

Heber Valley Storm Water Management Plan



June 2000

DRAFT

Prepared For:

Wasatch County

Prepared By:

P S O M A S

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Executive Summary

Introduction

The Heber Valley Stormwater Management Plan is an effort to first, identify canals that can be used for urban and agricultural stormwater runoff; and second, to control the pollution from runoff of the local streams and reservoirs through the planning of sediment settling ponds throughout the Heber Valley.

Problem Definition

The problem with Heber Valley is that the majority of the streams have high concentrations of the nutrient phosphorus. The streams in the valley are exceeding the indicator standards that have been set to maintain healthy water in Deer Creek. The majority of the phosphorus exceedences occur in the runoff season. And it has been discovered that phosphorus levels are directly related to stream flow. Meaning that higher flows have higher concentrations of phosphorus. The Best Management Practice (BMP) for removing these pollutants is through sediment basins and/or wetlands. This plan gives a proposal for the implementation of these BMPs in the Heber Valley.

Heber Valley Drainage

Drainage in the Heber Valley is complex because of the old irrigation canals that criss-cross natural drainage paths. These canals have been identified in this plan in Figure 9 and a GIS database has been created for Wasatch County. Along with this identification process, a hydrology study was performed to determine the 2-year storm, peak flows in each of the canals to aid in the planning of detention/sediment basins. The results of this drainage study are given in the following table:

Executive Summary

Sub-Basin	Flow (cfs)	Settling Basin Size (ac-ft)
<i>Epperson Ditch</i>	76	12.6
<i>Snake Creek</i>	286	47.3
<i>Upper Provo River</i>	117	19.3
<i>Lower Provo River</i>	61	10.1
<i>Westside Ditch</i>	70	11.6
<i>Daniels Canyon</i>	298	49.3
<i>Timpanogos Canal</i>	33	5.5
<i>Center Creek – Timpanogos</i>	36	6.0
<i>Daniels 1</i>	32	5.3
<i>Wasatch Canal</i>	52	8.6
<i>Lake Creek</i>	382	63.1
<i>Humbug Canal</i>	5	0.8
<i>Lower Lake Creek</i>	26	4.3
<i>Sage Brush & Spring Creek</i>	206	34.0
<i>Daniels 2</i>	1	0.2
<i>Middle Ditch</i>	41	6.8
<i>Rock-Spring-Upper Charleston</i>	46	7.6
<i>Daniels 3</i>	1	0.2
<i>Lower Charleston</i>	2	0.3
<i>Daniels 4</i>	1	0.2

The second column shows the size of basin that would have a 2-hour detention time to allow for the removal of sediments and pollutants.

Sediment Basin Alternatives

ALTERNATIVE A

Two alternatives for locating sediment basins have been prepared. Alternative A is the original proposed alternative which sited ten sediment basins in the Heber Valley that would be used to detain the two-year storm shown in the table above for two hours. These ten locations with basin size are as follow (see map in Figure 13):

- Rock Ditch (7.6 acre-feet)
- Middle Ditch (11.6 acre-feet)
- Spring Ditch (5.5 acre-feet)
- Lake Creek (63.1 acre-feet)
- Big Hollow Creek (0.2 acre-feet)
- Wasatch/Humbug Canal (8.8 acre-feet)
- Sagebrush & Spring Creek Canal (34 acre-feet)
- Upper Charleston Canal (7.6 acre-feet)
- Lower Charleston Canal (0.3 acre-feet)
- Epperson Ditch (12.6 acre-feet)
- Snake Creek (47.3 acre-feet)

These basins would provide pollution reduction advantages as well as reduction of flood peak discharges.

Executive Summary

ALTERNATIVE B

Alternative B is the result of recommendations by the County to reduce the number of sediment basins for capital costs and maintenance concerns. Four locations have been identified. These ponds are located near the mouths of Daniels Creek, Snake Creek, the Flood Channel and Spring Creek (See Figure 14). Because of the locations, it is not necessary to reduce flood peak discharges less conservative basin sizing criteria was used. It was determined the two-year peak daily flow (based on USGS gage stations) could be used. These ponds would more fully incorporate the wet pond BMP design that would provide better pollutant reduction through integration of wetlands. Especially in terms of dissolved phosphorus removal

COMPARISON OF ALTERNATIVES

Both alternatives have advantages and disadvantages. Alternative A has larger ponds that would have flood control advantages as well as pollutant reduction advantages. Yet, Alternative B would only provide pollutant reduction advantages. The pollution reduction capabilities of Alternative B, however, would be enhanced over Alternative A. Aesthetically, the wet ponds of Alternative B could be nicely incorporated into a park feature that could even provide fishing opportunities. Alternative A would be less aesthetic especially the larger basins that would require large dikes. The costs in terms of maintenance and capital facilities favors Alternative B, since it has fewer and smaller basins. The capital costs of Alternative A and B are estimated at approximately \$2,000,000 and \$800,000, respectively.

The following table is a summary of the comparison of alternatives using a rating scale for each criteria of 1 to 4:

<i>Alternative</i>	<i>Pollution Reduction Scale (1- 4)</i>	<i>Flood Control Scale (1-4)</i>	<i>Aesthetic Features</i>	<i>Capital and O&M Costs</i>	<i>Total Score</i>
<i>A – Ten Detention /Sediment Basin</i>	3	4	1	2	10
<i>B – Four Wet Ponds</i>	4	1	4	4	13

This table indicates that Alternative B may be a better alternative based on the given criteria. However, if flood control is needed in the valley, Alternative A may need to be seriously considered instead.

Implementation Plan

The implementation plan is crucial to action being taken on the issues presented in this plan. The following steps are recommended in the implementation plan:

Executive Summary

1. Wasatch County should identify or create an administrative body,
2. The administrative body should identify funding sources from State and Federal programs,
3. Easements and right-of-ways should be collected for canals that are used for conveyance,
4. Detention ponds should be designed and constructed per this plan
5. The administrative body should continue oversight of costs, operations and maintenance.

This plan is an excellent opportunity for Wasatch County to take a step towards a clean water and an improved environment. The Federal and State funding should be available for these improvements. It is confidently recommended that the implementation of this plan be pursued.

Chapter 1: Introduction

The Heber Valley Stormwater Management Plan is an effort to first, identify canals that can be used for urban and agricultural stormwater runoff; and second, to control the pollution from runoff of the local streams and reservoirs through the planning of sediment settling ponds throughout the Heber Valley.

The identification of required storm water routes would be beneficial so that the county can maintain the required canals by acquiring access easements. The sediment basins would help capture much of the pollutants and help prevent them from being transported further downstream into Deer Creek Reservoir. The benefits of implementing this plan will allow the water quality impact of Heber Valley's continual development to be minimized. Cleaner water will be beneficial to Wasatch County and all other Provo River basin water users.

Scope of Work

This plan is based on a hydrologic analysis of the Heber Valley drainage basin completed by EWP Engineering. The hydrologic analysis required information on soil type, land use, vegetation, basin geography and precipitation events. From this analysis, maximum storm water runoff flows were determined in the canals and streams. These flows are the basis for sizing proposed settling basins throughout the valley.

Psomas has created a GIS (Geographical Information System) database of the streams and canals to help identify the drainage patterns in the basin. From this database an assessment of the storm drainage system was made to help identify basin locations and canals needed for flood conveyance.

This plan presents the recommended locations for sediment basins. It also presents a recommended plan of implementation for the design and construction of the needed basins and obtaining flood conveyance easements in private canals.

Contents

Contained in this plan are the following Chapters:

Chapter 2 – Heber Valley Pollution Problem: This chapter discusses the pollution problems in Deer Creek Reservoir particularly, phosphorus pollution. A presentation of the relationship between suspended sediments and dissolved phosphorus is given.

Chapter 3 – Heber Valley Area Description: This chapter discusses the relevant hydrologic characteristics of the Heber Valley. The drainage of the valley is described

Chapter 1

with a GIS map of the important streams and canals. The results of the EWP hydrologic study are presented as well.

Chapter 4 – Sediment Basin Alternatives: This chapter discusses two alternative plans that will help in management of storm water. The first alternative is a plan for detention/sediment basins that will control peak flood discharges and capture sediments. The second alternative is a plan for sediment basins that would be designed to capture sediments and not control peak flood levels.

Chapter 5 – Implementation Plan: This chapter discusses the steps to implementation of this Storm Water Management Plan.

Chapter 2:

Heber Valley Pollution Problem

The Provo River Watershed supports many beneficial uses to the people in Wasatch, Utah and Salt Lake County. These uses included drinking, irrigation, fishing, swimming, boating, and water skiing. The water quality must be protected to ensure its safe use.

The main problem with this watershed is maintaining a healthy balance of nutrients. Too many nutrients, a condition called eutrophication, can cause major problems in Deer Creek Reservoir because of excessive algae growth. Some types of algae can produce toxic conditions in water, which severely limits the water use for drinking and recreation. Algae also contribute to other water quality problems such as bad taste and odors, depleted oxygen levels, and fish kills.

History of Phosphorus Monitoring

In 1981, because of eutrophication evidences in Deer Creek Reservoir, Utah Governor Scott Matheson established the Jordanelle Reservoir Water Quality Technical Advisory Committee (JTAC). The JTAC was organized for the purpose of developing a reservoir management plan for Deer Creek Reservoir and the then future Jordanelle Reservoir. JTAC is comprised of over twenty federal, state, local, and private agencies.

In 1984, the Water Quality Management Plan for Deer Creek and Jordanelle Reservoirs was implemented by JTAC. The plan identified phosphorus as the principle problem with eutrophication in Deer Creek Reservoir and set a goal of reducing total phosphorus concentrations in streams to 0.04 mg/l. This was 20% lower than the State of Utah pollution indicator concentration, which is 0.05 mg/l.

