UPPER SEVIER RIVER
Total Maximum Daily Load and Water Quality Management Plan

Prepared by

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Utah Department of Water Quality, Division of Water Quality
TMDL Section
Upper Sevier River

Waterbody ID	Sevier River and tributaries from Circleville Irrigation Diversion upstream to Horse Valley Diversion, UT16030001-005
Location	Garfield County; South-Central Utah
Pollutants of Concern	Total Phosphorus (TP), Habitat Alteration
Impaired Beneficial Uses	Class 3A: Cold water fishery
Loading Assessment	
Current Loading	5846 kg/year TP
Loading Capacity	2583 kg/year TP
Margin of Safety	Implicit in determination of loading capacity
Wasteload Allocation	N.A
Load Allocation	5846 kg/yr TP
Load Reduction	3263 kg/yr TP
Defined Targets/Endpoints	Instream TP concentration 0.05 mg/l Annual Load of 2583 kg/yr at Station 494945 Shift from sediment and phosphorus tolerant macroinvertebrates to intolerant species.
Implementation Strategy	Eight (8) miles of streambank restoration and/or stabilization. Riparian fencing and grazing management.
This document is identified as a TMDL for the Upper Sevier River and is officially submitted under §303d of the CWA for EPA approval.	

Utah Department of Water Quality, Division of Water Quality
TMDL Section
Upper Sevier River

Waterbody ID	Sevier River and tributaries from Horse Valley Diversion upstream to Long Canal Diversion excluding Panguitch Creek, Bear Creek, and their tributaries, UT16030001-007
Location	Garfield County; South-Central Utah
Pollutants of Concern	Total Phosphorus (TP), Habitat Alteration
Impaired Beneficial Uses	Class 3A: Cold water fishery
Loading Assessment	
Current Loading	3999 kg/year TP
Loading Capacity	2078 kg/year TP
Margin of Safety	Implicit in determination of loading capacity
Wasteload Allocation	N.A
Load Allocation	3999 kg/yr TP
Load Reduction	1921 kg/yr TP
Defined Targets/Endpoints	Instream TP concentration 0.05 mg/l Annual Load of 2078 kg/yr at Station 494964 Shift from sediment and phosphorus tolerant macroinvertebrates to intolerant species.
Implementation Strategy	Thirteen miles of streambank restoration and/or stabilization. Riparian fencing and grazing management. Reduce irrigation by increasing efficiency and riparian buffers.
This document is identified as a TMDL for the Upper Sevier River and is officially submitted under §303d of the CWA for EPA approval.	

Utah Department of Water Quality, Division of Water Quality
TMDL Section
Upper Sevier River

Waterbody ID	Sevier River and tributaries from Long Canal to Mammoth Creek confluence, UT16030001-012
Location	Garfield County; South-Central Utah
Pollutants of Concern	Total Phosphorus, Habitat Alteration
Impaired Beneficial Uses	Class 3A: Cold water fishery
Loading Assessment	
Current Loading	1871 kg/year TP
Loading Capacity	1528 kg/year TP
Margin of Safety	Implicit in determination of loading capacity
Wasteload Allocation	N.A
Load Allocation	1871 kg/yr TP
Load Reduction	343 kg/yr TP
Defined Targets/Endpoints	Instream TP concentration 0.05 mg/l Annual Load of 1528 kg/yr Shift from sediment and phosphorus tolerant macroinvertebrates to intolerant species.
Implementation Strategy	Twelve mile miles of streambank restoration and/or stabilization. Riparian fencing and grazing management. Improve habitat by increasing channel meanders.
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Utah Department of Water Quality, Division of Water Quality
TMDL Section
Upper Sevier River

Waterbody ID	Mammoth Creek
Location	Garfield County; South-Central Utah
Pollutants of Concern	Total Phosphorus
Impaired Beneficial Uses	Class 3A: Cold water fishery
Loading Assessment **Current Loading** **Loading Capacity** **Margin of Safety**	 945 kg/year TP 654 kg/year TP Implicit in determination of loading capacity
Wasteload Allocation **Load Allocation** **Load Reduction**	299 kg/yr TP 646 kg/yr TP 291 kg/yr TP
Defined Targets/Endpoints	Instream TP concentration 0.05 mg/l Annual load reduction of 291 kg/yr. Shift from sediment and phosphorus tolerant macroinvertebrates to intolerant species.
Implementation Strategy	Eight (8) miles of streambank restoration and/or stabilization. Riparian fencing and grazing management. Reduce impacts on-site systems
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I. Introduction

Watershed Description

The Upper Sevier River Watershed is located in south central Utah within the borders of Garfield, Kane, Piute, and Iron counties. The Upper Sevier watershed (Hydrologic Unit Code (HUC) #16030001) extends upstream from its confluence with the East Fork Sevier River near Piute Reservoir and is comprised of the major tributaries of Mammoth , Asay, Panguitch, and Bear Creeks. The headwaters of the Sevier River, the Upper Sevier is straddled by the mountains of the Markagunt Plateau to the west and the Paunsaugunt Plateau to the east. The main portion of the watershed (excluding the East Fork Sevier River) is approximately 831,000 acres and is comprised of 425,539 acres Forest Service (FS), 188,249 acres Bureau of Land Management (BLM), 132,136 acres private, 84,377 State and 841 acres of National Park Service (NPS) lands (Map 1). Private lands comprise approximately 16% of the total land area of the watershed (see Table 1).

Table 1. Land ownership in the Upper Sevier River Watershed.

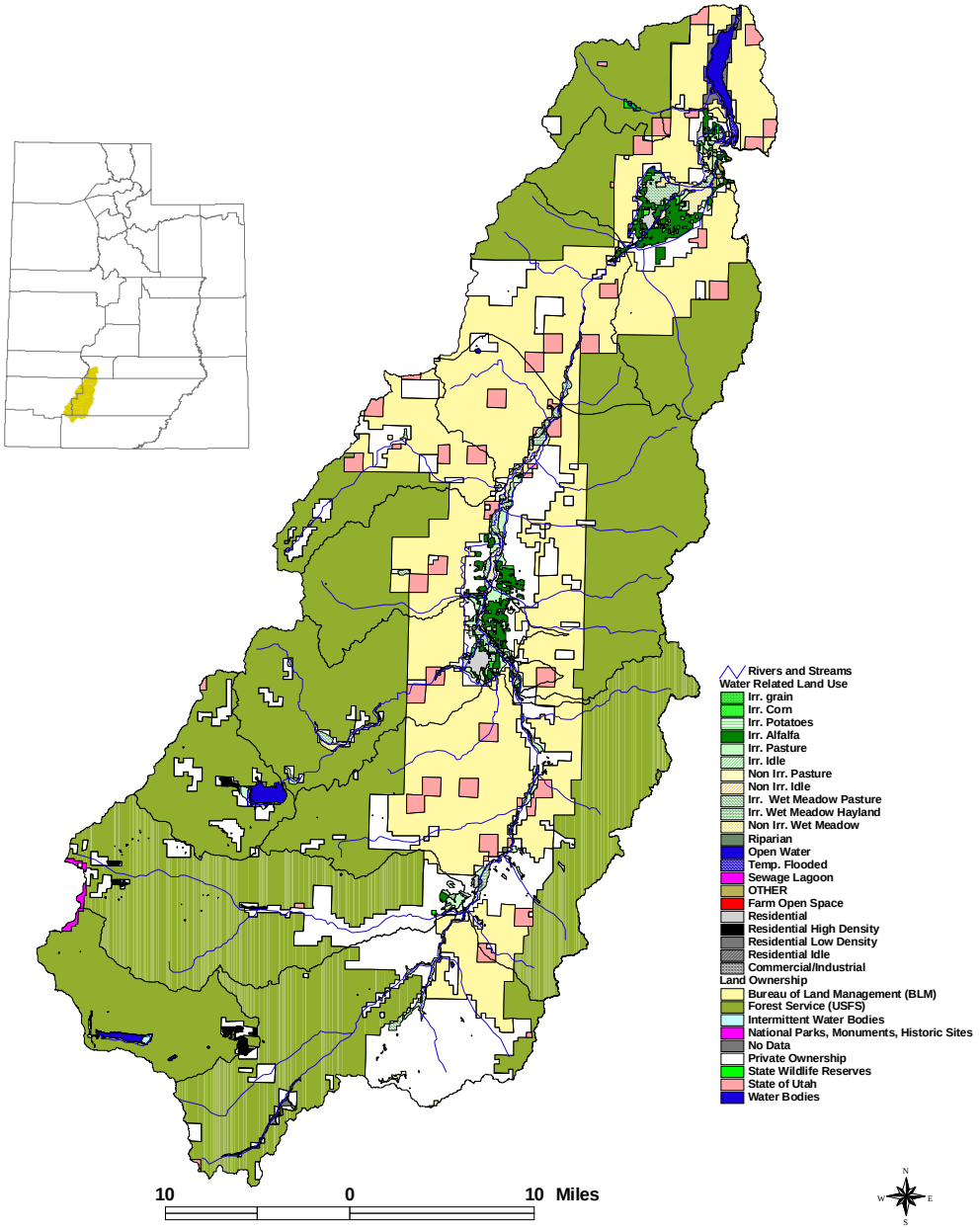
Sub-Watershed	FS	BLM	NPS	Private	State	Total	Percent of Watershed
Asay Creek	78253	1	300	9767	0	88321	11
Mammoth Creek	61729	54	541	12402	41	74767	9
Panguitch Creek	63408	9390	0	8809	2324	83931	10
Pass Cr.-Sevier R.	68635	55104	0	44252	5944	173935	21
Bear Creek-Sevier R.	88522	64175	0	30380	67074	250151	30
City Cr.-Sevier R.	64992	59525	0	26526	8994	160037	19
Total	425539	188249	841	132136	84377	831142	
% of Watershed	51	23	<1	16	10		100

The Upper Sevier River Watershed falls within the Great Basin Region and is bordered to the South by the Lower Colorado Region, and to the East by the Upper Colorado Region. The major ecoregions of the watershed include High Plateaus, Semiarid Foothills, and Mountain Valleys (Woods et al 2001).

Vegetation within the watershed ranges from sparse, desert-type plants such as sage and grasses in the lower elevations to stands of low growing pinyon pine and juniper in the mid-elevations. Aspen, and conifer species such as pine, spruce and fir dominate at higher elevations (Map 2). Table 2 summarizes the dominant vegetation types of the Sub watersheds of the Upper Sevier River. Of these types, sage/grass communities in the mountain valleys and alluvial fans comprise 19% of the land coverage. Pinyon and juniper cover 39% of the total watershed and are found primarily on the mid elevation foothills surrounding Panguitch and Circleville Valleys.

Map 1.

Landownership and Water Related Land Use in the Upper Sevier River Watershed



Map 2.

Vegetation in the Upper Sevier River Watershed

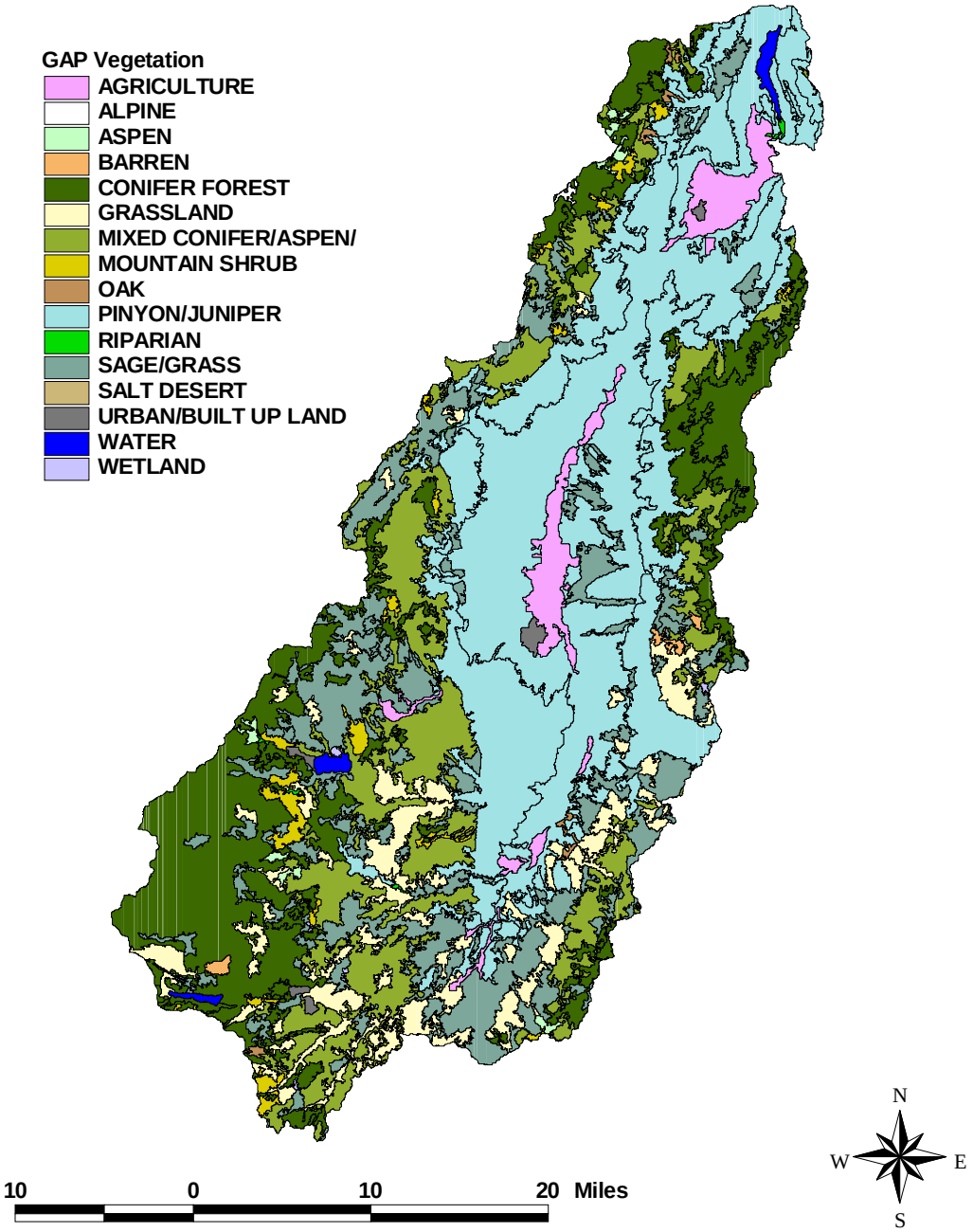


Table 2. Dominant vegetation types in the Upper Sevier River Watershed.

Dominant Vegetation	Asay Creek	Mammoth Creek	Panguitch Creek	Pass Cr. - Sevier R.	Bear Cr.- Sevier R.	City Cr.- Sevier R.	Total
Agriculture	4805	452	669	2930	9430	10853	29139
Aspen	17818	6753	9369	779	37	2312	37068
Grass/Forbs	1180	4977	4660	13646	4459	2361	31283
Mixed Conifer	2067	6985	3040	6115	5102	2349	25658
Mtn. Shrub	0	76	3873	1593	15497	3119	24158
Pinion/Juniper	58539	4372	17129	62495	95446	88676	326657
Ponderosa	4075	18135	8416	15909	4881	14317	65733
Sage/Grass	43392	8980	23930	38456	25563	17958	158279
Spruce/Fir	20870	15812	9224	153	17398	12294	75751
Urban	0	0	455	0	687	339	1481
Other	4141	8225	3163	31858	10652	4408	62447
Total	156887	74767	83928	173934	189152	158986	837654

Land under agricultural production represents only 3% of the land cover in the watershed and occupies lower elevation fields and meadows concentrated near rivers and streams (Map 1) . Water related land use data (Table 3) from the Division of Water Resources details the land cover associated with crop irrigation and municipal water use and development. In the Upper Sevier River watershed, the dominant agricultural crop is alfalfa. Combined with pastures and wet meadows utilized for grazing, land cover associated with cattle production comprise 64% by acreage of water related land uses.

Additional land use on both private and public land include rangeland for grazing, silviculture, urban, and recreation. Recreational opportunities throughout the watershed include camping, hunting, wildlife viewing, fishing, bicycling, ATV riding, horseback riding and snowmobiling in winter months. The proximity of the watershed to several national parks also brings visitors for picnicking, lodging, and general sight-seeing. According to the Upper Sevier River Community Watershed Project Plan approximately 3,991 miles of paved, improved gravel and other type roads are found throughout the watershed (including the East Fork Sevier River). Although current forest plan standards and guidelines call for road densities not to exceed 2 miles per square miles of wildlife habitat, recent on-ground evaluations in forested areas suggests that in some areas this number may be higher. Total road miles does not take into consideration non-classified or user-created roads.

Table 3. Water related landuse in the Upper Sevier River

Water Related Land Use	Acres	Percent Total
Irrigated Grain	780	2.2
Irrigated Corn	472	1.3
Irrigated Potatoes	3	0.0
Irrigated Alfalfa	7939	22.3
Irrigated Pasture	5794	16.3
Irrigated Idle	223	0.6
Non Irrigated Pasture	134	0.4
Non Irrigated Idle	43	0.1
Irrigated Wet Meadow Pasture	5386	15.1
Irrigated Wet Meadow Hayland	718	2.0
Non Irrigated Wet Meadow	3760	10.6
Riparian	2164	6.1
Open Water	3763	10.6
Temp. Flooded	358	1.0
Sewage Lagoon	3	0.0
Other	739	2.1
Farm Open Space	5	0.0
Residential	1748	4.9
Residential - High Density	1378	3.9
Residential - Low Density	112	0.3
Residential - Idle	60	0.2
Commercial/Industrial	34	0.1
Total	35616	100

Geologically, the area consists of mixed volcanics (recent basalts, andesite, rhyolite, etc.), and Wasatch Limestone formations. Large basalt flows are present at higher elevations within the western portion of the watershed (8,000+ feet). The plateau is an uplifted fault block tilted to the northeast. Several north-south faults occur on the north end of the watershed. The tableland to the south is coarsely dissected, benchy and slopes to the northeast. The west front consists of a ridge and valley system between the tableland and the edge of the plateau, marked by the Hurricane Fault. The north end of the watershed consists of rounded hills and broad valleys. Rock areas consist primarily of Wasatch Formation (limestone and sandstone) in the form of cliffs, escarpments and tertiary volcanic soils. This is the distinctive formation of Bryce Canyon and Cedar Breaks which produces the white to reddish-pink spires and canyons unique to these areas.

Climate and Streamflow

Precipitation varies widely in the watershed due mainly to topography and elevation with lows near 5 in. in valley bottoms up to 40 in. per year at Brian Head Peak. Table 4 summarizes monthly temperature ranges, snowfall and rainfall for Panguitch, Utah.

Table 4. Period of Record Monthly Climate Summary for Panguitch, UT (5/ 1/1904 to 12/31/2002)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Average Max. Temperature (F)	39.3	43.3	50.5	60.1	69.6	79.3	84.4	82	75.7	65.1	51.2	40.9	61.8
Average Min. Temperature (F)	7.5	12.8	19.2	24.7	31.5	38.1	45.4	44.1	35.5	25.6	16.6	9.1	25.8
Average Total Precip. (in.)	0.54	0.58	0.79	0.65	0.63	0.51	1.4	1.65	0.99	0.9	0.68	0.51	9.85
Average Total SnowFall (in.)	6	4.6	4.2	1.2	0.3	0	0	0	0	0.8	2.8	4.4	24.2
Average Snow Depth (in.)	1	1	0	0	0	0	0	0	0	0	0	0	0

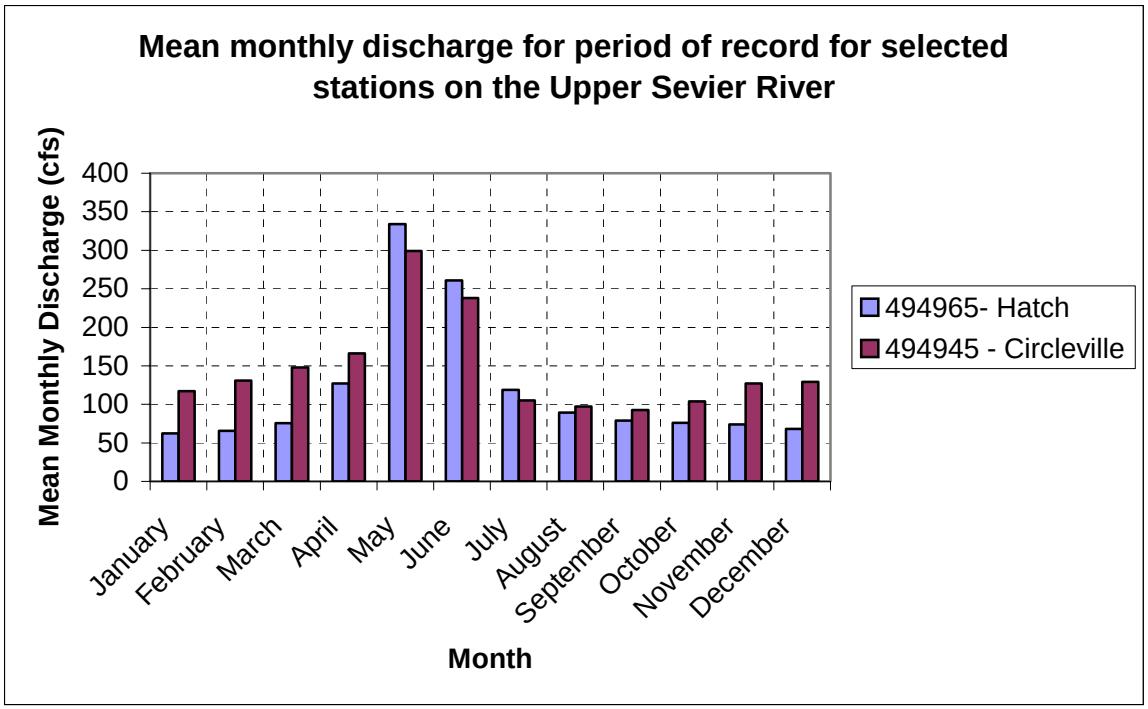
Percent of possible observations for period of record.
Max. Temp.: 84.3% Min. Temp.: 84.3% Precipitation: 89.9% Snowfall: 80.1% Snow Depth: 73.4%
(Source : Western Regional Climate Center)

Surface and Groundwater Hydrology

The headwaters of the Upper Sevier River primarily originate from the high Markagunt Plateau and are formed by the confluence of Asay and Mammoth Creeks near the town of Hatch. From there the river flows generally north through the Panguitch Valley, through Circleville Canyon and into Circleville Valley where it is fully utilized for irrigation. Inflows to Piute Reservoir are primarily composed of flow from the East Fork Sevier River and recharge in the channel of the Sevier River.

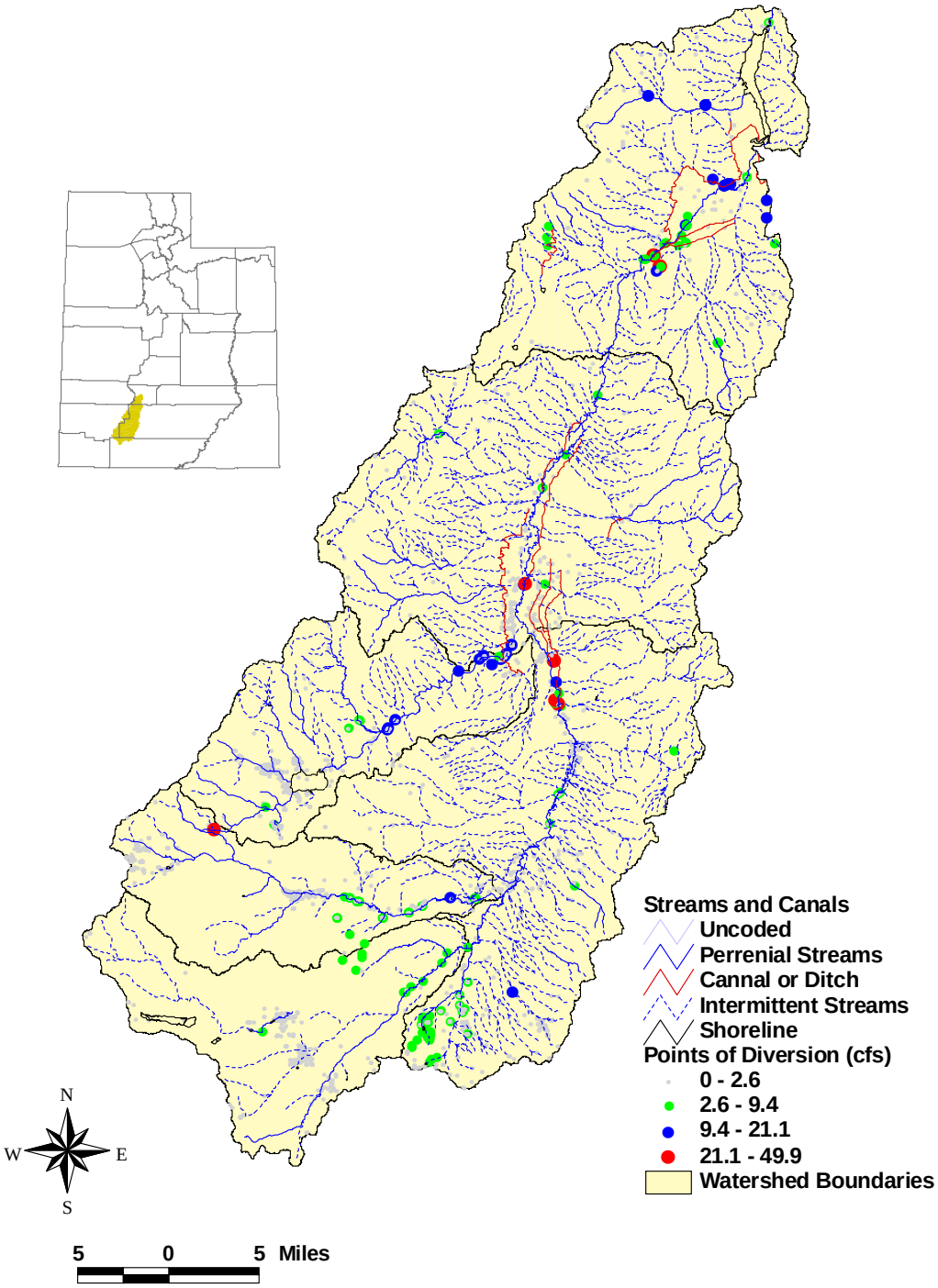
Available flow data for the Upper Sevier River are summarized in Figure 1. which shows the mean monthly discharge for two stations on the river located near Hatch in the upper watershed and the lower river in Circleville Canyon. With the exception of the irrigation season, flows are greater at the downstream station near Circleville. An average of approximately 68,400 acre-ft of water is diverted from the river and its tributaries in the Panguitch Valley during the irrigation season. According to a study by the Utah Department of Natural Resources (1993), of this irrigation water, approximately 33% or 22,950 acre-feet is consumed by crops. The remaining irrigation water discharges to streams and groundwater as tailwater, valley fill recharge and leakage from canals (11,110 acre-ft, 21,500 acre-ft, and 12,840 acre-ft, respectively). With the exception of a small stream section near Hatch, the length of the Upper Sevier River through Panguitch Valley is a gaining stream. The river is heavily influenced by irrigation diversions particularly near Panguitch, where several complete diversions are operated (see Map 3).

