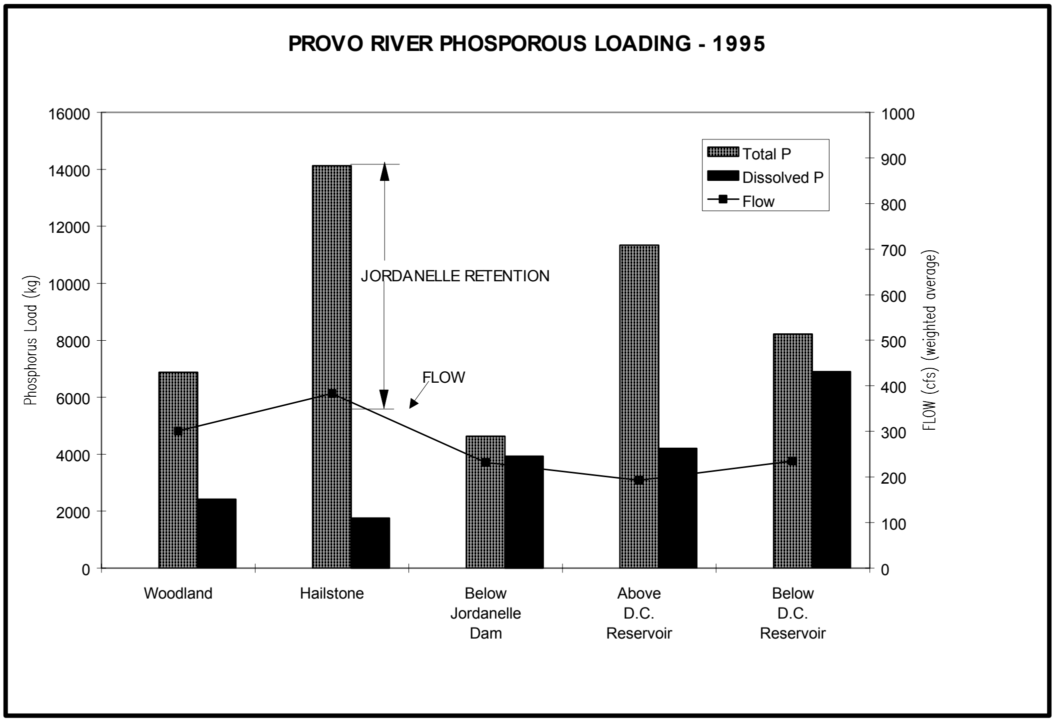

Figure 20 *TP and DTP loading during the 1995 water year at various water quality stations on the Provo River. The two reservoirs reduced the loading of Total Phosphorus but increased the load of Dissolved Phosphorus in their discharge.*

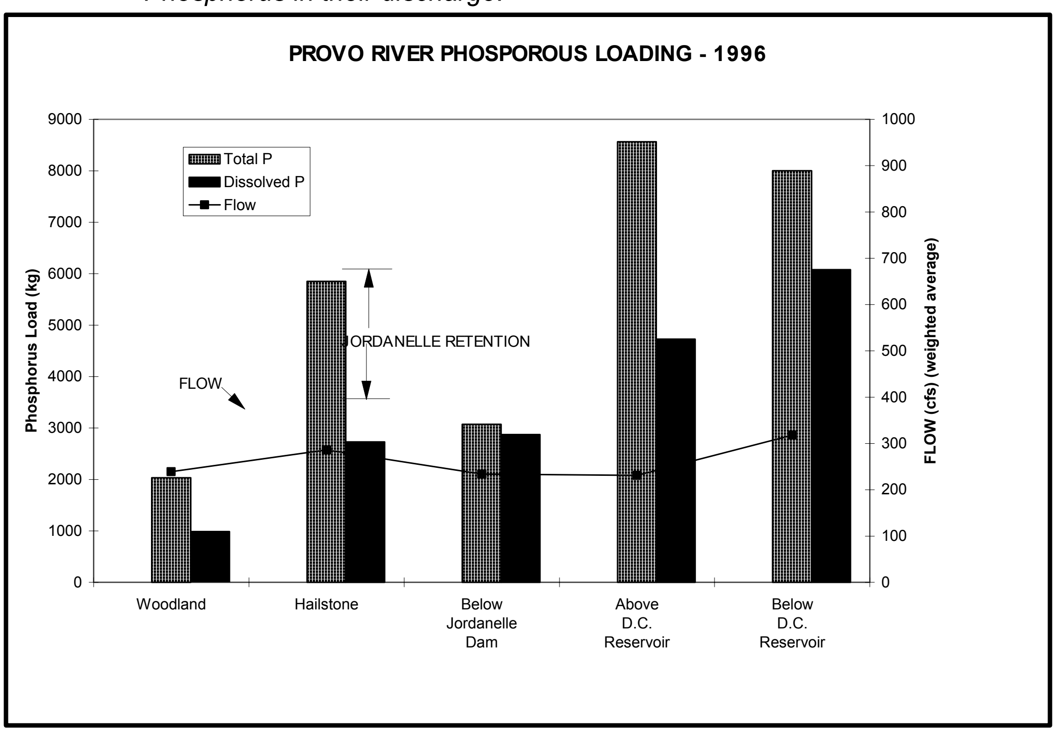

Figure 21 *TP and DTP loading during the 1996 water year at various water quality stations on the Provo River. The increase in DTP loads was*

limited below Jordanelle Reservoir. This is thought to be a result of the operation of the SLOW.

5. Fish Hatcheries

The effluent from the Kamas and Midway Fish Hatcheries continue to play a role in the amount of DTP entering both Deer Creek and Jordanelle Reservoirs. During the 1996 water year, the Midway Fish Hatchery discharged 432.6 kg of TP into the Provo River system. The Kamas Fish Hatchery is not required to monitor for TP in its UPDES permit. However, the State of Utah samples the Kamas Fish Hatchery discharge for TP and total dissolved phosphorus. In 1996, the Kamas Fish Hatchery discharged 236 kg of TP into Beaver Creek.

6. Groundwater

Another area which should be looked at more closely is the influence groundwater water quality has on the reservoir. Ever year it is estimated that almost 15% of the phosphorus load entering Deer Creek Reservoir comes from the groundwater. However, this is a guess at best. The phosphorus concentration and volume of water entering the reservoir should be calculated. A series of monitoring wells should be established and a regular sampling schedule developed in order to more accurately asses the impact the groundwater has on the reservoir water quality.

7. Golf Course Management

The golf courses currently in Wasatch County and those that have been proposed for new developments in the Upper Provo River Basin may have a detrimental influence on the water quality in the county. Return flows from golf courses are traditionally high in phosphorus because of the heavy fertilization that takes place. Water quality monitoring results have not indicated a problem at this golf course. Efforts should be made, however, to insure that phosphorus in not entering the water stream and further degrading the water quality in Deer Creek and Jordanelle Reservoirs.