Since this time, JTAC has been monitoring water quality in the basin. In 1999, JTAC released the draft of Upper Provo River Water Quality Management Plan, which ascribes TMDLs to nine stream segments along the upper Provo River including the segments of Snake Creek, Daniels Creek and the Provo River through Heber Valley. Figure 1 illustrates the monitoring results for 1998, showing the creeks that flow into Deer Creek Reservoir and the total suspended sediment (TSS), total phosphorus (TP), and total dissolved phosphorus (TDS) annual load. It also indicates how often each monitoring point recorded an exceedence of the 0.04 mg/l total phosphorus standard in 1998.

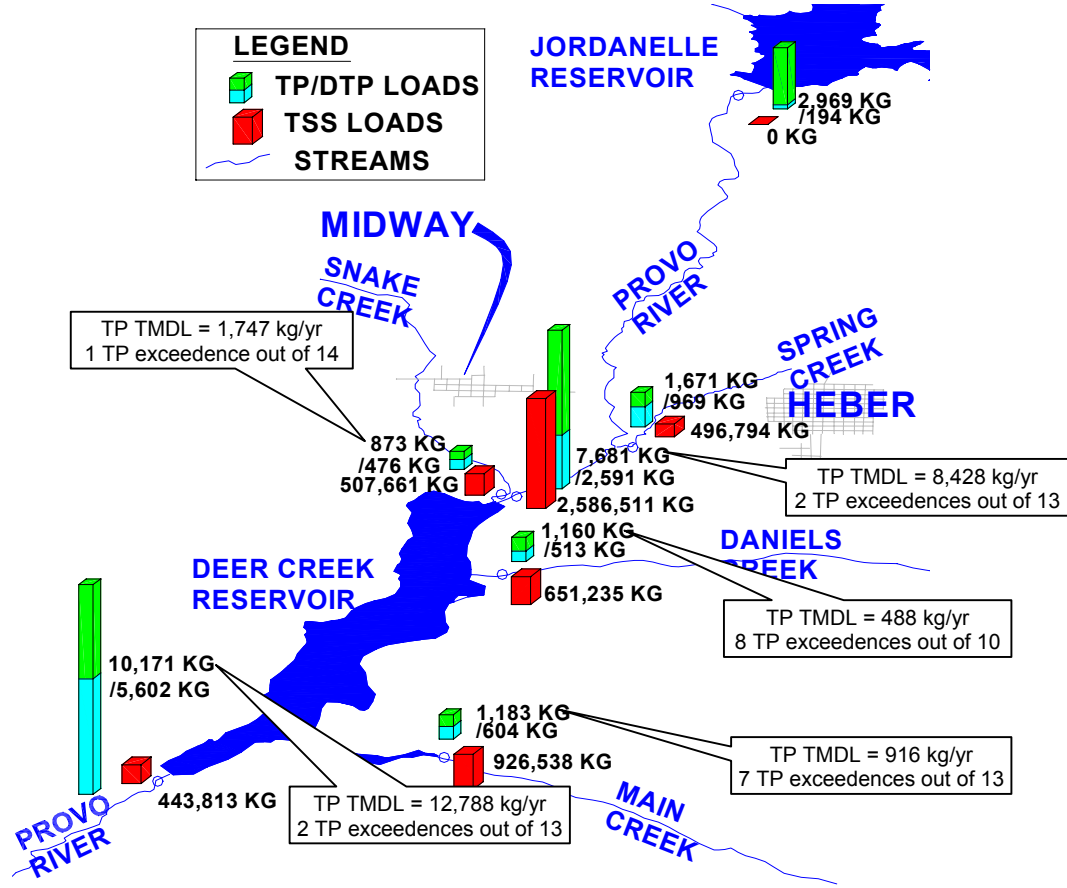


Figure 1. Map of Total Phosphorus, Dissolved Phosphorus and Total Suspended Solids Loads

This map shows the increase in TSS, TP, and DTP loads as the Provo River meanders through the Heber Valley. The increased pollutant loads indicate that the Heber Valley is a significant pollution contributor. This graphic also shows the contributions of Spring Creek, Daniels Creek and Snake Creek to the phosphorus loading to Deer Creek Reservoir.

In Table 1, the historical water quality figures for TSS, TP, and DTP are presented. This table shows that historically the phosphorus loads increase 2.5 times in the Provo River through the Heber Valley.

Table 1. Heber Valley 1993-1998 Stream Loadings

	1993	1994	1995	1996	1997	1998
Provo River below Jordanelle, STORET 499733						
Weighted Average Flow (cfs)	317	139	238	270	324	350
TP Weighted Average (mg/l)	0.036	0.022	0.020	0.015	-	0.010
TP Annual Load (kg/yr)	10,271	2,722	4,272	3,496	-	2,969
DTP Weighted Average (mg/l)	-	-	0.021	0.012	-	0.001
DTP Annual Load (kg/yr)	-	-	4,367	2,876	-	194
TSS Weighted Average (mg/l)	11.6	5.2	0.0	0.1	0.0	0.0
TSS Annual Load (kg/yr)	3,286,183	648,241	0	19,957	0	0
Spring Creek at Provo River, STORET 499725						
Weighted Average Flow (cfs)	-	-	-	-	25	35
TP Weighted Average (mg/l)	-	-	-	-	-	0.054
TP Annual Load (kg/yr)	-	-	-	-	-	1,671
DTP Weighted Average (mg/l)	-	-	-	-	-	0.031
DTP Annual Load (kg/yr)	-	-	-	-	-	969
TSS Weighted Average (mg/l)	-	-	-	-	28.3	15.9
TSS Annual Load (kg/yr)	-	-	-	-	634,393	496,794
Provo River above Deer Creek, STORET 591363						
Weighted Average Flow (cfs)	314	138	198	262	303	332
TP Weighted Average (mg/l)	0.077	0.040	0.060	0.047	-	0.026
TP Annual Load (kg/yr)	21,671	4,975	10,472	10,866	-	7,681
DTP Weighted Average (mg/l)	-	-	0.025	0.025	-	0.009
DTP Annual Load (kg/yr)	-	-	4,478	5,773	-	2,591
TSS Weighted Average (mg/l)	24.2	7.7	27.1	11.2	18.6	8.7
TSS Annual Load (kg/yr)	6,778,611	944,936	4,774,856	2,629,371	5,025,665	2,586,511
Snake Creek above Deer Creek, STORET 591016						
Weighted Average Flow (cfs)	45	38	50	54	48	57
TP Weighted Average (mg/l)	0.057	0.058	0.061	0.038	-	0.017
TP Annual Load (kg/yr)	2,259	1,934	2,690	1,860	-	873
DTP Weighted Average (mg/l)	-	-	0.029	0.023	-	0.009
DTP Annual Load (kg/yr)	-	-	1,270	1,134	-	476
TSS Weighted Average (mg/l)	5.4	11.0	14.0	8.7	10.1	10.1
TSS Annual Load (kg/yr)	213,742	369,582	616,915	421,925	431,283	507,661
Provo River TP Increase Ratio	2.1	1.8	2.5	3.1	-	2.6

Many actions have occurred in Wasatch County to help control phosphorus pollution in the watershed. One of the benefits of the Jordanelle Reservoir is its retention of much of the phosphorus that was being transported down from the upper portion of the Provo River. In a sense, the Jordanelle Reservoir can be considered a large settling basin. There are other projects in the process of being implemented which will help water quality such as the Wasatch County Water Efficiency Project, the Provo River Restoration Project, Tri-Valley Watershed Improvements, and Jordanelle SLOW Tower Revised Operation Plan.

Stormwater management is one of these next steps to be implemented to help control phosphorus pollution. Stormwater is the major transportation method for phosphorus pollution from agricultural and urban sources. Since a great portion of phosphorus is tied to storm runoff sediments, stormwater settling ponds would help reduce the pollution of phosphorus as well as other urban pollutants.

Relationship of Runoff, Total Phosphorus and Dissolved Total Phosphorus

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. The following is the result of the study performed as part of the 1999 Upper Provo River Water Quality Management Plan.

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 vary directly with the average flow in the river (Figure 2). 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 2. 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 3.

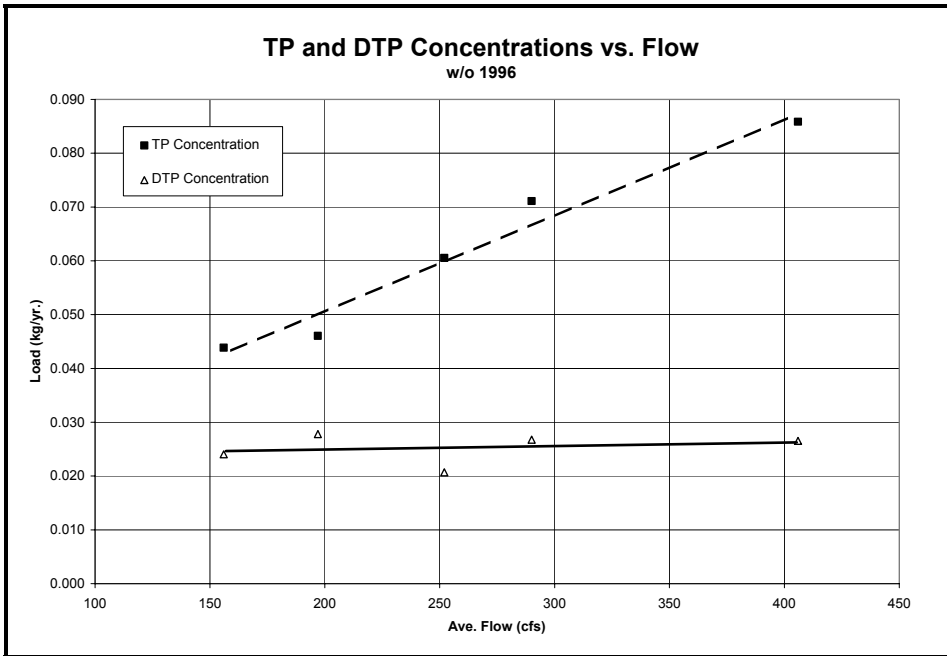


Figure 2. Flow Weighted Total Phosphorus and Dissolved Total Phosphorus Concentrations Into Deer Creek Reservoir Plotted Against Average Flow Into Deer Creek Reservoir For Five Years From 1991-1995.

