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PARIA RIVER WATERSHED
WATER QUALITY MANAGEMENT PLAN

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1.0 INTRODUCTION

1.1 Background and Document Organization

This document presents a Water Quality Management Plan (WQMP) for the Paria River Watershed located in southern Utah. The Utah Division of Water Quality (DWQ) developed this Water Quality Management Plan with assistance from the Canyonlands Soil Conservation District. The DWQ contracted Millennium Science & Engineering to assess water quality impairments of the Paria River, quantify loadings for limiting water quality parameters, develop Total Maximum Daily Loads, and assist the Canyonlands Soil Conservation District in developing this Watershed Water Quality Management Plan. Many private individuals, agencies, and consultants contributed to these efforts. A list of contributors is provided in **Appendix 1.**

Utah's Year 2002 303(d) list identifies two reaches of the Paria River as being impaired due to exceedence of Utah's total dissolved solids (TDS) criteria for protection of agricultural uses, Class-4 waters. The upper and lower reaches ("Reach-1" and "Reach-3", respectively) are listed due to the measured elevated TDS concentrations (the "Listed Sections"). The middle reach is not listed as a water quality limited segment.

The Paria River flows from the headwaters in Bryce Canyon National Park and Dixie National Forest through private agricultural lands in Garfield County, Utah and south through the BLM administered Grand Staircase-Escalante National Monument (GSENM) into Arizona and the Colorado River below Glen Canyon Dam. The river flows through the Grand Staircase region, a series of multi-colored cliffs which begin at the rim of the Grand Canyon, and ascend over 5,000 feet across GSENM to end at the cliffs in Bryce Canyon. The small towns of Tropic, Cannonville and Henrieville at the northern end of the basin are based on a primarily agricultural economy dependent on irrigation from surface waters. Downstream from private lands near Henrieville Wash the river enters GSENM and flows through these primitive public lands for approximately 45 river miles to the Arizona border. The Paria River is situated in a dry desert climate so the majority of surface streams and washes are intermittent. The Paria River is perennial for most but not all of its length through the state.

Section 1 of the Water Quality Management Plan provides background on the Environmental Protection Agency (EPA) Total Maximum Daily Load (TMDL) process, Utah's watershed management approach, and describes the characteristics of the watershed. **Section 2** describes the water quality criteria that apply to the TMDL. **Section 3** evaluates impairment by evaluating the water quality, water quantity and TDS data. **Section 4** describes the TMDL (sources of pollution, loading calculations and allocation if appropriate, water quality goals and targets) and evaluation of site-specific criteria. **Section 5** describes the project implementation plans (PIPs) and best management practices (BMPs) to attain the water quality goals and targets, and describes a monitoring plan to evaluate implementation and effectiveness. Conclusions and recommendations are presented in **Section 6**. A list of references cited in this document is provided in **Section 7**.

Appendix 1 lists the people that contributed to this document. All maps are provided in **Appendix 2**. **Appendices 3 through 5** provide supporting data on water quality, flow conditions, and climate. **Appendix 6** lists acronyms used in the document. Review comments and responses are provided in **Appendix 7**.

1.2 The TMDL Process

Water quality standards are set by States, Territories, and Tribes. They identify the scientific criteria to support a waterbody's beneficial uses such as for drinking water supply, contact recreation (swimming), and agricultural uses (including irrigation of crops and stock watering). A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards (EPA, 1999). The Clean Water Act, Section 303(d), establishes the TMDL program. As part of the TMDL process, the maximum amount of the pollutant of concern is allocated to its contributing sources. Therefore, a TMDL is the sum of the allowable loads of the pollutant of concern from all contributing point and nonpoint sources. The calculation must include a margin of safety to account for future growth and changes in land use, uncertainties in data collection, analysis, and interpretation.

Section 303(d) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130), requires that States report waterbodies (i.e., lakes, reservoirs, rivers, and streams) that currently do not support their designated beneficial use(s). EPA regulations require that each State submit a prioritized list of waterbodies to be targeted for improvement to EPA every two years. These regulations also require States to develop TMDLs for those targeted waterbodies. Thus, those waterbodies that are not currently achieving, or are not expected to achieve, applicable water quality standards are identified as water quality limited. Waterbodies can be water quality limited due to point sources of pollution and nonpoint sources of pollution. Pollutants that can cause use impairment include heavy metals, pathogens and nutrients for which there are numeric standards. In addition to pollutants, impairments may originate from sources such as habitat alteration or hydrologic modification that have associated narrative standards (DWQ, 2002). Section 303(d)(1)(A) and the implementing regulations (40 CFR 130.7(b)) provide States with latitude to determine their own priorities for developing and implementing TMDLs.

Once a waterbody is identified as water quality limited, the State, Tribe, or EPA is required to determine the source(s) of the pollutant and to allocate the responsibility for controlling it. The goal of the TMDL is reduction in pollutant loading necessary for a waterbody to meet water quality standards and support its beneficial uses. This process determines: 1) the amount of a specific pollutant that a waterbody can receive without exceeding its water quality standard or impair a beneficial use; 2) the allocation of the load to point and nonpoint sources; and 3) a margin of safety. While the term TMDL implies that the target load (loading capacity) is determined on a daily time scale, TMDLs can range from meeting an instantaneous concentration (e.g., an acute standard) to computing an acceptable annual load to a waterbody (DWQ, 2002).

The Paria River is listed on Utah's 2002 303d list (DWQ, 2002) for waters requiring the development of a TMDL due to the exceedences of the agricultural criteria for Beneficial Use 4. Cooperative monitoring by DWQ and BLM have identified several monitoring stations where TDS concentrations exceeded State criteria. Therefore, DWQ prompted this TMDL to identify and quantify sources contributing to TDS increase in the Paria River watershed.

1.3 Utah's Watershed Approach

Utah's watershed approach is aimed at improving and protecting the State's surface and groundwater resources. Characteristics of the approach include a high level of stakeholder involvement, water quality monitoring and information gathering, problem targeting and prioritization, and integrated solutions that make use of multiple agencies and groups. Federal and state regulations appoint DWQ with the task of preventing, controlling, and abating water pollution. Other state and local agencies have associated responsibilities. Utah's watershed approach is to form partnerships with accountable government agencies and interested groups to combine resources and increase the effectiveness of existing programs.

Throughout the State of Utah a series of ten nested management units provide spatial focus to watershed management activities, thereby improving coordination. Watershed management units in the State may contain more than one stream system, or watershed, defined as the entire area drained by a stream and its tributaries. Watershed management units are consistent with the hydrologic basins defined by the Utah Department of Natural Resources - Division of Water Resources for the State Water Plan project (Utah Division of Water Resources, 1990). The watershed management units provide boundaries for evaluating the impact of various stressors on commonly shared resources, provide boundaries for evaluating the impacts of management actions, and provide a better perspective for DWQ and stakeholders to determine environmental objectives and to develop management strategies that account for local and regional considerations.

Each watershed plan will establish management actions at several spatial scales ranging from the watershed scale to specific sites that are influenced by unique environmental conditions. Watershed plans consider a holistic approach to watershed management in which groundwater hydrologic basins and eco-regions encompassed within the units are considered. The goal of Utah's watershed approach is better coordination and integration of the State's existing resources and water quality management programs to improve protection for surface and groundwater resources. Better coordination and integration extends beyond the tiers of government agencies to include all stakeholders in the watershed.

Utah's watershed approach is based on hydrologically defined watershed boundaries and aims to de-emphasize jurisdictional delineations in watershed management efforts. This approach is expected to accelerate improvements in water quality as a result of increased coordination and sharing of resources. Statewide watershed management is not a new regulatory program, it is a means of operating within existing regulatory and non-regulatory programs to more efficiently and effectively protect, enhance, and restore aquatic resources. The Statewide watershed management approach has been introduced to establish a framework to integrate existing programs and coordinate management activities geographically (DWQ, 2000c).