Figure 1. Mean monthly discharge for selected stations on the Upper Sevier River.



Source: United State Geological Survey.

Map 3. Irrigation diversions on the Upper Sevier River and tributaries (DWR, 2003)



In addition, the entire flow of Panguitch Creek is diverted and used for irrigation southeast of the town of Panguitch. As a result, much of the flow in the channel downstream of Panguitch is recharge from groundwater and tailwater from irrigation. Several areas of irrigation return flow from fields were identified during SVAP surveys and were present throughout the length of the valley associated with flooded pastures.

Statement of Intent

This Total Maximum Daily Load (TMDL) addresses the water quality impairment of waterbodies within the Upper Sevier River watershed for submittal to the United States Environmental Protection Agency. The goal of the TMDL is to meet water quality standards associated with the waterbody's designated beneficial uses.

II. Water Quality Standards

This document addresses water quality impairments within the Upper Sevier River watershed through the establishment of Total Maximum Daily Loads (TMDLs) for pollutants and sources of concern. Segments of the Upper Sevier River have been listed on the 2002 303(d) list of impaired waters (Map 4). The State of Utah has designated these waterbodies as coldwater (3A) fisheries and impairment of this designated use exists due to a number of pollutants and sources, including habitat alteration, total phosphorus (TP), and total suspended sediments (TSS). Upper Sevier River waterbodies and their associated impairment are listed in Table 5. While there is one point source in the basin (Mammoth Fish Hatchery) the primary sources are habitat degradation from agricultural activities, nonpoint source pollution from rangeland, summer home development, septic systems, recreational activities, and urban runoff.

Impaired Waters

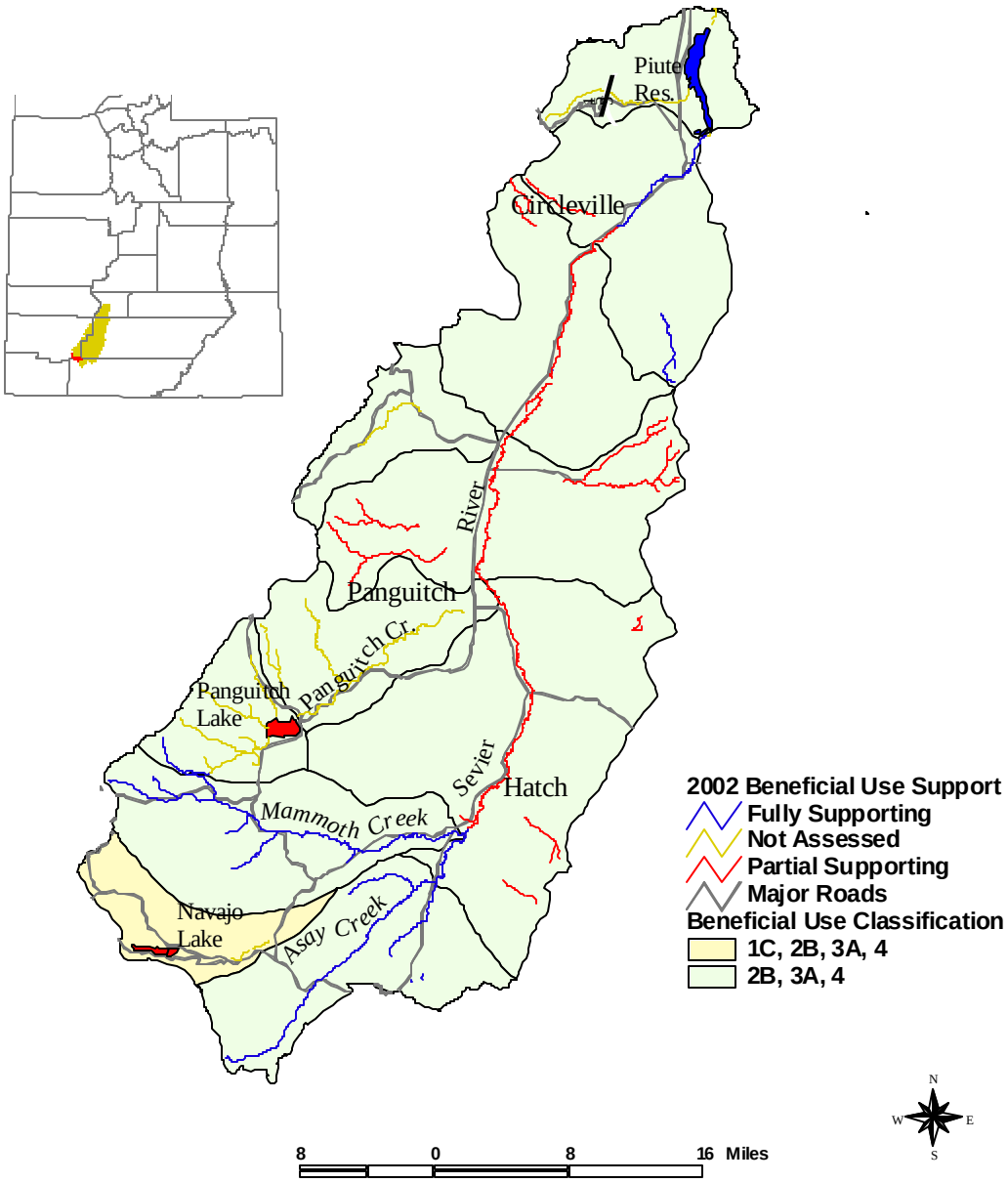
Utah's Year 2002 303(d) list identifies three segments of the Sevier River as being impaired due to water quality numeric exceedences. Impaired waterbodies and pollutants of concern are listed in Table 5.

Table 5. Impaired waterbodies and pollutants of concern (2002 303d List).

Waterbody	Waterbody ID	Impaired Use	Cause of Impairment	Priority
Sevier River and tributaries from Circleville Irrigation Diversion upstream to Horse Valley Diversion	**UT16030001-005**	**3A**	**Habitat Alteration, TSS, TP**	**Low**
Sevier River and tributaries from Horse Valley Diversion upstream to Long Canal Diversion excluding Panguitch Creek, Bear Creek, and their tributaries	**UT16030001-007**	**3A**	**Habitat Alteration, TSS, TP**	**Low**
Sevier River and tributaries from Long Canal to Mammoth Creek confluence	**UT16030001-012**	**3A**	**Habitat Alteration, TSS, TP**	**Low**

Map 4.

Beneficial Use Classification and Support Status (2002) for the Upper Sevier River Watershed



Waterbodies were originally listed on the 303d list as low priority for TMDL development. However, the Sevier River TMDL was targeted for completion in 2004 due to the active planning efforts in the watershed guided by local stakeholder groups and the establishment of the watershed as one of the USFS Large-scale Watershed Projects. The completion of this TMDL will not preclude the development of high priority TMDLs that are scheduled for completion.

The listing is based on an intensive water quality survey completed in 1996-1997 by DWQ. The beneficial uses, as designated by the State of Utah (DWQ, 2000b), for the Sevier River are:

- 2B – Protected for secondary contact recreation such as boating, wading, or similar uses;
- 3A - Protected for cold water species of game fish and other coldwater aquatic life, including the necessary aquatic organisms in their food chain.
- 3C – Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain;
- 3D – Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
- 4 – Protected for agricultural uses including irrigation of crops and stock watering

II. Water Quality Standards and Impairments

Utah water quality standards (Utah WQS) (State of Utah, 2000, UAC R317-2) and the 303(d) listing criteria (UDEQ - DWQ, 2002) provide the criteria to make an initial assessment of water quality conditions. The Utah water quality standards establish a narrative criteria for coldwater fishery (Class 3A) waters (Table 6.). While additional designated uses exist for the waters of the Upper Sevier River, 3A classification carries the strictest criteria for the pollutants of concern (POCs).

Table 6. Utah Water Quality Criteria for Class 3A Waters

Target Parameters	Criterion Maximum Concentration
Total Suspended Solids*	35 mg/L
Total Phosphorus*	
-Streams	0.05 mg/l
-Lakes	0.025 mg/l
Dissolved Oxygen	
-Lakes	4.0 mg/l

*Pollution Indicators. TSS criterion no longer part of the State of Utah Water Quality Standards.

DWQ lists any waterbody assessed as ‘partially supporting’ or ‘not supporting’ its beneficial uses on the 303(d) list with the exception of those waterbodies for which a TMDL study has already been completed and approved by the EPA. According to

DWQ's assessment of the Upper Sevier River, segments of the river are not meeting beneficial uses associated with coldwater fishery (3A) . The 303(d) listing criteria provide guidance on evaluating beneficial use support status based on the number of violations of the water quality criterion as listed in Table 7.

Table 7. 303 (d) Criteria for Assessing Beneficial Use Support

Degree of Use Support	Conventional Parameter	Toxic Parameters
Full	Criterion exceeded in less than two samples and in less than 10% of the samples if there were two or more exceedences.	For any one pollutant, no more than one violation of criterion.
Partial	Criterion was exceeded two times, and criterion was exceeded in more than 10% but not more than 25% of the samples.	For any one pollutant, two or more violations of the criterion, but violations occurred in less than or equal to 10% of the samples.
Non-support	Criterion was exceeded two times, and criterion was exceeded in more than 25% of the samples.	For any one pollutant, two or more violations of the criterion, and violations occurred in more than 10% of the samples.
Non-Support (3A Lakes)	Any lake profile with >50% of water column below the 4.0 mg/l DO criterion.	

Table 8 lists the monitoring stations and the number and percentage of samples exceeding the criterion of 0.05 mg/l for total phosphorus. This information was compiled from data collected during 1996-97.

Table 8. Exceedence report for total phosphorus for selected stations 1996-97.

STORET	Location	Number Exceeding Criterion	Number of Samples	% Exceeded	Mean Conc. (mg/l)	Support
494945	Circleville Canyon	11	20	55 %	.090	Non-Support
494964	Sevier above Sanford Ck.	7	16	44 %	.079	Non-Support
494966	Sevier R. East of Panguitch	4	14	29 %	.075	Non-Support
494963	Sevier R. at U12 Crossing	6	18	33 %	.063	Non-Support
494970	Mammoth Creek	5	15	33%	.051	Non-Support
494990	Asay Creek	3	16	19%	.021	Partial Support

III. Pollution Assessment

Nonpoint Sources of Pollution

Natural Sources

Within natural forested landscapes mass erosion such as geological creep, and to a lesser degree slump and debris avalanches, are the dominant upland erosion processes. After intense wildfire, surface erosion is a dominant factor. In valley bottoms, stream channel erosion, including both bed and bank erosion, may deposit materials into the channel, where transport, storage and deposition may influence stream integrity. Prior to European settlement, stream channels in this watershed were most likely in dynamic equilibrium, and experienced natural erosion processes. Stream riparian habitat most likely consisted of mosaics of thick willows and late seral grasses. Cottonwood and willow communities were present at lower elevations along the Sevier River. Expansive and diverse riparian grasses, along with willow and cottonwood, helped reduce sediment influx, maintained coarser stream substrate, contributed to cooler stream temperatures, and supported normal flow regimes. As with sediment, natural sources of nutrients exist in every watershed, derived from parent material, sediment and inputs from organic matter deposited in or near streams. While headwater streams tend to be less productive than lower elevation rivers, historical accounts of the Upper Sevier River watershed suggest streams and lakes in the area were productive and contained abundant fish.

Human Sources

As early settlers moved into the Upper Sevier River Watershed, surface erosion processes have become more prevalent in areas where road constructing, mining, timber harvest and grazing occur. Roads have increased surface and mass erosion rates beyond those associated with natural watershed disturbances. An extensive network of roads constructed in areas such as stream bottoms and un-stable land types has resulted in large scale mass erosion. Like roads, livestock grazing and silviculture can alter the hydrology of a watershed, reducing protective vegetation and infiltration, and increasing the magnitude of runoff events. Grazing and recreation in stream channels and riparian areas reduces the stability of banks and results in erosion of bank materials to the channel and receiving waterbodies. In addition to sources from erosion, nutrient enrichment from livestock waste can result from grazing in the stream channel, flood irrigation of pasture land and runoff from animal feeding operations.

An extensive survey using the Stream Visualization Assessment Protocol or SVAP (USDA, 1998) was completed in October of 2002 on a total of 65 stream miles on the Upper Sevier River and Mammoth Creek (see Map 5). Selected results pertaining to streambank condition are contained in Table 12. In addition to SVAP additional erosion information was derived using the Streambank Erosion Condition Index or SECI (USDA,). SECI is essentially an erosion hazard index used to estimate bank erosion in

combination with simple measurements such as bank height, length, and soil bulk density. Results of the SECI survey are included in Appendix C .

In addition waterbody assessments were developed by the Watershed Steering Committee in 1997 And are summarized in Appendix D. These assessments rated the current conditions and feasibility for restoration and recommended BMPs for improvement of water quality and habitat.

A major concern in the upper watershed tributaries is the concentration of summer home development near streams and lakes. The Human Uses work group for the Upper Sevier Community Watershed Project identified key issues associated with human uses in the watershed. The group estimated approximately 4,163 developed lots in the Strawberry Valley (841), Duck Creek (1450), Swain's Creek (1,107, and Strawberry Point - Zions View (765) subwatersheds, all currently using septic tanks. In the Mammoth Creek watershed they identified approximately 1,114 developed lots in the Ireland Meadows (36), Meadow Lakes Estates (445), Rainbow Meadows(90), and Tommy Creek (194) areas. As development continues to increase, impacts to surface and groundwater from poorly designed, located and installed septic systems may be a potential problem particularly since the claron-limestone and volcanic substrates present from Duck Creek to Panguitch Lake are not suitable and conducive to septic system use. Dispersed recreation associated with these developments, in areas where few or no sanitary facilities exists, may also potentially impact surface and groundwater. While local effects of these developments may occur in surface waters, monitoring data are inadequate to determine loading to tributaries and the effects to the mainstem of the Sevier River is uncertain. In addition, use of tributary flow for irrigation (e.g. Panguitch and Mammoth Creek) may reduce the loading from these sources.

Point Sources of Pollution

There is only one point source in the Upper Sevier River Watershed. Located on lower Mammoth Creek, the Mammoth Creek Fish Hatchery is operated by the State of Utah Division of Wildlife Resources. The Mammoth Creek Fish Hatchery is currently out of production due to contamination by whirling disease. The facility went offline on July 22, 2002 and will remain under investigation to determine sources of contamination of the disease.

Table 9. Summary statistics for Mammoth Creek Fish Hatchery*

	Flow (cfs)	**TP (mg/l)**	**TP Load (kg/day)**
Mean	3.03	0.11	0.77
Max	4.10	0.24	1.67
Min	2.00	0.06	0.40

*Based on monthly sampling from 5/1996 – 4/1997 and 7/2001-6/2002

Discharge from the facility varies only slightly, with a mean of 3 cfs. The yearly load of TP, based on monthly averages from the available data set, is approximately 299 kg/year.

This represents approximately 33% of the TP load in Mammoth Creek near its confluence with the Upper Sevier River at station 494970. Outfall data is the only data available for the facility, therefore phosphorus load into the facility from spring sources cannot be determined. Additionally data upstream of the facility is incomplete and loading capacity of the stream cannot be determined at this time. Therefore, loading from the hatchery will be discussed in terms of its relative contribution to the total phosphorus entering the Sevier River at the mouth of Mammoth Creek.

IV. Linkage Analysis

The State of Utah Division of water Quality adopted pollution indicator values for TSS and TP of 35 mg/l and 0.05 mg/l, respectively. Recently, narrative criteria for TSS were removed from state water quality standards (UDEQ, 2003). While exceeding these values did not automatically prompt listing on the 303d list, additional information was required to validate impairments. In March and November of 1996, the Division of Water Quality sampled macroinvertebrates and developed metrics using the Biotic Condition Index (BCI). The average BCI for the site near Circleville (STORET # 494945) was 65.5 or "Poor" rating, indicating tolerance to sediment and nutrients which supports the water chemistry data. Impairment based on "Habitat Alteration" was determined by the Upper Sevier Watershed Steering Committee as the primary cause of instream impairment and potential sources of sediment from streambank erosion. Sedimentation and siltation affect fisheries and aquatic resources by covering and eliminating gravel spawning beds, covering fish eggs (which reduces oxygen supply and survival of eggs and fry), and reducing the amount of habitat available for aquatic invertebrates that are an important part of the food chain.

An assessment of the fishery performed by the Utah Division of Wildlife Resources (Beckstrom, 1998) also found that conditions were inadequate to support a viable fishery in most areas of the Upper Sevier River: "Based on the electroshocking surveys and the long-term personal knowledge of regional fishery biologists, UDWR recognizes that trout populations, recruitment, and yearly survival in the main Sevier River above Annabella Diversion, lower Asay Creek, lower Mammoth Creek…and other basin water bodies are well below the standards necessary for these waters to be considered supporting a cold water game fishery."

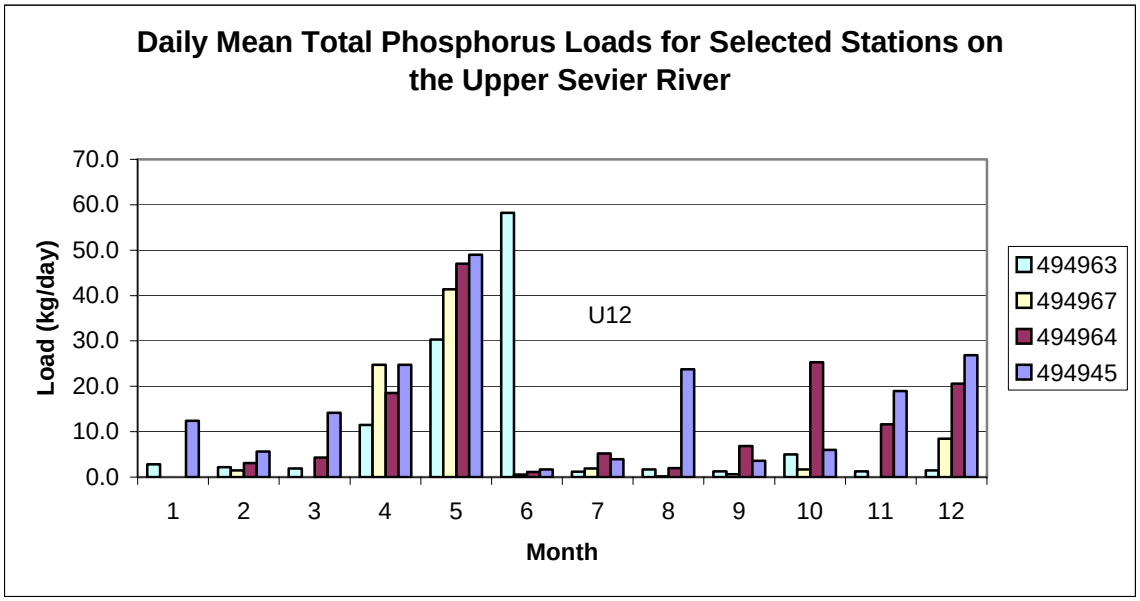
During the development of this TMDL the DWQ modified its water quality standards in 2003 by removing the statewide criterion of 35 mg/l TSS for coldwater fisheries due to concerns that it may not be appropriate for all coldwater fisheries statewide. Therefore, this TMDL will address TSS as it relates to "Habitat Alteration" and associated impacts on the existing biological community (e.g. macroinvertebrates).

Water Quality Analysis

Total Phosphorus

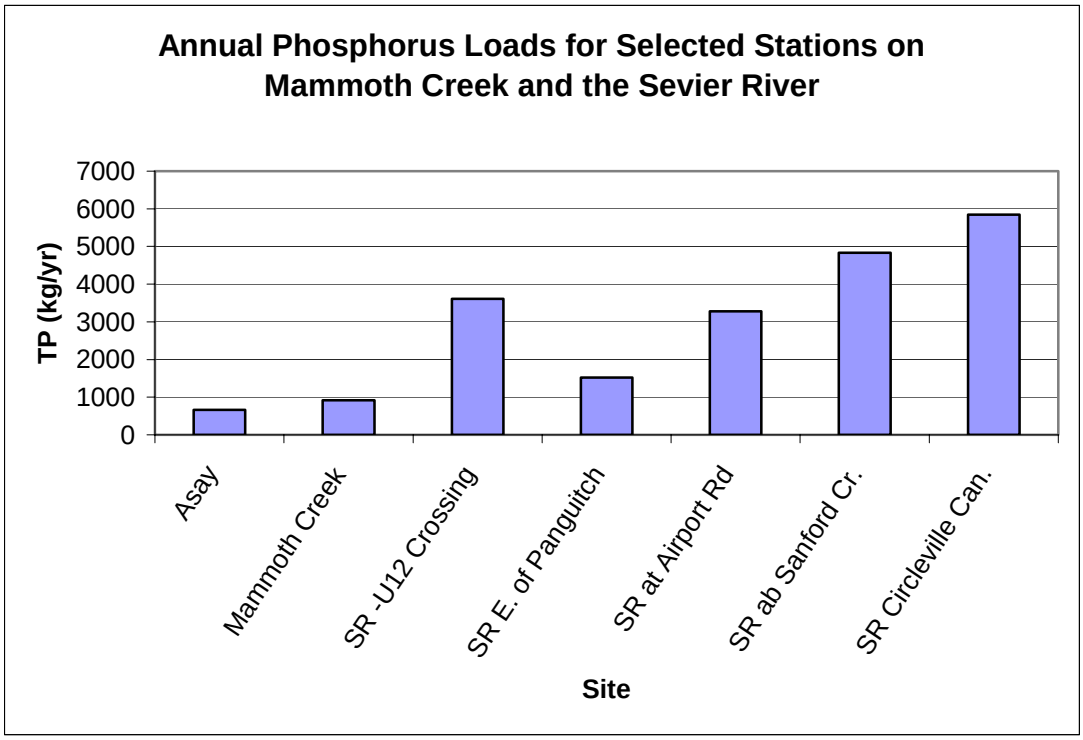
Mean total phosphorus concentrations and loads were calculated by sorting data by month and obtaining monthly averages (see Appendix B for summaries). Figure 3 indicates that loads are highest during April and May, which corresponds with the spring runoff. The sharp drop in loading in the middle and lower river during June may reflect the effect of irrigation diversions reducing flows and concentrations due to land application. Loads remain low in the upper river the remainder of the year while higher loads in the lower river reflect irrigation return flows and streambank erosion from higher fall stream flows. In addition, levels may increase in downstream reaches as a result of over-wintering of livestock in the Panguitch Valley.

Figure 3. Mean TP loads for selected stations on the Upper Sevier River.