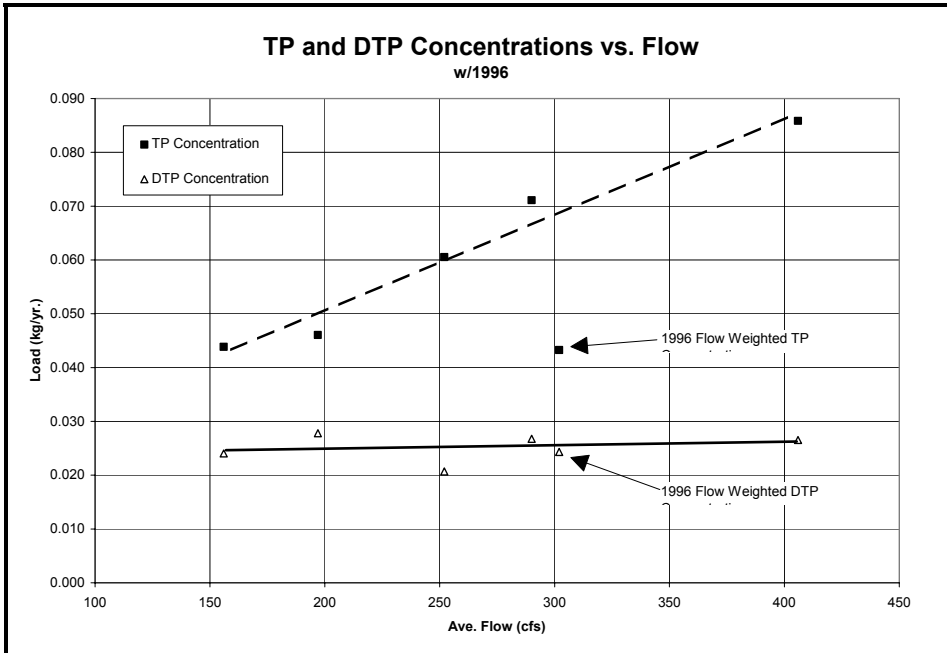


Figure 3. Flow Weighted Total Phosphorus And Dissolved Total Phosphorus Concentrations Into Deer Creek Reservoir Plotted Against Average Flow Into Deer Creek Reservoir For Five Years From 1991-1995. The Impact Of The SLOW Operation On TP Concentrations Is Clearly Seen.

Figure 4 through Figure 6 show the TP and DTP concentrations versus average flow at various 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.

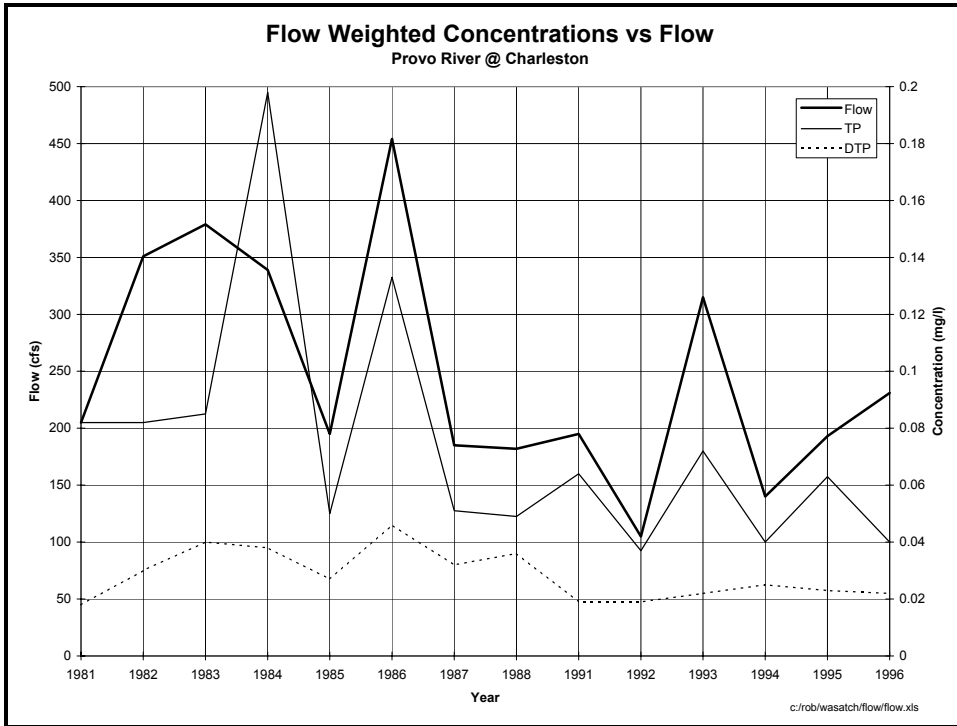


Figure 4. TP, DTP and Flow comparison in Provo River at Midway; 1981-1988, 1991-1996.

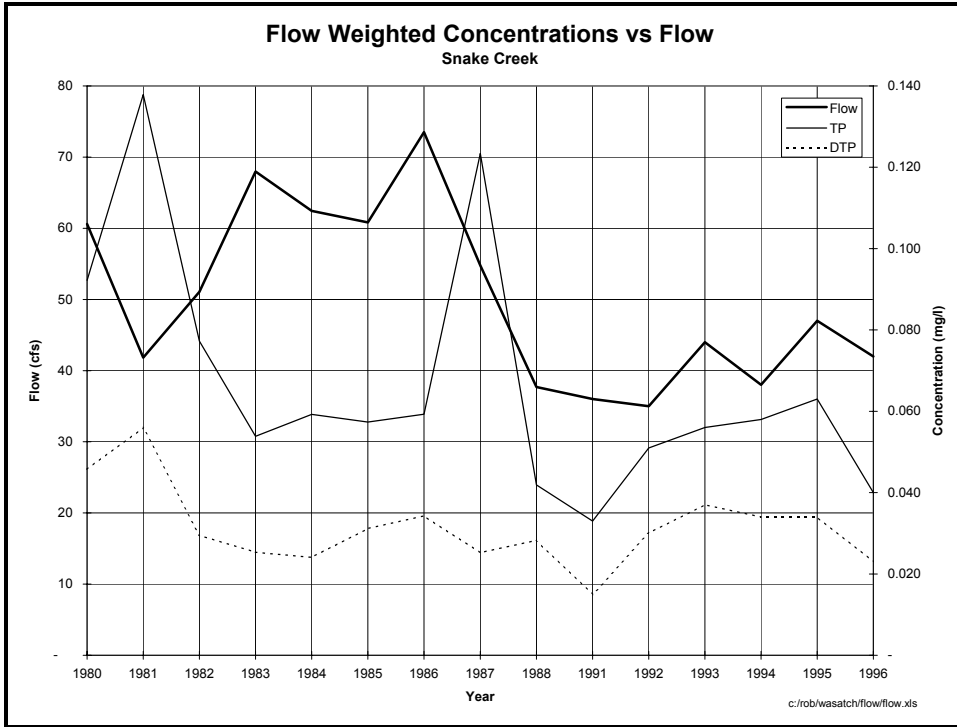


Figure 5. TP, DTP and Flow comparison in Snake Creek; 1981-1988, 1991-1996.

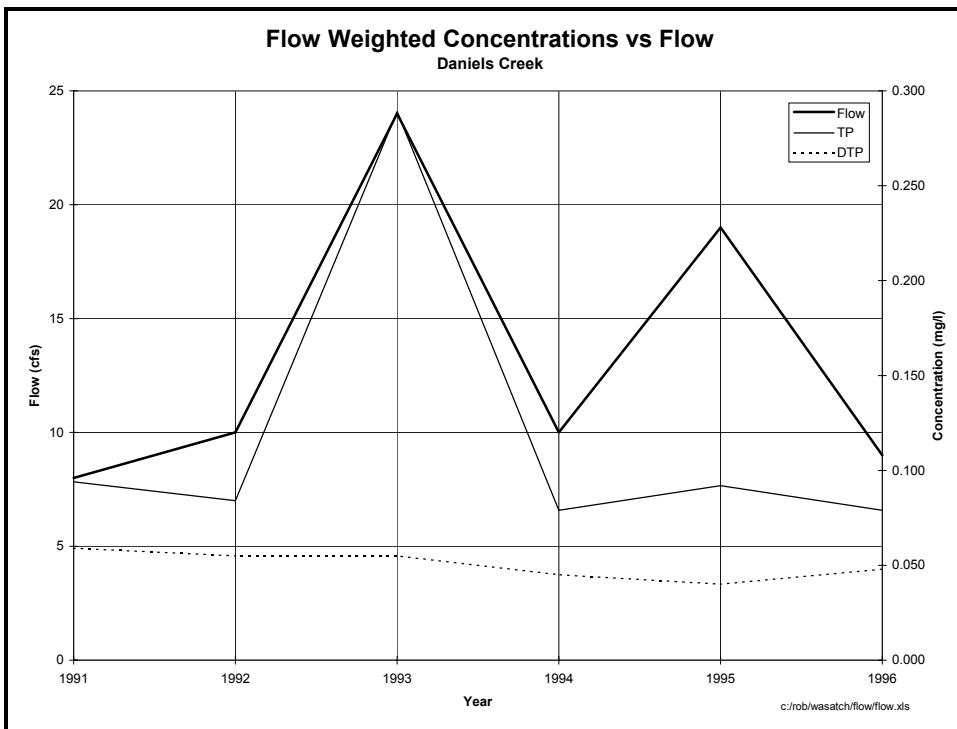


Figure 6. TP, DTP and Flow comparison in Daniels Creek; 1991-1996.

Chapter 2

In observing Figure 4 through Figure 6, 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 7 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 8).

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 that 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.