In addition to the technical components, Utah's watershed approach is dependant on the critical role stakeholders play in watershed water quality management. The success of the implementation plan, and ultimately the restoration of water quality, depends on the voluntary participation of the stakeholders in Utah's watersheds. Therefore, to be successful, the TMDL development approach must ensure public participation and input at critical points throughout the process.

A successful water quality management plan and TMDL relies as much on voluntary stakeholder participation and buy-in as on the rigor of technical analysis. The advantages of involving stakeholders throughout the TMDL development and implementation process are numerous. Through their voluntary participation, the stakeholders can become more comfortable that the monitoring and modeling programs generate reliable data that are scientifically defensible. Further, effluent limits and BMPs developed by the Stakeholders are less prone to credibility challenges and litigation. Stakeholders are more apt to agree to pollutant reduction or habitat improvement schemes that they helped to formulate.

The boundaries of watershed management units in Utah were drawn so that stakeholders would be aggregated or grouped into areas sharing common environmental characteristics. Defining watershed management units in this way is intended to encourage a sense of ownership in the resident stakeholders and to encourage involvement in stewardship activities. Based on a model successfully used by other states, the program draws on the expertise of those involved in or affected by water quality management decisions. These stakeholders help gather information and design BMPs, then become involved in stewardship activities.

In the Paria River watershed, both governmental and non-governmental entities worked to achieve a skillful and honest presentation of technical information to the Canyonlands Soil Conservation District throughout this study. These efforts have resulted in a Water Quality Management Plan that assures control of nonpoint source pollution that are acceptable to those living and working in the watershed.

1.4 Watershed Characterization

1.4.1 Location and Population

The Paria River is located in Garfield and Kane Counties in southern Utah and contained in part within the GSENM (Figure 1-1). The locations of the water quality limited sections of the Paria River are also indicated in Figure 1-1.

Garfield County had the fifth smallest population in the State of Utah, 4,599 in 2002, and is the least densely populated[1]. The county's average annual growth rate from 1990-2000 was 1.8%; lower than the state average of 2.7%. Total nonagricultural employment totaled 2,129 in 2001 in Garfield County. Services accounted for the greatest share of nonagricultural employment at 45.2% and government accounted for 28.7% of Garfield County's 2001 employment. Agriculture and trade were also important. Growth in tourism-related industries is expected to continue at a more accelerated pace because of the designation in 1996 of the GSENM. Garfield County had 121,381 acres of private land on 285 farms; 116 were full-time farms (1997). The market value of agricultural products sold was $7.6 million in 1997; crop sales accounted for 18% of agricultural products and livestock sales for 82%. Cattle, hay, dairy products, and sheep are all significant agricultural products of the county. There are 3,330,924 land acres in Garfield County. Of that amount, 90% is federally owned, while 5.4% is state owned. The remaining land in Garfield is privately owned, owned by municipal organizations, or state sovereign lands.

Kane County's population was 5,958 in 2002. With a population density of 1.5 persons per square mile, the county was one of the least densely populated in the state. Kane County sustained an average growth rate of 1.6% per year from 1990 to 2000. Kane's Census 2000 average household size, 2.67 people, was one of the lowest in the state. By 2030, Kane County's population is expected to swell to over 13,628 people. Nonagricultural employment reached 2,902 in 2001. Services (41%) and government (25.4%) accounted for the largest shares of employment. Manufacturing (12.9%) and trade (12.7%) also occupied an important presence. Kane's economy is specialized in tourism-related industries, agriculture, and non-metallic minerals extraction.

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[1] County Economic Profiles. Governor's Office of Planning and Budget, Demographic and Economic Analysis. http://governor.utah.gov/dea/WrittenProfiles.PDF

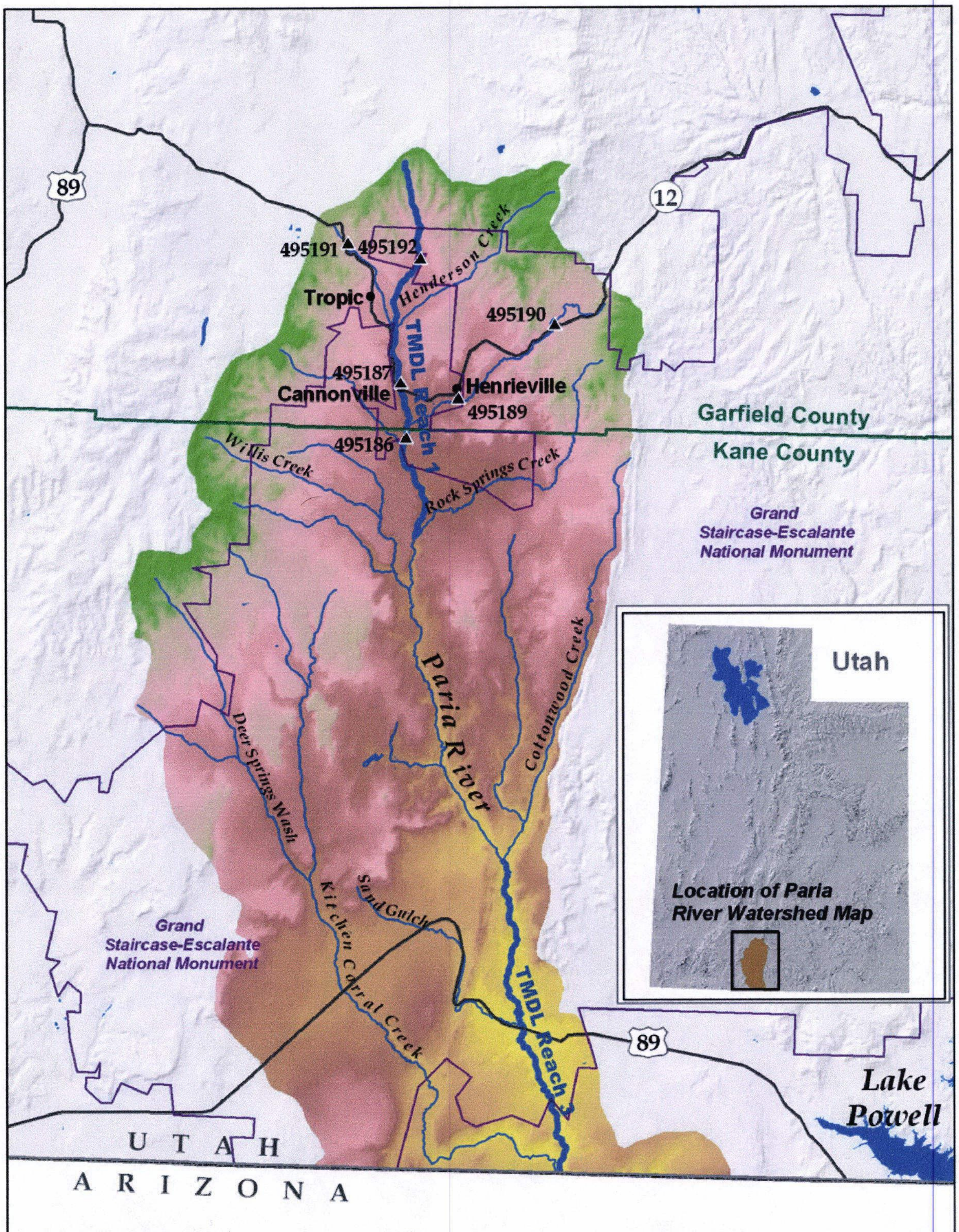

Figure 1-1 Location of Paria River

1.4.2 Land Use/Land Cover

Land ownership patterns are shown in Map 6, and summarized in Table 1-1. The northern end of the watershed is bordered by Bryce Canyon National Park and Dixie National Forest. Below the national park and forest service boundary the watershed, excluding private land, has been incorporated into the GSENM.