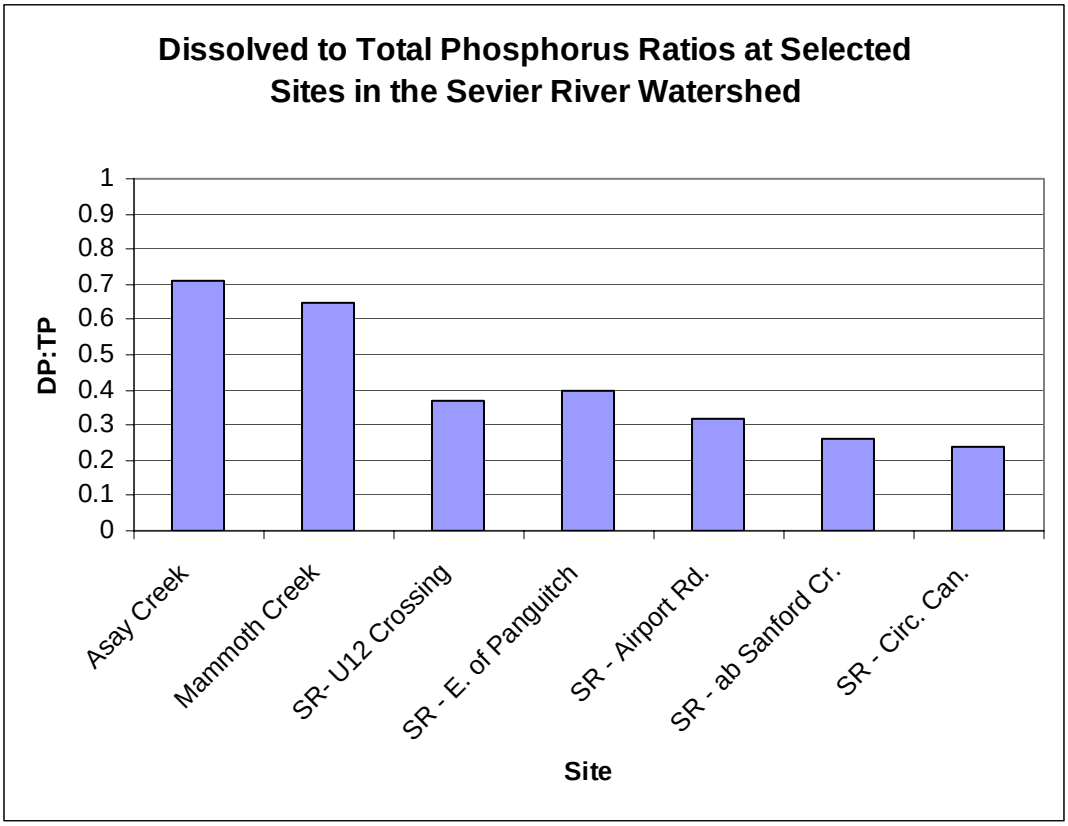
Annual loads (see Figure 4.) were calculated by averaging monthly loads and multiplying by 365 days in the year. In general, loads increase with downstream reach. The exception to this trend occurs at 494963 (Sevier River at U12 Crossing) in June which may be due to higher flows in this reach which is located upstream from major irrigation diversions. The site 494966 (Sevier River East of Panguitch) is located below a major diversion which accounts for the lower TP loads observed at this site.

Figure 4. Annual TP loads for selected stations.



Dissolved phosphorus appears in surface waters usually from sources of organic nutrient enrichment such as a wastewater treatment plant, animal feedlot waste, or other point source discharge. Examination of ratios of dissolved to total phosphorus concentrations can be used to indicate whether sources are predominantly organic in nature as is the case when high ratios are found in surface water. Ratios were calculated for selected sites on the Upper Sevier River, Asay and Mammoth Creeks and are presented in Figure 5.

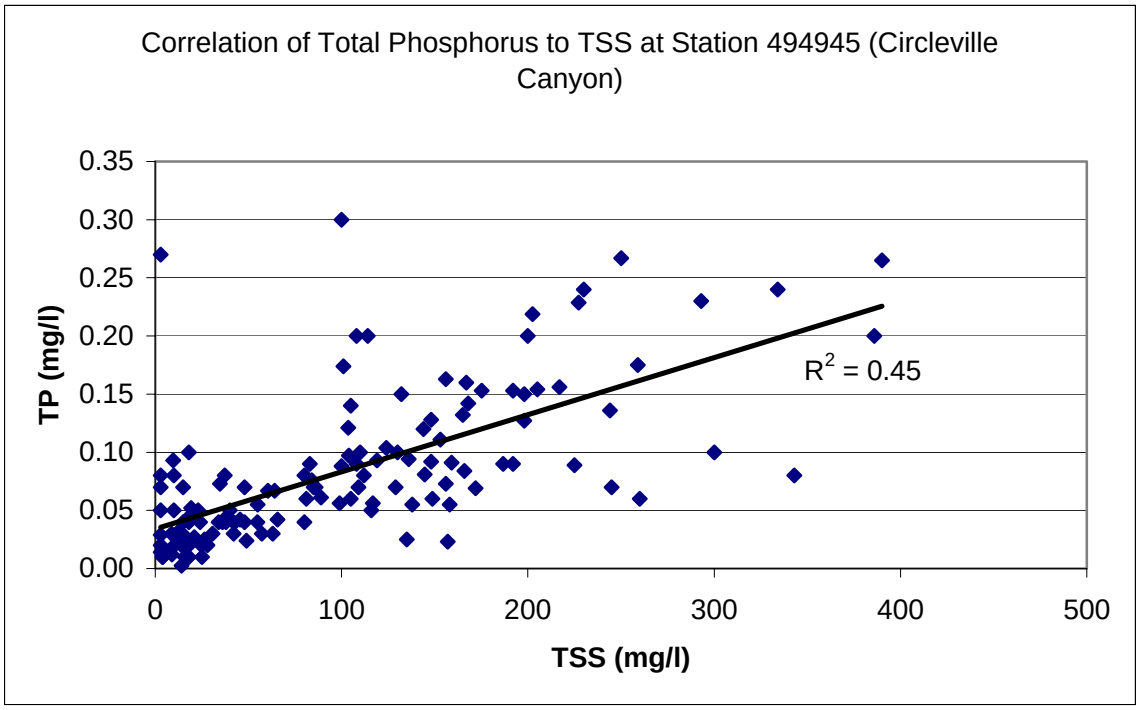
Figure 5. Dissolved and total phosphorus ratios.



Ratios of DP to TP were low (0.24) in the lower river suggesting that TP was not readily bioavailable but adhered to soil or sediment particles. Conversely ratios in Mammoth and Asay Creeks were high (0.65) indicating organic enrichment related to sources such as the Mammoth Fish Hatchery, grazing and high numbers of septic systems from home development in both the Asay and Mammoth creek watersheds.

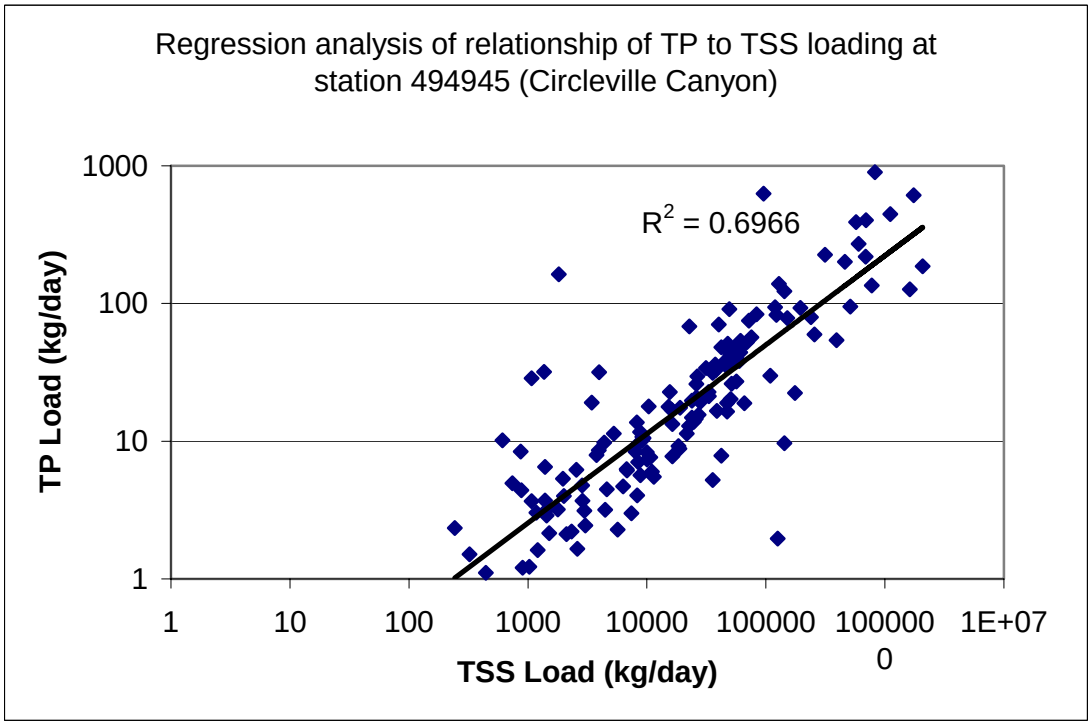
In addition to dissolved to total phosphorus ratios, correlations between TP and Total Suspended Solids (TSS) were graphed (see Figure 6). While the relationship between TSS and TP is not particularly strong for the entire dataset (R^2= .45) the majority of high phosphorus measurements (> 0.05 mg/l) occur when TSS is also high. Analysis of the dataset for Asay Creek (494990) reveals a similar relationship between TSS and TP (R^2 =0.49) while Mammoth Creek (R^2 = 0.002) did not bear a relationship, thus indicating that TP concentrations are not likely a function of sediment-borne phosphorus, but primarily organic in nature.

Figure 6. Correlation of TP to TSS at station 494945.



In addition, regression analysis of the relationship between TP load and TSS load (Figure 7) provides stronger evidence that high loads of TP are flow related and associated with high sediment loads.

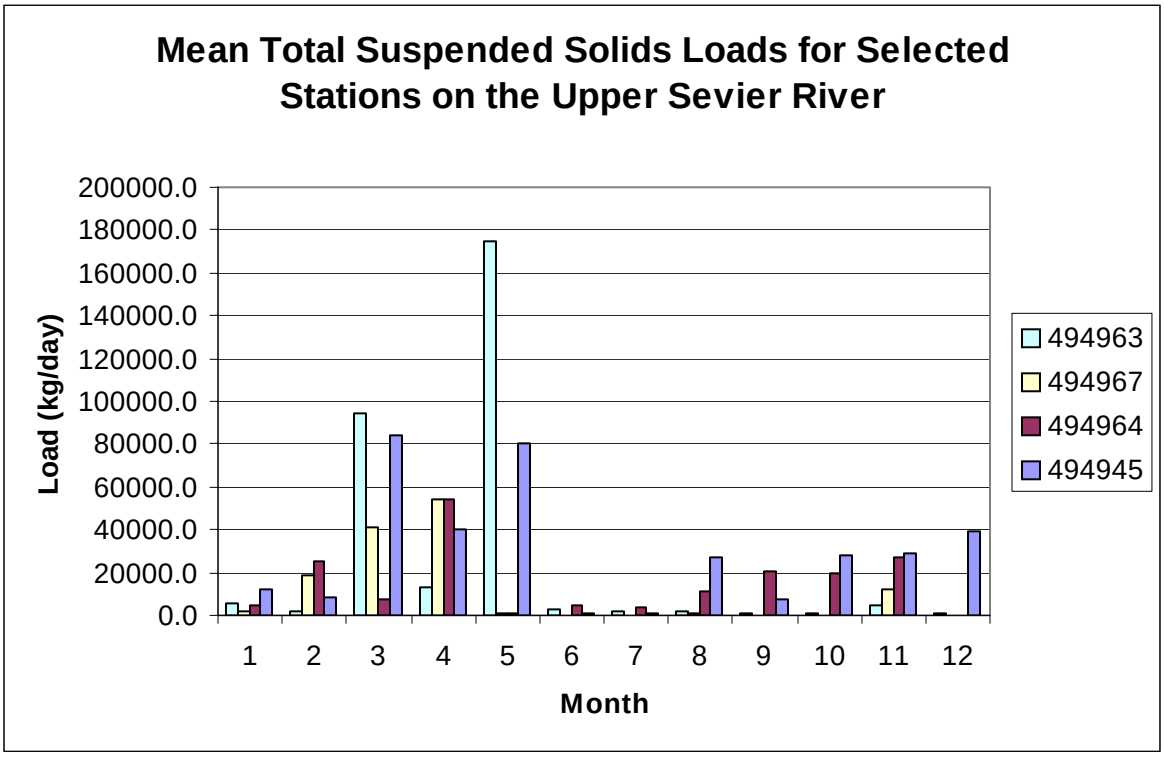
Figure 7. Regression analysis of TP and TSS Loads for Station 494945.



TSS

Mean total suspended solids (TSS) concentrations and loads were calculated by sorting data by month and obtaining monthly averages (see Appendix B for summaries). Figure 8 indicates that loads are highest during April and May, which corresponds with the spring runoff. The sharp drop in loading in the middle and lower river during June may reflect the effect of irrigation diversions reducing flows and concentrations due to land application of river water. Loads remain low in the upper river the remainder of the year while higher loads in the lower river reflect irrigation return flows and streambank erosion from higher fall stream flows.

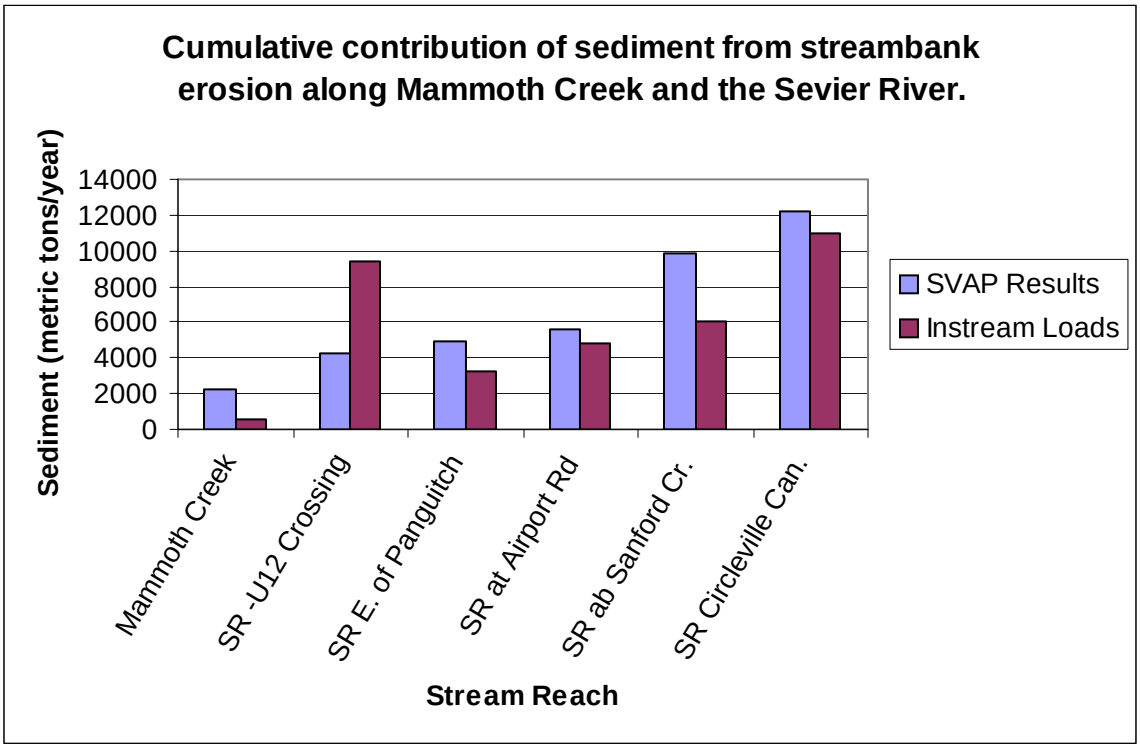
Figure 8. TSS loads at selected stations on the Upper Sevier River



As is typical of stream with snowmelt dominated hydrograph, TSS values generally peak in the months of spring runoff as tributary inflows and bank erosion from high flows contribute sediment to the system. A notable exception can be seen in May values, where irrigation withdrawals not only effect discharge but the TSS load. Peaks in TSS load early in March and April may be a result of low elevation snowmelt mobilizing sediment from valley bottoms and foothill rangeland. The lower river (represented by 494964 and 494945), exhibits an increase in TSS load as stream flows increase in the lower river after irrigation season. In this situation, streambank and in- channel erosion is most likely occurring from increased flows from groundwater recharge and fall storm events. However, analysis of the correlation between flow and TSS concentrations for the period of record at 494945 did not show TSS to be well correlated to flow (R^2 =.28)

TSS Concentrations at 494963 were highly variable from year to year. Data from 1996-7 averaged 46 mg/l while 2001-2 data averaged 1008 mg/l TSS (with several dates exceeding 1500 mg/l). It is not recommended that TMDLs be based on TSS data for waters in this basin. TSS doesn't actually reflect the overall sediment load present in the stream and therefore, TMDL endpoints related to TSS will not be established in this study.

Figure 9. Estimated sediment loads from streambank erosion.



Relative increases in sediment as TSS as measured in instream loads from water quality data mirror the increases predicted during the survey using SECI protocol. While the SECI estimates the total amount of sediment delivered to the stream from the volume of material being lost each year, TSS only measures the suspended fraction of sediment transported in the stream. The estimates of streambank erosion would be expected to be higher since not all of the material entering a stream would be suspended in the water column but comprise bed load as well. Since the SECI survey was incomplete and did not include other tributaries we would expect the sediment contribution to be much greater. The site at SR at U12 crossing exhibited extremely high TSS values in the 2001-02 intensive sampling season which is responsible for the spike in TSS load at this site. In addition, numerous irrigation withdrawals in the area upstream of Panguitch may regulate the amount of TSS in the river since in some cases the withdrawals are complete dry dams and the water is flooded onto fields to the east of the Valley. The monitoring station 494966 (Sevier River East of Panguitch) is one such site, located below a complete diversion which had resulted in lower observed stream flow and loads for both TSS and phosphorus.

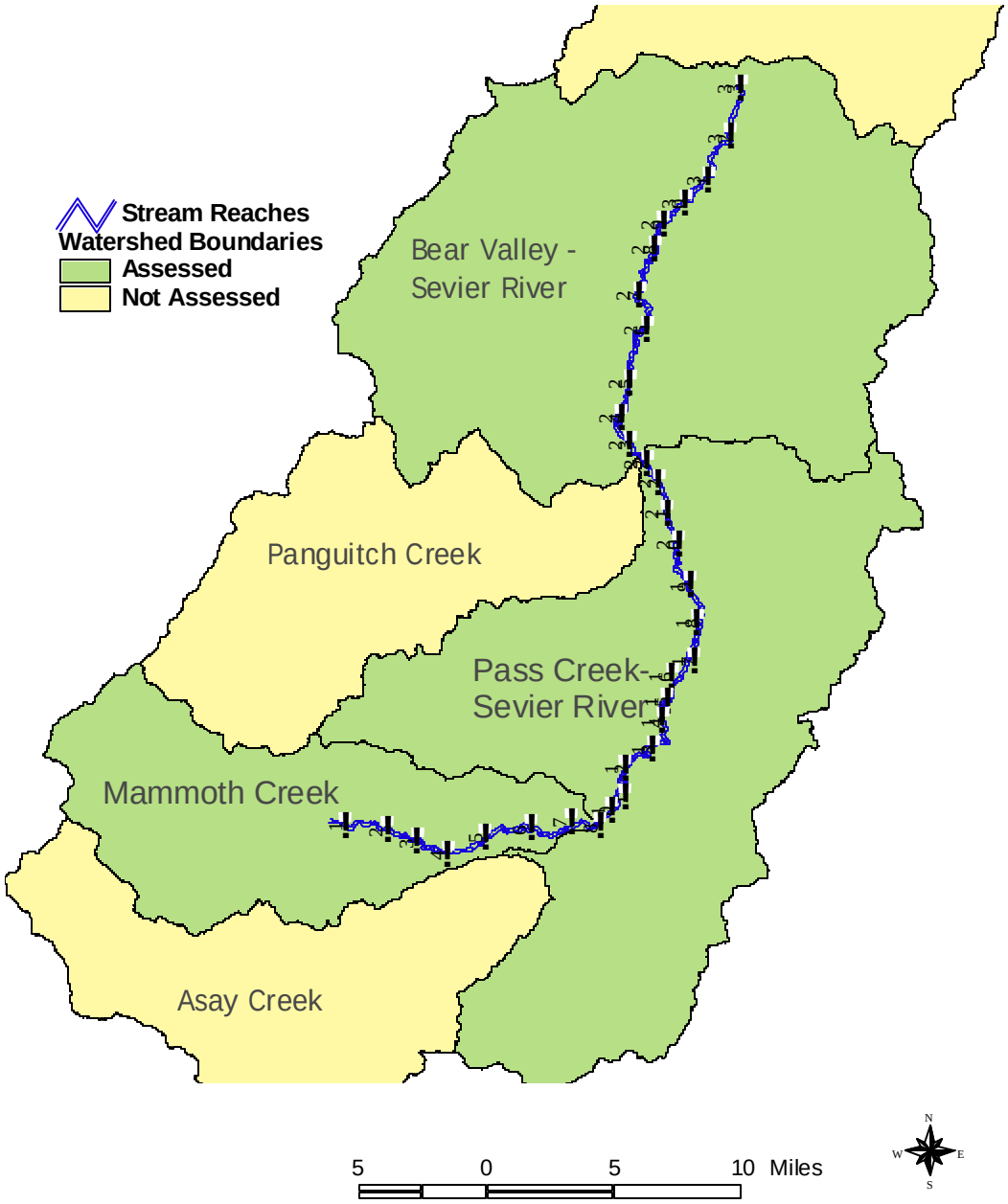
Habitat Alteration

Stream habitat conditions on the Sevier River have long been a concern and a major contributor to the impairment of the fishery. Eroding banks, sedimentation, and a lack of woody vegetation are readily apparent causes of habitat alteration on the river. These conditions prompted the Steering Committee to organize a stream survey using the Stream Visual Assessment Protocol (SVAP) developed by the NRCS. Utilized in a number of watershed around the state, SVAP is a generalized tool integrating primarily visual assessments of physical, biological, and chemical condition of streams. Although not a monitoring tool, the protocol is well suited to comparing a given stream reach to a potential reference site or ranking reaches for restoration priority. In addition to compiling information fish habitat, macroinvertebrates, vegetation, nutrient impacts, channel condition, and hydro-modification, the teams also completed the Stream Erosion Condition Index (SECI) forms which provided some estimation of sediment delivery to the river from eroding streambanks. SVAP scores and SECI erosion estimates for the 65 miles of stream surveyed are contained in Appendix D. Table 10 summarizes those scores for elements in SVAP which are most indicative of habitat alteration.

Note that reaches 1-8 are located on Mammoth Creek and reaches 9-33 extend from the confluence of Mammoth and Asay Creeks to Circleville canyon (see Map 5).

Map 5.

Stream reaches assessed using the Stream Visual Assessment Protocol



In the SVAP, “channel condition” is categorized by human altered streams (berms, dikes, riprap, channelization, etc.) and streams exhibiting excessive lateral cutting, incisement, or aggradation. Regardless of the particular activity or hydrologic effects to the channel, this rating addresses the level of channel alteration from a natural channel. The average score for channel condition for reaches on the Sevier River was 5.6 (Poor to Fair). Reaches upstream from Panguitch which scored poorly in this category typically were impacted by the presence of Highway 89 which constrains the floodplain and in places the river is channelized and bermed. Channel condition is impaired in the lower reaches due mostly to excessive lateral movement and stream downcutting, although in some areas riprap and other attempts at containing the channel have been attempted.

The scores for “riparian zone” reflect the extent to which the floodplain is vegetated (10 = at least 2 active channel widths on each side of stream) or denuded of natural vegetation (1= less than 1/3 channel width and/or not regenerating). For this element, the word *natural* means plant communities with (1) all appropriate structural components and (2) species native to the site or introduced species that function similar to native species at reference sites. The average score for the riparian zone for reaches on the Sevier River was 3.3 (Poor). In all but a few cases, the majority of the Sevier River has very little natural vegetation on its floodplain, particularly in the lower river where there is an absence of regeneration, heavy grazing pressure, and an incised channel which has isolated the stream from its historic floodplain.

“Bank stability” is the existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream. This element primarily incorporates bank height and deep rooted vegetation for determination of scoring. The average score for bank stability for reaches on the Sevier River was 4.2 (Poor). Since this element depends on the presence of deep rooted plants, the lack of bank stability can be directly related to the absence of a natural or functioning riparian zone.
“Fish Cover” measures availability of physical habitat for fish. The potential for the maintenance of a healthy fish community and its ability to recover from disturbance is dependent on the variety and abundance of suitable habitat and cover available. The average score for fish cover for reaches on the Sevier River was 3.7 (Poor). This average reflects a typical stream reach which would have 3-4 types of fish cover, and for reaches on the Sevier River these would typically include riffles, undercut banks, boulder/ cobbles, and occasional deep pools and large woody debris.