IX. TMDL'S FOR PROVO RIVER BASIN

A. The TMDL Process

Section 303(d) of the Clean Water Act establishes the Total Maximum Daily Load (TMDL) process to provide for more stringent water quality-based controls when technology-based controls are inadequate to achieve State water quality standards. The TMDL process is a watershed management approach that measures how much of a given pollutant a water body or river can accommodate without exceeding its water quality standards or causing a loss of a beneficial use.

The TMDL is usually expressed as a load, or mass, of a particular pollutant. Numeric nutrient and sediment water quality standards for non-point sources are usually not developed by states. The State of Utah has a numeric water quality criteria of 0.05 mg/l for total phosphorus. The TMDL standards also allow an indicator or set of indicators to show a direct relationship to loading reductions such as application of irrigation BMPs to increase the efficiencies on a certain number of acres. By using the total mass instead of the concentration of a pollutant, easier comparisons can be made between different points in a river and the relative importance of different sources of the pollutant. A TMDL can be expressed as an allowable load for an entire drainage, for different reaches within a drainage, or for a receiving water body. Once an allowable load is determined, the actual loading can be compared to this value. If the actual measured loading is in excess of the TMDL, reductions must be made to attain the TMDL and the intended beneficial use.

The following eight review criteria are given by the EPA for establishing TMDLs:

- TMDLs result in maintaining and attaining water quality standards
- TMDLs have a quantified target or endpoint
- TMDLs include a quantified pollutant reduction target, but this target can be expressed in any appropriate manner
- TMDLs must consider all significant sources of the stressor of concern
- TMDLs are supported by an appropriate level of technical analysis
- TMDLs must contain a margin of safety and consider seasonality
- TMDLs apportion responsibility for taking actions
- TMDLs involve some level of public involvement or review

The TMDL established for phosphorus and TSS complies with these eight criteria. The TMDLs for TSS are construction of detention basins and replacement of flood irrigation with sprinkler irrigation to increase the irrigation efficiency of 1600 acres in Wasatch County. TMDLs for flow have already been established as low flow requirements for fisheries and the environment.

Pollutant loads are divided into several broad categories. Waste load allocations (WLA) are pollutant loads from point sources. In the Upper Provo Basin there are only two permitted point sources. These are the Midway Fish Hatchery and the United Park City Mines. The Kamas Fish Hatchery is a permitted point source that could effect the Upper Provo Basin via the Weber/Provo diversion canal.

Load allocations (LA) are pollutant loads from non-point sources. In this basin, these sources include agricultural runoff and irrigation return flows, stormwater inputs, unstable streambanks, runoff from construction activities and other sources. The TMDL also contains an estimate of background pollutants, defined either as the upstream load of a pollutant entering a reach controlled by a TMDL, or as an estimate of undisturbed or "natural" loading. Finally, the TMDL contains a margin of safety to assure protection of the resource over varying conditions.

The TMDL process is intended to be reviewed periodically. The first part of this process involves the Division of Water Quality's biennial report of their 303D list. This list contains the rivers or drainages which are not expected to achieve their water quality standards after the implementation of technology based controls. The 303D list for waters in the Upper Provo Basin were detailed previously in Table 13.

This report represents the second phase of this process. It involves identifying the LA's and WLA's of the Provo River and it's tributaries and tries to develop a management strategy for bringing the Provo River up to the State's water quality criteria. The third phase will be to evaluate the success of these recommendations and determine if they were adequate in meeting the water quality needs of the basin. With the implementation of water quality improvement strategies, continued monitoring and a refining of the TMDL's must still occur. Inherent to the basin wide nature of this method is a more coherent and well integrated plan for improving and maintaining water quality throughout the Upper Provo River Basin. (Bear River)

B. Public Involvement

In order to better understand the needs and concerns of the involved agencies, a number of meetings have been held. Preliminary results and progress was presented to members of the Jordanelle Technical Advisory Committee (JTAC) in December 1995. In addition another meeting was held in December between members of the CUWCD, Wasatch County Planning Department, Wasatch County Engineering Department and the Salt Lake City Department of Public Utilities. This meeting was held to discuss the more technical details of the management plan and the TMDL process. Furthermore, the results of this TMDL analysis were presented to JTAC on March 26, 1996, to the Wasatch County Water Board on April 19, 1996 and to the Wasatch County Commissioners on April 22, 1996.

C. Developing TMDL's for the Upper Provo River Basin

The TMDL for a given stream segment consists of two parts, a concentration and a flow. Each part will be discussed in more detail below.

1. Contaminant Concentrations

The choice of concentration used in the determination of TMDL serves a number of purposes. It should insure that the acute water quality standards set forth by the state are not exceeded as well as provide a level of safety in case projected flows and actual in-stream concentrations differ from what is projected. As a result of the recommendations made in the 1984 Sowby and Berg report, JTAC as adopted a pollution indicator concentration of 0.04 mg/l for total phosphorus as the target concentration rather than the state water quality standard of 0.05 mg/l. By using the JTAC indicator in computing the TMDL a factor of safety of 20% is automatically introduced into the TMDL for TP. A similar factor of safety of 20% will also be used for the other TMDL calculations. Also, for the margin of safety for a non-point source, the TMDLs require post-implementation monitoring to assure control practices are working and water quality endpoints are being met.

2. Flow

The next step is to determine the appropriate flow to be used for the TMDL. The Provo River watershed has a number of unique segments with different flow as well as pollution characteristics. For this reason and so each segment could have a unique management scenario developed, the entire Upper Provo River Basin was divided into smaller sub basins. The terminus for each sub basin was selected such that water quality and water quantity data were available for an extended period of time. The sub basins are listed in Table 15 and shown in Figure 22.

Table 15 Sub Watershed names and terminus locations.

NAME	AREA (MI^2)	TERMINUS	USGS #	USBR #	STORET #	LATITUDE	LONGITUDE
Provo River @ Woodland	162	Woodland USGS Gage	10154200		499840	40°33’18”	111°10’04”
Provo River @ Hailstone	68	Hailstone USGS Gage	10155000		499808 499813	40°36’03”	111°19’51”
Provo River @ Jordanelle	22	Jordanelle Dam	10155100	1004	499733	40°35’42”	111°25’41”
Provo River @ Charleston	98	Confluence with Snake Creek	10155500	1008	591363	40°29’03”	111°27’46”
Provo River @ Deer Creek	33.6	Deer Creek Dam	10159500		591321	40°24’12”	111°31’44”
Snake Creek	31.8	Confluence with Provo River	10156000	1010	591016	40°29’07”	111°27’59”
Daniels Creek	60.2	Inlet into Deer Creek Reservoir	10157500	1011	591352	40°25’54”	111°21’07”
Main Creek	71.4	Inlet into Deer Creek Reservoir		1013	591346		