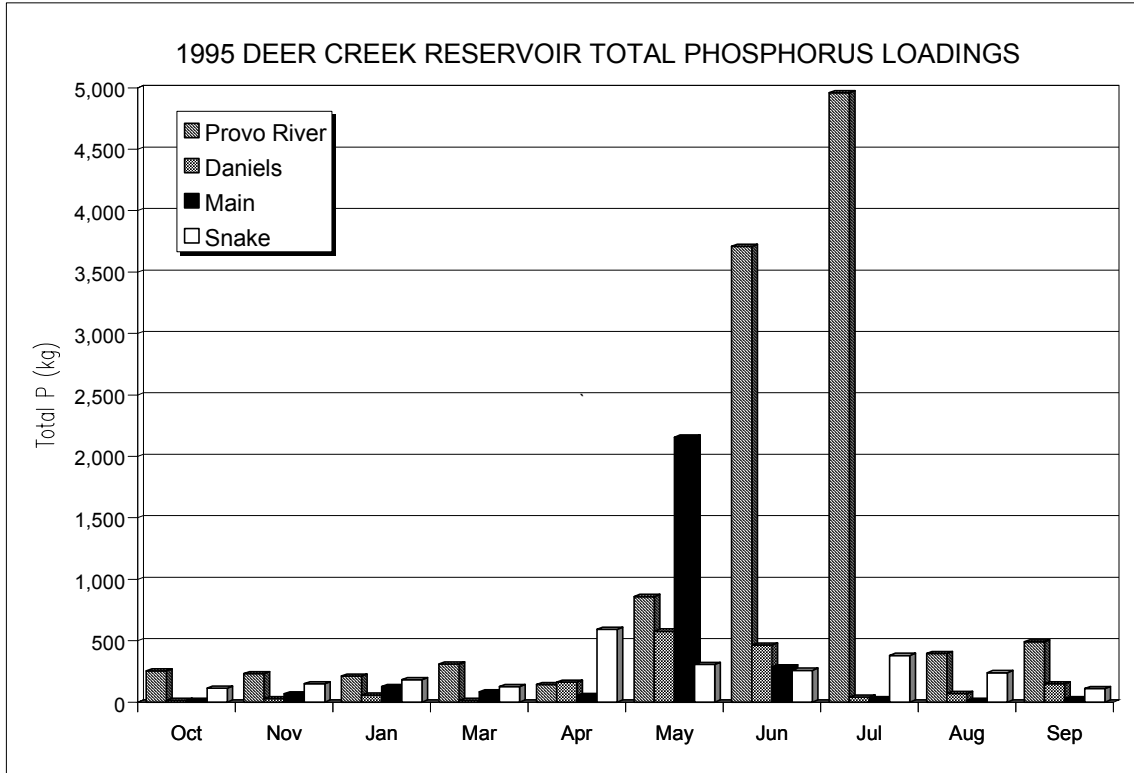


Figure 7. Total Phosphorus Loads into Deer Creek Reservoir during 1995.

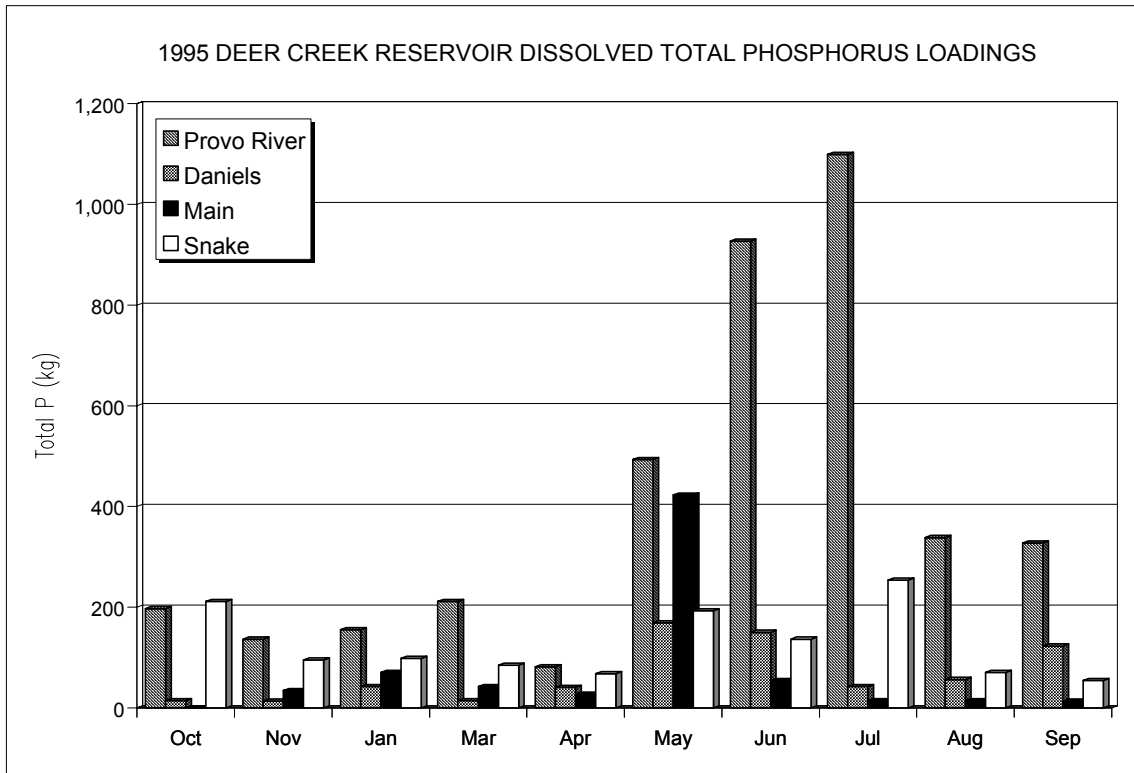


Figure 8. Dissolved Total Phosphorus Loads into Deer Creek Reservoir, 1995.

Chapter 3: **Heber Valley Area Description**

Description of Heber Valley Natural Creeks

The valley's natural channels are well defined and have historically been capable of carrying the flows developed in the valley.

On the west side of the valley, there are two major creeks, Snake Creek and Berkenshaw Creek. The natural channels of these creeks begin in the Wasatch Mountains to the northwest and run generally in a southward direction, paralleling the Provo River some distance before finally discharging into the river.

On the east side of Heber Valley, there are four main creeks; they are Spring Creek, Lake Creek, Center Creek and Daniels Creek. The natural channels of these creeks generally run from the east to the west across the valley, through Heber City to the Provo River. In addition to the natural channels, a new flood channel has been constructed recently which conveys excess flows east to west from the Center and Lake Creek drainages into the Provo River.

There are four major storm water conveyance channels from the Heber Valley into the Provo River Drainage System. They are, from upstream to downstream, Spring Creek, the Flood Channel, Snake Creek, and Daniels Creek.

Heber Valley Canal System

Over one hundred years ago, the early pioneers in the Heber Valley developed a system of irrigation canals which crisscrosses many of the natural stream channels. These canals generally run from the north to the south, running parallel to the Provo River and approximately perpendicular to the natural drainage patterns with some exceptions.

In 1970, Wasatch County adopted a storm drain management plan, which recognized each of these canals. The County diverts peak flows during the high flow period and distributes that water into the irrigation canals. The canals channel the water into open fields where it is soaked into the ground. This practice of distribution has served the County well and resulted in nothing more than a higher water table.

This practice cannot be indefinitely continued because of increasing urban development in these areas. Therefore the objective of the Stormwater Management Plan is to adapt the current and historic practices of stormwater management with the new urbanization patterns seen in the Heber Valley.

On the west side of the valley, the West Bench Ditch, Epperson Ditch and River Ditch are identified as having the best potential for storm water management. Each of these