Similar to fish cover, “invertebrate habitat” measures the number of substrates available for insects and invertebrates to occupy. Substrate refers to the stream bottom, woody debris, or other surfaces on which invertebrates can live. Optimal conditions include a variety of substrate types within a relatively small area of the stream. The average score for insect habitat for reaches on the Sevier River was 4.3 (Poor), which would translate to approximately 3 types of substrate, comprised primarily of coarse gravel, cobble, and undercut banks.

Table 10 . Selected SVAP scores for reaches Mammoth Creek and the Upper Sevier River.

Reach	Channel Condition	Riparian Zone	Bank Stability	Fish Cover	Inverte-brate Habitat	Riffle Embedded-ness
1	6.3	8.6	8.3	9	10	8
2	9	3	5	10	7	8
3	3	3	2	4	2	3
4	10	9	10	10	10	7
5	8	5	3	5	7	3
6						
7	9	10	10	10	10	8
8	8	1	3	5	6	10
9	6	1	7.5	1	1	5
10	7	8	9	10	10	9
11	4.5	1	2	4	3	8
12	5.3	2.3	4.1	2.5	5.6	
13	4.7	4.7	3.7	6	8	8.3
14	4.7	6.3	5.7	4.3	5.3	6
15	7.3	4.7	4	4.3	4.6	4
16	6.3	5	8	4.5	6.5	9
17	8	4	7	5	7	7
18	7.6	3.8	6.5	4	6	6
19	7.5	6.3	5.5	4.5	3.5	2.5
20	3	1	2.5	4	6	4
21	8	7	7	8	7	4
22	3	3	3	5	7	4
23	8	4	5	5	7	2
24	7	2	1	3	1	4
25	8	8	5	3	3	8
26	2	1	1	2	3	2
27	2	1	1	2	1	2
28	7	4	6	2	1	1
29	2	1	3	3	3	2
30	3	1	4	3	4	5
31	6	1	1	1.5	1.5	3
32	6	1	1.5	1	1	3
33	6	1	2	1	1	3

"Riffle Embeddedness" measures the degree to which gravel and cobble substrate are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation. The average score for riffle embeddedness for reaches on the Sevier River was 4.7 (Poor). This score is indicative of a system in which sedimentation from tributaries and bank erosion and

hydro-modification (irrigation withdrawals) have resulted in excessive bed load of sediment and fines.

In general, the reaches assessed using the SVAP, describe a stream heavily impacted by grazing and roads which has resulted in de-vegetation of the riparian zone, unstable banks, channelization and a stream which lacks in-stream habitat for insects and fish due to excessive sediment. Deriving value from the SVAP assessment requires the establishment of reference conditions for all or some of the elements of the protocol. One such potential reference site would be found on reach 7 on lower Mammoth Creek. Although impacted by other factors such as nutrient enrichment from upstream sources which is reflected in its final rating of "Fair" (there were no "Good" condition reaches identified in this survey) this may be a feasible reference site for the habitat elements listed in Table 10. Lower Mammoth Creek above highway 89 is relatively unimpacted by human activity such as grazing since its floodplain is isolated by the highway and steep canyon walls. The suitability and appropriate indicator elements will be further discussed below when endpoints for habitat alteration are determined (see below).

Water Quality Targets and Endpoints

Total Phosphorus

Total phosphorus loads were calculated using DWQ data from the intensive monitoring surveys completed in 1996-97 and 2001-02. Data were sorted by month, concentrations were multiplied by flow and a conversion factor, and monthly loads were summed to obtain a yearly instream load. Loading capacity was calculated in the same fashion by substituting the state criterion of 0.05 mg/l where data exceeded that criterion. Load reductions necessary to ensure that state standards are not violated are summarized in Table 11.

Table 11. Annual TP concentrations, loads, loading capacity, and load reduction

Station	TP Conc. (mg/l)	TP Load (kg/yr)	TP Load Capacity	Reduction (kg/yr)	% Reduction
Asay Creek at Mouth	0.021	665	574	92	14
Mammoth Cr. FH	0.11	299	135	164	55
Mammoth Cr. at Mouth	0.048	945	654	291	31
Sevier @ U12	0.023	1871	1528	343	18
Sevier E. of Panguitch	0.033	1525	931	594	39
Sevier @ Airport Road	0.046	2564	1536	1028	40
Sevier R. AB Sanford Cr.	0.062	3999	2078	1921	48
Sevier (Circleville Can.)	0.079	5846	2583	3263	56

*Based on monthly sampling from 5/1996 – 4/1997 and 7/2001-6/2002

Although, Total Suspended Solids (TSS) loads were calculated using DWQ data from the intensive monitoring surveys completed in 1996-97 and 2001-02 (Table 12), as previously discussed TSS endpoints will not be established to evaluate the restoration of water quality defined endpoints. Data were sorted by month, concentrations were multiplied by flow and a conversion factor, and monthly loads were summed to obtain a yearly instream load. Loading capacity was calculated in the same fashion by substituting the old state criterion of 35 mg/l where data exceeded that criterion. Load reductions necessary to ensure that state narrative standards for 3A coldwater fisheries are not violated were determined but are presented here as support information that excessive TSS are present in impaired waterbodies.

Table 12 . Total suspended solids loads and loading capacity at selected stations.

Station	TSS Conc. (mg/l)	TSS Load (Mton/yr)	TSS Load Capacity	Reduction (Mton/yr)	% Reduction
Asay Cr.	40	940	466	474	50
Mammoth Cr.	21	521	326	195	37
Sevier @ U12	501	9378	1459	7919	84
Sevier E. of Panguitch	44	3268	735	2533	78
Sevier @ Airport Road	69	4769	1727	3042	64
Sevier R. AB Sanford Cr.	88	5992	1626	4366	73
Sevier (Circleville Can.)	189	10967	1911	9056	83

*Based on monthly sampling from 5/1996 – 4/1997 and 7/2001-6/2002

V. TMDL Allocations

Total Phosphorus

Point Sources

Mammoth Creek Fish Hatchery is currently the only point source in the Upper Sevier Watershed. Measured loads are relatively constant and average 299 kg/year. This load represents approximately 33% of the load in Mammoth Creek measured at the mouth. In addition, Mammoth Creek Fish Hatchery contributes approximately 16% of the load in the Upper Sevier River as measured at the U12 crossing (494963). While reduction in total phosphorus from the hatchery may not have a profound effect on instream loads and concentrations in the Sevier River, the hatchery is a major contributor to the load in Mammoth Creek which, though not listed for TMDL development, does exceed the phosphorus criterion in 33% of the dataset.

The Mammoth Creek Fish Hatchery ceased production due to an infestation with whirling disease in July of 2002, which corresponds with the end of the dataset used in TMDL. Additional discharge data after production stopped is inadequate to assess the relative contribution of the facility while not feeding and rearing trout. Also, a lack of upstream or inflow data precludes the accurate estimation of the facilities phosphorus

contribution to Mammoth Creek. Some data exist for a site located above the hatchery located at the USGS Station (494979) from the period of 11/2002 to 7/2003 which indicate that concentration in Mammoth Creek is low with a mean total phosphorus of 0.028 mg/l. Stream flow data from the USGS station were obtained and phosphorus loads estimated to be approximately 500 kg/year TP. Although the dataset above the hatchery is incomplete, limited data suggest that instream concentrations are low and upstream loads are consistent with load estimates for nonpoint sources in the watershed (~650 kg/year TP) Sources of total phosphorus downstream of the facility are limited since Mammoth Creek enters a canyon above its confluence with the Sevier River and grazing is absent in that reach.

The newly designed facility is not expected to change in terms of its production level, inflows or outflows, since these are determined largely by their spring water source. The facility will be rebuilt to limit the infestation of whirling disease and will likely utilize a microfiltration system (Wilson, 2004). This system may reduce total phosphorus entering the plant but currently it is unknown what concentration, if any of particulate-bound phosphorus is contributing load to the hatchery. It has been determined by dye studies that surface waters are infiltrating the spring source for the hatchery (Wilson, 2004) Ultimately, extensive monitoring must occur to estimate this load and to determine the hatcheries contribution to the waste load.

Based on the historical load contribution of the hatchery to Mammoth Creek and the Upper Sevier River (33% and 16% of TP load, respectively), it is recommended that in the future a permit limit be established to protect the fishery in the receiving waterbodies. As a future source of total phosphorus a wasteload allocation will need to be determined to assess the contribution of the facility to the instream total phosphorus load. Since insufficient data exist to impose this permit limit at this time, its determination will require additional monitoring to assess the water quality of inflows to the facility, sampling upstream of the hatchery and continued monitoring downstream of its discharge. During the process of design for the new facility, it is recommended that the DWR employ best available technology (BAT) for the reduction of total phosphorus in the hatchery's effluent. Some of these BAT may include floating and/or low phosphorus feed and proper management and/or upgrade of settling basins for removal of solids and phosphorus from the effluent.

Nonpoint Sources

As mentioned above, nonpoint sources of phosphorus include natural background sources from the weathering of parent material and organic matter delivered to the streams as soil and plant litter. The movement of nutrients such as phosphorus through a watershed is a complex process since plant and algal uptake plays a strong role in the cycling of nutrients. In addition, the nature of the Sevier River watershed is such that water is continually diverted and land applied and returning to the channel via overland flow and shallow groundwater return flows. In the process, phosphorus (as well TSS) loads and concentrations can be reduced when irrigation water from the river is distributed to crops. Water from Panguitch Creek watershed, which is a major portion of the watershed, does

not enter the Sevier River via its channel, but is completely consumed by irrigation for the majority of the year. Upon irrigation application, TSS settles out and phosphorus binds with soils or is consumed by crop uptake. As a result, data from stations along the Sevier River in Panguitch Valley may represent the contribution of very localized sources of irrigation return flow, grazing, and streambank erosion occurring between major irrigation withdrawals on the River. Similarly, a station such as 494966 (East of Panguitch) which are located downstream of a major irrigation diversion may not be suitable for calculating an instream load and relating it to land uses and determining an allocation for the watershed upstream. The diffuse nature of sources such as grazing precludes the ability to present allocations in great detail. Consequently, contributions from pollution sources are allocated on a watershed scale since land use is dispersed and essentially uniform. However, priority areas are identifiable in terms of streambank erosion and sediment from upland source, discussed below.

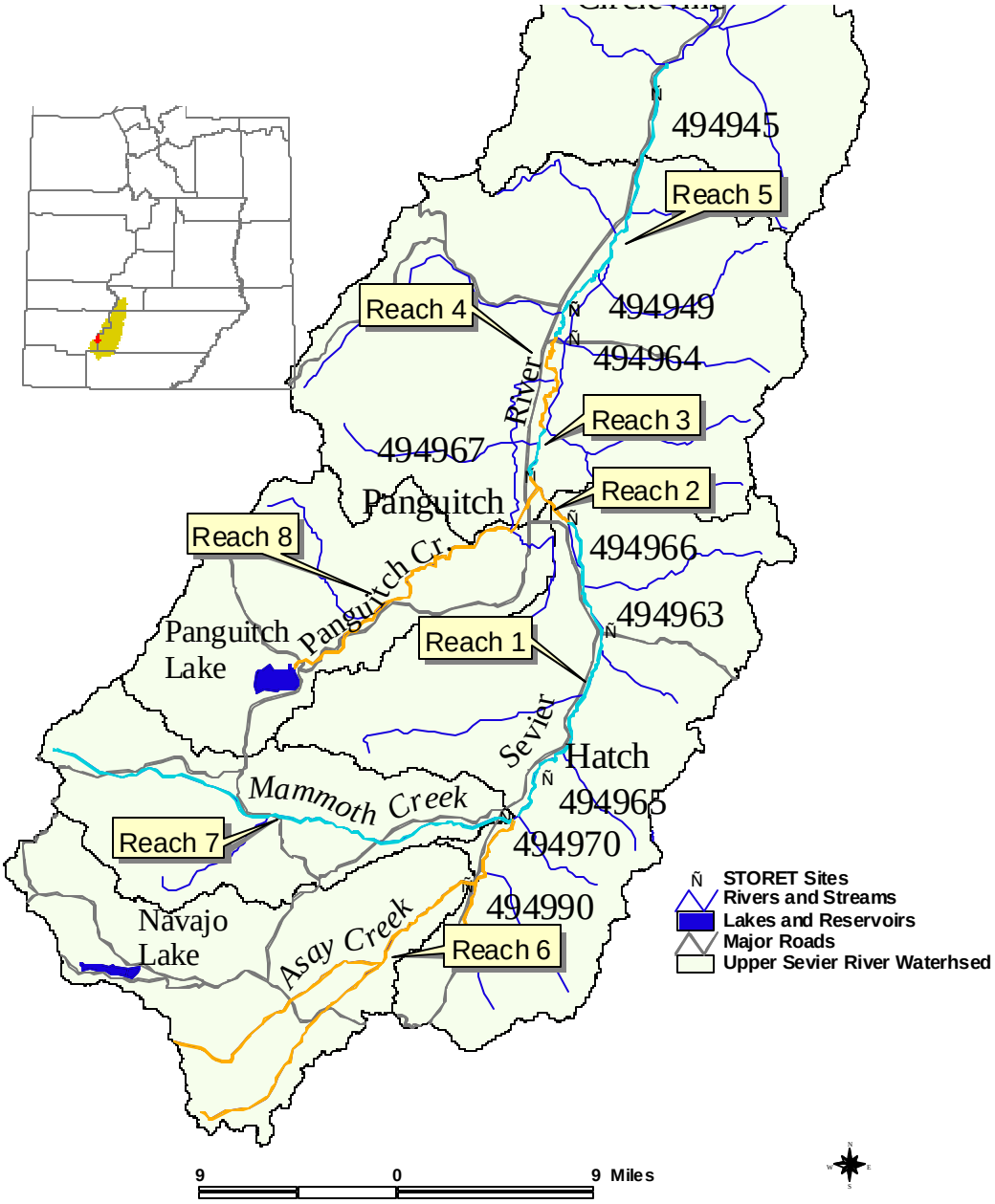
Primary mechanisms of phosphorus delivery from cattle to streams include direct deposition in streams and on streambanks and return flows from flooding of pasture utilized for grazing and/or fertilized with manure. In an effort to estimate contributions of total phosphorus from grazing, cattle numbers were obtained from the landowners in the watershed and were divided by subwatershed (Dodds, 2003). The total number of animals in each watershed varies by season as cattle are moved from summer to winter range, as well as into and out of the watershed. The numbers and loading estimates presented here are based on the numbers of animal in close proximity to a stream or the river with full access to the stream channel. Table 13. summarizes the numbers of animals by reach for each month of the year. Map 6 provides the location of the sub-watersheds and reaches.

Table 13. Cattle numbers by month, stream reach, and sub-watershed.

Month/Reach	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Jan	50	650	250	100	700	0	250	0	**2000**
Feb	50	650	250	100	700	0	250	0	**2000**
Mar	50	650	250	100	700	0	250	0	**2050**
Apr	50	450	250	100	850	0	250	0	**3000**
May	200	250	450	100	900	250	250	400	**4200**
Jun	200	250	300	1700	600	250	500	400	**4200**
Jul	200	250	300	1700	600	250	500	400	**4200**
Aug	200	250	300	1700	600	250	500	400	**4200**
Sep	200	250	300	1500	500	250	500	400	**3900**
Oct	50	600	250	500	500	0	500	400	**2800**
Nov	50	650	250	200	700	0	350	100	**2300**
Dec	50	650	250	200	700	0	250	100	**2200**

Map 6.

Reaches assessed for cattle numbers and loading estimates.



Overall, it was estimated that approximately 2037 kg/year of total phosphorus is attributed to the presence of cattle in the Sevier River upstream of Circleville Canyon. The load from grazing sources represents approximately 35% of the total measured annual load at the lowest STORET station of 494945. Table 14 summarizes the monthly load contribution from cattle in each reach (Note: Panguitch Creek was not included in the assessment since the stream is diverted into sprinkler systems during the majority of

Overall, it was estimated that approximately 2037 kg/year of total phosphorus is attributed to the presence of cattle in the Sevier River upstream of Circleville Canyon. The load from grazing sources represents approximately 35% of the total measured annual load at the lowest STORET station of 494945. Table 14 summarizes the monthly load contribution from cattle in each reach (Note: Panguitch Creek was not included in the assessment since the stream is diverted into sprinkler systems during the majority of the year and does not likely contribute a load from cattle due to the seasonality of grazing in the Panguitch Creek watershed).

Table 14. Load summaries from cattle by month for subwatersheds and river reach.

Reach	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Load
1.0	3.4	3.1	3.4	3.3	13.6	13.1	13.6	13.6	13.1	3.4	3.3	3.4	**90.1**
2.0	44.1	39.8	44.1	29.5	16.9	16.4	16.9	16.9	16.4	40.7	42.6	44.1	**368.5**
3.0	16.9	15.3	16.9	16.4	30.5	19.7	20.3	20.3	19.7	16.9	16.4	16.9	**226.5**
4.0	6.8	6.1	6.8	6.6	6.8	111.5	115.3	115.3	98.4	33.9	13.1	13.6	**534.1**
5.0	47.5	42.9	47.5	55.8	61.0	39.4	40.7	40.7	32.8	33.9	45.9	47.5	**535.4**
6.0	0.0	0.0	0.0	0.0	16.9	16.4	16.9	16.9	16.4	0.0	0.0	0.0	**83.7**
7.0	16.9	15.3	16.9	16.4	16.9	32.8	33.9	33.9	32.8	33.9	23.0	16.9	**289.8**
Total	**132.2**	**119.4**	**132.2**	**124.7**	**149.2**	**236.2**	**244.1**	**244.1**	**216.5**	**159.3**	**141.1**	**139.0**	**2037.8**

Septic Systems

The highest concentrations of summer home development occur in the Asay Creek/Sevier River Headwaters, Mammoth Creek and Panguitch Creek watersheds. Since Panguitch creek is diverted and land applied for the majority of the year, its load to the mainstem of the Sevier River is negligible. Asay and Mammoth Creeks therefore represent the main tributaries with septic system sources. Simple methods were used to estimate the contribution of systems in these watersheds and include the following. The number of developed lots in each area were estimated as part of the Upper Sevier River Community Watershed Project. Assuming an average occupancy of 2.5 persons for 6 months of the year and applying a loading rate of 5 kg/person/year TP (Sarac et al, 2001), the phosphorus content of septic effluent was estimated. Based on best professional judgment a 20% failure rate was applied to these calculations to generate a load for the septic systems in the Mammoth and Asay Creek watersheds to the upper Sevier River. Results of these estimations are presented in Table 15.

Total Phosphorus Allocation

The Sevier River is listed as impaired for 3 river segments (see above). Therefore, appropriate water quality stations were selected to determine loading for each reach and to represent compliance points for future monitoring and assessment purposes. Two STORET stations on the Upper Sevier were obvious choices (494945- Sevier River in Circleville Canyon, and 494964 – Sevier River above Sanford Creek) since they are located at the most downstream point of their respective listed river segments (Sevier River and tributaries from Circleville Irrigation Diversion upstream to Horse Valley Diversion and Sevier River from Horse Valley Diversion upstream to Long Canal Diversion, respectively.) The STORET site located East of Panguitch (494966) is not

adequate for determining loads and allocations for the segment from the Long Canal Diversion upstream to the confluence with Mammoth Creek since it is located below the diversion and is therefore not representative of the instream loads for that reach. Therefore, 494963 located upstream at the U12 crossing was selected for load calculations and the determination of allocations for this listed segment. For lack of better information on phosphorus content of sediment delivered to the Sevier River, the proportions of the sediment load from streambank erosion and upland erosion were utilized to partition the remaining TP load after other sources were estimated. Table 15 summarizes the allocations for total phosphorus in the Sevier River.

Table 15. Annual total phosphorus load allocations (units are in kg/year).

Waterbody	**Up-stream Load**	**WLA**	**Grazing/ Animal Waste**	**Septic Systems**	**Stream bank Erosion**	**Upland Erosion**	**Measured Load**
Asay Creek	-	-	83.7	520	n.a.	n.a.	665
Mammoth Creek	-	299	290	140	89	127	945
Sevier River from Long Canal to Mammoth Creek	1510	-	90	-	108	163	1871
Sevier River - Horse Valley Div. to Long Canal Div.	1525	-	1129	-	538	807	3999
Sevier River - Circleville Irrigation Div. to Horse Valley Div.	3999	-	535	-	739	1108	5846

Allocations for total phosphorus load reductions were also estimated for each impaired river segment including Mammoth Creek and Asay Creek where feasible. These estimates are based on load reductions achievable through implementation and management practices designed to address major sources (see Implementation Plan for greater detail on recommended BMPs). Where applicable, the influence of upstream load reductions are integrated into the allocation of load reductions within the downstream reach. One area where this was not applied was for the reach extending from Horse Valley Diversion upstream to the Long Canal Diversion. This segment is effectively isolated from the upper river by a series of complete diversions in the vicinity of Panguitch and its flow and instream load is primarily derived from sources within the reach. Therefore, and 18% reduction in TP load was applied to the existing loads below the diversion to estimated the effect of upstream load reductions on the middle segment of the river.

Table 16. Estimated load reduction for impaired river segments (units in kg/yr).

Waterbody	Current Load	Up-stream Reduction	Point Source	Septic Systems	Grazing/ Animal Waste	Stream bank Erosion	Upland Erosion	Loading Capacity
Asay Creek	665	-	-	n.a.				574
Mammoth Creek	945	-	0*	70	145	45	31	654
Sevier River from Long Canal to Mammoth Creek	1871	382	0*		116	63		1528
Sevier River from Horse Valley Diversion to Long Canal Diversion	3999	275	-		841	403	402	2078
Sevier River -Circleville Irrigation Diversion to Horse Valley Diversion	5846	1921	-		401	554	387	2583

* Currently no load reduction is recommended due to insufficient data. The load reductions are therefore distributed among other sources of nonpoint sources.

Implementation endpoints and priority areas for BMPs associated with these reductions are discussed in the Implementation Strategy. Note that load reductions proposed for the Sevier River from the Long Canal to the confluence with Mammoth exceeds the actual reductions calculated to meet the loading capacity. This is an added margin of safety since the load for this reach was calculated at station 494963 (U12 Crossing) which is not at the lowest point on the impaired reach and therefore additional implementation is recommended to account for the downstream load not represented in the dataset. The reductions for septic systems were not assessed in this study since it is unclear as to the connectivity between areas such as Duck Creek in the headwaters and the station at 494990 (Asay Creek at mouth). Many of these headwater streams are intermittent and as is the case with Duck Creek, flows are influenced by sinks and underlying volcanic rock and lava tubes.