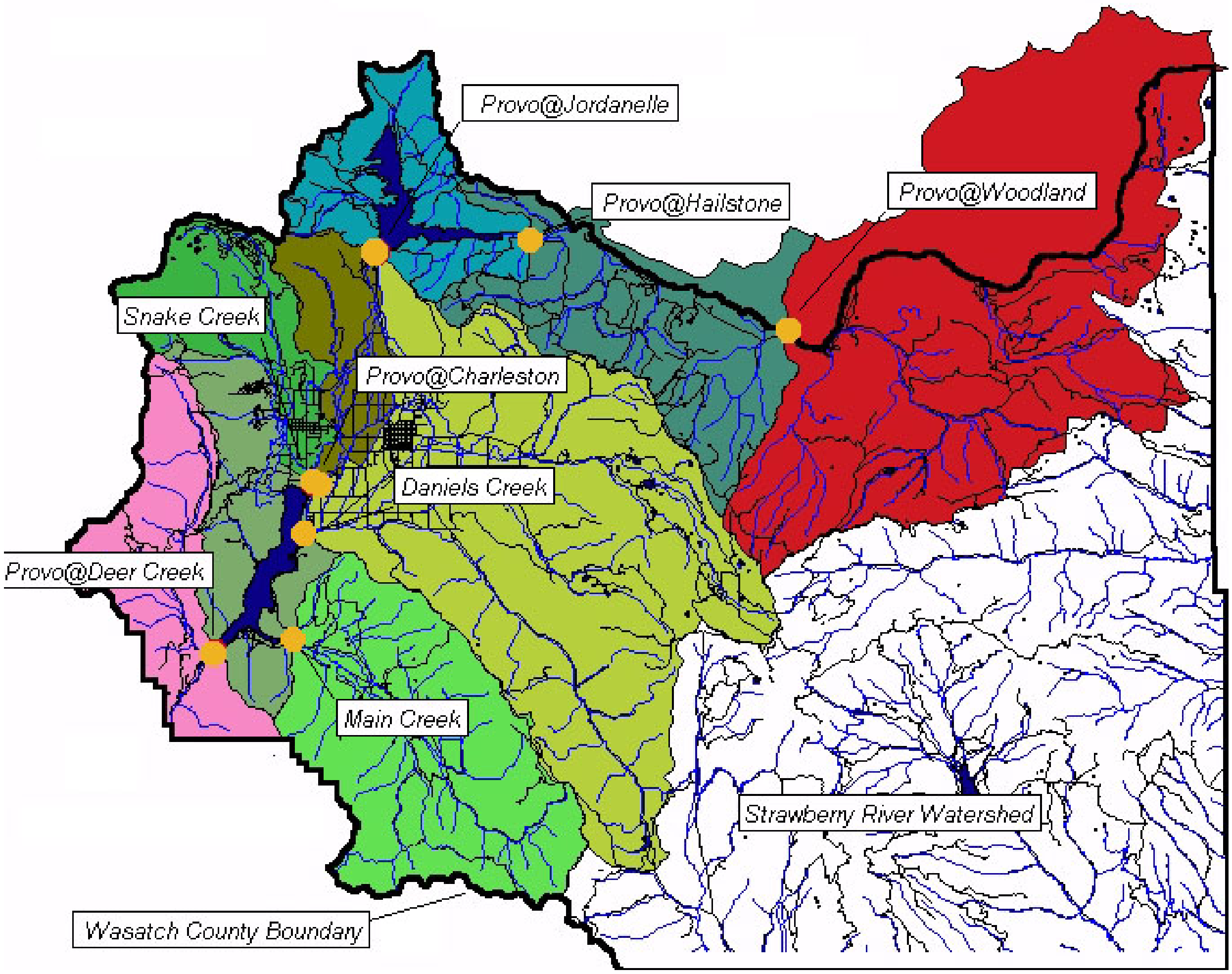

Figure 22 Sub Watershed boundaries and terminus locations.

Typically the EPA $_7Q_{10}$ flow has been used for determining the TMDL flow. The $_7Q_{10}$ is calculated by determining the minimum consecutive 7 day flow average for a specific period and then finding the 10 year return period for this flow. Table 16 compares the $_7Q_{10}$ flow with the median, average, maximum and minimum flows at each sub basin terminus.

Table 16 Summary of flow statistics for sub watershed stream segments.

WATERSHED NAME	USGS # USBOR #	USEPA $_7Q_{10}$ (cfs)	MEDIAN (cfs)	AVE. (cfs)	MAX. (cfs)	MIN. (cfs)	PERIOD OF RECORD
Provo @ Woodland	10154200	32.8	80.0	216.5	6,040	16	7/12/63-9/30/93
Kamas Fish Hatchery	492900	3.6	5.3	5.7	14.2	0.81	2/24/77-8/27/98
Provo @ Hailstone	10155000	23.7	103.0	275.0	6,100	11	10/1/49-9/30/93
Provo @ Jordanelle	10155100	29.2	85.0	202.4	2,920	23	10/1/91-9/30/94
Provo @ Midway	10155500	12.0	89.0	190.3	2,280	13	10/1/88-9/30/94
Provo @ Deer Creek	10159500	37.2	313.0	362.4	2,260	0	5/1/53-9/30/93
Snake Creek	10156000	25.7	46.0	49.0	126	19	4/16/93-9/30/94
Daniels Creek	10157000	0.0	5.3	14.4	170	1.1	5/1/93-9/30/94
Main Creek	10158500	3.2	14.0	26.0	399	0	10/1/84-9/30/90

As can be noted from Table 16, the $_7Q_{10}$ flow is substantially smaller than the other flows. This is because the TMDL was created to set a maximum load that the river segment can handle. In rivers that do not experience large seasonal variations, the $_7Q_{10}$ gives a good flow value to work with. However, because most of the flow in this Upper Provo River basin occurs during the spring runoff, a TMDL based on the $_7Q_{10}$ low flow unrealistically limits the loading that is allowed during spring runoff. If the $_7Q_{10}$ approach is followed, then the allowable concentration of phosphorus, or any constituent, would be almost zero during high flow periods.

In water bodies that experience large flow fluctuations, such as the Provo River and its tributaries, the $_7Q_{10}$ flow was found to be unusable in creating a management approach. Therefore, in order to help create a more manageable TMDL, the average flow was used. Furthermore, the average flow was found and a TMDL calculated for each month during the water year. This approach more closely approximates the natural conditions and provides targets that can actually be attained and was approved by the State Division of Water Quality. The TMDL based on average flow calculated on a monthly basis allows problem areas to be more easily identified and allows projects to be designed to better meet the needs of the water in the basin.

Below Jordanelle Dam and below Deer Creek Reservoir, recent changes in the operation procedures create a unique situation for determining the TMDL flow. As part of the Environmental Impact Statement for the Jordanelle Dam and Reservoir a compact was signed concerning water flow to insure adequate water in the River for fish and other beneficial uses. This compact states that the flow in the Provo River below Jordanelle Dam cannot go below 50 cfs during the time of filling. After the regular operation of the dam begins, the flow cannot go below 125 cfs. In addition, because of the numerous diversions from the river just below the dam, the compact also states that the flow in the river at the US40 bridge, minus the diversions cannot be below 20 cfs during filling and 125 cfs after filling. Therefore, the minimum flow and the TMDL flow for this reach of the river will be 125 cfs.