Table 1-1
Landownership Patterns in the Paria Study Area

Watershed	Land Ownership Area (square miles)					
	BLM	**USFS**	**NPS**	**Utah**	**Private**	**Total**
Paria River Reach-1						
(Paria Reach-1)	34.1	14.7		5.1	10.8	
Rock Springs Creek[1]	50.1	1.5		0.6	5.2	57.4
Henrieville Wash	53.4	5.4		0.8	4.0	63.6
Yellow Creek	8.2		4.6	0.7	2.1	15.7
Henderson Creek	10.5	16.6		0.1	2.1	29.2
Tropic Ditch	3.9	0.7	17.6	0.6	6.0	28.8
Total	160.3	38.9	22.1	7.9	30.2	194.7
Paria River Reach-3						
Kitchen Corral Creek[2]	292.3	10.3	4.0	1.2	17.8	325.7
Sand Gulch	36.6				3.7	40.3
(Paria Reach-3)	62.2			12.2	1.4	75.9
Total	391.1	10.3	4.0	13.4	22.9	441.8

Notes to Table: Subwatersheds Reach-1 and Reach-3 (in parentheses) are the land areas that drain directly to the river, and do not include the tributaries in the table. [1] Rock Springs Creek with Wiggler Wash tributary as headwaters. [2] Kitchen Corral Creek with Deer Springs Wash tributary as headwaters.

The Paria River occurs within the Grand Staircase physiographic region. The Grand Staircase region is a series of multi-colored cliffs which begin at the rim of the Grand Canyon, and ascend nearly 5,500 feet across the southwestern side of GSENM, to end with a final stair of pink cliffs in Bryce Canyon National Park. These stairs consist of "risers" of resistant and non-resistant rock formations up to 2,000 feet high, and "treads" which are valleys or plateaus up to 15 miles wide. The stairs include the Chocolate Cliffs, Vermilion Cliffs, White Cliffs, Gray Cliffs, and Pink Cliffs, all large expanses of exposed, virtually undeformed rock strata which provide a relatively continuous stratigraphic record from Grand Canyon (Precambrian) to Bryce Canyon (Tertiary).

Map 5 shows the vegetation patterns as identified by the Utah GAP vegetation analysis. GAP refers to a process to identify "gaps" in protection of high biodiversity areas for wildlife species. The resulting maps characterize plant communities at a broad scale, and are not particularly useful for streamside zones. Vegetation in Paria River Reach-1 transitions from mountain shrub and juniper at higher elevations and wetter sites to salt desert scrub. In Paria River Reach-3, salt desert scrub transitions to blackbrush communities toward the Arizona border.

1.4.3 Geology and Soils

The Paria River flows through a series of topographic benches and cliffs that form the Grand Staircase region. From its headwaters approximately 5 miles northeast of Tropic, Utah, to where it joins the Colorado River near the town of Lee's Ferry, Arizona, the Paria River cuts through sedimentary strata of several geologic formations ranging from Late Triassic to Early Tertiary (middle to late Eocene) in age.

The upper Listed Section of the Paria River flows through the Claron Formation in the northern most part of the study area. The Claron is characterized by upper white limestone and lower pink limestone members (Bowers, 1972), which are continuous throughout the Markagunt, Paunsaugunt, Seiver and Table Cliffs Plateaus (GSA, 2002).

As the river flows south to Cannonville (near STORET 495187), it crosses the Wahweap Sandstone and Tropic Shale Formation and Dakota Sandstone. The Wahweap is composed of interbedded mudstones, siltstones sandstones, and conglomerates (Doelling, et al., 2000), that accumulated in fluvial, flood plain and lacustrine environments. Locally rich fossil-bearing sections of the Wahweap contain petrified wood, vertebrates (including dinosaurs), and gastropods. The Tropic Shale is characteristically blue-gray in color and represents deposition of muds in a deep water marine environment. It forms distinctive slopes that are prone to landslides and slumps that likely contribute much of the sediment loading to the Paria. Bentonite beds are abundant throughout the Tropic Shale and are correlated with well established ammonite biozones (Cobban, et al., 2000) The lower part of the Tropic Shale contains limestone concretions, rich in molluscan fauna, whereas the upper Tropic becomes sandy (GSA, 2002). The Dakota Sandstone is composed of sandstone, conglomerate, mudstone, siltstone and coal deposited in coastal flood plain and shallow marine environments.

Approximately 8 miles south of Cannonville, the Paria River crosses the Entrada and Carmel formations of middle Jurassic age. The Entrada is highly variable, but is most often associated with cross bedded eolian sandstones in the region (Peterson, 1994). The Entrada has three members (Gunsite Butte, Cannonville, and Escalante) consisting of white to reddish-orange, silty to fine grained sandstones with sparse, medium to coarse frosted sand grains (Doelling, et al., 2000). Lower Jurassic formations (Navajo Sandstone, Kayenta Formation, Moenave Formation and Wingate Sandstone) are well developed in the Vermillion Cliffs, Wygaret Terrace and White Cliffs. They consist predominantly of red sandstones (Moenave and Kayenta Formations) that are crossed by the Paria River in the lower part of the upper Listed Section (Reach-1).

The lower Listed Section Paria River begins approximately 2 miles south of STORET Site 599455. Here, the Paria again crosses Entrada/Carmel Formation, Wahweap Sandstone, Tropic Shale, Dakota Sandstone and Navajo/Kayenta/Moenave Formations, as it flows south to the Arizona Border.

Throughout much of its entire length the Paria River flows through alluvium. From STORET Site 495192 to the end of the upper Listed Section, the Paria flows through thick deposits of Quaternary age alluvium. In the lower Listed Section, the Paria flows almost entirely though alluvium. These valley-fill deposits are extensive, extending across the entire width of the valley between bedrock margins. The alluvium formed by repeated (cut and fill) episodes of valley erosion and stream entrenchment followed by aggradation and build up of the stream bed (Hereford, 1997).

Considering the geology of the Paria River Watershed, the Tropic Shale is identified as a potential source of TDS to the Paria River. Given its deposition in a marine environment it contains salts that could leach out to surface and groundwater. Furthermore, because its slopes are prone to landslides and slumps, percolating surface waters could also carry significant loads of saline sediments to the Paria River.

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to map soils in the Paria River Watershed. General soils data and map unit delineations for the area are provided as part of the State Soil Geographic (STATSGO) database. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. Map 4 shows the general soil unit boundaries in the Paria River Watershed.

1.4.4 Climate

Extreme changes in weather are characteristic of the canyons and plateaus of the Grand Staircase region. Powder-dry arroyos can change suddenly into boiling, muddy stream channels by thunderstorms many miles away. Scorching desert heat during the day gives way to cold, clear nights. During the summer months, small springs and tinajas (small temporary rock pools) provide oasis for wildlife. When winter arrives, bitter cold temperatures rule the canyons, while snows blanket the higher plateaus.

Annual precipitation varies from about 6 inches at the lowest elevations to approximately 25 inches at the highest elevations. The variation in elevation and precipitation produce three different climate zones: upland, semi-desert, and desert. At the highest elevations, precipitation falls primarily in the winter as snow. The majority of rainfall in the semi-desert areas occurs during the summer months as intense but localized thunderstorms. The climatic zones for the GSENM are summarized in Table 1-2 (BLM, 1999).

Table 1-2
Climate zones for the GSENM including Paria River Watershed

	Desert	Semi-desert	Upland
Precipitation (inches)	6 to 8	8 to 12	12 to 16
Soil temperature (degrees F)	50 to 57	47 to 55	43 to 50
Frost Free Period (days)	170 to 300	125 to 170	100 to 125
Elevation (feet)	4,000 to 4,800	4,800 to 6,200	6,200 to 7,500

The weather station at the town of Tropic, Utah (6295 feet elevation) is the closest long term climate station (Station Number 428847). Data was obtained from the Western Regional Climate Center (WRC) operated by the Desert Research Institute (Reno, Nevada), a clearinghouse for the National Climatic Data Center.