Total Suspended Solids

Land erosion in the Sevier River watershed was estimated using the Universal Soil Loss Equation (USLE). The USLE (Wischmeier and Smith, 1978) is the most common and best known method to estimate gross annual soil loss from upland erosion. The USLE is an index method having factors that represent how climate, soil, topography, and land use affect soil erosion caused by raindrop impact and surface runoff. Rather than explicitly representing the fundamental processes of detachment, deposition, and transport by rainfall and runoff, the USLE represents the effects of these processes on soil loss. These influences are described in the USLE with the equation:

$$A = (R)\,(K)\,(LS)\,(C)\,(P)$$

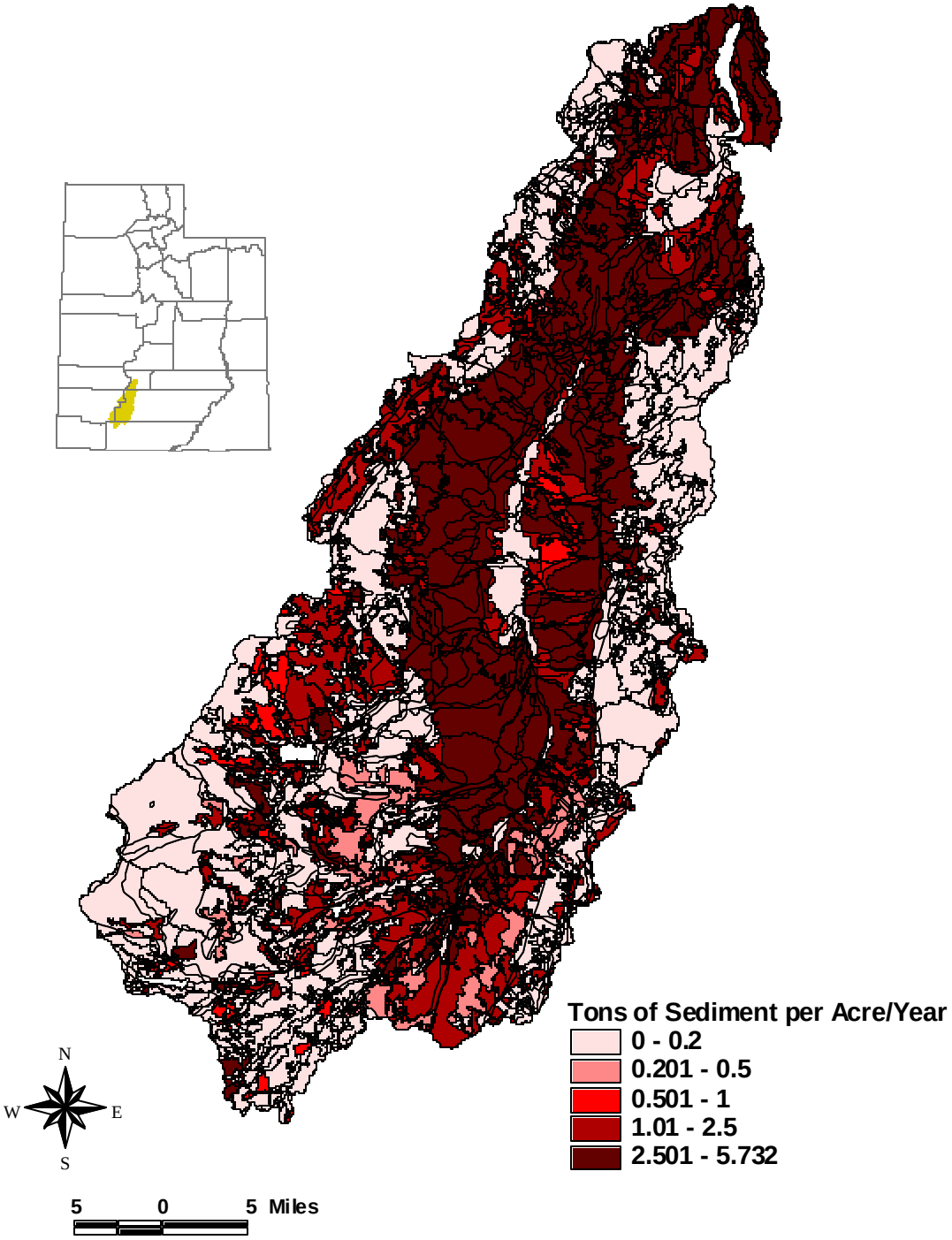
where, A is estimated soil loss in tons/hectare for a given storm or period; R is a rainfall energy factor; K is a soil erodibility factor; LS is a slope-length, slope steepness factor; C is vegetative cover factor; and P is a conservation practice factor. The USLE factors for the Sevier River watershed were estimated based on available GIS data. The 30-meter digital elevation model was used to derive slope-length and slope steepness and the NRCS STATSGO soils database was used to derive the soil erodibility factor. The results of the USLE analyses for the entire watershed are shown in Figure 5-3. Sediment yield to the river was extrapolated from soil erosion estimates using literature values for the Sediment Delivery Ratio (SDR) based on watershed size (Vanoni, 1975). Sediment delivery by subwatershed is presented in Table 17. Note that the total load delivered upstream of Circleville Canyon is not a simple sum of all component watersheds but is rated using the SDR which is inversely proportional to the size of the watershed.

Table 17. Sediment delivery by subwatershed.

Subwatershed	Sediment Load (Mt/yr)
Asay Creek	8577
Bear Creek	27933
Bear Valley Junction	67861
Big Hollow	50012
Blue Springs	3746
Butler Creek	6244
Casto Canyon	4799
Clear Creek	3803
Duck Creek	2108
Echard Creek	24351
Graveyard Hollow	22558
Haycock Creek	4225
Limekiln Creek	12864
Lower Mammoth Creek	10272
Middle Mammoth Creek	6017
Mud Spring	21678
Panguitch Creek	9032
Pass Creek	17251
Peterson Wash	34104
Pole Canyon	70087
Proctor Canyon	65381
Red Canyon	27032
Sandy Creek	11694
Sanford Creek	13447
Smith Canyon	23582
South Canyon	17682
Spry	24937
Strawberry Creek	1497
Sunset Cliffs	17219
Swains Creek	1574
Tebbs Hollow	23396
Threemile Creek	12527
Tommy Creek	1205
Upper Mammoth Creek	1143
Upper Midway Creek	842
Upper Sevier Headwaters	7343
Total Upstream of 494945 (Circleville Canyon)	178941

The erosion results of USLE (before applying the SDR) are displayed in Map 7 in tons of sediment per acre per year. Area with the highest rates of erosion occur in the foothill rangeland where soils are highly erodible, conditions are arid and ground cover poor.

Map 7. Sediment delivery rates (USLE model results)



Streambank Erosion

Streambank erosion was estimated while performing the SVAP survey applying the Stream Erosion Condition Index (SECI) to the streambank length and average bank height for each reach to determine the volume and mass of bank material lost each year. Results of this estimation are presented in Table 18.

Table 18. Upper Sevier Streambank Erosion Condition Inventory (October, 2001)

Reach	Length (ft)	Bank Height (ft)	Erosion Severity	LRR Index Value	Slight Erosion Length	Moderate Erosion Length	Severe Erosion Length	Lateral Recession Rate (ft/yr)	Erosion Rate (tons/yr)	Erosion Rate kg/year
1	6302	2.5	Slight	2.00	6302	0	0	0.02	11	9752
2	11634	4.0	Moderate	7.00	0	11634	0	0.18	322	292148
3	18455	4.0	Severe	10.00	0	0	18455	0.35	935	848618
4	3314	3.0	Slight	1.00	3314	0	0	0.01	2	1748
5	15157	3.5	Severe	9.00	0	0	15157	0.29	555	503700
6	16667	3.0	Severe	9.00	0	0	16667	0.29	546	495370
7	7575	4.0	Slight	2.00	7575	0	0	0.02	24	22016
8	4462	1.8	Severe	10.00	0	0	4462	0.35	108	97571
9	2802	5.0	Severe	11.00	0	0	2802	0.42	229	208120
10	5715	2.0	Slight	0.50	5715	0	0	0.00	1	621
11	8153	3.5	Severe	11.50	0	0	8153	0.45	507	459544
12	12828	4.0	Moderate	6.75	0	12828	0	0.17	346	314121
13	13540	3.0	Moderate	7.25	0	13540	0	0.20	312	283110
14	3402	4.0	Slight	4.00	3402	0	0	0.07	38	34800
15	11283	3.0	Moderate	8.00	0	11283	0	0.24	311	282075
16	5669	3.0	Slight	3.30	5669	0	0	0.05	31	28400
17	4272	4.0	Moderate	6.50	0	4272	0	0.16	108	97673
18	12825	2.5	Moderate	8.25	0	12825	0	0.25	311	282539
19	19905	3.0	Moderate	6.75	0	19905	0	0.17	403	365557
20	5325	5.0	Moderate	8.50	0	5325	0	0.26	273	247684
21	9692	3.0	Moderate	5.00	0	9692	0	0.10	114	103225
22	12369	5.0	Severe	9.00	0	0	12369	0.29	704	638242
23	9633	3.5	Moderate	8.00	0	9633	0	0.24	310	280954
24	16086	5.0	Severe	10.00	0	0	16086	0.35	1108	1005018
25	4564	3.0	Slight	2.00	4564	0	0	0.02	10	9210
26	25144	6.0	Severe	11.50	0	0	25144	0.45	2678	2429626
27	15791	2.5	Severe	10.00	0	0	15791	0.35	544	493285
28	10367	4.0	Severe	10.00	0	0	10367	0.35	571	518190
29	10955	4.0	Severe	10.50	0	0	10955	0.39	659	598254
30	9039	3.0	Severe	9.50	0	0	9039	0.32	340	308705
31	12795	2.5	Severe	10.50	0	0	12795	0.39	481	436731
32	7470	2.5	Severe	9.50	0	0	7470	0.32	234	212620
33	12415	2.5	Severe	9.50	0	0	12415	0.32	389	353340
Total Stream Length:	**65.46**	**Miles**							**Total yearly erosion (kg/year)**	12262566

Relating the estimates for the erosion sources directly to instream TSS loads is not possible since water quality grab sampling only measures the fraction of the total sediment load that is in the water column. Furthermore, the sampling protocol used is not a depth and cross-section integrated sample and may not be representative of the true suspended load of sediment in streams. Therefore, total sediment delivery from estimates of upland and streambank erosion was summed and their relative contributions were applied to TSS loads in the river at the watershed outlet in Circleville Canyon (see Table 19). Allocations by impaired river segment are not presented here, since no specific TSS load reductions are proposed for the watershed. Therefore, allocations on a watershed scale are presented here for purposes of relative contributions of major sources of sediment.

Table 19. Sediment allocation at Circleville Canyon

Sediment Source	Delivered Load (Mt/yr)	Ratio of Total	Instream Load as TSS (Mt/yr)
Streambank Erosion	122626	0.41	3713
Upland Erosion	178941	0.59	5343
Total	301567	1.00	9056

Habitat Alteration

Results of the habitat assessment from the SVAP survey discussed in this document indicate that the primary impairments of stream habitat are related to streambank erosion, excessive sediment, and nutrient enrichment in the Sevier River. The result of these impacts has been the decline of a once productive fishery and the aquatic life necessary to support the fishery. Therefore, a measurable endpoint for habitat alteration would be the shift in the aquatic macroinvertebrates from sediment and nutrient tolerant species to species indicative of a system unimpaired by sediment and excess phosphorus. Since the SVAP is not a monitoring tool, numeric shifts in habitat scores cannot be utilized to track improvement. However, future SVAP surveys, though inadequate for trend analysis, should demonstrate improved habitat scoring if implementation and management practices are successful, particularly in the areas of bank stability, fish and invertebrate habitat, and riparian zone condition. Since habitat alteration, sedimentation, and total phosphorus sources are strongly linked to grazing and other land management issues, implementation recommendations are intended to primary sources of concern in the stream corridor.

Margin of Safety and Seasonality

A margin of safety (MOS) is a mechanism used to address the uncertainty of a TMDL. The MOS is a required part of the TMDL development process. There are two basic methods for incorporating the MOS (EPA, 1991). One is to implicitly incorporate the MOS using conservative model assumptions to develop allocations. The other is to explicitly specify a portion of the total TMDL as the MOS, allocating the remainder to sources. For the Upper Sevier River watershed TMDL, the MOS was included implicity

in the calculation of the loading capacity used to determine TMDLs. Instead of basing the load capacity on the hydrology data and the maximum criterion of 0.05 mg/l TP to determine maximum allowable loads, this analysis only utilized the criterion to replace data that exceeded the criterion, thus retaining data with concentrations below the criterion. This resulted in a lower allowable instream load than if the maximum criterion were used for all substitutions in the dataset. The MOS may be adjusted based on additional sampling of runoff events and further evaluation of the seasonality of loading.

VI. Monitoring Plan

The middle and lower Upper Sevier River segments of the watershed are listed as impaired due to high levels of TDS. The data that were used to list these segments were instantaneous readings for TDS. In the future it will be useful to obtain TDS readings collected over a 24-hour period to better characterize the situation and assess progress towards meeting water quality goals. Furthermore, data for this TMDL were averaged over various periods of time to evaluate seasonal loads and consider the influence of irrigation practices. Additional analysis of the timing of loading events is recommended to further refine management efforts and assess whether water quality targets and endpoints are being met. Future monitoring in a process of evaluation and refinement of TMDL endpoints is recommended.

IX. Public Participation

The public participation process for this TMDL was addressed through a series of public meetings with the Upper Sevier River Watershed Committee. The Watershed Committee is comprised of individuals who represent the interest of stakeholders in the watershed. The committee has participated in this TMDL since the inception of the project, has supported the collection of relevant data and information, and has assisted with the development of management practices. In addition, the committee has developed Project Implementation Plans (PIPs) for implementation of management practices. With respect to the PIPs, the Group will select project participants and give oversight to project planning and implementation, and pursue funding mechanisms to address water quality issues in the watershed. This group actively seeks public input into the prioritization of natural resource problems and concerns. They anticipate volunteer help to be provided at many phases of the project including water conservation, irrigation improvement, tour planning, and media promotion.

A public hearing on the TMDLs was held on January 26th, 2004 with notification of the hearing published in the local newspapers. The comment period was opened on February 1st, 2004 and closed on March 1st, 2004. In addition, the TMDL and dates for public comment were posted on the Division of Water Quality's website at http://waterquality.utah.gov/TMDL/TMDL_WEB.HTM.

Coordination Plan

Lead Project Sponsor

The Upper Sevier Soil Conservation District (the District) will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement

measures for the prevention of nonpoint water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal, and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

The Upper Sevier River Watershed Committee (Local Work Group) has brought together citizens who are concerned about the future condition of the Upper Sevier River and its tributaries. They are the primary stakeholders in the future value and future problems that affect this watershed. Utah Association of Conservation Districts is a non-profit corporation that provides staffing for project coordination and financial administration to the Districts of the State of Utah, and specifically to the Upper Sevier Soil Conservation District.

The Upper Sevier River Watershed Committee or an empowered subcommittee, will provide oversight of project conceptualization, cooperator selection, volunteer efforts during implementation, and sharing of information generated by this project with others.

The Upper Sevier Soil Conservation District and the Upper Sevier River Watershed Committee will oversee detailed project development, planning, implementation, approval, creation of fact sheets and educational materials, administration and reporting. Some of these duties will be transferred to UACD, NRCS, DEQ, USU Extension Service and others as per Memoranda of Understanding. The Upper Sevier River Watershed Committee will be responsible for writing the final project report pursuant to EPA and State requirements.

UACD will oversee project administration, match documentation, and contracting with agencies and individuals. They will also provide staffing assistance at the direction of the District.

Local Support

The Upper Sevier River Watershed Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the Upper Sevier River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Watershed Committee, working with a Technical Advisory Committee will establish criteria and select cooperators for implementation of projects. This project will be used to show landowners and cooperators Best Management Practices (BMPs) for minimizing land use impacts on water quality in the Upper Sevier River and its tributaries.

Coordination and Linkages

The District and Upper Sevier River Watershed Stewardship Committee anticipate coordinating efforts with the following other entities, agencies, and organizations:

Cooperators - provide match for cost share, implementation of water quality plans
Utah State University Extension - I&E, Technical assistance
NRCS - Technical planning design and oversight
Dixi National Forest- Technical, planning and financial assistance

Utah Department of Agriculture & Food - Technical assistance, I&E assistance
Utah Division of Water Quality - Standard program monitoring, Technical assistance
EPA - Financial assistance
Utah Association of Conservation Districts - Administration, contracting, staff and technical assistance
Utah Division of Water Rights- Permits advisory, and monitoring assistance
Utah Division of Water Resources - Advisory
Upper Sevier County Irrigation Companies - Advisory and TAC coordination

XI Implementation Strategy

Point sources: The Mammoth Creek Fish Hatchery represents a significant load to Mammoth Creek and the Upper Sevier River. Water quality data exceed the pollution indicator of 0.05 mg/l in 33% of the samples downstream of the hatchery. It is therefore recommended that permit limit be determined at a level necessary to meet water quality standards. Implementation strategies for the remaining needed load reductions will be achieved through stream restoration and best management practices (discussed below). Currently, the Mammoth Creek Fish Hatchery is off-line but the Division of Wildlife Resources is planning to upgrade the hatchery to prevent contamination from whirling disease. The design for the facility is not yet complete, therefore final phosphorus load limits will be integrated into the facilities permit after adequate monitoring is completed to determine its contribution to the load in Mammoth Creek and the Upper Sevier River.

Nonpoint Sources: As discussed above, the major sources of phosphorus and sediment loading to the Sevier River occur as a result of management activities in the floodplain associated with agriculture, a landuse which covers only 15% of the watershed. The Upper Sevier River Steering Committee is currently developing a restoration strategy for the entire watershed which includes all Federal, State and Private lands. This implementation strategy is designed to guide restoration and management on private lands adjacent to the impaired reaches of the Sevier River. With few exceptions, the Sevier River from its headwaters at the confluence of Asay and Mammoth Creek is essentially uniform in it landuse, management and habitat condition. Appropriate management practices will have to be tailored to specific situations and management needs, however the follow restoration strategy is proposed for the impaired reaches of the river.

1. Grazing management: This could include a combination of timing, duration, and fencing to protect streambanks from trampling and limit the introduction of animal waste into canals, ditches and streams. Riparian fencing and pasture rotation are appropriate practices to protect sensitive areas and allow for controlled access to forage. Off-site watering could be provided for cattle that congregate in or near streams or other channels adjacent to pastures.
2. Streambank restoration: The re-establishment of woody, deep-rooted vegetation such as willows and sedges is recommend for the majority of the Sevier River from its headwaters to Circleville Canyon. The potential for bank stabilization and erosion control is high since the water table is typically high through out the

year. Practices could include willow pole planting, willow mats, temporary juniper revetments, and other soft bio-engineering techniques. These restoration projects would have to be coupled with grazing management, development of off-site water sources, and permanent or temporary electric fencing to allow for recovery of riparian vegetation. In some cases which were identified during the SVAP survey bank erosion was so severe that the installation of hard structures such as rock barbs or weirs rock may be necessary to direct flow away from re-vegetating stream banks.

3. Irrigation efficiency and buffers: In order to reduce the amount of runoff containing sediment and nutrients from field under flood irrigation, it is recommended that irrigation efficiency projects be implemented on fields and pasture adjacent to the Sevier River and its tributaries. Where applicable, vegetative buffers should also be developed to filter nutrients and moderate loss of flood irrigation.

Implementation Endpoints

The following implementation goals and endpoints are based on estimations of the load allocations for each impaired reach and the necessary level of restoration and management necessary to meet water quality standards. Priority status for potential projects was derived from information gathered during the SVAP survey.

Mammoth Creek- Endpoints for restoration activities include 8 miles of streambank and riparian restoration. This should include a combination of fencing of the riparian corridor, revegatation, and riparian pasture management to control the timing and duration of cattle access to the stream corridor. Project priority should be placed on potential implementation in Reaches 3,5,6, and 8 (see SVAP map above) which exhibited severe erosion rates and poor vegetation structure and canopy cover.

In addition, since this TMDL did not fully address the loading from septic systems in the Upper Mammoth Creek watershed, it is strongly recommended that continues monitoring and inspection of septic systems and their potential impacts to surface and groundwater be evaluated in conjunction with implementation.

Sevier River From the Long Canal Diversion upstream to Mammoth Creek- Recommended endpoints for implementation include 12.5 miles of streambank restoration to reduce sediment and total phosphorus from erosion and unrestricted grazing in the stream corridor. In addition, fishery habitat in several reaches in this segment are impacted by channelization and berming in proximity to Highway 89, which may require the restoration of natural meanders and riffle/pool structures for fishery habitat. Priority areas for streambank stabilization, fencing and revegetation include the following reaches: 9,11,12,13,15,18,20, and 22.

Sevier River from Horse Valley Diversion upstream to Long Canal Diversion- This reach which includes Panguitch Valley holds the greatest concentration of cattle in the Upper Sevier, as well as receiving the majority of irrigation on pasture/hayland. Therefore, endpoints include the establishment of riparian buffers along 10 of the 13 miles of stream contained in this reach. Several areas in this segment require the

additional installation of in-stream structure such as rock barbs and weirs to protect banks, particularly where downcutting and lateral movement is most severe. Reach 25 which was placed in an easement for endangered species of wildflowers and a small section located on the USU Experimental farm demonstrate the potential for the re-establishment of riparian vegetation through planting and the exclusion of cattle from the stream channel. Additional buffers should be placed in areas where flood irrigation returns enter the stream and/or irrigation canals and ditches. Flood irrigation efficiency where feasible should be identified and implemented to reduce the erosion of animal waste and sediment from pastures near the river.

Sevier River from Circleville Canyon upstream to Horse Valley Diversion- This segment of the Upper Sevier River exhibits uniformly severe streambank erosion and poor to virtually absent riparian vegetation. In order to meet the endpoints of the TMDL for this reach it is recommended that 8 miles of streambank reconstruction and re-vegetation be implemented. The majority of this reach will require the installation of hard structures to stabilize severely eroding banks and allow for the re-establishment of riparian vegetation.

Selection Criteria: In addition to the above criteria for priority projects, it is further recommended that implementation proceed initially in the upper watershed where the highest potential for the improvement of the fishery exists. These areas should include Mammoth Creek and the Sevier River from Hatch downstream through the upper Panguitch Valley. In the SVAP, survey, these areas exhibited the greatest potential for fish and invertebrate habitat, as well as greatest potential for the establishment of riparian vegetation.

Evaluation and Monitoring Plan

An evaluation and monitoring plan will be implemented to document progress in achieving improved water quality conditions, to review effectiveness of BMP's, and to provide feedback on the direction of overall watershed health. Based upon the results of this monitoring program management strategies and implementation priorities may change under the direction of the project sponsors. The Division of Water Quality has a strong commitment to demonstration of success of these pollution prevention and remediation strategies, but a limited monitoring budget. The use of volunteer monitoring conducted by watershed stakeholders must be a part of the overall monitoring strategy to develop a more comprehensive assessment of water quality conditions. Studies that present water quality and stream health on a point-in-time basis, before and after project implementation, can be conducted quickly and relatively inexpensively.

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Appendix A – Data Tables

Asay Creek at U89 Crossing – 494990

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
8/11/1976			0.08	10	0.02		
9/8/1976				10	0.01		
10/13/1976				10	0.03		
12/1/1976				25	0.02		
1/19/1977			0.01	5	0.07		
3/23/1977			0.03				
5/25/1977			0.05	15	0.04		
7/28/1977				5	0.07		
9/28/1977				10	0.03		
10/20/1977					0.04		
11/16/1977				22	0.03		
12/7/1977				30			
1/11/1978		12		20	0.02	587	0.6
3/8/1978		24	0.03	40		2349	
5/10/1978		125		105	0.06	32111	18.3
7/12/1978		45	0.03	20		2202	
9/6/1978				20	0.04		
10/18/1978		25		30		1835	
11/14/1978				10	0.03		
1/17/1979				3	0.05		
3/21/1979			0.2	4			
5/16/1979				9	0.1		
8/15/1979		32	0.01	2	0.03	157	2.3
11/28/1979		20	0.01	1	0.03	49	1.5
12/12/1979			0.01	2	0.01		
6/17/1980			0.01	152	0.01		
10/29/1980		60.4	0.01		0.025		3.7
10/30/1980		25	0.01		0.06		3.7
1/14/1981		75	0.01		0.025		4.6
2/19/1981			0.01		0.025		
4/15/1981			0.02		0.025		
6/17/1981		29.6					
10/22/1981		39.6					
11/4/1981			0.01	11	0.06		
12/14/1981		32					
2/24/1982		30.2		47	0.05	3473	3.7
4/14/1982				406	0.25		
5/19/1982				89	0.1		
7/21/1982				7	0.07		
9/16/1982				19	0.1		
10/26/1982			0.01		0.025		

1/5/1983		62.3		26	0.02	3963	3.0
3/1/1983				124	0.08		
4/26/1983				588	0.23		
10/19/1983		73.2		3	0.005	537	0.9
8/2/1984		72.1	0.005	39	0.03	6880	5.3
8/29/1984		76.7	0.005	24	0.06	4504	11.3
10/9/1984		110	0.005	36	0.05	9688	13.5
4/24/1985		130	0.04	96	0.04	30533	12.7
5/22/1985		248.3	0.01	62	0.03	37664	18.2
7/10/1985		78	0.03	14	0.03	2672	5.7
8/7/1985		55.9	0.04	16	0.04	2188	5.5
9/4/1985		58.6	0.03	3	0.02	430	2.9
10/1/1985		73.4	0.0025	18	0.02	3232	3.6
10/29/1985		63.8	0.01	3	0.008	468	1.2
12/3/1985		55.6	0.0025	3	0.01	408	1.4
1/29/1986		50.2	0.01	13	0.02	1597	2.5
3/12/1986		40.3	0.01	28	0.04	2761	3.9
4/22/1986		87.5	0.007	36	0.03	7707	6.4
6/4/1986		88	0.0025	19	0.02	4091	4.3
7/8/1986		79.3	0.0025	9	0.02	1746	3.9
8/19/1986		48.4	0.0025	3	0.008	355	0.9
9/30/1986		64.8	0.0025	12	0.02	1902	3.2
11/12/1986		58.4	0.0025	5	0.02	714	2.9
12/17/1986		49.8	0.007	8	0.059	975	7.2
2/3/1987		47.9	0.01	16	0.02	1875	2.3
3/18/1987		39	0.01	24	0.03	2290	2.9
4/29/1987		104.9	0.01	45	0.04	11549	10.3
6/24/1987		86.2	0.0025	4	0.01	844	2.1
8/5/1987		59	0.0025	18	0.02	2598	2.9
9/15/1987		63	0.0025	4	0.02	617	3.1
11/10/1987		59.7	0.0025	3	0.02	438	2.9
12/15/1987		52	0.005	3	0.01	382	1.3
1/26/1988		39.3	0.0025	3	0.03	288	2.9
3/7/1988		30	0.02	3	0.05	220	3.7
4/20/1988			0.02	73	0.02		
6/1/1988		102.3	0.0025	3	0.08	751	20.0
8/3/1988		68	0.0025	77	0.02	12810	3.3
9/7/1988		35	0.0025	3	0.02	257	1.7
10/26/1988		16.8	0.009	3	0.006	123	0.2
12/7/1988			0.008	3	0.0025		
1/25/1989		20.5	0.018	3	0.02	150	1.0
3/1/1989		39	0.007	48	0.029	4580	2.8
4/12/1989		50.2	0.013	58	0.026	7123	3.2
5/18/1989		50.8	0.011	3	0.017	373	2.1
6/21/1989		41	0.0025	3	0.025	301	2.5
9/6/1989		31.9	0.011	7	0.01	546	0.8
10/18/1989		36	0.0025	6	0.0025	528	0.2
11/30/1989		21	0.0025	22	0.008	1130	0.4