Below Deer Creek Reservoir, similar agreements insure adequate flow for fish and other beneficial uses in that reach of the river. This agreement states that the flow from the dam combined with the flow from Little Deer Creek must equal 100 cfs. Therefore, the minimum flow and the TMDL flow will be 100 cfs.

3. TMDL Values

Using the average flows calculated from flow data and based on the assumptions described above, a TMDL for total phosphorus was generated for each stream segment. Table 17 shows the sum of the monthly total phosphorus TMDL loads along with the six-year average total phosphorus load for each stream segment. Table 18 shows the monthly TP TMDL for each stream segment.

Table 17 TP TMDL load and 1995 TP loads for stream segments in the Upper Provo River Basin.

WATERSHED NAME	SUM OF MONTHLY TMDL'S TP - kg/yr	SIX YEAR FWA TP LOAD - kg/yr
Provo @ Woodland	7,681	3,644
Kamas Fish Hatchery	173	322
Provo @ Hailstone	9,837	9,601
Provo @ Jordanelle	8,685	4,786
Provo @ Charleston	8,428	9,830
Provo @ Deer Creek	12,788	8,796
Snake Creek	1,747	1,828
Daniels Creek	488	1,753
Main Creek	916	1,431

Table 18 Monthly Total Phosphorus TMDL loads (kg/yr) for each stream segment in the Upper Provo River Basin.

WATERSHED NAME	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Provo @ Woodland	220	192	184	178	163	218	570	2337	2277	743	359	241
Kamas Fish Hatchery	12.9	11.7	13.6	11.0	14.1	14.1	14.9	18.4	17.7	17.8	14.4	12.2
Provo @ Hailstone	257	277	275	263	260	344	903	3085	2847	783	308	234
Provo @ Jordanelle	303	294	303	303	284	303	524	2478	2099	1020	434	340
Provo @ Charleston	334	375	387	377	386	556	912	2143	1869	433	334	323
Provo @ Deer Creek	630	546	686	619	596	738	952	1815	2437	1513	1260	997
Snake Creek	155	150	142	134	126	151	144	168	180	142	127	127
Daniels Creek	18	11	11	11	11	14	39	186	107	31	30	20
Main Creek	47	47	54	55	95	123	210	156	51	25	24	30

These TMDLs must meet the criterion given by the EPA. The manner in which each requirement is attained is summarized in Table 19. Following Table 19, Figure 23 through Figure 30 show the monthly loading calculated for each stream segment along with the load from the 1996 water year in comparison to the monthly TMDLs.

Table 19 Summary of TMDL Required Criteria Checklist

Requirement	Comment
• TMDLs result in maintaining and attaining water quality standards	Since the CUWCDs Deer Creek Model validated the 0.04 mg/l TP as a good goal to improve water quality in Deer Creek. This concentration was incorporated into the TMDL calculations, meaning that reaching TMDL goals, in essence, should correspond with meeting the 0.04 mg/l goal as well.
• TMDLs have a quantified target or endpoint	Several endpoints could be used to determine our target. For this watershed a target has already been established by JTAC for the in-stream concentration of TP of 0.04 mg/l. This target is also tied into the calculation of the TMDLs, which act as a target in of itself. The TMDLs individually serve as a quantifying target load for each stream segment. Another basin-wide target has come from earlier reports on the watershed, which set the goal of 12,000 kg/year of TP discharge into Deer Creek Reservoir.
• TMDLs include a quantified pollutant reduction target, but this target can be expressed in any appropriate manner	This plan has set the TMDLs in terms of a mass loading per month; from which, a mass loading per year for each stream is also derived. The value of each TMDL indicates the level of reduction needed for each stream segment. Also, certain projects within the basin should reduce TP loading to Deer Creek Reservoir as described in Table 20.
• TMDLs must consider all significant sources of the stressor of concern	The analysis of data in this plan has identified the possible sources of phosphorus and the recommended actions have been given to control them.
• TMDLs are supported by an appropriate level of technical analysis	To determine the TMDLs, an analysis of phosphorus data and stream flows has been the major technique used to determine appropriate targets.
• TMDLs must contain a margin of safety and consider seasonality	A margin of safety of 20% has been incorporated into the TMDLs, mostly due to the difference between the state standard for TP concentration of 0.05 mg/l and the JTAC standard of 0.04 mg/l. The TMDLs are set as monthly loads which incorporates the seasonality of stream flows and phosphorus concentrations.
• TMDLs apportion responsibility for taking actions	This plan makes several recommendations that are likely to improve water quality conditions. Also, the plan identifies several phosphorus control actions and estimates the reduction of loading anticipated from these actions. In Table 20 of the plan, certain reductions and responsibilities are outlined.
• TMDLs involve some level of public involvement or review	Since JTAC is comprised of several federal, state, local, and private entities, discussions within JTAC has helped facilitate public involvement and review. Also this plan has been reviewed and comments have been addressed by several agencies.

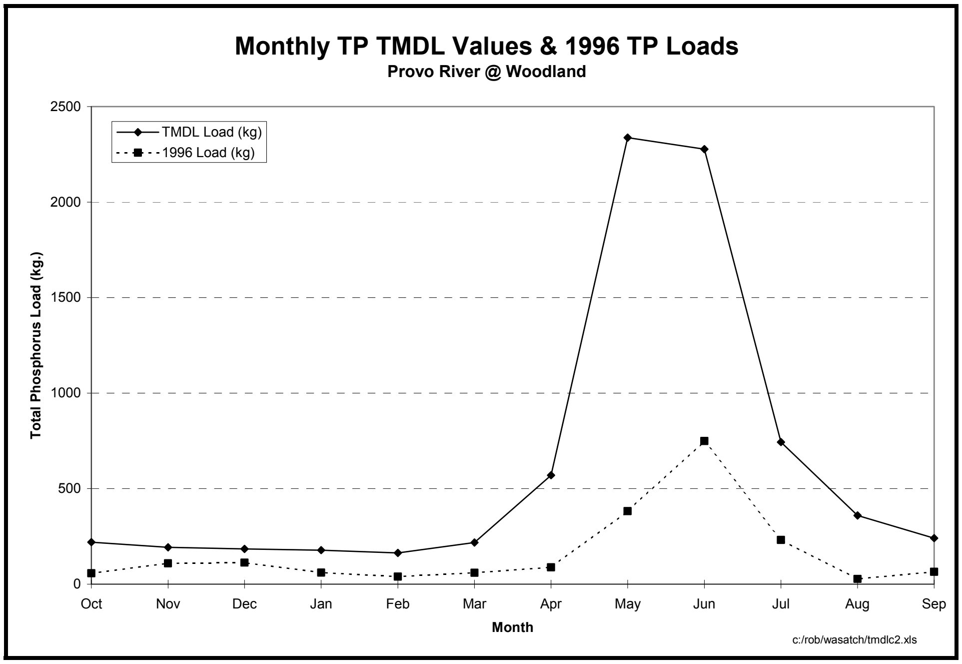

Figure 23 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads at the Provo River at Woodland Site.