The average monthly temperatures and average total precipitation for the 52-year period are shown in Table 1-3. The months of June, July and August are the warmest months during the year with average maximum temperatures between 80 - 85 degrees Fahrenheit. The higher precipitation in the late summer is due to the monsoon-type weather that influences climate in southern Utah. Additional climatic summaries for the Paria weather station (428847) are provided in Appendix 5.

Table 1-3
Monthly Climate Summary, Tropic Utah (428847)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	41	46	52	61	70	80	85	83	76	65	52	43	62.7
Average Min. Temperature (F)	15	19	24	30	37	45	52	50	43	34	24	17	32.3
Average Total Precipitation (in.)	1	1	1	0.7	0.7	0.5	1.1	1.8	1.2	1.2	0.9	0.9	12.08

Utah is experiencing a drought cycle that has influenced both the flow and TDS measurements in the Paria River system. Previous droughts occurred during 1896-1905, 1930-36, 1953-65, 1974-78, and more recently during 1988-93 and 1999-2002 (USGS 2003). Southern Utah began experiencing drought conditions during the winter of 1998-99. By 2000, drought conditions were evident throughout all of Utah. The current drought (1999-present) is generally comparable in length and magnitude to previous droughts. During 2002, the fourth straight year of nearly statewide drought conditions, some areas of Utah experienced record-low stream flows. Several record-low stream flows occurred in streams with records dating back to the 1900s.

The intensity and duration of the drought is illustrated by precipitation for the recent 10-year period (Figure 1-2) prepared by the Utah Division of Water Resources for the Southeast Colorado River Basin[2]. The figure uses a water year, which runs from the previous October 1st through September 30th.

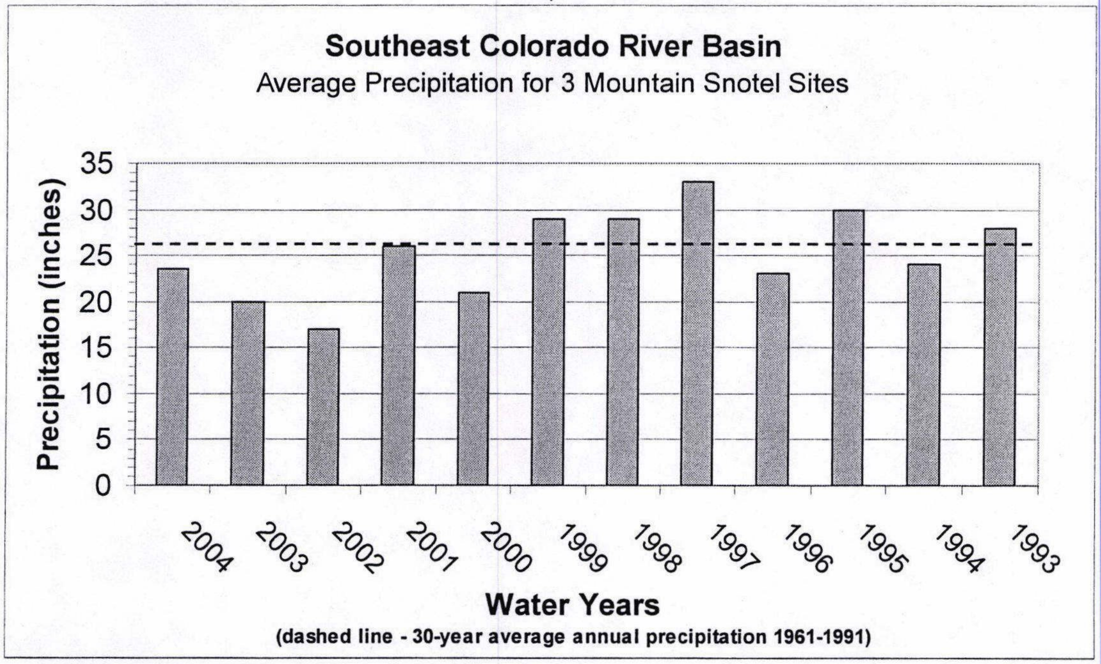

Figure 1-2 Average Precipitation for Southeast Colorado for the Most Recent 10-Year Period (Utah Division of Water Resources website)

The recent five-year period starting with Water Year 2000 (October 1999) is well below the average precipitation when compared to the 30-Year average annual precipitation for the region. The TDS data available in STORET needs to be interpreted in the context of the drought when making policy and regulatory decisions.

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[2] Basin Drought Reports. Utah Division of Water Resources. http://www.water.utah.gov/droughtconditions/BasinDroughtReports/SeColorado/default.asp

1.4.5 Surface Water Hydrology

Map 1, Watershed Overview, shows the primary stream network. Although indicated as a continuous blue line many of the stream reaches are not perennial. BLM roughly estimated that 10% of the 2,500 miles of stream channels and washes on the GSENM are perennial, (BLM 1999). The map delineates the 303(d) Listed Sections of the Paria River (Reach-1 and Reach-3) in red. The middle section of the watershed is not listed as a water quality limited stream segment.

Paria River Reach-1 includes the headwaters of the Paria River and four major tributaries. Tropic Ditch is used for irrigation in the irrigated lands near the town of Tropic, bringing in irrigation water originating in the Sevier River basin. A smaller irrigation tract occurs within the vicinity of Cannonville and Henrieville. Watershed area and elevation are summarized in Table 1-4.

The lower listed section, indicated as Reach-3 on Map 1 includes the Paria River from the Arizona-Utah Stateline to the confluence with Cottonwood Creek. Two major tributaries enter within the listed section; Sand Gulch that runs along Highway 89, and Kitchen Corral Creek that drains a large subwatershed on the western side of the basin. In addition, there are a number of washes and spring systems that drain into this reach of the river. The quantity and quality of water in these potential tributaries however is unknown.

Table 1-4
Watershed Characteristics within the Paria Study Area

Watershed	Stream Miles	Sq mi	Elevation (ft) minimum	Elevation (ft) maximum	Elevation (ft) mean	River Mile Index
Paria River Reach-1	21.0					39 to 60
Rock Springs Creek[1]	17.8	57.4	5,431	9,245	6,579	39
Henrieville Wash	15.4	63.6	5,741	10,073	6,914	46
Yellow Creek	9.3	15.7	5,669	8,292	6,628	50
Henderson Creek	12.2	29.2	6,093	10,270	7,752	50.5
Tropic Ditch	6.5	28.8	6,082	8,290	7,031	51
Paria River Reach-3	19.4					0 to 19.5
Kitchen Corral Creek[2]	46.8	325.8	4,323	9,392	6,178	0.1
Sand Gulch	14.9	40.3	4,360	6,712	5,293	9.5
Paria River TMDL Reach 3						

Notes to Table: River/creek miles are approximate and measure the length of the primary channel as indicated as the blue and red lines on Map 7. [1] Rock Springs Creek with Wiggler Wash tributary as headwaters. [2] Kitchen Corral Creek with Deer Springs Wash tributary as headwaters.

Narrative Description of Surface Hydrology in the Paria River Basin

The Paria River drains the GSENM's west central area into Arizona and eventually the Colorado River. The towns of Tropic, Cannonville, and Henrieville, located high in the drainage, are the highest concentration of private and municipal water rights. Most of the mainstem of the Paria River within the GSENM flows on a perennial basis, with small reaches near the upper and lower extremities of the river within the Monument that are typically dry. The flowing reaches are fed by subsurface flows, springs and other groundwater expressions, and by bank storage after high flows.

A four-mile section of Cottonwood Creek is also perennial, but the creek is normally dry about 2 miles above its confluence with the Paria River. The gaining reaches of the Paria River and Cottonwood Creek are followed by losing reaches that are intermittent, flowing only after precipitation events. Little or no water storage occurs upstream of the GSENM. All upstream depletions result from direct diversions.