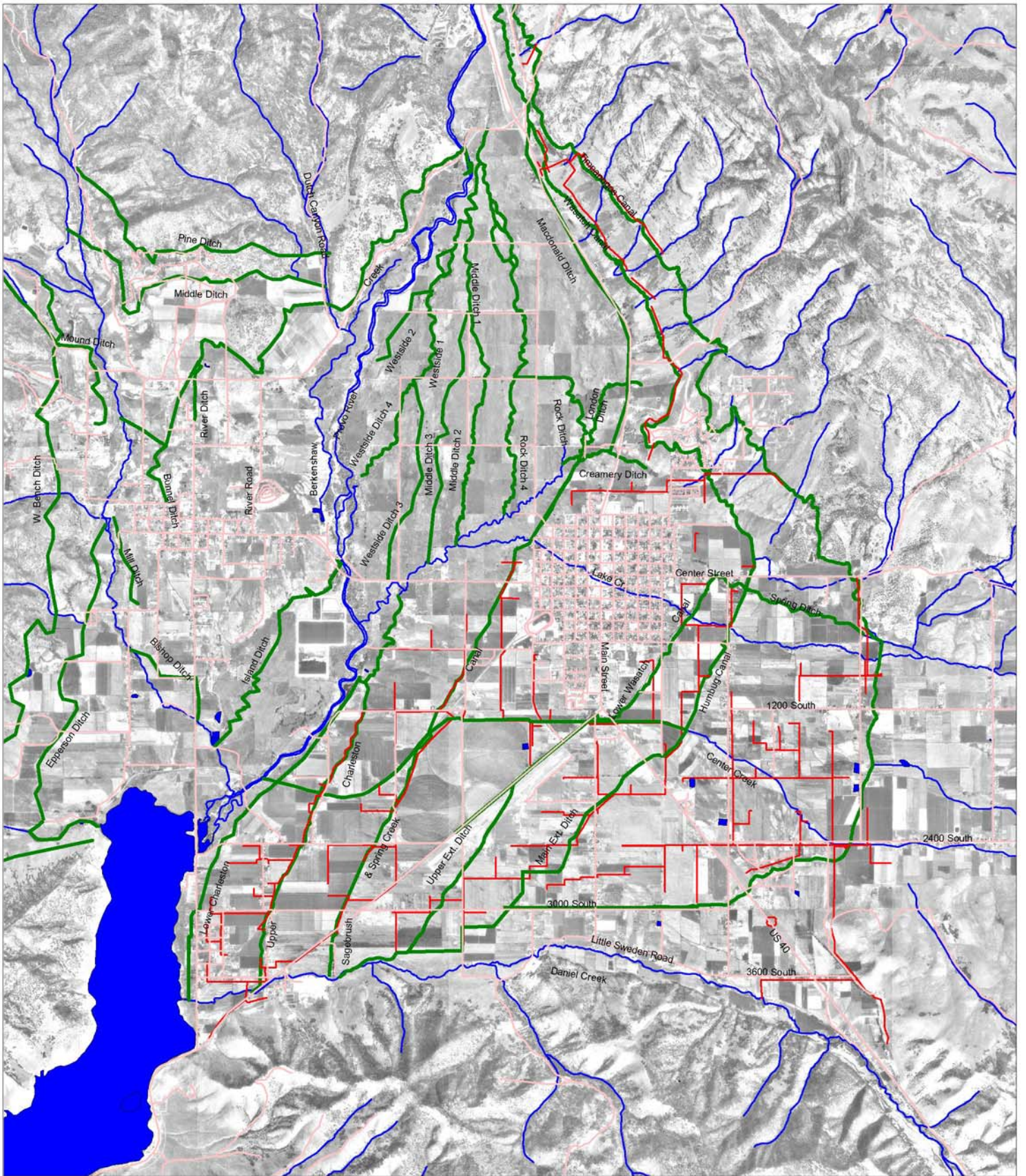


Figure 9
Heber Valley Canals and Streams

P S O M A S

-  Roads
-  Ditches
-  Lakes
-  WCWEP & DRP
-  Canals
-  Streams



SCALE 1" = 1 MILE

ditches could bring storm water into Snake Creek, which is the principal drainage conveyance conduit in this area.

On the east side of the valley, the canals that have the most potential for storm water management are those that efficiently bring water into the larger channels of the natural creeks. They include Timpanogos Canal, Wasatch Canal, Humbug Extension Canal, Sagebrush Canal, Upper Charleston Canal and Lower Charleston Canal.

Heber Valley Existing Ponds and Debris Basins

There are several existing ponds in the Heber Valley which are used for either flood control or irrigation regulation. Figure 10 below identifies the location of five ponds/basins that were considered in this study to have a potential for water quality and/or flood control.

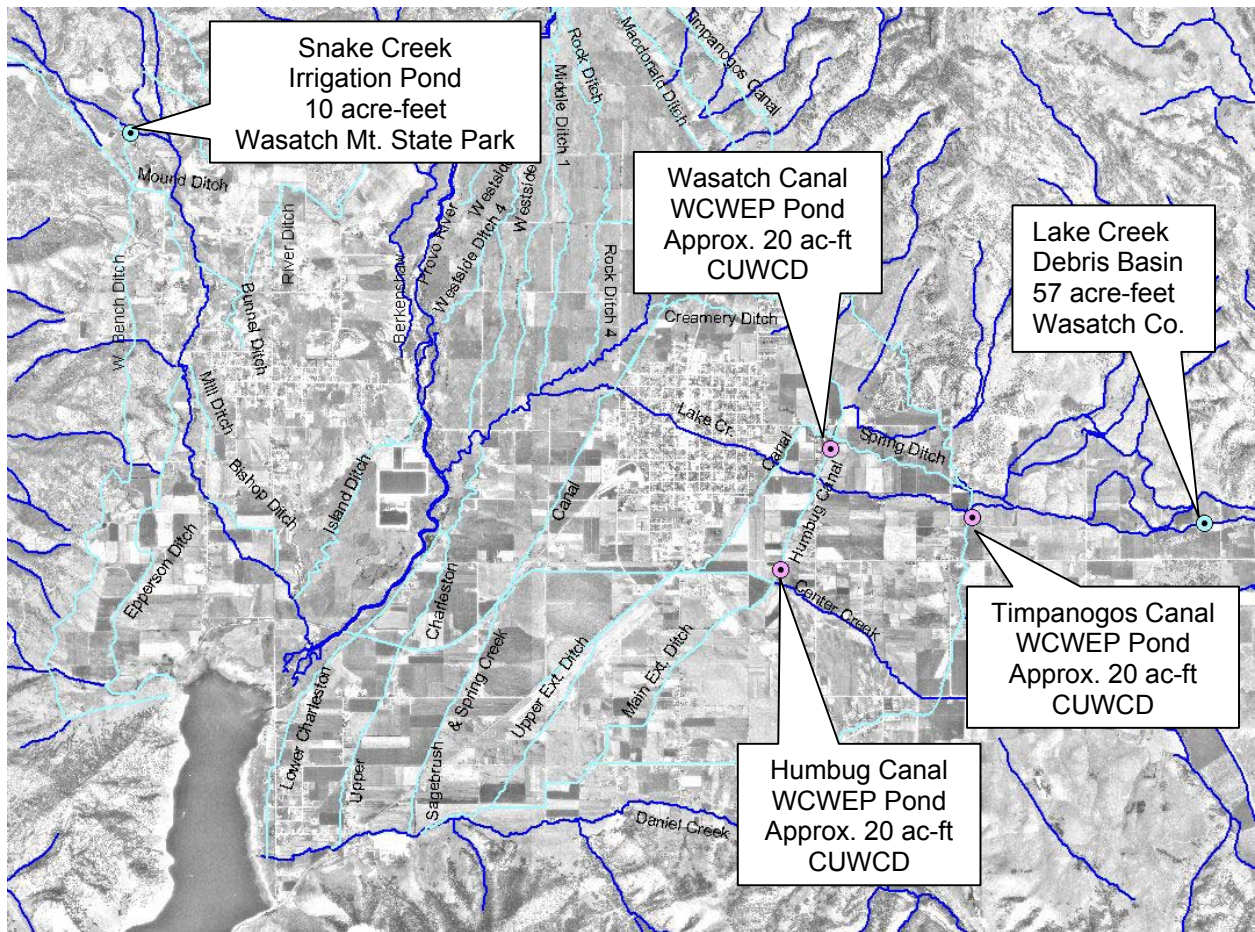


Figure 10. Existing Irrigation Ponds and Debris Basins in Wasatch County

These five ponds consist of the Lake Creek Debris Basin, three ponds that were built on irrigation canals as part of the Wasatch County Water Efficiency Project (WCWEP), and an irrigation pond on Snake Creek located in Wasatch Mountain State Park.

Lake Creek Debris Basin has a capacity of 57 acre-feet and serves as a flood control measure against flooding in Lake Creek. This current basin has no ponding during low flow periods, limiting its ability to remove sediments to only during periods of high flow. The basin, however, could be modified to include a wet pond and provide additional water quality treatment. The basin is maintained and owned by Wasatch County.

The WCWEP has installed several regulating ponds throughout the east side of the Heber Valley. These ponds serve to provide a stilling basin and water storage to the pumping facilities used for pressurized irrigation. Each pond has a capacity of approximately 20 acre-feet. The three ponds identified in Figure 10 are located on the canal and coincidentally may have a water quality impact. Water that passes through the pond over the outlet weir to continue through the canal toward Daniels Creek would have much of the sediment removed by these ponds. These ponds, however, have minimal capacity for any flood control. These ponds are owned and maintained by the Central Utah Water Conservancy District.

The final pond considered in this study is a pond located on Snake Creek in the Wasatch Mountain State Park. The State Park and Midway Irrigation Company use water from this pond for irrigation. This pond incidentally has the same effect as the WCWEP Ponds because Snake Creek is routed through the pond. The pond has a total capacity of approximately 10 acre-feet.

These five basins have a beneficial impact on the water quality in the valley by removing sediments that come from the upper watersheds. These upper watersheds, however, are not considered to be the largest contributors of sediments and other pollutants. But rather, the major sources come from agricultural return flows, and urban and agricultural storm run off. Thus, the ability to incorporate these basins into the overall water quality improvement plan is somewhat limited.

Watershed 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.

Watershed 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.

Watershed 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 debris-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).

Watershed Soils and Erosion Potential

In general, soils in the Upper Provo Watershed are 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 11.