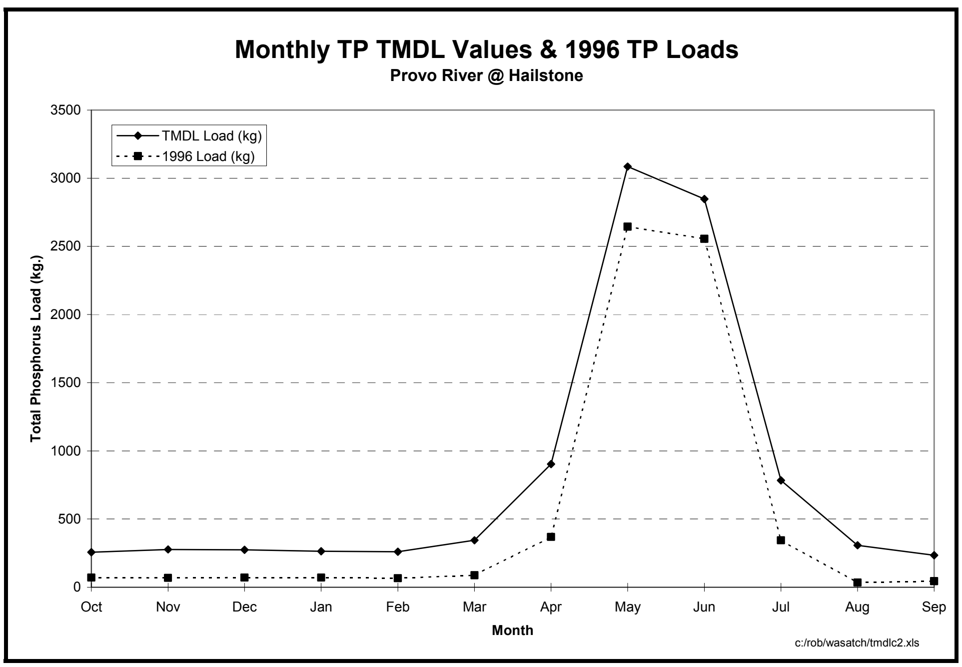

Figure 24 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads at the Provo River Below at Hailstone Site.

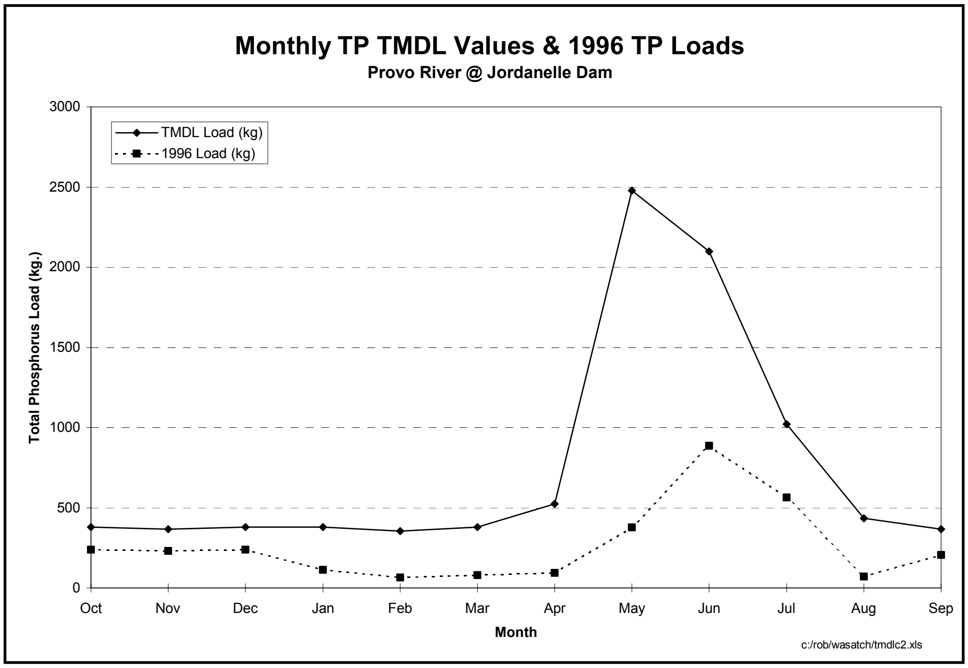

Figure 25 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads at the Provo River Below Jordanelle Dam Site.

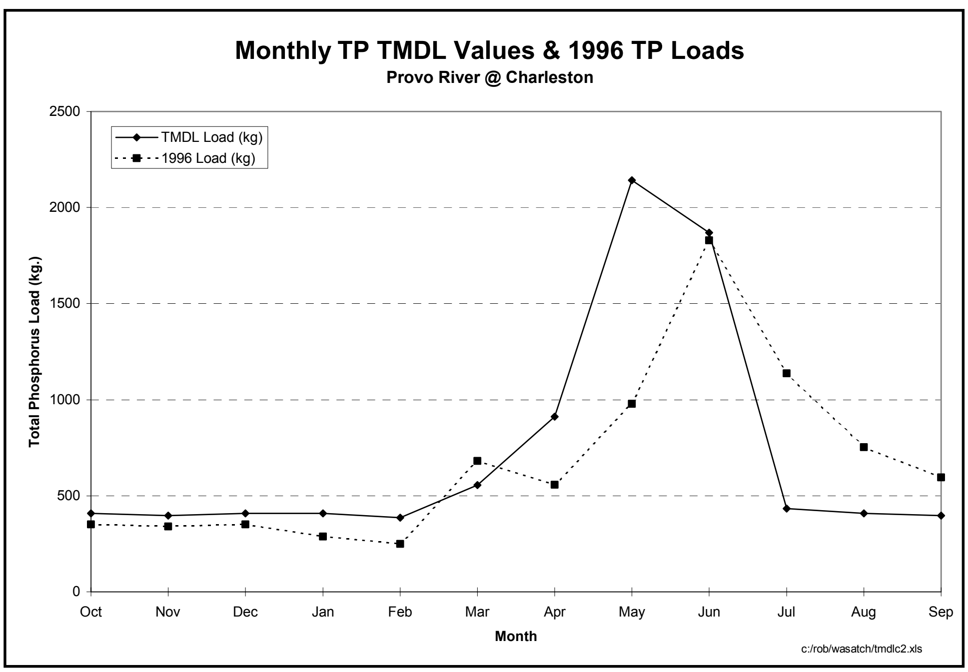

Figure 26 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads at the Provo River at Charleston Site.