A BLM assessment[3] noted that the Paria River is depleted but still flowing when it reaches the northern GSENM boundary. However, shortly after entering GSENM the Paria River commonly dries up for about one mile, then reappears and flows continuously until a point about four miles from where it again leaves the Monument boundaries. Outside the irrigation season, lesser upstream depletion results from the municipal uses of the towns of Tropic, Cannonville, and Henrieville. The USGS gage "Paria River near Cannonville", with 20 years of record (1951-55 and 1959-74), is located inside GSENM in the intermittent reach of the river, below the stream emerging from Little Dry Valley but upstream of the river's confluence with Rock Springs Creek, and shows a mean daily flow of 9.08 cubic feet per second (cfs) despite the intermittent character of the stream in this reach.

Water stored in Tropic Reservoir is imported from the Sevier River drainage via the "Tropic Ditch". Upstream use has a more substantial impact on base flows near the northern boundary of the GSENM. Henrieville Creek contributes flow to the Paria River downstream from the irrigated lands. Three miles inside GSENM the Paria River becomes perennial at the confluence with Rock Springs Creek.

Other water-related concerns in the Paria River drainage relates to this stream as a source of sediment and salinity loading to the Colorado River system, largely as a result of the geologic formations through which it passes (claystone and siltstone of the Chinle Formation and Tropic Shale).

US Geological Survey (USGS) Stream Gaging Stations

There are two USGS stream gaging stations located within the Listed Sections: one in Reach-1 at Paria River near Cannonville, Utah; and the second station on Reach-3 at Paria River near Kanab, Utah. The USGS gaging station number, name, and period of data coverage are summarized in Table 1-5. The locations of these gaging stations are shown on Map 7. The Paria River near Kanab gage was restarted January, 2002. Data for the Paria River near Kanab gage was initiated September, 2002, but the data is not yet available.

Table 1-5
USGS Stream Gaging Stations

USGS Gage Station #	USGS Gage Name	Data Coverage
093381500	Paria River near Cannonville, Utah	12/1950 - 09/1955 and 01/2002 - Present
093381800	Paria River near Kanab, Utah	09/2002 - Present

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[3] Chapter 3, Affected Environment. EIS for the Grand Staircase-Escalante National Monument. (BLM 1999).
Note: The 1959-1974 stream gage records are only peak stream flow measurements.

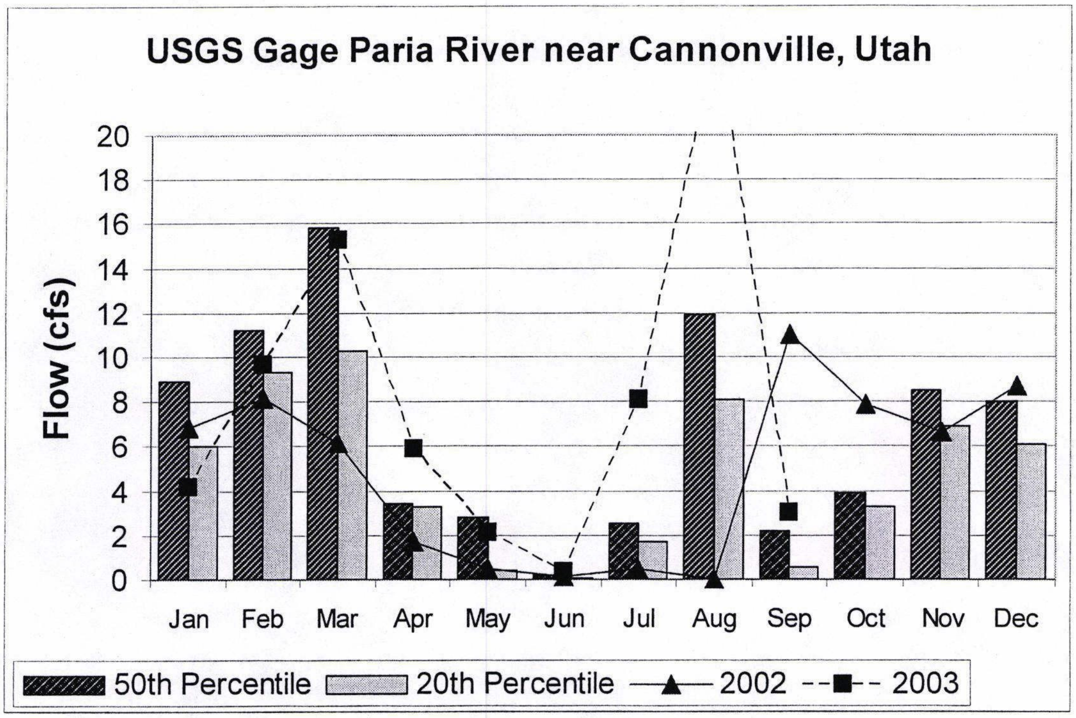

Figure 1-3 Historical Flows Compared to 2002 and 2003 Flows

Average monthly flow for 2002 and 2003, the period of analysis for this report, compared to historical monthly flows is shown in Figure 1-3. The historical record covers only the period from January 1950 to September 1955, which is generally an insufficient period of time to estimate normal flow patterns; however, it is useful in placing the 2002 and 2003 flows into context. Years 2002 and 2003 experienced lower monthly flows than normal (50th percentile) and below normal (20th percentile) [4] flows in the winter and spring in 2002, and above average flows in the fall. Year 2003 appeared to be comparable to the 1950's record with above average flow in September. It should be noted that USGS considers the period 1953-1965 as one of the cyclic drought periods in southeastern Utah.

1.4.6 Groundwater Hydrogeology

Hydrogeology refers to the occurrence and movement of water below the Earth's surface. The source of groundwater and its quality, and whether the Paria River loses or gains water along the Listed Sections, are of particular importance. Surface water and groundwater interactions with saline (marine) rocks and soils can significantly increase TDS concentrations in the Paria River.

Groundwater is present in most of the consolidated rocks within the area. Freethy (1997) suggests that the period of major recharge for these aquifers was prior to 10,000 years ago during the waning stages of the last glacial period. Five regional aquifers occur within the watershed (Figure 1-4). In descending aquifer location, these are the:

(1) Mesaverde aquifer, including Straight Cliffs and Wahweap Formations;
(2) Dakota Formation aquifer;
(3) Morrison Formation aquifer;
(4) Entrada Formation aquifer; and
(5) Glen Canyon aquifer including the Navajo, Kayenta, and Moenave (Wingate) Formations.

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[4] The 50th percentile is considered a "normal" year. The 20th percentile is considered "below normal".

The Glen Canyon aquifer is the thickest and most extensive of the principal aquifers. The rocks of the Glen Canyon aquifer are exposed in the Grand Staircase and in the Escalante Canyons regions of the Monument, but lie in the subsurface beneath the Kaiparowits Plateau to depths approaching 4,500 feet. The volume of water contained within the aquifer is estimated to be greater than 400,000,000 acre-feet (Freethy, 1997). In recharge areas of the Glen Canyon aquifer, or where water table conditions exist (unconfined parts of the aquifer), the water is generally fresh (<1,000 mg/L total dissolved solids (TDS)) and of the type calcium magnesium, bicarbonate. Where the Glen Canyon aquifer is confined, primarily beneath the Kaiparowits Plateau, ground water is generally slightly saline (1,000 to 3,000 mg/L TDS), and is sodium, sulfate type. The lowest TDS concentration in ground water occurs in the Glen Canyon aquifer (191 mg/L). The highest TDS concentration in ground water occurs in the Mesaverde aquifer (5,920 mg/L). The lowest TDS concentration in streams is in Boulder Creek (172 mg/L). The highest TDS concentration in streams is in the Paria River (3,980 mg/L). The potentiometric surface within the Glen Canyon aquifer in areas near Lake Powel has risen as much as 357 feet due to the inundation by the lake (Blanchard, 1986).

Public Water Reserves were established by Executive Order of April 17, 1926. They were established to reserve for general public use all important springs and water holes on public lands, and to prevent monopolization of the public domain through control of these water sources. There are 248 public water reserves within the GSENM.