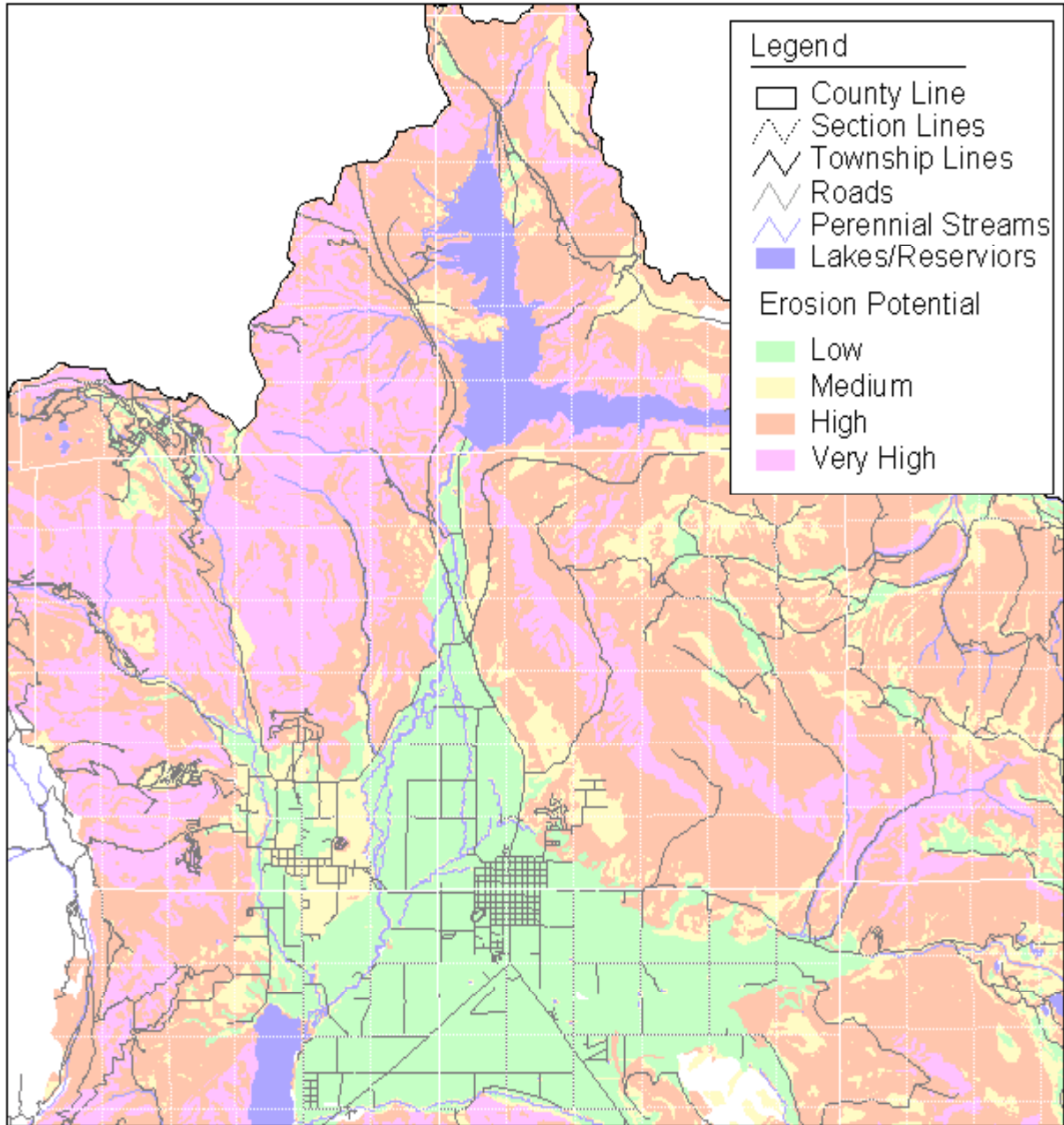


Figure 11. Soil Erosion Potential. From “A Guide for Erosion and Sediment Control, Wasatch County Utah”.

Heber Valley Hydrologic Analysis

EWP Engineering performed the hydrologic analysis in 1997. This section briefly describes the process and the results of the EWP's study.

The hydrologic analysis of the valley began with a delineation of drainage subbasins that flow into the major local streams and canals. GIS tools were used in this analysis to help identify the boundaries of the drainage basins. This delineation was difficult because of the farmland that uses the canals for its storm water runoff. The final delineation is a mixture of those subbasins defined by natural topography and those defined by the canal locations. The result of the delineation is shown in Figure 12.

The delineation shows the subbasins on the far east side of the Valley (Lake Creek, Center Creek, and Daniels Canyon) that are more delineated by natural topography. Moving from east to west the next subbasins that appear as crescent slivers are basins that were delineated by the locations of the canals thus assuming that the canals capture the most of the stormwater runoff. And finally looking at the subbasins on the west side of the valley, again the subbasins are more defined by the natural drainages such as the Snake Creek drainage.

For the hydrologic analysis, each subbasin was analyzed for slopes, drainage paths, time of concentration, soil conditions, vegetation, and land use. Each of these factors was considered for input into a HEC-1 computer hydrology model. SEDIMOT was originally considered for computer modeling because of its sediment modeling capabilities as well as hydrology computation. However, because of the large area encompassed by the Heber Valley, it was necessary to use HEC-1 because SEDIMOT is limited to basins under 5000 acres.

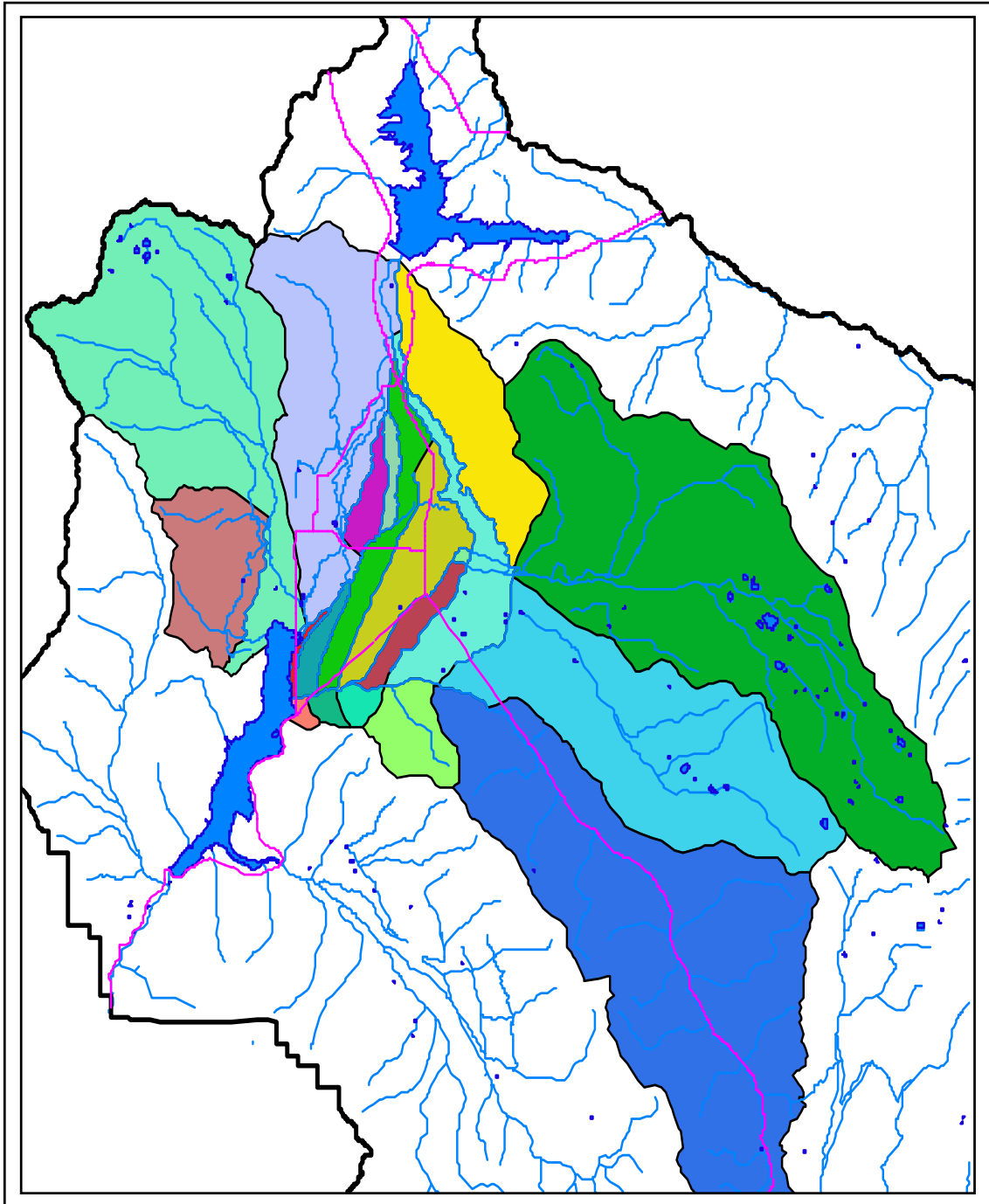


Figure 12. Hydrologic Subbasin Delineation of Heber Valley.

Table 2 shows the result of the 2-year 24-hour storm HEC-1 computer model. The size of a settling basin for each drainage was calculated to show the relationship between flow and basin size for a two-hour detention.

Table 2. Results of Hydrology Model (2-year 24-storm)

<i>Sub-Basin</i>	<i>Flow (cfs)</i>	<i>Settling Basin Size (ac-ft)</i>
<i>Epperson Ditch</i>	76	12.6
<i>Snake Creek</i>	286	47.3
<i>Upper Provo River</i>	117	19.3
<i>Lower Provo River</i>	61	10.1
<i>Westside Ditch</i>	70	11.6
<i>Daniels Canyon</i>	298	49.3
<i>Timpanogos Canal</i>	33	5.5
<i>Center Creek – Timpanogos</i>	36	6.0
<i>Daniels 1</i>	32	5.3
<i>Wasatch Canal</i>	52	8.6
<i>Lake Creek</i>	382	63.1
<i>Humbug Canal</i>	5	0.8
<i>Lower Lake Creek</i>	26	4.3
<i>Sage Brush & Spring Creek</i>	206	34.0
<i>Daniels 2</i>	1	0.2
<i>Middle Ditch</i>	41	6.8
<i>Rock-Spring-Upper Charleston</i>	46	7.6
<i>Daniels 3</i>	1	0.2
<i>Lower Charleston</i>	2	0.3
<i>Daniels 4</i>	1	0.2

Chapter 4: Sediment Basin Alternatives

From the 1997 EWP Engineering hydrologic study, an alternative was proposed for the construction of settling basins. Since then a revised scenario has been identified with fewer settling basins. Both alternatives are presented as follows.

Alternative A Original Proposed Alternative

The original alternative proposed consisted of a designation of ten detention basins to be constructed throughout the Heber Valley. Figure 13 is a map of the proposed locations of these basins labeled with the proposed sizes from the hydrology study. The detention basins were proposed at:

- Rock Ditch (7.6 acre-feet)
- Middle Ditch (11.6 acre-feet)
- Spring Ditch (5.5 acre-feet)
- Lake Creek (63.1 acre-feet)
- Big Hollow Creek (0.2 acre-feet)
- Wasatch/Humbug Canal (8.8 acre-feet)
- Sagebrush & Spring Creek Canal (34 acre-feet)
- Upper Charleston Canal (7.6 acre-feet)
- Lower Charleston Canal (0.3 acre-feet)
- Epperson Ditch (12.6 acre-feet)
- Snake Creek (47.3 acre-feet)

This scenario would be very effective and would help reduce the sediment loading into the Provo River System. The costs of this alternative were estimated. There were many assumptions that were made to make the estimate. The detailed cost estimates, showing the assumptions are located in Appendix A. The results of this cost estimate are given below in Table 3. As shown the resulting cost of this alternative is over two million dollars.