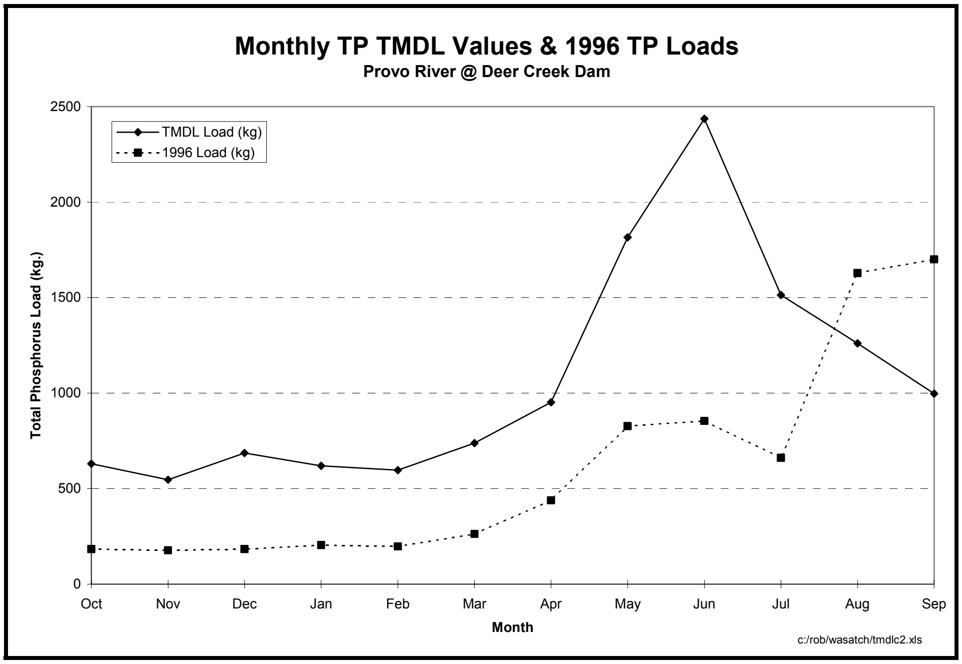

Figure 27 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads at the Provo River Below Deer Creek Dam Site.

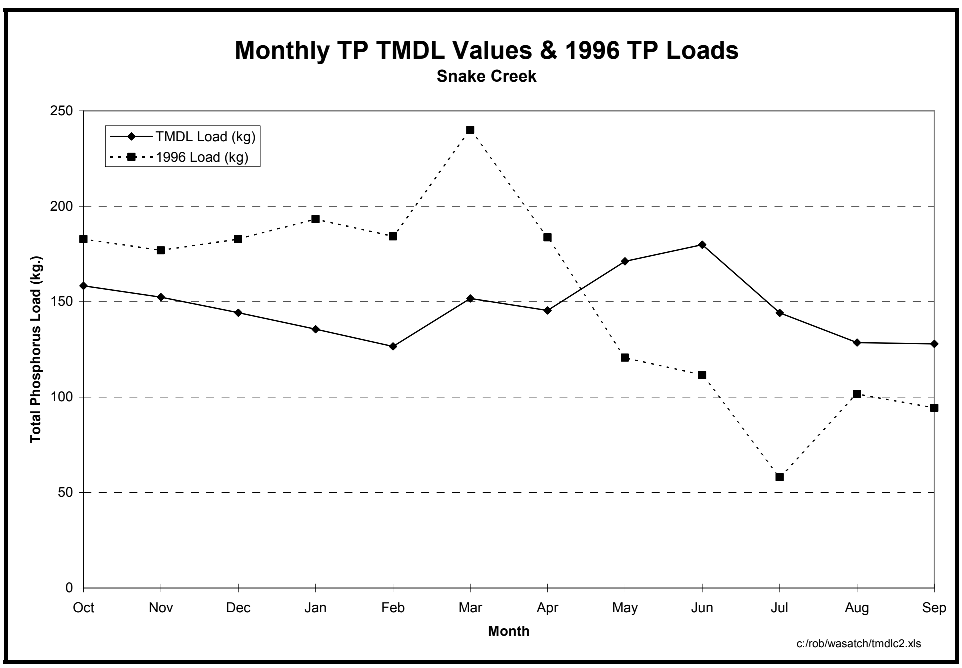

Figure 28 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads in Snake Creek.

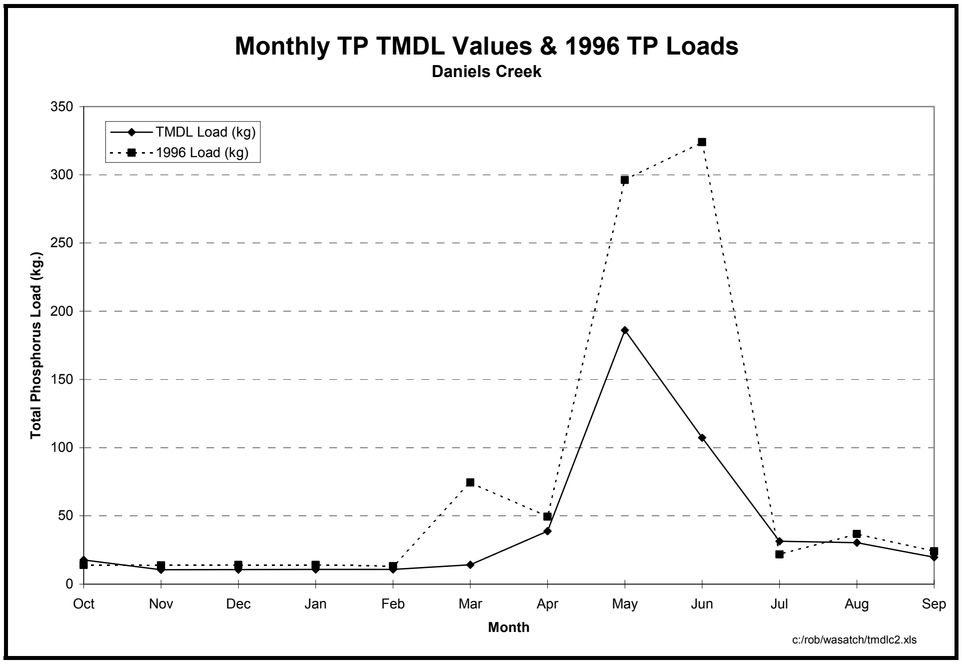

Figure 29 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads in Daniels Creek.

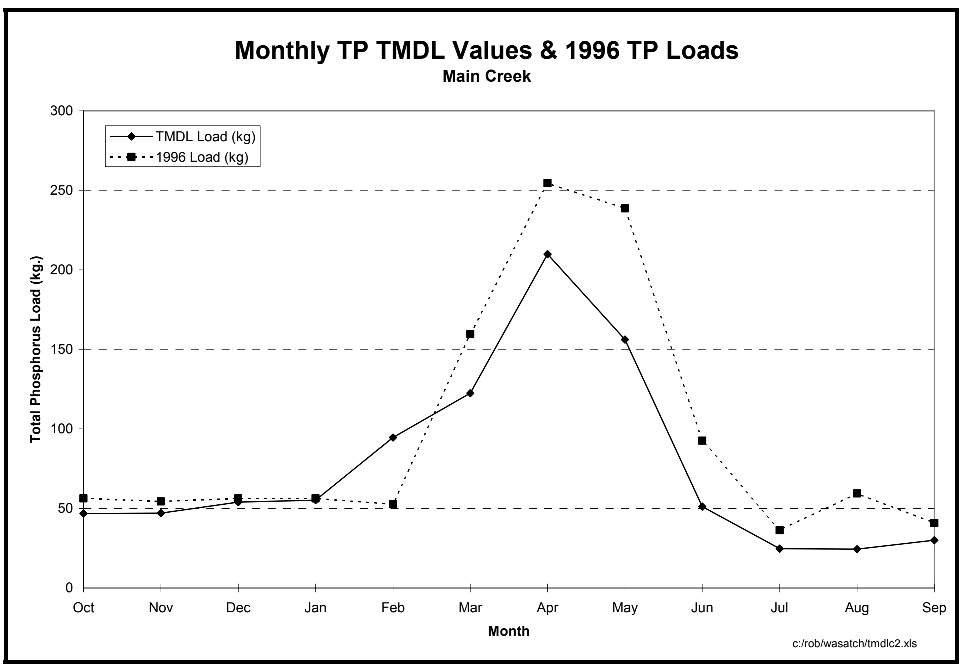

Figure 30 Monthly Total Phosphorus Loads and 1996 Total Phosphorus Loads in Main Creek.