1/10/1990		30.4	0.011	23	0.018	1711	1.3
3/6/1990		25.1	0.009	36	0.03	2211	1.8
4/11/1990		26	0.011	20	0.037	1272	2.4
5/2/1990		56.1	0.0025	23	0.039	3157	5.4
6/13/1990		39.7	0.015	4	0.106	389	10.3
9/5/1990	0.04	29.5		10	0.042	722	3.0
10/16/1990	0.008	29.9		9	0.02	658	1.5
1/16/1991	0.02	4.5		48	0.05	528	0.6
2/27/1991	0.011	25		33	0.034	2018	2.1
6/5/1991	0.024	51.8		12	0.037	1521	4.7
7/31/1991	0.005	74.8		6	0.024	1098	4.4
9/18/1991	0.005	15.8		16	0.017	618	0.7
10/30/1991	0.005	20		36	0.022	1762	1.1
1/8/1992	0.005	14		39	0.028	1336	1.0
2/19/1992	0.005				0.032		
4/9/1992	0.028	20			0.06		2.9
5/20/1992	0.01			21	0.017		
7/15/1992	0.005			4	0.005		
10/14/1992	0.005			13	0.021		
11/18/1992	0.045	36.7		34	0.064	3053	5.7
2/3/1993	0.005	44		30	0.01	3229	1.1
3/17/1993	0.018			109	0.005		
4/4/1996	0.005	44		14	0.01	1507	1.1
4/25/1996	0.005	55		8	0.01	1076	1.3
5/8/1996	0.005	70		8.8	0.01	1507	1.7
5/22/1996	0.01	52.2		8.8	0.03	1124	3.8
6/6/1996	0.005	45		11.2	0.01	1233	1.1
6/19/1996	0.01	42		10.4	0.01	1069	1.0
7/8/1996	0.01	38		12.4	0.01	1153	0.9
8/21/1996	0.005	25		4.8	0.005	294	0.3
9/18/1996	0.01	47		4	0.005	460	0.6
10/30/1996	0.005	45		4	0.06136	440	6.8
12/10/1996	0.01434	30		7.2	0.005	528	0.4
1/29/1997	0.0279	19		11.2	0.01994	521	0.9
2/25/1997	0.005	35		17.2	0.01433	1473	1.2
3/19/1997	0.01751	16		68.7		2689	
4/9/1997	0.01223	35		5.6	0.005	480	0.4
4/23/1997		60		58.8	0.0542	8632	8.0
5/7/1997		15		38.4		1409	
5/21/1997		58		25.2	0.08203	3576	11.6
6/5/1997		14		7.6		260	
7/11/2001	0.01	18.2		110	0.08	4898	3.6
8/15/2001	0.01	41		9.2	0.01	923	1.0
9/13/2001	0.01	25		112	0.02	6850	1.2
10/18/2001	0.01	18		110	0.01	4844	0.4
11/15/2001	0.01	25		8	0.01	489	0.6
12/6/2001	0.01	40.4		9.6	0.023	949	2.3
1/16/2002	0.01	35.7		112	0.01	9782	0.9

2/27/2002	0.01	29.8		102	0.022	7437	1.6
3/27/2002	0.01	21		96	0.02	4932	1.0
4/10/2002		36.9					
5/1/2002	0.01	22		92	0.01	4952	0.5
6/12/2002	0.01	36.4		4	0.02	356	1.8

Mammoth Creek at U89 Crossing – 494970

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
9/8/1976				10	0.05		
10/13/1976			0.02	5	0.05		
1/19/1977			0.03		0.07		
2/9/1977			0.02	20	0.16		
3/23/1977			0.1				
5/25/1977			0.07	10	0.06		
7/28/1977				75	0.1		
9/28/1977				60	0.07		
12/7/1977				15			
1/11/1978		7		15	0.05	257	0.9
3/8/1978		11.9	0.03	80		2329	
5/10/1978				20	0.07		
7/12/1978		20		10		489	
9/6/1978			0.04	30	0.07		
11/14/1978				5	0.08		
3/21/1979			0.11	1			
5/16/1979				34	0.28		
7/18/1979		45		1	0.05	110	5.5
8/15/1979		29	0.03	2	0.05	142	3.5
11/28/1979		12.5	0.04	3	0.07	92	2.1
6/17/1980			0.02		0.02		
10/29/1980		58.2	0.01		0.025		3.6
1/14/1981		80	0.01		0.06		11.7
2/19/1981			0.03		0.025		
4/15/1981			0.04		0.025		
6/17/1981		28.9					
10/22/1981		31.6					
12/17/1981		26					
2/24/1982				56	0.07		
4/14/1982				94	0.15		
5/19/1982				160	0.15		
7/21/1982				3	0.07		
9/16/1982				7	0.1		
11/10/1982				7	0.15		
1/5/1983				25	0.11		
3/1/1983				36	0.1		
4/26/1983				231	0.1		
6/21/1983				144	0.06		
8/2/1984			0.01	63	0.07		
8/29/1984			0.005	17	0.07		
4/24/1985			0.05	58	0.07		
5/22/1985		203	0.04	60	0.06	29799	29.8
7/10/1985			0.03	9	0.97		

9/4/1985		33.6	0.02	3	0.03	247	2.5
10/1/1985		11.6	0.02	3	0.04	85	1.1
10/29/1985		16.2	0.02	3	0.03	119	1.2
12/3/1985		24.4	0.03	3	0.04	179	2.4
1/29/1986		19.3	0.04	9	0.05	425	2.4
3/12/1986		24.2	0.03	11	0.04	651	2.4
4/22/1986		27.5	0.04	45	0.07	3028	4.7
6/4/1986		164	0.04	33	0.06	13241	24.1
7/8/1986		22	0.03	10	0.05	538	2.7
8/19/1986		33.1	0.01	10	0.04	810	3.2
9/30/1986		21.2	0.02	8	0.07	415	3.6
11/12/1986		26.1	0.03	18	0.05	1149	3.2
12/17/1986		17	0.2	7	0.565	291	23.5
2/3/1987		15.4	0.05	11	0.06	414	2.3
3/18/1987		4.5	0.04	18	0.06	198	0.7
4/29/1987		116.1	0.11	198	0.18	56241	51.1
6/24/1987		45.9	0.01	5	0.04	561	4.5
8/5/1987		22	0.03	18	0.04	969	2.2
9/15/1987		13	0.01	15	0.06	477	1.9
11/10/1987		30	0.01	3	0.04	220	2.9
12/15/1987		13	0.04	3	0.04	95	1.3
1/26/1988		16.7	0.04	88	0.05	3595	2.0
3/7/1988		41	0.07	3	0.1	301	10.0
4/20/1988		20	0.03	3	0.04	147	2.0
6/1/1988		232.7	0.0025	3	0.06	1708	34.2
8/3/1988		59	0.03	277	0.009	39984	1.3
9/7/1988		42	0.01	3	0.05	308	5.1
10/26/1988		55	0.02	3	0.04	404	5.4
12/7/1988			0.05	17	0.05		
1/25/1989		31.5	0.049	3	0.062	231	4.8
3/1/1989		22	0.038	3	0.012	161	0.6
4/12/1989		66	0.036	90	0.035	14533	5.7
5/18/1989		29	0.019	18	0.012	1277	0.9
6/21/1989		21	0.025	6	0.056	308	2.9
9/6/1989		18	0.031	16	0.036	705	1.6
10/18/1989			0.023	3	0.013		
11/30/1989			0.006	22	0.0025		
1/10/1990			0.039	11	0.049		
3/7/1990			0.033	16	0.065		
4/11/1990			0.051	10	0.077		
5/2/1990			0.033	32	0.076		
6/13/1990			0.015	9	0.042		
9/5/1990	0.056			74	0.115		
10/16/1990	0.024			14	0.04		
1/16/1991	0.05			66	0.11		
2/27/1991	0.04			17	0.067		
6/5/1991	0.03			42	0.077		
7/31/1991	0.045			12	0.068		

9/18/1991	0.027			14	0.038		
10/30/1991	0.029			59	0.092		
1/8/1992	0.046			56	0.076		
4/4/1996	0.03	17		14	0.04	582	1.7
4/25/1996	0.04	21		7.6	0.05	390	2.6
5/8/1996	0.03	91.8		44.8	0.04	10062	9.0
5/22/1996	0.03	60		15.2	0.03	2231	4.4
6/6/1996	0.02	20.6		8.8	0.06	444	3.0
6/19/1996	0.02	11		4	0.03	108	0.8
7/8/1996	0.03	8		25.6	0.06	501	1.2
8/21/1996	0.02	4		4	0.02	39	0.2
9/18/1996	0.03	8		4	0.03	78	0.6
10/29/1996	0.03552	9		4	0.10461	88	2.3
12/10/1996	0.02776	8		4	0.03719	78	0.7
1/29/1997		9		7.6		167	
2/25/1997	0.01513	9		7.6	0.03073	167	0.7
3/19/1997	0.03714	6		48.4		710	
4/9/1997	0.02178	11		5.6	0.02434	151	0.7
4/23/1997		42		74.4	0.09814	7645	10.1
5/7/1997		50		258		31561	
5/21/1997		90		34	0.11458	7487	25.2
6/5/1997		18		12.4		546	
7/11/2001	0.024	32.4		62	0.063	4915	5.0
8/15/2001	0.03	13.1		16.8	0.043	538	1.4
9/13/2001	0.02	13.7		58	0.031	1944	1.0
11/15/2001	0.021	13.7		16	0.024	536	0.8
12/6/2001	0.031	15		14.8	0.043	543	1.6
1/16/2002	0.054	8.2		4	0.04	80	0.8
2/27/2002	0.146	8.2		4	0.049	80	1.0
3/27/2002		7.4					
3/28/2002	0.01			4	0.046		
4/10/2002		6.5					
5/1/2002	0.021	54.3		4	0.034	531	4.5
6/12/2002	0.031	4		4	0.044	39	0.4

Sevier River at U12 Crossing - 494963

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
11/17/1980			0.01		0.05		
1/27/1981			0.3		0.3		
5/5/1981				13	0.1		
1/12/1982				53	0.07		
5/11/1982				395	0.2		
4/4/1996	0.005	69		22	0.03	3714	5.1
4/25/1996	0.005	70		12	0.02	2055	3.4
5/8/1996	0.01	125		107.2	0.07	32784	21.4
5/23/1996	0.01	60		28.8	0.02	4228	2.9
6/4/1996	0.005	30		11.2	0.02	822	1.5
6/18/1996	0.005	25		6.4	0.01	391	0.6
7/8/1996	0.01	25		33.6	0.02	2055	1.2
8/20/1996	0.005	20		9.2	0.01	450	0.5
9/18/1996	0.005	45		6	0.01	661	1.1
10/29/1996	0.005	56		6.8	0.06799	932	9.3
12/11/1996	0.005	59		7.2	0.01006	1039	1.5
1/28/1997	0.005	60		35.6	0.0194	5226	2.8
2/25/1997	0.01007	52		14.8	0.01737	1883	2.2
3/18/1997	0.03221	77		192		36170	
4/8/1997	0.005	73		19.6	0.01402	3501	2.5
4/24/1997		259		104	0.08072	65901	51.1
5/6/1997		238		341		198559	
5/21/1997		288		83.6	0.12473	58906	87.9
6/5/1997		136		24.8	0.51989	8252	173.0
7/11/2001	0.032	96.6		1660	0.962	392322	227.4
8/15/2001	0.024	39.2		38.4	0.03	3683	2.9
9/13/2001	0.01	56		1592	0.01	218117	1.4
10/18/2001	0.01	30		1661	0.01	121913	0.7
11/15/2001	0.01	50.8		40	0.01	4971	1.2
12/6/2001	0.01			40	0.033		
1/16/2002	0.01			1610	0.025		
2/27/2002	0.01			1728	0.01		
3/28/2002	0.01	34		1830	0.023	152226	1.9
4/10/2002	0.01	43.4		12.4	0.032	1317	3.4
5/1/2002	0.01	85.6		1880	0.01	393722	2.1
6/12/2002	0.01	26.2		4	0.01	256	0.6

Sevier River East of Panguitch – 494966

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
5/9/1996	0.01	81.6		113.2	0.06	22599	12.0
5/23/1996	0.01	90		9.2	0.01	2026	2.2
6/4/1996	0.005	1		7.2	0.02	18	0.0
6/18/1996	0.005	1.5		14.8	0.04	54	0.1
7/8/1996	0.01	2		9.2	0.03	45	0.1
8/20/1996	0.005	0.5		24	0.02	29	0.0
9/18/1996	0.005	0.6		8.8	0.01	13	0.0
10/29/1996	0.005	1		12.4	0.0732	30	0.2
12/11/1996	0.005	65		4	0.0126	636	2.0
1/28/1997	0.01184			25.2	0.0113		
2/25/1997	0.005	50		20.8	0.0182	2544	2.2
3/18/1997	0.02785	35		160		13701	
4/8/1997	0.01095	38		119.6	0.0256	11119	2.4
4/23/1997		110		348	0.255	93655	68.6
5/21/1997		240		156	0.8815	91600	517.6
6/5/1997		35		22		1884	
7/11/2001	0.024	25		12780		781680	129.7
8/15/2001	0.141	1.5		11.2	0.025	41	0.1
9/13/2001	0.01	6		13130	0.028	192741	0.4
10/18/2001	0.01	1.5		12855	0.021	47176	0.1
11/15/2001	0.01	5		10	0.01	122	0.1
12/6/2001	0.01	12		12	0.043	352	1.3
3/28/2002	0.01	37.2		14	0.025	1274	2.3
4/10/2002		1.8					
5/1/2002	0.01	4		16	0.01	157	0.1
6/12/2002	0.01	1		4	0.01	10	0.0

Sevier River at Airport Road Crossing – 494967

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
5/8/1996	0.01	100		210	0.12	51378	29.4
5/22/1996	0.01	30.7		20	0.02	1502	1.5
6/4/1996	0.005	14.8		4.8	0.02	174	0.7
6/18/1996	0.01	7		4	0.02	69	0.3
7/8/1996	0.01	13		8.4	0.06	267	1.9
8/20/1996	0.01	3		34	0.02	250	0.1
9/18/1996	0.005	13		42.4	0.02	1349	0.6
10/29/1996	0.01025	9.5		11.6	0.07348	270	1.7
12/10/1996	0.01129	85		56.8	0.04051	11812	8.4
1/28/1997	0.005			24	0.005		
2/25/1997	0.005	29		26.4	0.0208	1873	1.5
3/18/1997	0.02985	43		175		18410	
4/8/1997	0.01062	40		10.4	0.01705	1018	1.7
4/24/1997		115		288.7	0.16994	81227	47.8
5/6/1997				455			
5/21/1997		206		162.7	0.13354	82000	67.3
6/3/1997		35		24		2055	

Sevier River at Sanford Road Crossing – 494964

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
4/4/1996	0.005	9		50	0.03	1101	0.7
4/25/1996	0.005	10		15.6	0.01	382	0.2
5/8/1996	0.01	150		102	0.06	37433	22.0
5/22/1996	0.01	51		13.6	0.02	1697	2.5
6/4/1996	0.005	28.7		7.6	0.03	534	2.1
6/18/1996	0.005	31.5		11.2	0.02	863	1.5
7/8/1996	0.01	25		32	0.03	1957	1.8
8/24/1996	0.005	24.4		75.2	0.03	4489	1.8
9/18/1996	0.005	60		120.4	0.08	17674	11.7
10/29/1996	0.02163	90		180.7	0.22918	39789	50.5
12/10/1996	0.01874	105		154.4	0.13597	39664	34.9
1/28/1997	0.005			44.4	0.03952		
2/25/1997	0.01128	50		40	0.02553	4893	3.1
3/18/1997	0.03204	55		321		43194	
4/8/1997	0.01415	70		87	0.10854	14900	18.6
4/23/1997		120			0.18582		54.6
5/6/1997				205			
5/21/1997		224		260	0.23441	142488	128.5
6/5/1997		50		20		2447	
7/11/2001	0.02	71.3		46	0.049	8024	8.5
8/15/2001	0.032	9.73		112	0.092	2666	2.2
9/13/2001	0.01	35		48	0.023	4110	2.0
10/18/2001	0.01	8		52	0.01	1018	0.2
11/15/2001	0.01	72		114	0.066	20081	11.6
12/6/2001	0.024	52		115	0.049	14631	6.2
1/16/2002	0.01			48	0.059		
2/28/2002	0.01			52	0.044		
3/28/2002	0.01	52		56	0.034	7124	4.3
4/10/2002		36.2					
5/2/2002	0.01	10		60	0.01	1468	0.2
6/13/2002	0.01	19.7		4	0.01	193	0.5

Sevier River 2.5 Miles South of Circleville – 494945

Date	Dissolved Phosphorus (mg/l)	Flow (cfs)	Ortho-phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	TSS Load (kg/day)	TP Load (kg/day)
6/3/1976		110.0		110.0		29603.5	
7/15/1976		49.0		20.0		2397.6	
8/12/1976		40.0	0.0	15.0		1467.9	
9/9/1976		38.0		15.0	0.07	1394.5	6.5
10/14/1976		94.0		80.0	0.04	18398.2	9.2
12/2/1976		101.0			0.24		59.3
1/19/1977		93.0	0.0	100.0	0.30	22753.1	68.3
3/23/1977		75.0	0.0				
5/25/1977		38.0	0.0	15.0	0.04	1394.5	3.7
7/28/1977		34.0		105.0	0.14	8734.3	11.6
9/28/1977		33.0		15.0	0.02	1211.1	1.6
11/16/1977		78.0	0.0	86.0	0.07	16411.6	13.4
12/7/1977		88.0		60.0		12917.9	
1/11/1978		88.0		105.0	0.06	22606.3	12.9
3/8/1978		96.0	0.0	585.0		137399.5	
5/10/1978		128.0		230.0	0.24	72027.1	75.2
5/22/1978		288.0					
7/11/1978		69.0	0.0	10.0		1688.1	
9/5/1978		36.0	0.0	25.0		2201.9	
9/6/1978		36.0	0.0	10.0	0.05	880.8	4.4
11/15/1978				260.0	0.06		
1/17/1979		56.0			0.11		15.1
3/21/1979		56.0	0.1	28.0		3836.2	
5/16/1979		514.0		76.0	0.50	95572.9	628.8
11/28/1979		162.0	0.0	10.0	0.08	3963.4	31.7
6/18/1980		733.0	0.0	460.0	0.50	824935.1	896.7
10/28/1980		191.0	0.1		0.03		11.7
1/15/1981		158.0	0.0		0.05		19.3
2/19/1981		149.0	0.0		0.03		9.1
4/15/1981		89.0	0.0		0.03		5.4
6/18/1981		78.0		15.0	0.03	2862.5	4.8
8/19/1981		187.0			0.03		11.4
10/22/1981		128.0		135.0	0.03	42276.8	7.8
12/17/1981		131.0		132.0	0.15	42306.1	48.1
4/14/1982		163.0		1730.0	0.55	689908.8	219.3
5/19/1982		235.0		799.0	0.35	459380.6	201.2
7/21/1982		78.0		18.0	0.10	3435.0	19.1
9/16/1982		144.0		114.0	0.20	40162.9	70.5
11/10/1982		186.0		108.0	0.20	49146.7	91.0
1/5/1983		140.0		24.0	0.04	8220.5	13.7
3/2/1983		259.0		2550.0	0.20	1615838.5	126.7
4/26/1983		347.0		2448.0	0.22	2078255.3	186.8
6/21/1983		####		686.0	0.24	1745482.3	610.7
8/2/1984		178.0	0.0	1780.0	0.31	775171.9	135.0
8/29/1984		216.0	0.0	969.0	0.18	512077.3	95.1
4/24/1985		316.0	0.4	780.0	0.35	603031.1	270.6
5/22/1985		385.0	0.2	334.0	0.24	314604.7	226.1

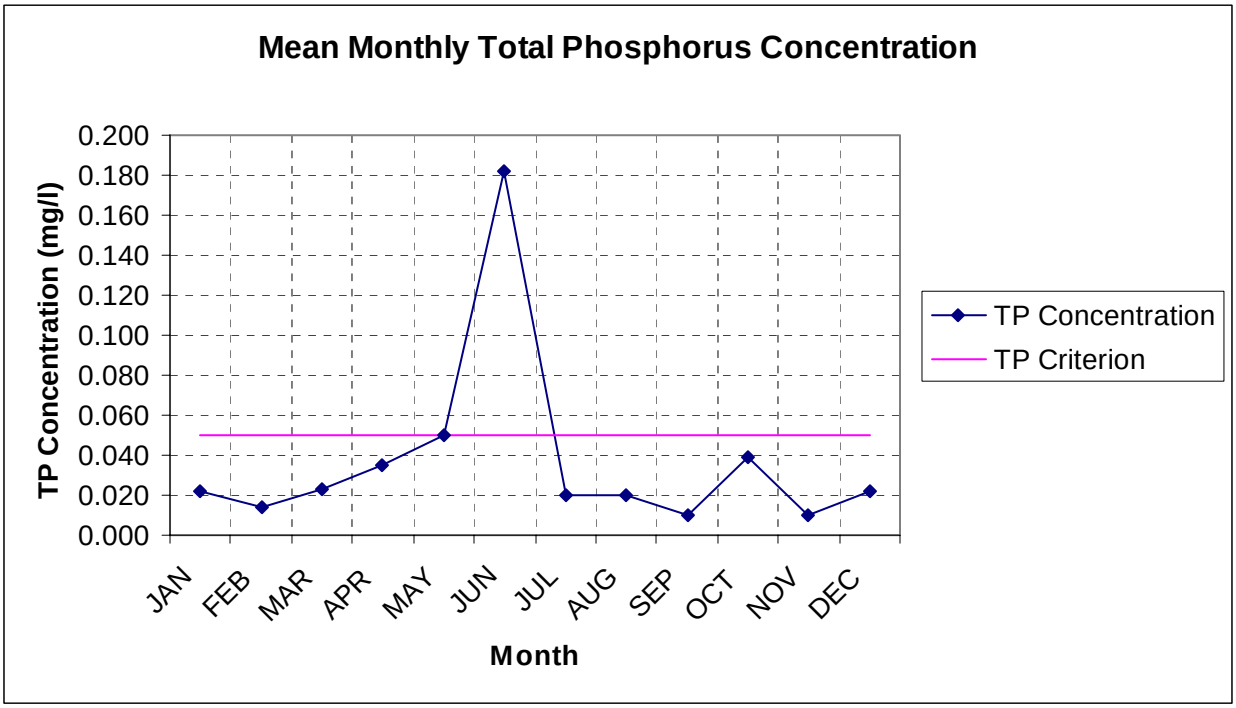
7/10/1985		104.0	0.0	36.0	0.04	9160.0	10.2
8/7/1985		93.0	0.0	25.0	0.01	5688.3	2.3
9/4/1985		104.0	0.0	42.0	0.03	10686.6	7.6
10/1/1985		110.0	0.0	34.0	0.04	9150.2	10.8
10/29/1985		106.0	0.0	63.0	0.03	16338.2	7.8
1/28/1986		31.9	0.1	81.0	0.06	6321.7	4.7
3/11/1986		150.0	0.1	144.0	0.12	52846.0	44.0
4/22/1986			0.0	40.0	0.05		
6/4/1986		160.0	0.2	386.0	0.20	151100.3	78.3
7/10/1986			0.0	18.0	0.02		
8/20/1986		5.0	0.0		0.19		2.3
10/2/1986		133.0	0.0	48.0	0.07	15618.9	22.8
11/13/1986		136.0	0.0	116.0	0.05	38597.1	16.6
12/17/1986		146.0	0.1	100.0	0.09	35720.0	31.4
2/4/1987		143.0	0.1	198.0	0.15	69272.2	52.5
4/28/1987		171.0	0.2	200.0	0.20	83672.8	83.7
6/25/1987		99.6	0.0	18.0	0.04	4386.2	9.7
8/4/1987		115.0	0.1	85.0	0.07	23915.2	19.7
9/16/1987		70.1	0.0	23.0	0.05	3944.6	8.6
11/11/1987		145.0	0.0	130.0	0.10	46117.9	35.5
12/16/1987		186.0	0.1	3.0	0.07	1365.2	31.9
1/26/1988		146.0	0.0	3.0	0.08	1071.6	28.6
3/7/1988		167.0	0.2	293.0	0.23	119713.2	94.0
4/21/1988		247.0	0.0	3.0	0.27	1812.9	163.2
6/1/1988		304.0	0.0	343.0	0.08	255109.0	59.5
8/3/1988		99.0	0.0	591.0	0.04	143146.5	9.7
9/8/1988		83.0	0.0	3.0	0.05	609.2	10.2
10/27/1988		101.0	0.0	3.0	0.02	741.3	4.9
12/8/1988		124.0	0.1	109.0	0.07	33067.9	21.2
1/26/1989		93.0	0.1	157.0	0.02	35722.4	5.2
2/28/1989		106.0	0.0	421.0	0.12	109180.7	29.8
4/11/1989		92.0	0.0	37.0	0.04	8328.1	9.5
5/18/1989		69.0	0.0	49.0	0.02	8271.9	4.1
6/21/1989		33.0	0.0	3.0	0.03	242.2	2.3
9/7/1989		40.0	0.0	12.0	0.03	1174.4	3.0
10/19/1989			0.0	7.0			
11/29/1989			0.0	225.0	0.09		
1/9/1990		99.0	0.0	136.0	0.09	32940.6	22.8
3/7/1990		110.0	0.0	245.0	0.07	65935.1	18.8
4/12/1990		55.0	0.0	19.0	0.05	2556.7	6.2
5/3/1990		44.0	0.0	14.0	0.00	1507.1	0.3
6/13/1990		40.0	0.0	192.0	0.09	18789.7	8.8
9/6/1990	0.1	42.0		101.0	0.17	10378.4	17.9
10/16/1990	0.0	44.0		14.0	0.02	1507.1	2.2
1/17/1991	0.0	92.0		167.0	0.16	37589.1	36.0
2/28/1991	0.0	95.0		217.0	0.16	50436.1	36.3
6/5/1991	0.0	122.0		158.0	0.06	47160.1	16.4
7/31/1991	0.0	30.0		19.0	0.04	1394.5	3.1
9/18/1991	0.0	44.0		3.0	0.01	322.9	1.5
10/30/1991	0.0	65.0		28.0	0.02	4452.8	3.2
1/9/1992	0.0	85.0		48.0	0.04	9982.0	8.3
2/19/1992	0.0	105.0		148.0	0.13	38019.7	32.9
4/9/1992	0.1	78.0		250.0	0.27	47708.2	51.0