Water resources research in the Monument has been limited to studies of historic and prehistoric flooding events (Webb, 1985) and assessment of groundwater aquifers in anticipation of coal development in the Kaiparowits Plateau (Blanchard, 1986). Several stream courses within the GSENM are perennial, but most are ephemeral, experiencing periodic flooding during storm runoff. Springs issue where canyons cut into the saturated zones of aquifers.

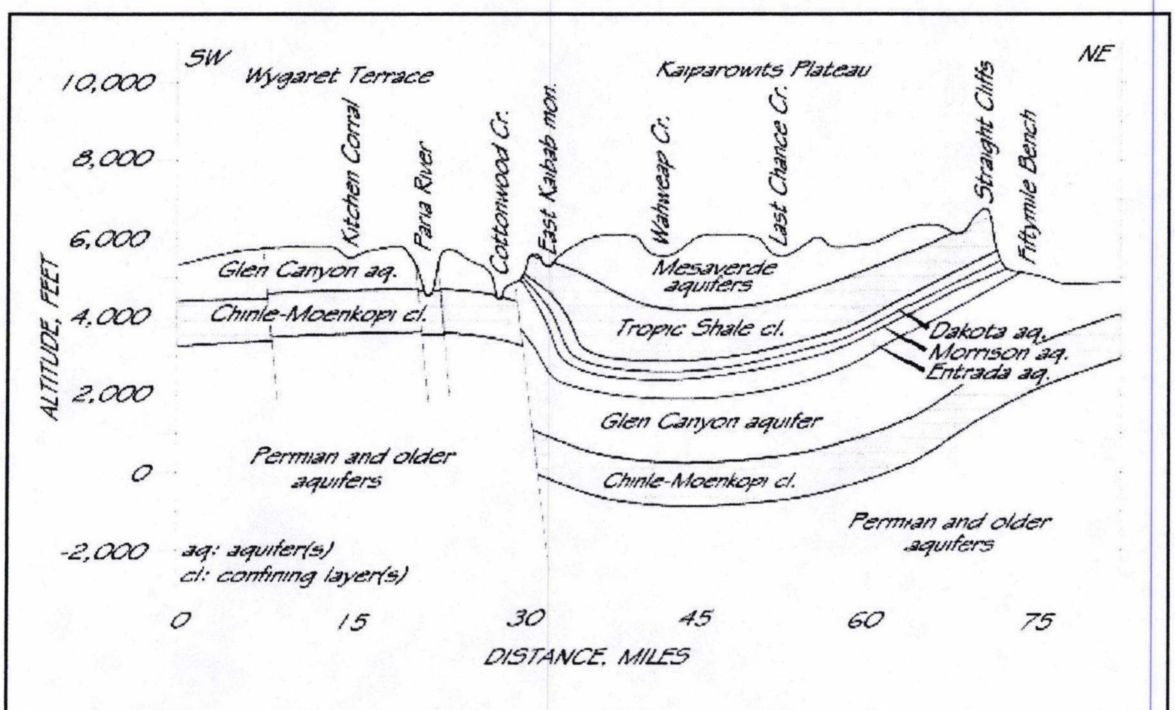

Figure 1-4 Regional Aquifers in the Paria River Area (BLM 1999)

2.0 WATER QUALITY CRITERIA

2.1 Beneficial Uses and 303(d) Listed Section

The Paria River and its tributaries are identified as having the following beneficial uses: Class 2-B secondary contact recreation, Class 3C- non-game fishery, and Class 4 - agriculture (Standards of Quality for Waters of the State § R317-2, UAC).

Two reaches of the Paria River are listed on Utah's 2002 303(d) list (DWQ, 2002) for waters requiring the development of a TMDL due to the exceedence of TDS criteria for beneficial use Class-4 (agriculture), including irrigation of crops and stock watering. The Listed Sections are described in Utah's Year 2000 303(d) list and summarized in Table 2-1. The 303(d) Listed Sections, watershed boundaries, and other descriptive features are illustrated on Map 1.

Table 2-1
303(d) Listed Segments in the Paria River Watersheds

Waterbody ID	Waterbody Name	Waterbody Description	HUC Unit	Beneficial Use Class	Perennial Stream Miles	Cause
UT14070007-001	Paria River-1 "Reach -1"	Paria River from confluence of Rock Springs Creek to headwaters	14070007	4	17.01	TDS
UT14070007-005	Paria River-3 "Reach-3"	Paria River from Arizona-Utah Border to confluence of Cottonwood Wash	14070007	4	12.09	TDS

2.2 Water Quality Standards

Utah's Standards of Quality for Waters of the State (§R317-2, UAC) establishes the numeric criterion of 1,200 mg/L TDS for protection of beneficial use Class 4 (agricultural) waters. In addition, the Utah Standards of Quality for Waters of the State also provide numeric criteria for pH, boron, and metals as summarized in Table 2-2.

Table 2-2
Utah Water Quality Criteria for TDS and Related Parameters

Parameter	Criterion, Maximum Concentration
Target Parameters*	
Total Dissolved Solids	1,200 mg/L
Secondary Parameters**	
pH	6.5 - 9.0 pH units
Boron	0.75 mg/L
Arsenic	0.10 mg/L
Cadmium	0.01 mg/L
Chromium	0.10 mg/L
Copper	0.20 mg/L
Lead	0.10 mg/L
Selenium	0.05 mg/L

Utah's Water Quality Standards clarify that TDS limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water.

Additional criteria are used to determine the degree of beneficial use support. Utah's 2002 303d list (DWQ, 2002) provides guidance on how to apply the numeric water quality criteria for determining the degree of beneficial use support. These criteria are used to evaluate the listing and delisting of a waterbody. The 303(d) criterion for assessing the degree of support for beneficial use Class 4 is provided in Table 2-3.

Table 2-3
303(d) Criteria for Assessing Agricultural Beneficial Use Support - Class 4

Degree of Use Support	Conventional Parameter (Total Dissolved Solids - 1,200 mg/L)	Toxic Parameters
Full Support	Criterion exceeded in less than two samples or in less than 10% of the samples if there were two or more exceedances.	For any one pollutant, no more than one violation of criterion.
Partial Support	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.

Based on the above criteria, Utah's 2002 303(d) list identified two sections of the Paria River as non-supporting based on exceedence of the TDS concentrations.

Relation of Total Dissolved Solids to Beneficial Uses

TDS is listed as a criterion for protection of agricultural uses because of the negative effect of high salinity on crop production. The major components of salinity are the cations: calcium, magnesium, and sodium; and the anions: chlorine, sulfate, and bicarbonate. Potassium and nitrate ions are minor components of salinity. Salinity reduces crop growth by reducing the ability of plant roots to absorb water (known as salinity hazard), and is evaluated by the relationship of salt tolerance to crops. Unlike salinity hazard, excessive sodium does not impair the uptake of water by plants, but does impair the infiltration of water into the soil. The growth of plants is, thus, affected by the availability of water. The reduction in infiltration of water can usually be attributed to surface crusting, the dispersion and migration of clay into the soil pores, and the swelling of expandable clays. The hazard from sodium is evaluated using the Sodium Absorption Ratio (SAR), a ratio of sodium to calcium and magnesium in the irrigation water; in relation to the irrigation water TDS (Tanji, 1990).

Boron is the primary toxic element of concern in irrigation waters. Boron is an essential trace element at low concentrations, but becomes toxic to crops at higher concentrations. Other trace elements, as listed in Table 2-2 above, are potentially toxic to plants and animals. High pH ($pH > 9.0$) directly and adversely affects infiltration as well as limiting calcium concentrations and contributing to high SAR.

3.0 IMPAIRMENT ANALYSIS

3.1 Geographic Extent of the Water Quality Management Plan

The Water Quality Management Plan (WQMP) addresses only the 303(d) listed sections of the Paria River: Reach-1, Paria River from confluence of Rock Springs Creek to headwaters, and Reach-3, Paria River from Arizona-Utah Border to confluence of Cottonwood Wash. These river sections are defined in the 303(d) listing (Table 2-1) and are shown on Figure 1-1 and Map 1.