X. RECOMMENDATIONS FOR TARGETED SEGMENTS

A. *Potential Reduction in Phosphorus Loading*

The main goal of this management plan is to identify reduction strategies to limit the phosphorus loading into Jordanelle and Deer Creek Reservoirs. Therefore this section will present a number of possible management scenarios to help reduce total phosphorus levels. Each sub basin mentioned above will be addressed separately. This section focuses only on phosphorus because it is the nutrient of primary concern.

1. Provo River above Jordanelle Reservoir

Non-point sources are the primary cause of total phosphorus loads in the section of the Provo River between Woodland and Hailstone. These loads can have an effect on the water quality of Jordanelle Reservoir. Farming and grazing practices in this area should be observed and Best Management Practices implemented where necessary. Furthermore, stream banks should be examined to determine if stream bank erosion is a significant problem during spring runoff.

Many new developments are being planned that will be located in the Provo River Drainage above Jordanelle Reservoir. Wasatch County currently has adopted the manual *A Guide for Erosion and Sediment Control* to be followed for all new development. This guide should be strictly enforced to limit the impact that these developments will have on the water quality in the area. Furthermore, all new developments should comply with Wasatch County guidelines for Storm Water Management as outlined in *A Guide for Erosion and Sediment Control* that call for the containment of the entire runoff volume from a 2-year, 24-hour storm event. Following these measures will help limit the impact to the water quality in the upper Provo River basin.

Approximately 40% of the Provo River drainage above Jordanelle Reservoir lies within Summit County. JTAC should work with Summit County officials to insure that similar measures are being taken in that county to insure good water quality in the Provo River.

2. Provo River below Jordanelle Reservoir

The operating agreement governing the release of water out of Jordanelle Reservoir currently requires the monitoring and regulating of DO and temperature in the outlet waters. The efforts by the BOR and the CUWCD to closely monitor the outlet temperature and DO should be continued. Furthermore, a study should be conducted to see if the operation of the SLOW to maintain the temperature and DO also has an effect on the TP concentrations. Early results from the 1996 water year suggest that TP concentrations and loads are impacted by the operation of the SLOW tower. Continued effort should be made to evaluate the effectiveness of the SLOW to improve the water quality in the Provo River below the dam.

3. Provo River above confluence with Snake Creek

The majority of total phosphorus entering this section of the Provo River can be attributed to storm water runoff, spring snowmelt runoff, and the return flow from irrigation in the valley. These flows bring with it contaminants picked up from the land as the water flows over it. With the increasing urbanization in Wasatch County, storm water runoff is expected to increase as a significant source of pollution. JTAC is currently creating a Storm Water Management Plan to evaluate the best options on how to control the quality and quantity of storm water and irrigation return flow entering the Provo River. Wasatch County and JTAC should adopt the measures suggested in this plan and work on their implementation.

4. Provo River below Deer Creek Reservoir

The Provo River below Deer Creek Reservoir is influenced primarily by the water quality in the reservoir. Since much of the water released from the reservoir is for culinary purposes, it is important to maintain the water quality in the reservoir. Therefore most of the efforts discussed previously are primarily aimed at improving the water quality in Deer Creek Reservoir. In addition to the efforts discussed previously, efforts should be made to support the Resource Management Plan being adopted by the Bureau of Reclamation for the operation of Deer Creek Reservoir.

5. Snake Creek above confluence with Provo River

A major source of phosphorus in Snake Creek comes from the Midway Fish Hatchery. The fish hatchery has a UPDES permit of 626 kg/yr of total phosphorus. During 1999 429 kg of TP was introduced into Snake Creek by the Fish Hatchery. This marks a trend of decreasing TP discharge from the hatchery. Continued efforts should be made to maintain this trend of low TP loads coming from the hatchery. These efforts include maintenance of sedimentation ponds and the use of low phosphorus food for the fish.
In addition, efforts should be made to implement Best Management Practices and erosion control measures in this area. This could include a fertilizer management plan to help reduce the phosphorus from the golf courses in the area. The United States Golf Association has conducted a great deal of research on how to limit the environmental impacts of golf courses. A number of publications have been published and it is recommended that these resources be fully investigated and more specific recommendations made.
Because much of Snake Creek flows through the town of Midway, an effort to coordinate water quality efforts with the town should be made. The forthcoming Stormwater Management Plan should detail ways in which the County and town of Midway can work together to improve the water quality in Snake Creek.

6. Daniels Creek above Deer Creek Reservoir

Daniels Creek continues to have poor water quality. This is largely attributed to the high percentage of irrigation return flows and from spring and storm runoff. Many of the dairy farms which contributed to the poor water quality in Daniels Creek have been sold and therefore, animal waste is not as great a concern as it has been in the past. However, because of the continued poor water quality, additional efforts must be made. This can include implementation of best management practices and implementation of the forthcoming Stormwater Management Plan. Potential projects which can improve the water quality include stormwater basins and detention facilities on the canals and tributaries that feed Daniels Creek.

7. Main Creek above Deer Creek Dam

Main Creek has consistently had phosphorus concentrations above state water quality standards. Factors that have contributed to this poor water quality include spring snowmelt and stormwater causing streambank erosion and irrigation return flows. The Tri-Valley report suggests that septic tank failure might also be contributing to this problem. However, this has not been confirmed. JTAC should continue efforts to help landowners implement Best Management Practices and support other efforts of erosion control in this area.

The current workplan for the Stormwater Management Plan that has been discussed in this document only pertains to the Heber Valley and not to Round Valley. It is recommended that a similar document be prepared for Round Valley so that measures to reduce TP in Main Creek be considered.

B. Potential Phosphorus Reductions to Deer Creek Reservoir

Table 20 presents anticipated reductions in TP due to the various management techniques discussed in this document. Attempting to put a numeric figure on the amount of phosphorus removed by certain management techniques is not an exact science. The actual amount of a particular constituent that is removed depends on a variety of factors. The potential reductions due to the operation of the SLOW is based on data from the 1996 water year, the only year for which data is available when the SLOW was operational. Potential reductions in Heber Valley to the implementation of the Stormwater Management plan are based using detention ponds to trap sediments that contain phosphorus.