Table 3. Summary of Alternative A Capital Cost Estimate

Settling Basin Name	Pond Size (acre-feet)	Average Depth (feet)	Pond Area (acres)	Property Cost	Basin Cost	Total Cost
<i>Rock Ditch Basin</i>	7.6	8	1	\$ 33,000	\$ 69,000	\$ 102,000
<i>Middle Ditch Basin</i>	11.6	10	1.2	39,000	96,000	135,000
<i>Spring Ditch Basin</i>	5.5	6	0.9	29,000	55,000	84,000
<i>Lake Creek Basin</i>	63.1	16	3.9	127,000	425,000	552,000
<i>Big Hollow Creek Basin</i>	0.2	4	0.05	2,000	20,000	22,000
<i>Wasatch/Humbug Canal Basin</i>	8.8	8	1.1	36,000	77,000	113,000
<i>Sagebrush/Spring Creek Canal</i>	34	12	2.83	92,000	240,000	332,000
<i>Upper Charleston Canal</i>	7.6	8	0.95	31,000	68,000	99,000
<i>Lower Charleston Canal</i>	0.3	4	0.08	3,000	23,000	26,000
<i>Epperson Ditch Basin</i>	12.6	10	1.26	41,000	101,000	142,000
<i>Snake Creek Basin</i>	47.3	14	3.4	110,000	322,000	432,000
Totals				\$ 543,000	\$ 1,496,000	\$ 2,039,000

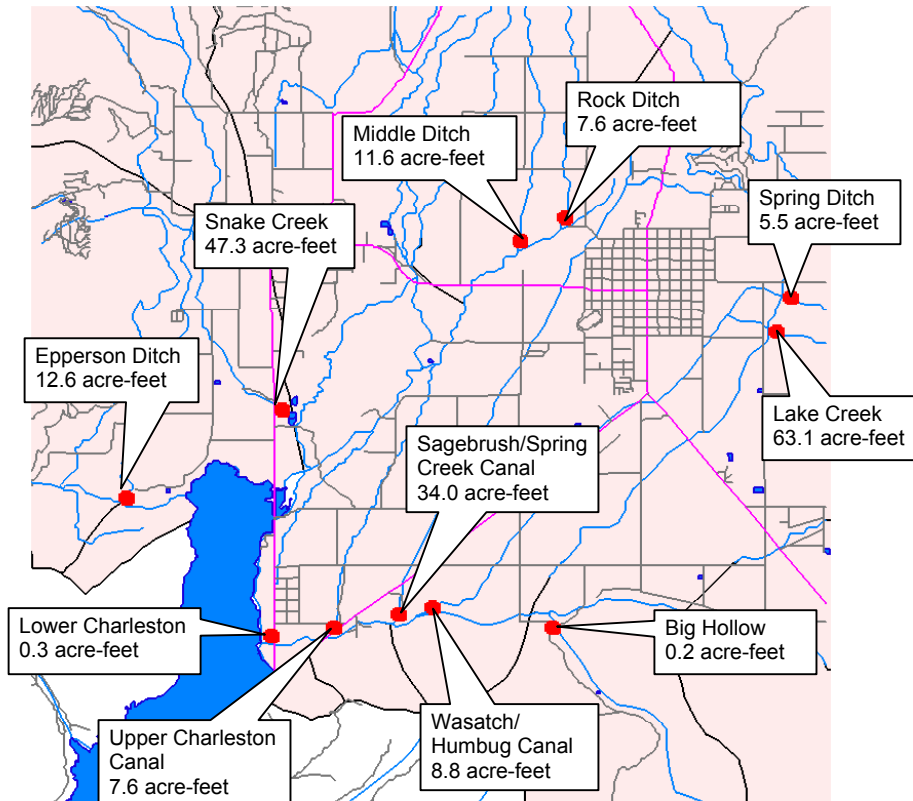


Figure 13. Alternative A Original Proposed Settling Basin Locations and Sizes

ALTERNATIVE A DETENTION BASIN DESIGN CRITERIA

The detention basin design would be based on a similar design used for other detention basins in Wasatch County. However, it would be advantageous to implement a wet pond aspect to the detention pond, where a certain portion of the basin remains inundated to take advantage of wetland processes that naturally remove pollutants and improve water quality. Some of these detention structures are large enough to qualify by state standards as small dams and would have to abide dam building specifications.

ALTERNATIVE A CONCLUSIONS

The main disadvantage with this original proposal was first, as shown in Table 3, the high capital costs; and also, the prospect of maintaining and managing ten basins is daunting. Maintenance of so many basins may become difficult to the County. The advantages of this alternative are that the basins could be used for flood management and reduce peak day flows during storms as well as provide sediment collection to aid in water quality.

However, because of the high costs and maintenance problems presented by this alternative, an additional alternative with fewer basins was considered. This alternative is described in the following sections.

Alternative B Revised Alternative

This alternative examines the four major conveyance channels from Heber Valley into the Provo River System: Spring Creek, the Flood Channel, Snake Creek, and Daniels Creek. Figure 14 is a map of the proposed basins approximate locations. The majority of Heber Valley drainage is accounted for through these discharge points. They each contribute flows with high levels of sediments and phosphorus because of agricultural and urban runoff.

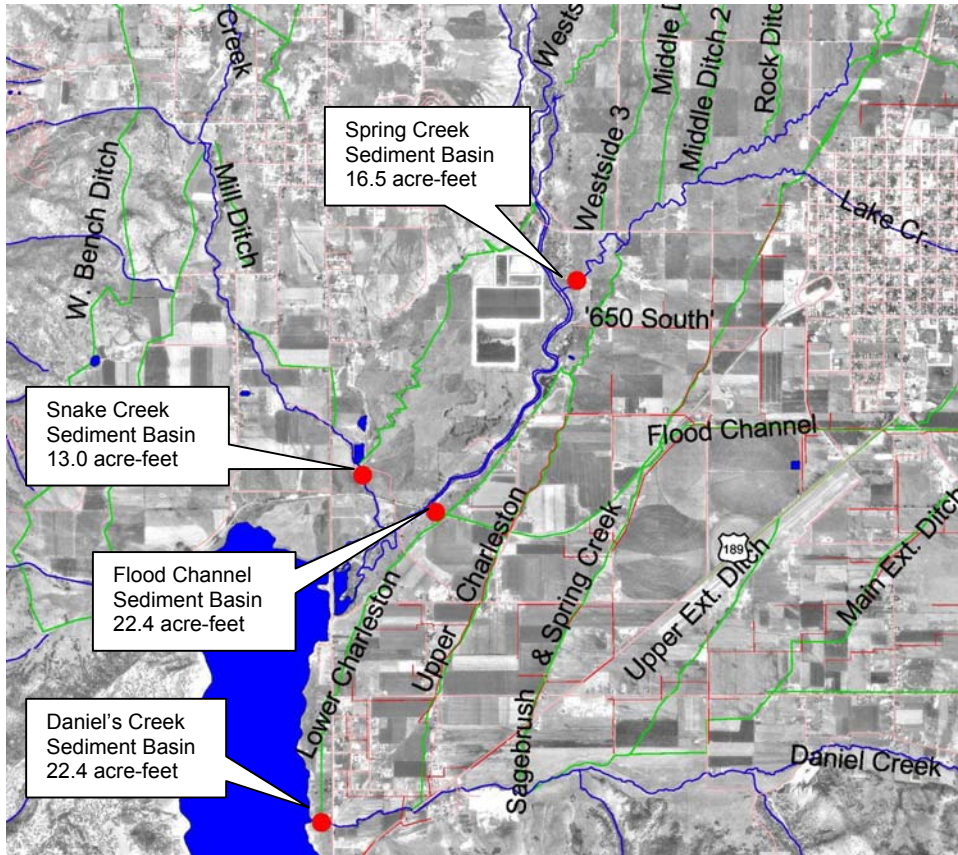


Figure 14. Map of Approximate Locations for Proposed Settling Basins

The sizing of the basins uses a different design philosophy than the other alternative. Rather than use the two-year 24-hour storm peak flow from a hypothetical storm created by HEC-1, the basins for this alternative would be designed from historical peak average daily flows recorded by USGS. This methodology will not be able to remove sediments from the short-duration, peak flows, but the majority of the time the flows will be captured by the ponds. USGS has flow gauging stations near the proposed basin locations at Spring Creek, Snake Creek, and Daniels Creek. Unfortunately, there are no flow gages on the Flood Channel, and the two-year flow would have to be approximated by other means.

Chapter 4

Table 4 shows the USGS peak flows in the three channels for water year 1993-94 to 1997-98. Also, an average of the five years of peak flows is shown in this table as well. The average can be used as an approximation of the 50% probable peak average-day flow, or in other words, the 2-year flow.

Table 4. Historical Peak Day Flows at Basin Locations 1993-94 to 1997-98

Location	Peak Day Flows					Average
	1993-94	1994-95	1995-96	1996-97	1997-98	(Design Flow)
Spring Creek (USGS #10155400)	78	131	76	111	103	99.8
Snake Creek (USGS #10157500)	54	99	82	80	79	78.8
Daniels Creek (USGS #10156000)	45	244	115	137	not avail.	135.3

It is unfortunate that the Flood Channel does not have recorded flows, however, as a preliminary means of estimating the size of the proposed settling basin, it is estimated that the flows would be similar to those in Daniels Creek and the basin could be sized the same for estimation purposes.

The basins are thus sized according to the average of the peak flows calculated which is shown in the last column of Table 4. The sizing assumes a two-hour detention time of this peak flow. These settling basin sizes along with estimated capital costs are shown in Table 5.