3.2 Water Quality Data in STORET

The most complete water quality monitoring station summaries and water quality observation data for the Paria River exist in the STORET database. STORET, short for STOrage and RETrieval, is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. Each data entry in the STORET database is accompanied by information on where the sample was taken (latitude, longitude, state, county, Hydrologic Unit Code, and a brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring.

The STORET database for the Paria River contains 21 stations. These stations are listed in Appendix 3. Of these 21 stations, the Arizona Department of Environmental Quality, Water Quality Division, provided data for seven stations. Of these seven stations, three are on the Utah border and within the Paria River Reach-3 Listed Section. DWQ and BLM collected data for the other 14 stations.

There are 330 TDS measurements in the STORET database for the Paria River. The Arizona stations have specific conductance (SC) data, but no TDS data for the Paria River. There are 374 SC measurements in the STORET database and 244 of these SC measurements have associated TDS measurements for the Paria River. Therefore, TDS values were generated from the SC data using a ratio between the measured TDS and SC data pairs. The conversion for TDS is 0.687 times the SC (umhos/cm). It should be noted that a regression analysis was calculated, but was a poor predictor at lower values. For the Arizona data set, 76 TDS values were generated using the conversion factor. For the remaining STORET data, 130 TDS values were generated.

The calculated TDS values were combined with the measured TDS values into one data series (marking the calculated values in bold text and using one decimal point to maintain the distinction between calculated and measured values) as shown in Appendix 3. A summary of available TDS data for the Paria River, including the TDS values generated from SC data, are summarized in Table 3-1.

As shown in Table 3-1, seven of the 17 stations have more than 10% exceedence of the TDS criteria for the period of record. It should be noted that two of the STORET stations that exceed the TDS criteria (599434 and 599435) are located on tributaries that flow to a segment of the Paria River that are outside the Listed Sections.

Statistical Assessment of Data

A statistical summary of data for the 17 STORET stations listed in Table 3-1 is provided in Appendix 3. Although not all of these stations would likely be used in the TMDL calculations, they may shed some light on the distribution of TDS in the watershed and therefore aid in identifying source contributions. For each station the data is tabulated and followed by descriptive statistics. The statistics list the number, mean, median, standard deviation, minimum, maximum, number greater than the criteria, and percent exceedence.

Table 3-1
Summary of STORET Stations and Available TDS Data

STORET	Description	Mean TDS	Max TDS	% TDS Exceed-ence	No. of TDS Values	Begin Date	End Date	No. of TDS Values 1993-2002	Paria River Reach -
495191	Tropic Ditch at U12 crossing	229	267	0	11	09/17/97	09/25/02	20	1
495192	Paria River 3 Miles NNE of Tropic	436	526	0	6	04/30/98	06/09/98	6	1
495187	Paria River at U12 crossing	923	1400	18	30	01/27/81	12/31/02	47	1
495190	Henrieville Wash at U-12 crossing 8 Miles East of Cannonville	387	530	0	27	08/20/98	12/30/02	38	1
495189	Henrieville Wash 3 Miles East of Cannonville	914	2048	14	49	09/17/97	12/31/02	49	1
495186	Paria River at Kodachrome Basin Road crossing	1651	4030	50	16	10/04/00	12/31/02	18	1
599434	Sheep Creek at Skutumpah Road crossing	1553	2086	96	23	08/27/98	12/31/02	27	2
599435	Willis Creek at Skutumpah Road crossing	1210	1642	80	10	09/21/98	11/27/02	15	2
599455	Paria River at Old Town Site	957	1640	7	54	08/13/98	08/12/02	85	2
599471	Cottonwood Creek Above Confluence with Hackberry Canyon	657	1264	4	26	08/13/98	04/24/01	38	3
599454	Hackberry Canyon Above Confluence with Cottonwood Creek	287	481	0	43	10/06/98	04/24/01	48	3
495185	Paria River At US89 crossing	1174	2564	37	132	02/04/76	07/17/02	78	3
599465	Deer Spring Wash Below Deer Spring Ranch	822	1086	0	31	09/25/98	08/12/02	41	3
599461	Nephi Wash Spring Development	1062	1980	25	8	08/08/98	08/16/02	12	3
101078	Paria River above Buckskin Gulch	840	1156	0	10	10/01/98	07/28/00	10	3
101079	Buckskin Gulch	244	400	0	10	10/01/98	07/28/00	10	3
101077	Paria River below Buckskin Gulch	659	1116	0	9	03/03/99	07/28/00	9	3

Stations highlight in grey are located on tributaries to or on Paria River Reach-2, that is not on the 303(d) list.

Reliability and Applicability of the TDS Data Set for the TMDL

The Paria River Listed Sections are comprised of two separate and disconnected stream reaches: Paria River Reach-1 the upper watershed, and Paria River Reach-3 the lower watershed. The middle reach (Paria River Reach-2), approximately 20 river miles in length, is not a 303(d) listed section. The Listed Sections of the Paria River are discussed in detail below.

<u>Paria River Reach-1: From the Confluence of Rock Springs Creek to the Headwaters:</u>

Paria River Reach-1 is located near the communities of Tropic, Cannonville, and Henrieville in Garfield County. Tropic Ditch and Henrieville Wash are tributaries monitored within this Listed Section. TDS increases in concentration from the STORET stations higher in the watershed to the Paria River at Kodachrome Basin Road (station 495186). The Paria River at this station exceeds TDS criteria 50% of the time (see Table 3-1) indicating a source of salinity within the reach.

Willis Creek enters below the Paria River Reach-1 Listed Section, near river mile 36 (see Map 7) and is therefore not a source for this Listed Section. Also, as an ephemeral stream, the confluence of Willis Creek and Paria River Reach-2 is located more than 20 miles above the upper boundary of Paria River Reach-3, and is therefore not expected to be an important TDS contributor to the lower Listed Section. Willis Creek, and its tributary Sheep Creek, however, exhibit high TDS concentrations (see Table 3-1) indicating a salinity source on the west side of the watershed. These stations may be helpful in associating surface water and groundwater TDS with saline rock types and soils.

<u>Paria River Reach-3: From the Arizona-Utah Border to Confluence of Cottonwood Wash</u>

Two STORET stations can be used to measure TDS entering the lower Paria River Reach-3 Listed Section. Paria River at Old Town Site (599455) and Cottonwood Creek above confluence with Hackberry Canyon (599471) exhibit fairly low TDS concentrations. The station in Hackberry Canyon (599454), a tributary to Cottonwood Creek, has particularly low TDS concentrations, indicating the variable pattern of TDS sources in this region. Ten miles downstream from the Cottonwood Creek confluence with the Paria River the TDS concentrations increase again where Highway 89 crosses the Paria River (495185) and TDS exceeds the criteria 37% of the time. This station on the Paria River at US89 (495185) represents the practical boundary compliance point for TDS on the Paria River Reach-3 Listed Section.

The remaining stations monitored in the watershed do not appear to contribute TDS to the Listed Sections. Two stations located on tributaries to the Paria River, Deer Spring (599465) and Nephi Wash Spring (599461), are monitored on the west side of the watershed and are over 30 river miles from the confluence with the Paria River; and the Paria River station below their confluence (101078) has no TDS criteria exceedences. In addition, these small tributaries have very low flows, generally less than 0.5 cfs.

The lower three stations at the Utah-Arizona border illustrate again the extreme TDS variability along the Paria River. The mean TDS concentration at the Utah border stations (101078, 101079 and 101077) are 840 mg/L, 244 mg/L and 659 mg/L, respectively and well below the Utah TDS criteria.

3.3 SOURCE ASSESSMENT

In evaluating the water quality data and land use patterns it is apparent that the predominant source of TDS loading into the Paria River is from naturally occurring saline geologic formations prevalent throughout the watershed, particularly Tropic shale. Therefore we are proposing the development of site specific criteria that reflects the natural background concentrations of TDS in the Paria River.