Table 20 Anticipated reductions in total phosphorus due to various management techniques.

MANAGEMENT STRATEGY	RESPONSIBILITY	POTENTIAL REDUCTION
Additional Reductions with Operation of SLOW Tower at Jordanelle Reservoir	CUWCD & USBR	2,800 kg/yr
Water Efficiency and Daniel Replacement Projects	CUWCD	100 kg/yr
Provo River Restoration Project	URMCC	100 kg/yr
Tri-Valley Watershed Improvements	NRCS	300 kg/yr
Stormwater Management	Wasatch County	448 kg/yr
Total Potential Reductions		3,748 kg/yr

C. Future Monitoring

Jordanelle has the greatest potential to release high DTP concentrations and loads from late August through November. After Heber Valley irrigation diversions stop in September, the full phosphorus load will be conveyed to the Deer Creek Reservoir. Deer Creek has the greatest potential to respond with blue-green algae blooms from mid September to mid November depending on temperatures. Therefore, with the Jordanelle Dam in operation greater emphasis needs to be placed on nutrient and plankton monitoring in the Provo River, Jordanelle and Deer Creek Reservoirs in September, October, and November. This may require dropping a sampling period in June or July. Greater sampling emphasis is needed from August to October to better determine the best operating procedures for the Jordanelle SLOW tower to produce the greatest benefit to

Deer Creek Reservoir. JTAC should consider this issue when evaluating next year's sampling schedule.
Continued efforts should be made to trace the sources of DTP entering the water system. This could have profound impact on reducing the DTP concentrations in Deer Creek Reservoir. In addition, efforts should be made to monitor the DTP levels of the water being discharged from the Jordanelle Reservoir. As has been noted, if the DTP concentration of water discharged from Jordanelle and thus entering Deer Creek Reservoir continues to increase, then the water quality problems in Deer Creek Reservoir might be compounded.
In order to help understand the impacts that activities in Heber Valley are having on the groundwater quality, a groundwater monitoring program should be implemented. This will help to insure that the water quality of the Heber Valley Aquifer is not being negatively impacted.

D. General Recommendations

1. The operation of the SLOW tower should be continued in accordance with the forthcoming SLOW operational plan. This will help to limit the amount of phosphorus, in dissolved and total form, from reaching Deer Creek Reservoir.

2. Programs that help to reduce erosion from the tributaries should be continued. This would include implementation of best management practices and erosion control efforts recommended in the Tri-valley report.

3. Provide educational information programs about water quality.

4. Develop and implement policies which will limit pollutants from new developments. This will include construction runoff as well as storm runoff from the finished facilities.

5. Continue to monitor the effectiveness of the indicators we are currently using to assess the value of the water quality control programs that are currently in place.

6. Evidence shows that spring runoff is the primary source of the total phosphorus load entering Deer Creek Reservoir. On average over 60% of the TP load entering Deer Creek Reservoir enters during the three months of the spring runoff and the majority of that load is in the form of suspended solids. This suggests that a series of strategically located stormwater detention basins could reduce the amount of total

phosphorus entering the reservoir from tributary streams by about 25%. These settling basins should be located at the terminus of the canals and ditches that catch the runoff and prevent the suspended solids from reaching the tributary streams.

7. Another area which should be looked at more closely is the influence groundwater quality has on Deer Creek Reservoir. Ever year it is estimated that almost 15% of the phosphorus load entering Deer Creek Reservoir comes from the groundwater. However, this is a guess at best. The phosphorus concentration and volume of water entering the reservoir should be calculated. A series of monitoring wells should be established and a regular sampling schedule developed in order to more accurately asses the impact the groundwater has on the reservoir water quality.

8. JTAC is currently developing a Stormwater Management Plan to evaluate options for controlling stormwater and spring runoff. This study will focus especially hard on the water quality considerations of stormwater and spring runoff. Wasatch County and JTAC should make every effort to adopt and implement the recommendations of this report.

E. Other Applicable Recommendations from 1984 Plan

The original water quality management plan that was prepared in 1984 by Sowby and Berg listed several recommended actions to reduce phosphorus loading. Many of these recommendations have already been implemented and therefore no longer apply to the watershed. The recommendations that still apply to the watershed have been included in this management plan to reinforce these important issues that have either not yet been addressed or only partially been addressed. They are as follows:

1. No Municipal Phosphorus Discharge

Require no-discharge, total containment or land application for all new future sewerage systems containing municipal wastes or domestic sewage effluents containing phosphorus for the entire Provo River drainage above Deer Creek Reservoir. This is now the case in the entire watershed with the construction of the Heber Valley Special Service District land application facility.

2. Private Developments

Require that any new private development be subject to regulations for control of runoff, pollutant control, and plan review similar to that required of Deer Valley and Mayflower Mountain Resorts. This means proper monitoring, feasibility studies, engineering evaluations, and signed agreements for compliance prior to construction.

3. Public Developments

Implement a process whereby any public development, be it state, federal or local, including recreational developments or facilities built around Deer Creek Reservoir or the proposed Jordanelle Reservoir, comply with the same requirements as for private developments. Also, continue the review process by State County Health Departments whereby proper sanitation facilities are constructed.

4. Amend County Zoning Ordinances

Require that zoning ordinances of Wasatch and Summit County be amended to prohibit runoff or discharges from animal concentration from entering any live stream or waterway that reaches Deer Creek Reservoir or the proposed Jordanelle Reservoir. A time limit should also be established for the elimination of all nonconforming uses to this amendment.

5. Mayflower Tailings

Upon construction of the Mayflower Mountain Resort, require the developers to include stabilization of the Mayflower tailings ponds in their plans. This should include preventing runoff or seepage of water from other polluted mines or mine dumps where water issues from the mine and runs over or through said dumps.

6. Public Education

Mount a public education campaign in cooperation with the Utah State Department of Agriculture, Soil Conservation Service, Soil Conservation Districts, etc. to control over-application of water and consequent runoff from farm lands, grazing lands, winter feeding operations, and pastures. This could mean encouraging sprinkler irrigation and implementing various practices to reduce the runoff from pasture and winter feeding operations. Also, the appropriate agency should be involved in assisting the farmers and ranchers with their plans for implementing BMPs in order to be eligible for certain types of federal assistance.

7. Continued Study and Funding

Continue the work and funding of the Deer Creek/Jordanelle Technical Team. There is need for continued effort in coordinating and reviewing plans of all agencies concerned with water quality monitoring, improvement, or enforcement. One additional task could be to conduct an aggressive educational campaign program on the need to reduce pollution in these streams and reservoirs. Funding for this effort should be supported by the following groups: Salt Lake City Metropolitan Water District, Central Utah Water Conservancy District, U. S. Bureau of Reclamation, State Department of Health, U. S. Environmental Protection Agency, and others.

8. Other Restoration Techniques

Continue to consider other restoration techniques or phosphorus reduction programs. There may be others that may have not yet proven cost-effective, been demonstrated as needed or conceived. There may still be other reductions achievable with little or no effort.

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