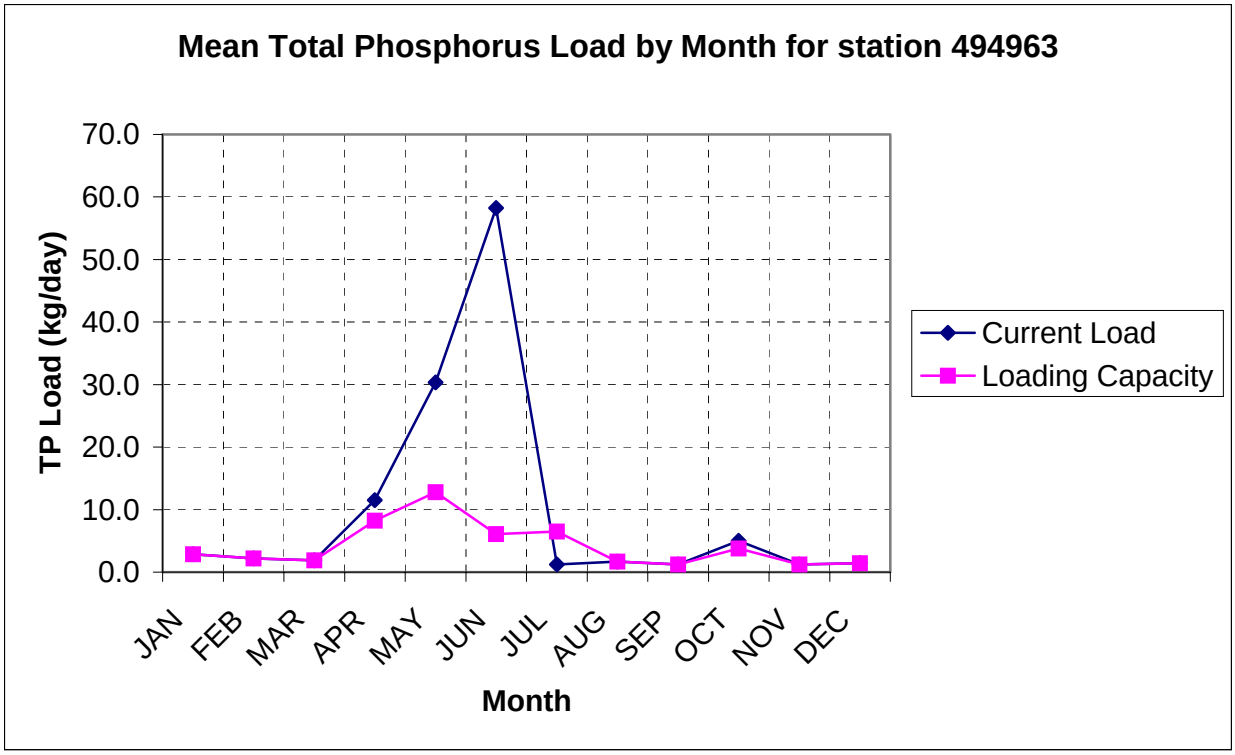
5/20/1992	0.0	163.0		153.0	0.11	61015.1	44.3
7/15/1992	0.0	33.0		84.0	0.08	6781.9	6.1
10/14/1992	0.0	49.0		12.0	0.02	1438.6	2.9
11/18/1992	0.0	123.0		198.0	0.13	59583.8	38.2
2/3/1993	0.0	106.0		99.0	0.06	25674.3	14.5
3/17/1993	0.0	198.0		808.0	0.11	391412.4	54.3
5/5/1993		643.0		704.0	0.28	1107494.6	445.2
6/9/1993		600.0		390.0	0.27	572497.8	389.0
8/18/1993		98.0		39.0	0.04	9350.8	10.5
9/22/1993		91.0		9.0	0.02	2003.7	4.0
11/10/1993		191.0		104.0	0.10	48598.7	45.3
1/12/1994		151.0		205.0	0.15	75733.6	56.9
2/23/1994		154.0		83.0	0.09	31272.1	33.9
4/6/1994		127.0		166.0	0.08	51578.6	26.1
5/11/1994		103.0		64.0	0.07	16127.8	16.9
6/15/1994		56.0		21.0	0.03	2877.2	3.7
7/27/1994		41.0		9.0	0.01	902.8	1.2
9/7/1994		66.0		148.0	0.09	23898.1	14.9
10/20/1994		125.0		192.0	0.15	58717.7	46.8
11/30/1994		122.0		168.0	0.14	50144.9	42.4
1/24/1995		129.0		89.0	0.06	28089.1	19.3
3/8/1995		137.0		581.0	0.28	194739.8	92.8
4/19/1995		193.0		259.0	0.18	122296.8	82.6
5/30/1995		500.0		567.0	0.33	693603.2	403.7
7/12/1995		326.0		300.0	0.10	239274.7	79.8
8/28/1995		133.0		80.0	0.08	26031.5	26.0
10/18/1995				110.0	0.10		
12/6/1995				112.0	0.08		
1/31/1996		32.0		108.0	0.09	8455.4	7.0
3/13/1996		35.0		129.0	0.07	11046.3	6.0
4/4/1996	0.0	32.0		38.0	0.04	2975.0	3.1
4/25/1996	0.0	50.0		24.8	0.02	3033.7	2.4
5/9/1996	0.0	75.0		54.8	0.04	10055.4	7.3
5/23/1996	0.0	61.0		30.8	0.03	4596.6	4.5
6/4/1996	0.0	50.0		8.8	0.03	1076.5	3.7
6/18/1996	0.0	31.7		4.0	0.01	310.2	0.8
7/8/1996	0.0	25.0		16.8	0.02	1027.6	1.2
8/20/1996	0.0	20.4		148.7	0.06	7421.6	3.0
9/18/1996	0.0	25.0		186.7	0.09	11419.4	5.5
10/29/1996	0.0	58.0		37.2	0.08	5278.7	11.4
12/10/1996	0.0	150.0		124.0	0.10	45506.2	38.1
1/28/1997	0.0	60.0		103.6	0.12	15207.9	17.8
2/25/1997	0.0	55.0		65.6	0.04	8827.2	5.7
3/18/1997	0.0	63.0		417.0		64273.9	
4/8/1997	0.0	70.0		144.7	0.08	24781.3	13.9
4/23/1997		145.0		404.0	0.35	143320.2	122.5
5/6/1997		160.0		228.0		89250.9	
5/21/1997		260.0		202.5	0.22	128812.0	139.2
6/5/1997		65.0		15.2		2417.2	
7/9/1997	0.1	37.0		9.6	0.09	869.0	8.4
8/14/1997		85.0		227.3	0.23	47269.0	47.5
10/1/1997		125.0		252.0		77067.0	
11/5/1997	0.0	104.0		38.8		9872.4	

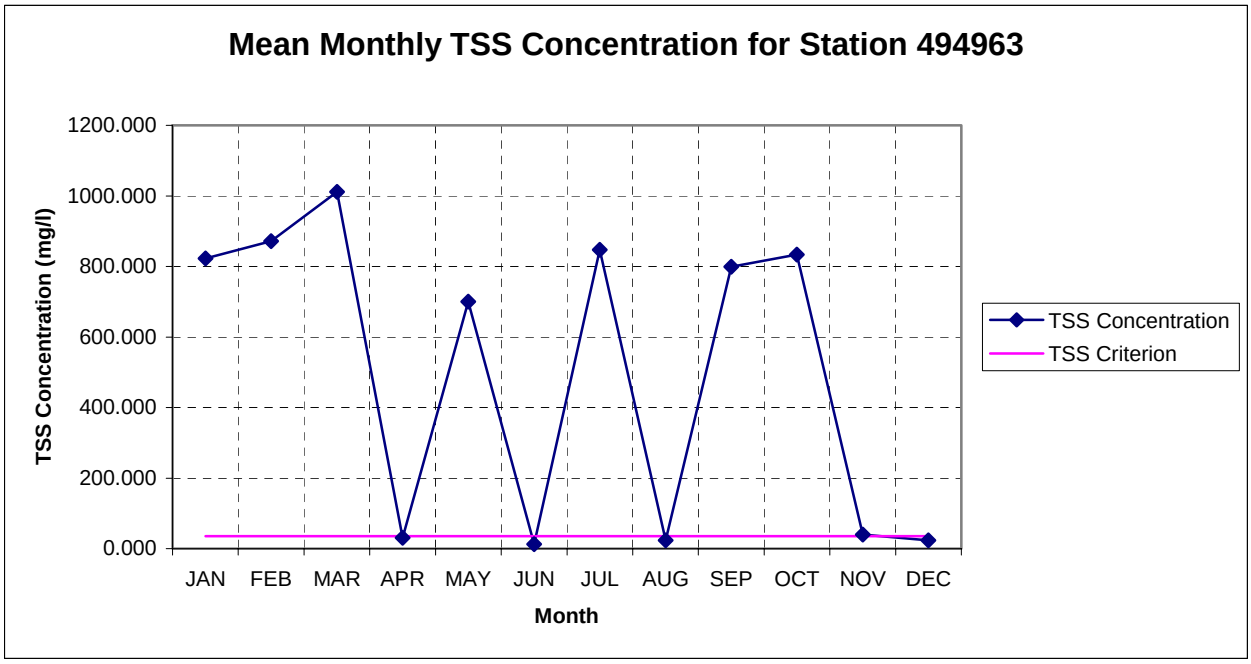
12/17/1997	0.0	90.0		202.4		44566.8	
2/11/1998	0.0	65.0		42.4	0.04	6742.8	6.3
3/26/1998	0.0			1840.0	1.07		
6/10/1998	0.0			244.0	0.14		
10/21/1998	0.0	180.0		60.4	0.07	26599.1	29.5
12/9/1998	0.0	198.0		116.8	0.06	56580.4	27.1
2/3/1999	0.0	170.0		45.6	0.04	18965.8	17.5
4/7/1999	0.2	42.0		19.2	0.05	1972.9	5.3
6/9/1999	0.0	143.0		175.2	0.15	61295.4	53.5
7/28/1999		21.0		156.0	0.16	8015.0	8.4
9/8/1999		36.0		26.4	0.03	2325.2	2.2
11/16/1999		155.0		57.2	0.03	21691.3	11.4
1/19/2000		204.0		119.0	0.09	59393.0	46.4
3/15/2000		150.0		138.0	0.06	50644.0	20.2
5/17/2000				156.0	0.07		
7/19/2000		44.5		34.7	0.07	3777.9	7.9
9/13/2000		14.0		16.4	0.01	561.7	0.3
10/25/2000				348.0			
4/18/2001				570.0	0.54		
6/20/2001				15.2	0.02		
7/11/2001	0.0			404.0	0.29		
8/15/2001	0.0	64.5		165.0	0.13	26037.6	20.8
9/13/2001	0.0	67.5		15.8	0.01	2609.3	1.7
10/18/2001	0.0	25.0		18.0	0.01	1101.0	0.6
11/15/2001	0.0	112.2		172.0	0.07	47214.9	18.9
12/6/2001	0.0	70.0		159.0	0.09	27230.3	15.6
1/16/2002	0.0			552.0	0.13		
2/28/2002	0.0			580.0	0.06		
3/28/2002	0.0	115.8		620.0	0.08	175654.1	22.4
4/10/2002	0.0	46.6		15.6	0.03	1778.6	3.2
5/2/2002	0.0	80.0		640.0	0.01	125264.5	2.0
6/13/2002	0.0	45.2		4.0	0.01	442.3	1.1
7/31/2002		15.7		55.0	0.06	2112.6	2.1
11/13/2002		71.3					

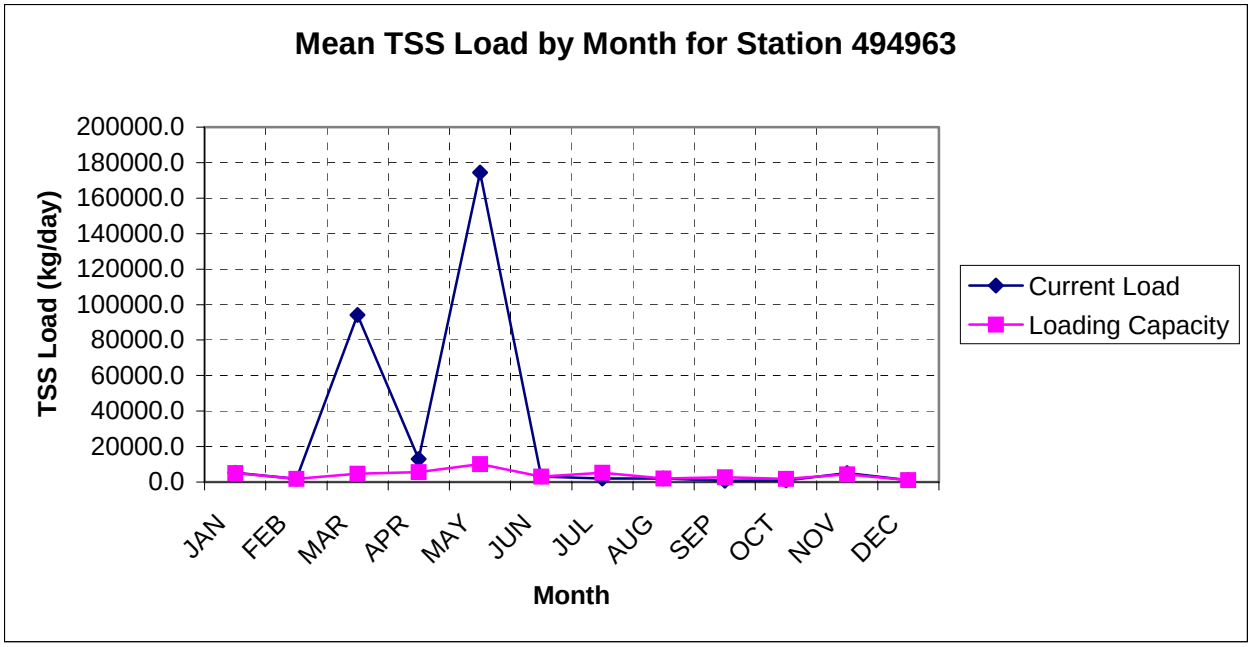
Appendix B Graphs

Sevier River at U12 Crossing – 494963

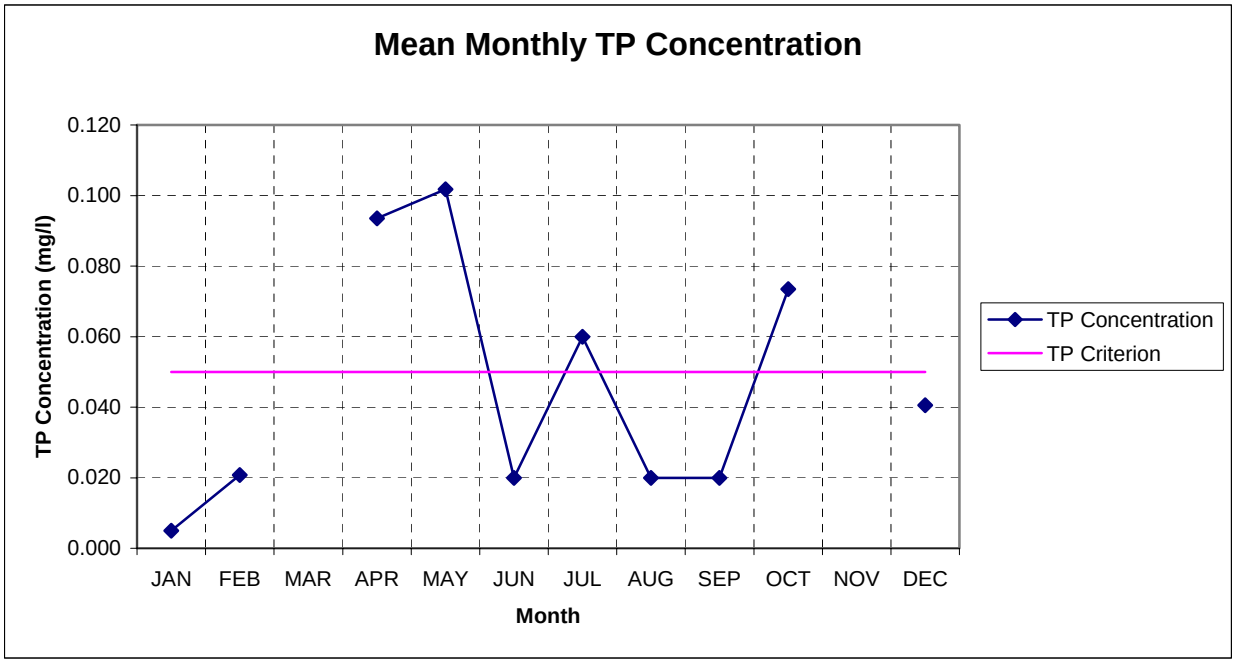


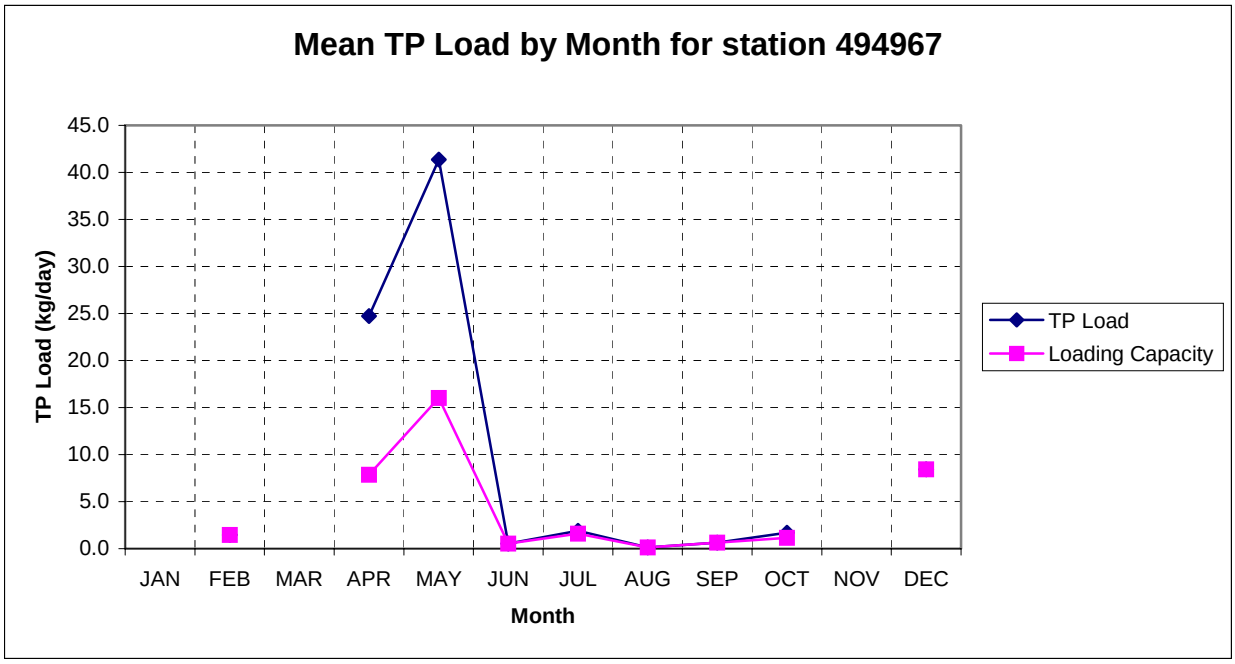

Mean Total Phosphorus Load by Month for station 494963
TP Load (kg/day)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Current Load
Loading Capacity

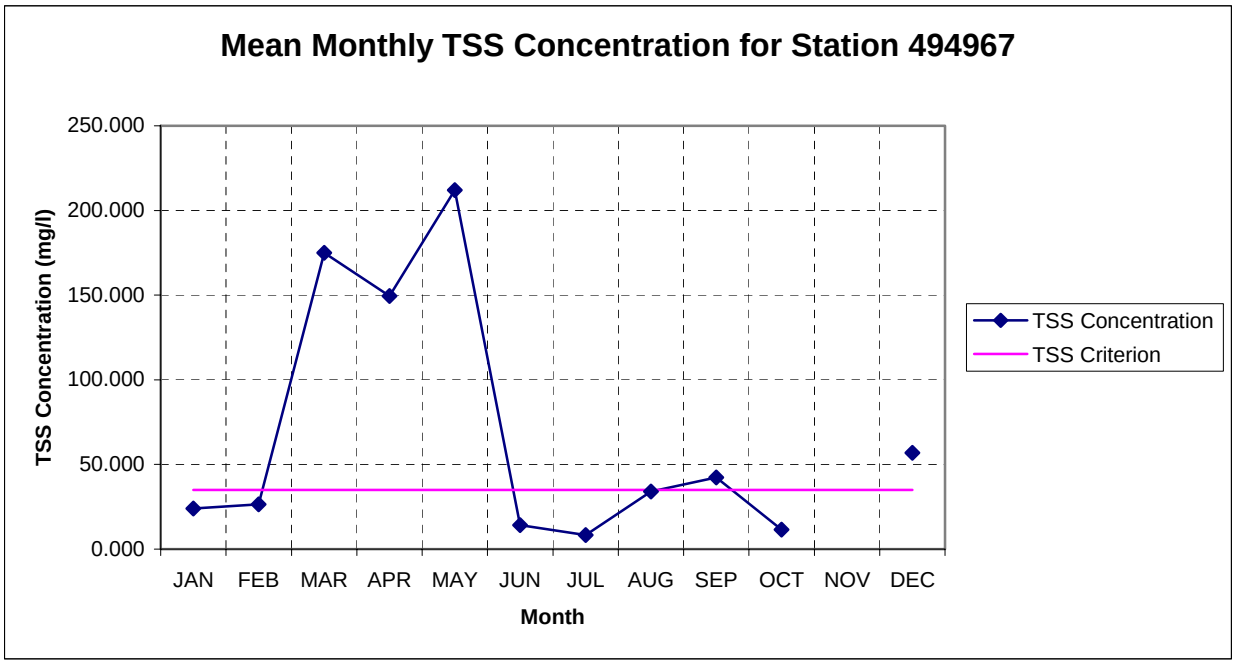

Mean Monthly TSS Concentration for Station 494963
TSS Concentration (mg/l)
1200.000
1000.000
800.000
600.000
400.000
200.000
0.000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TSS Concentration
TSS Criterion