Table 5. Summary of Alternative B Capital Cost Estimate

Settling Basin Name	Pond Size (acre-feet)	Average Depth (feet)	Pond Area (acres)	Property Cost	Basin Cost	Total Cost
Spring Creek Basin	16.5	10	1.6	\$ 52,000	\$ 128,000	\$ 180,000
Snake Creek Basin	13.0	10	1.3	42,000	104,000	146,000
Daniels Creek Basin	22.4	12	1.9	62,000	164,000	226,000
Flood Channel Basin	22.4	12	1.9	62,000	164,000	226,000
			Total	\$ 218,000	\$ 560,000	\$ 778,000

The capital costs of this alternative are substantially less than the original proposed alternative A. There are fewer basins, which reduces the costs, as well as the basin sizing was changed to build smaller less expensive structures. Additionally, maintenance would be less complex. Although, the sediment capture capabilities of the smaller basins are diminished, they would provide much sediment capture during the majority of the time. Only during short periods of high peaks would the settling basin be ineffective.

ALTERNATIVE B WET POND DESIGN CRITERIA

The vision of the settling basins is to incorporate a “wet pond” design. The wet pond is a cross between a settling basin, and a wetland. The theory is the pond remains at least partially full year-round to allow for the benefits of wetland treatment during lower flows while still providing settling capabilities during low and high flows. The wetland

characteristics will partially remove dissolved phosphorus and the settling capabilities of the pond will help remove particulate phosphorus that is tied to sediments.

This section gives the following guidelines to the design of the wet pond/settling basin.

- The basin should remain at least partially full of water to allow for sediment deposition for high and low levels of flow. Therefore, the main regular usage outlet should be a type of spillway crest or weir. Although an outlet at the bottom may be necessary for draining the basin. Design should ensure that sediments are minimally discharged during draining.
- A forebay area with shallower depths near the inlet is desirable to slow down flow, increase settling efficiencies, and promote wetland vegetative growth.
- The pond should not be deeper than 10 feet except during high peak flows. There is a potential for temperature stratification in a deep pond, which can cause odor problems.
- The pond should use energy dissipation devices such as baffles on the inlet to prevent excessive erosion and encourage better settling, while helping to prevent short-circuiting.
- Side slopes of the basin should have a maximum slope of 2:1 to allow for wetland vegetation growth. One area should have a maximum slope of 4:1 so that maintenance equipment may be able to enter the basin.
- An off-channel basin is envisioned which flows are diverted to from the original channel as diagramed in Figure 15. Outlet flows are then discharged back into the original channel further downstream. Flows then can be routed around the basin during draining and removal of the sediments. Of course, it may also be feasible to plan an on-channel basin with a constructed bypass channel.
- The outlet to the basin should be located at the point furthest from the inlet so that detention time is maximized and stagnant water is avoided. The basin geometry should also be such that stagnation and short-circuiting is avoided; a minimum 3:1 length to width ratio should be considered.
- All flows above the design flows given in Table 4 should be routed through the bypass channel to avoid flooding and over capacity problems in the settling basin. Or the outlet and inlet works of the settling basin should be designed to withstand up to the 100-year flood level.

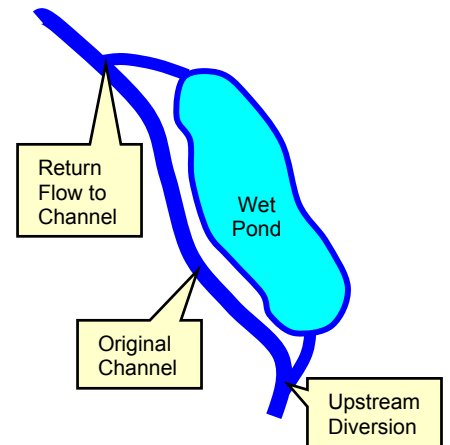


Figure 15. Example of Settling

Many of the site constraints will control the actual design of the basins. Although general locations have been identified, specific sites have not yet been selected. It is difficult to anticipate other requirements of the settling basins.

Comparison of Alternatives

Both alternatives have advantages and disadvantages. Alternative A has larger ponds that would have flood control advantages as well as pollutant reduction advantages. Yet, Alternative B would only provide pollutant reduction advantages. The pollutant reduction capabilities of Alternative B, however, would be enhanced over Alternative A.

Aesthetically, the wet ponds of Alternative B could be nicely incorporated into a park feature that could even provide fishing opportunities. Alternative A would be less aesthetic especially the larger basins that would require large dikes. The costs in terms of maintenance and capital facilities favors Alternative B, since it has fewer and smaller basins. The capital costs of Alternative A and B are estimated at approximately \$2,000,000 and \$800,000, respectively.

The following table is a summary of the comparison of alternatives using a rating scale for each criteria of 1 to 4:

Table 6. Sediment Basin Alternative Comparison

<i>Alternative</i>	<i>Pollution Reduction Scale (1- 4)</i>	<i>Flood Control Scale (1-4)</i>	<i>Aesthetic Features</i>	<i>Capital and O&M Costs</i>	<i>Total Score</i>
<i>A – Ten Detention /Sediment Basin</i>	3	4	1	2	10
<i>B – Four Wet Ponds</i>	4	1	4	4	13

This table indicates that Alternative B may be a better alternative based on the given criteria. However, if flood control is needed in the valley, Alternative A may need to be seriously considered instead.

Chapter 5: **Implementation Plan**

The key to success of this plan is to move from Wasatch County from discussion to action. This section identifies a plan for implementation of the improvements recommended in this plan.

Creation of an Administrative Body

The first step towards implementation is the creation of an administrative body to control the advancement of construction and yearly duties of maintenance. The creation of this body needs to come under the leadership of the Wasatch County Commissioners. Or the Commissioners may want to turn the duties of administration over to Wasatch County Public Works Department or Heber Valley Special Service District.

The duties will include:

- Coordination with individual water companies on canal right-of-way easements and canal maintenance
- Identify and obtain funding from local State and Federal sources for maintenance and construction costs
- Oversee design and construction of settling basins
- Determine and control a schedule for maintenance of basins and canals sampling
- Budget the costs of capital facilities, operations and maintenance.

Identify Funding Sources

There are many sources of Federal and State funding that might be available for use towards the implementation of this plan. The EPA is eager to help fund Best Management Practices such as the wet ponds identified in this plan. Also, since these improvements are recommended by the Upper Provo River Water Quality Management Plan, which established phosphorus TMDLs for Snake Creek, Daniels Creek, and the Provo River, the door should be open for at minimum partial funding of these projects. Once the administrative body is created, the body should explore all avenues of funding.

The following funding sources are listed as some of the alternatives that should be explored to implement the storm water management plan:

- **Clean Water State Revolving Funds (CWSRF) or Utah Water Quality Project Assistance Program (WQPAP)** – The CWSRF or WQPAP is a cooperative federal-state program, administered by the State of Utah with funds from both the State and the EPA. Low interest loans are given for high-priority water quality improvement projects. To obtain applications and additional information, you must contact the Utah Division of Water Quality. Also, you can refer to the following website for additional information: http://www.eq.state.ut.us/eqwq/con_asst.htm

- **Nonpoint Source Implementation Grants (319 Program)** – The 319 Program provides formula grants to states to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA). The County should contact the Utah Division of Water Quality for applications to this grant. This funding source usually requires the local agency to provide 40 percent of the total project cost.
- **Wetlands Program Development Grants** – The Wetlands Program Development Grants provide financial assistance to local governments to support the development of new, or augmentation and enhancement of existing wetland programs. Since part of the Storm Water Management Plan is to incorporate wetland features, this grant may be pursuable for implementation. Recipients must provide a 25 percent match of the total project cost. For applications and deadlines, refer to the following website: <http://www.epa.gov/owow/wetlands/2000grant/>
- **Reallocation of Charleston Sewer Grant** – The City of Charleston recently turned down over one million dollars in federal grant money that was to be allocated for a sewer installation. Since a recent city vote turned down this improvement money, it has been made available to other projects with the stipulation that it be used toward a capital improvement project that will improve water quality.

Obtain Right-of-Way Easements

It is the duty of the County to obtain easements in canals that are used for storm water conveyance. The purpose of the easements is to acknowledge the use of private canal facilities by the County for flood conveyance and to enable the County to legally access the canals for repairs, maintenance and improvements. The administrative body should coordinate this process by identifying the needed canals and purchasing the easements

Design and Construction of Settling Basins

The design and construction of the settling basins is the beginning of the true implementation of the plan. Depending on the availability of funding, the construction of the basins may need to be phased. In the likely event of phased construction, the basins should be built in a successive order starting with the most beneficial basin followed by the next and so on until all four basins have been constructed. The following order is suggested:

1. **Flood Channel Settling Basin** – This basin contains much of the runoff from Heber City and therefore is a potential heavy polluter of sediments and phosphorus to the Provo River. For this reason this should be the first basin to be constructed.
2. **Spring Creek Settling Basin** – Spring Creek is not identified in the Upper Provo River Water Quality Management Plan because it is a smaller tributary. However, its flow contains high levels of phosphorus and contributes significant pollution to the Provo River.
3. **Daniels Creek Settling Basin** – Daniels Creek is one of the major tributaries to Deer Creek Reservoir and has some of the highest phosphorus levels in the basin. The Upper Provo River Water Quality Management Plan identifies Daniels Creek as with high pollution levels and needs for reductions.

4. **Snake Creek Settling Basin** – Snake Creek is also identified as contributing significant levels of phosphorus, although not nearly as high as Daniels Creek.

Administration, Operation, and Maintenance

After construction of the detention facilities, the function of the facilities depends on keen administration and maintenance. The administrative body would continue to keep watch over the maintenance of the structures with an annual budget. A plan would need to be put together for operation, maintenance and monitoring.

Appendix A: **Cost Analysis**

Appendix B: **Literature on Wet Pond Design**