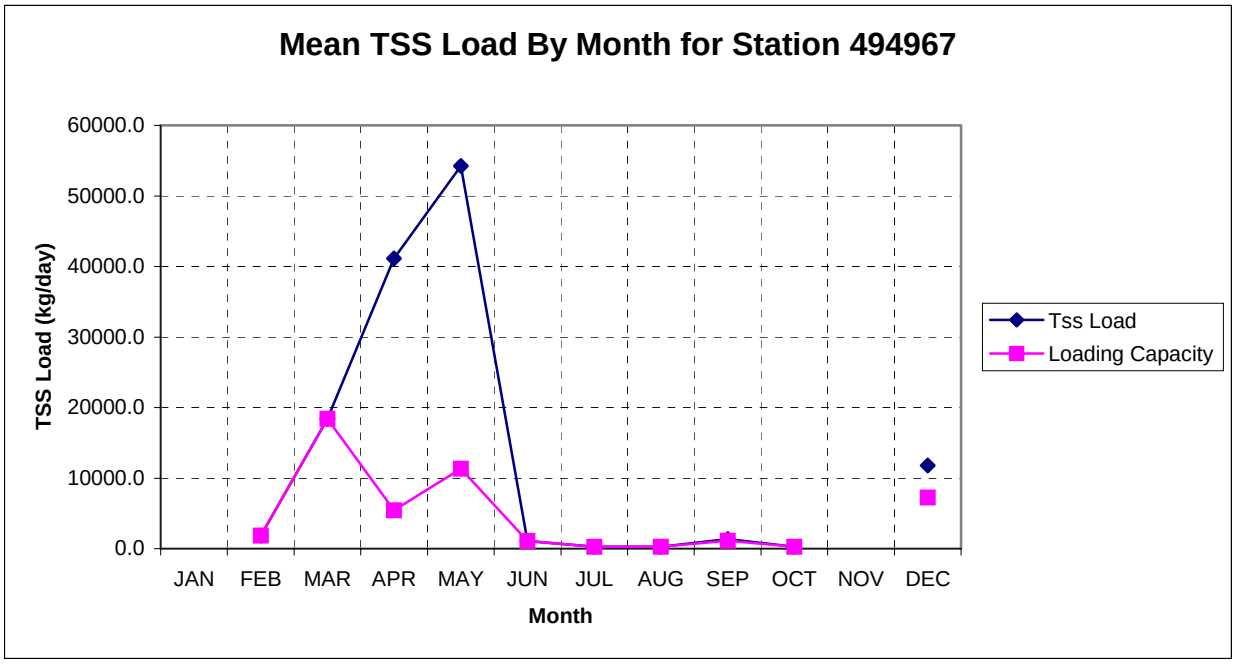


Sevier River at Panguitch Airport Road – 494967

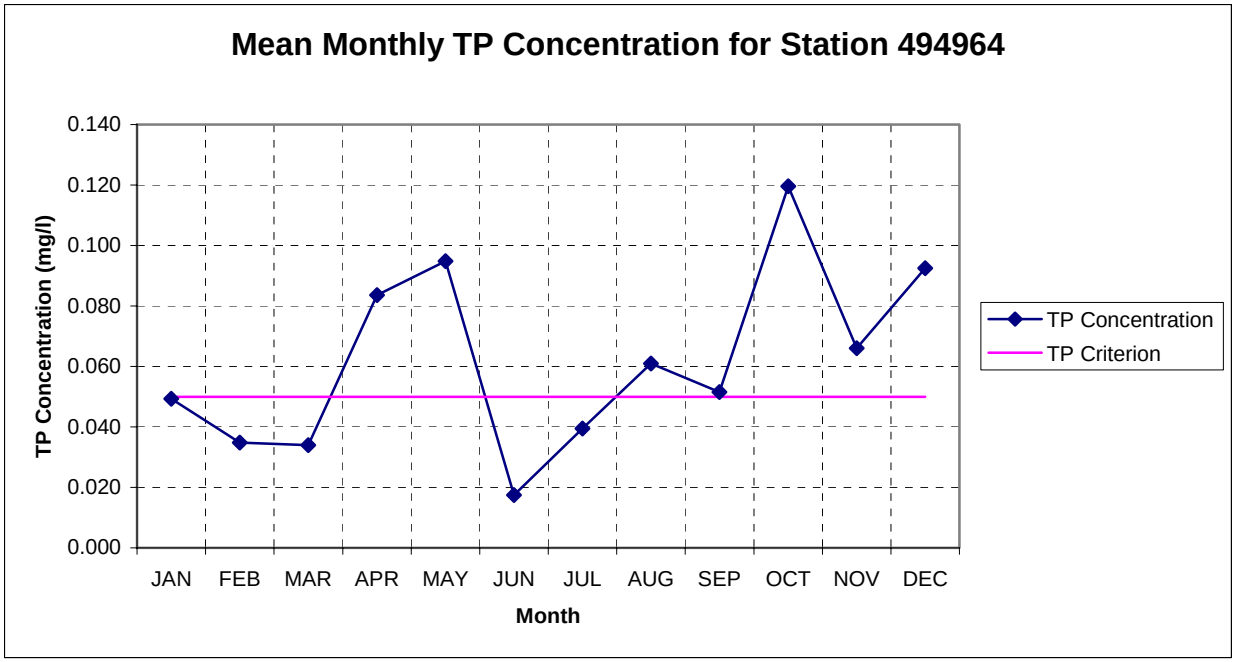


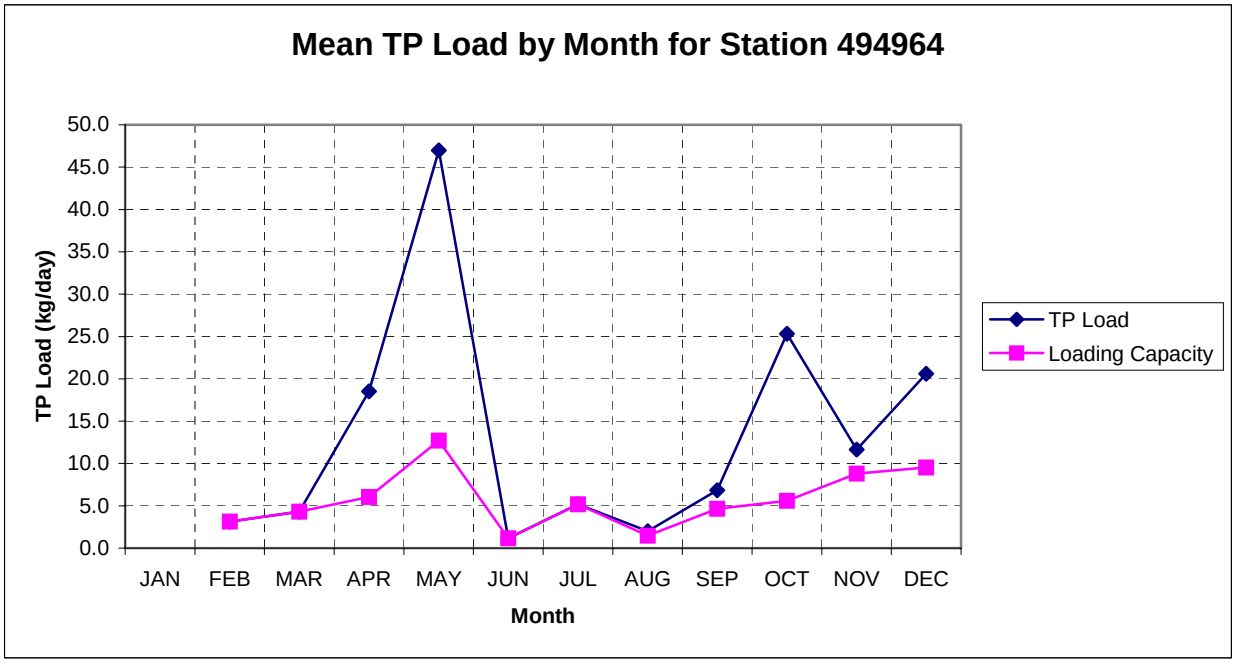

Mean TP Load by Month for station 494967
TP Load (kg/day)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TP Load
Loading Capacity

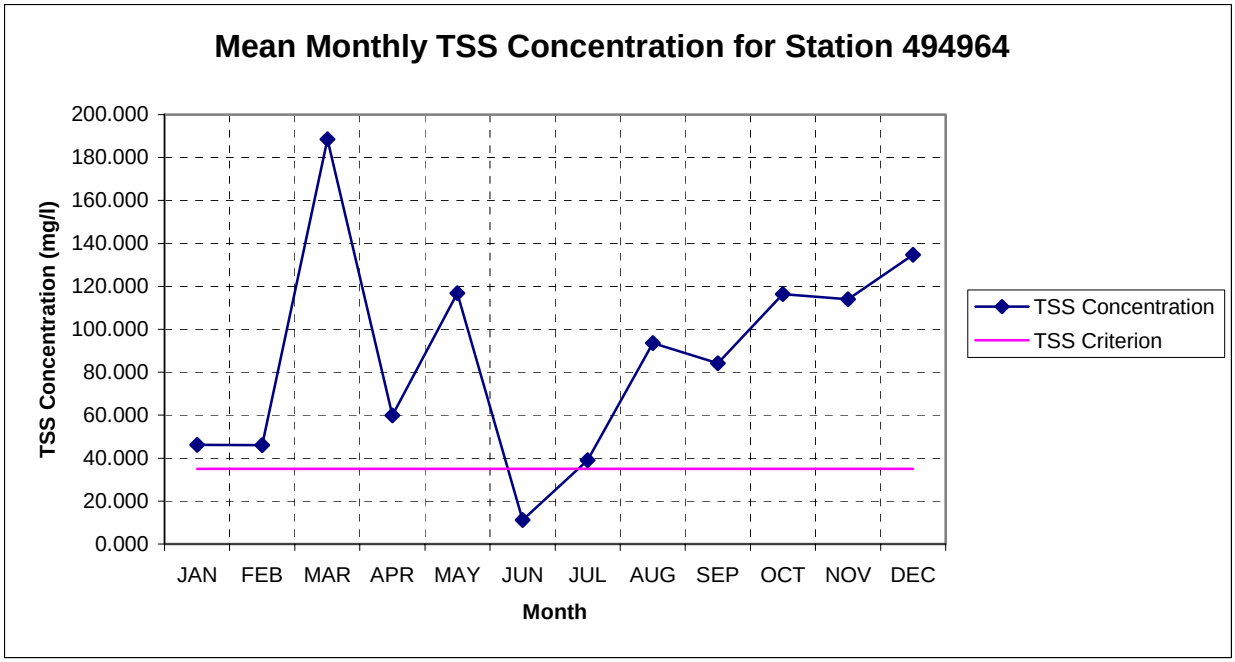

Mean Monthly TSS Concentration for Station 494967
TSS Concentration (mg/l)
250.000
200.000
150.000
100.000
50.000
0.000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TSS Concentration
TSS Criterion

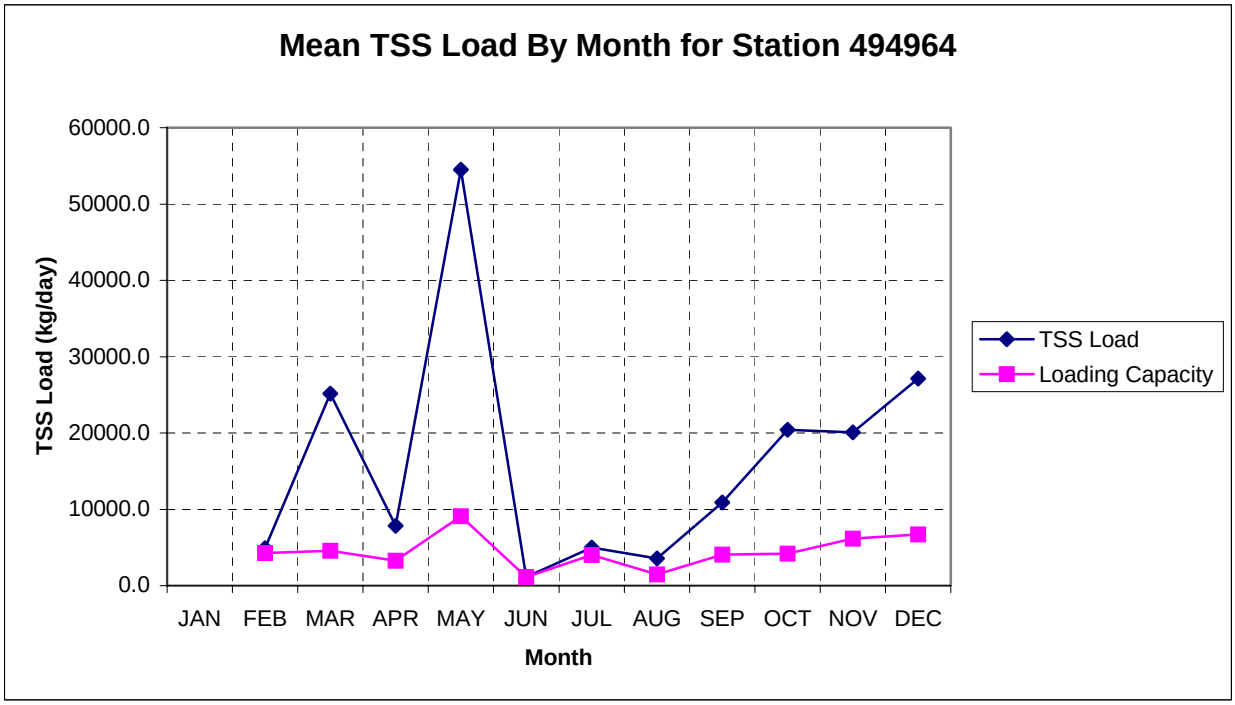


Sevier River above Sanford Creek – 494964

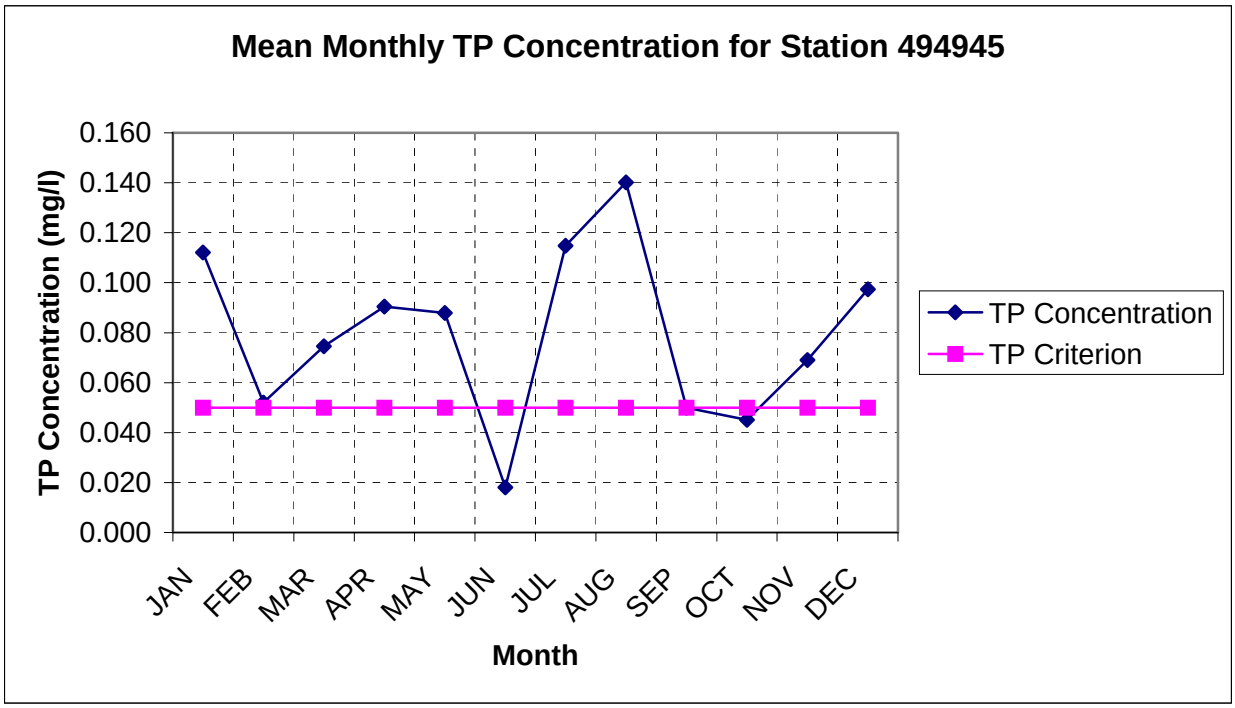

Mean Monthly TP Concentration for Station 494964
TP Concentration (mg/l)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TP Concentration
TP Criterion

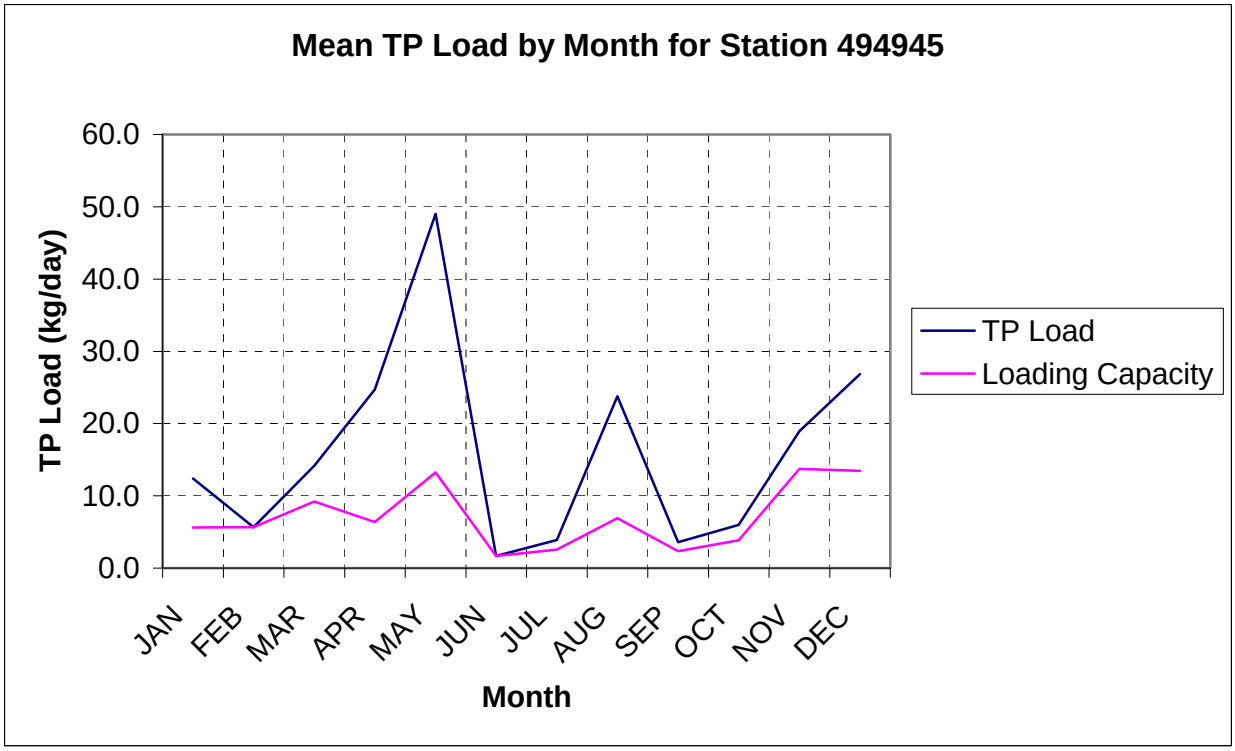

Mean TP Load by Month for Station 494964
TP Load (kg/day)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TP Load
Loading Capacity

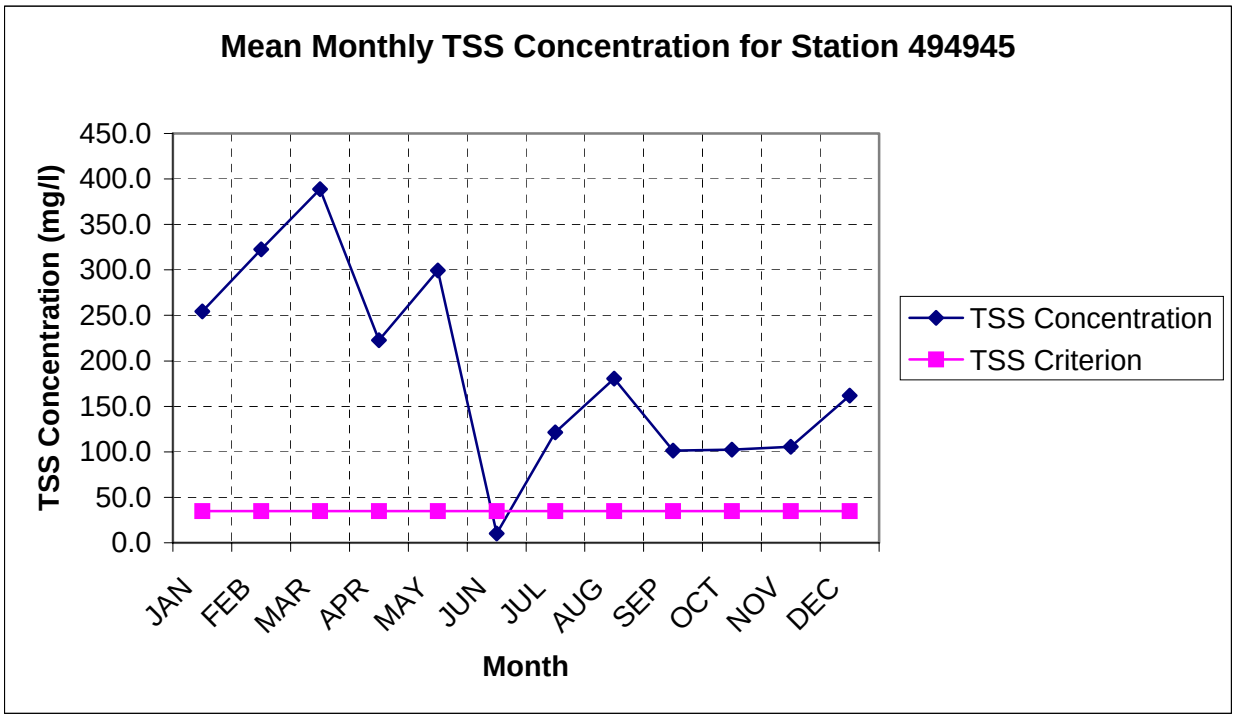

Mean Monthly TSS Concentration for Station 494964
TSS Concentration (mg/l)
200.000
180.000
160.000
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TSS Concentration
TSS Criterion

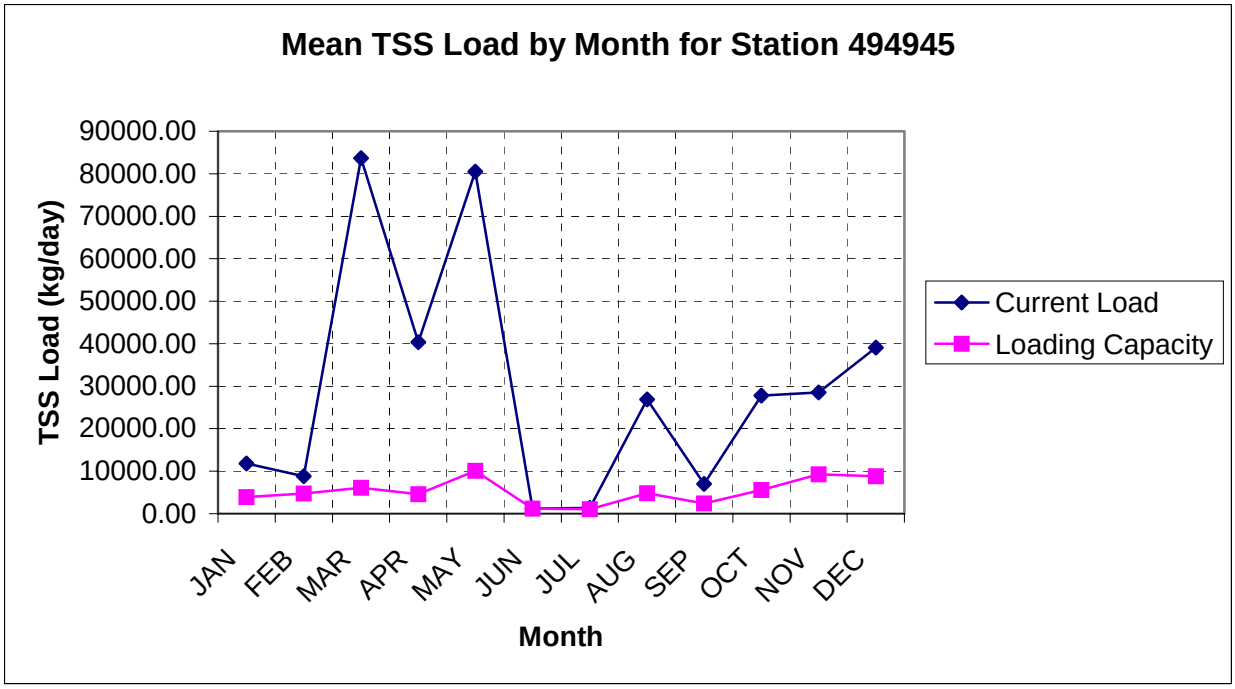

Mean TSS Load By Month for Station 494964
TSS Load (kg/day)
60000.0
50000.0
40000.0
30000.0
20000.0
10000.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TSS Load
Loading Capacity

Sevier River in Circleville Canyon – 494945




Mean TP Load by Month for Station 494945
TP Load (kg/day)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TP Load
Loading Capacity


Mean Monthly TSS Concentration for Station 494945
TSS Concentration (mg/l)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
TSS Concentration
TSS Criterion


Mean TSS Load by Month for Station 494945
TSS Load (kg/day)
90000.00
80000.00
70000.00
60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Current Load
Loading Capacity