4.0 TMDL/SITE-SPECIFIC CRITERIA

Development of site-specific criteria is recommended for the Listed Sections of the Paria River since the information available indicates that the observed spike in TDS at the lower end of the Paria River Reach-1 is due to inputs from a shallow alluvial aquifer. Paria River Reach-3 is located in a sparsely populated and relatively undeveloped landscape with no known anthropogenic sources of TDS.

Guidance for developing site-specific criteria is summarized in two memorandums issued by EPA. A Region 8 Memorandum (Moon 1997) addressed procedures for *Use Attainability Analysis and Ambient Based Criteria*, and a memorandum from EPA Office of Science and Technology (Davies 1997) addressed the subject: *Establishing Site-Specific Aquatic Life Criteria Equal to Natural Background*. These two memoranda were consulted for guidance and direction in developing site-specific criteria for the Paria River. The applicable points from these memoranda for developing site-specific criteria are:

1. Site-specific criteria are allowed by regulation subject to EPA review and approval;
2. Site-specific numeric aquatic life criteria may be set equal to natural background where natural background is defined as: background concentrations due only to non-anthropogenic sources; and
3. Previous guidance provided the direction to use the 85th percentile of the available representative data for natural ambient water quality conditions.

The Utah Standards of Quality for Waters of the State provide for adjustment of site-specific standards to background where the adjustment does not impair designated beneficial uses.

> "Total dissolved solids (TDS) limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water. The total dissolved solids (TDS) standards shall be at background where it can be shown that natural or un-alterable conditions prevent its attainment. In such cases rulemaking will be undertaken to modify the standard accordingly."[5]

Paria River Reach-1

Two stations within Paria River Reach-1 were evaluated for setting site-specific criteria. The Paria River at Highway U12 Crossing station (495187) measures TDS in the Paria River upstream of Cannonville. The second station, Paria River at Kodachrome Basin Road crossing (495186) is located at the lower end of the reach and below Henrieville Wash.

The data distribution for these two stations is illustrated using box and whisker plots (Figure 4-1). Box and whisker plots are commonly used for comparing distributions because the center, spread, and overall range of data are graphically apparent. In a box and whisker plot the ends of the box are the upper and lower quartiles, so the box spans the interquartile range, the median is marked by a solid light line inside the box, the mean is marked as a solid heavy line, and the whiskers are the two lines outside the box that extend to the highest and lowest observations.

The TDS data used to construct the box and whisker plots for each station were collected between August 2000 and December 2002. The box plot for the upper station (Paria River at Highway U12 Crossing - 495187) shows that the majority of data are below the statewide criteria

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[5] Footnote to Table 2.1.4.1, Numeric Criteria for Domestic, Recreation, and Agricultural Uses, R317-2, Standards of Quality for Waters of the State, UAC R-317-1, March 01, 2004, Utah Department of Administrative Rules.

of 1,200 mg/L; however, at the downstream station (Paria River at Kodachrome Basin Road crossing - 495186) the TDS concentration increases, with 50% of the TDS samples exceeding the 1,200 mg/L criteria.

There are irrigation water withdrawals within the Paria River Reach-1; however, there is not sufficient agricultural use to explain the spike of TDS at the lower end of the reach. There is qualitative information on the high TDS associated with saline aquifers in the area, which appears to be the most logical explanation for the increase in TDS concentrations observed.

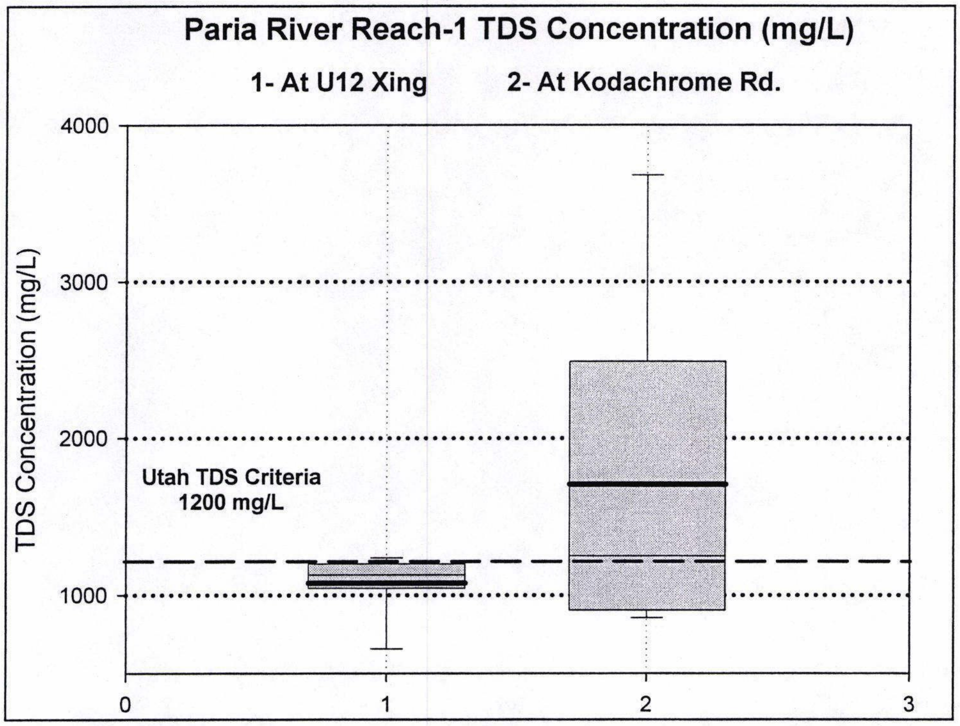

Figure 4-1 Concentration of TDS at Two Stations on Paria River Reach-1 Compared to the Utah Standard for Irrigation of 1,200 mg/L

Statistics for Paria River at Kodachrome Basin crossing (495186), the station with the highest TDS concentration, are summarized in Table 4-1. We recommend the site-specific criteria be 2,500 mg/L. This will ensure that the site-specific standard is set at an appropriate level that reflects the natural background concentrations of TDS.

Table 4-1
Statistics and Site-Specific Criteria for Paria River Reach-1
Based on Station 495186 - Paria River at Kodachrome Basin Road Crossing

Statistic	TDS Concentration (mg/L)
Count	15
Mean	1,492
Median	1,094
Min	822
Max	3,444
85th Percentile	2,461
State Criteria - Irrigation	1,200
State Criteria - Stockwater	2,000
Recommended Site-Specific Criteria	2,500

Notes: Data period, October, 2000 to December 2002.

Paria River Reach-3

Two stations within Paria River Reach-3 were evaluated for setting site-specific criteria. Paria River at Old Town Site station (599455), measures TDS in the Paria River just above the Listed Section, at river mile 21.5. Cottonwood Creek flows into the river approximately two miles below this site. Cottonwood Creek has a low TDS concentration with a mean of 657 mg/L, less than in the Paria River at that point. The second river station, Paria River at US89 Crossing (495185), located at river mile 9.5 has the highest TDS concentration in the reach. As indicated earlier, the TDS concentration decreases at the State line as measured by the Arizona state monitoring stations (101078 and 101077). (Note: River Miles were measured from the Utah-Arizona state line to provide a point of reference.)

The data distribution for these two stations are also illustrated in box and whisker plots (Figure 4-2). The data used to construct these box plots included the entire data record at the stations including the TDS values generated from correlation with specific conductance. The majority of data at the upper station, Old Town Site, is below the statewide criteria of 1,200 mg/L. Downstream 12 river miles the TDS concentration increases and 37% of the TDS samples exceeded the 1,200 mg/L criteria.

There are no current (or legacy) human activities in this primitive and mostly road-less reach that would explain this increase in TDS. There is evidence of some illicit off road vehicle use through the river channel in this area but we feel through continued public education and enforcement it can be addressed before it becomes a significant problem in terms of TDS loading The source of TDS is considered a natural condition related to input to surface water from a higher salinity aquifer as discussed in Section 1.4.6.

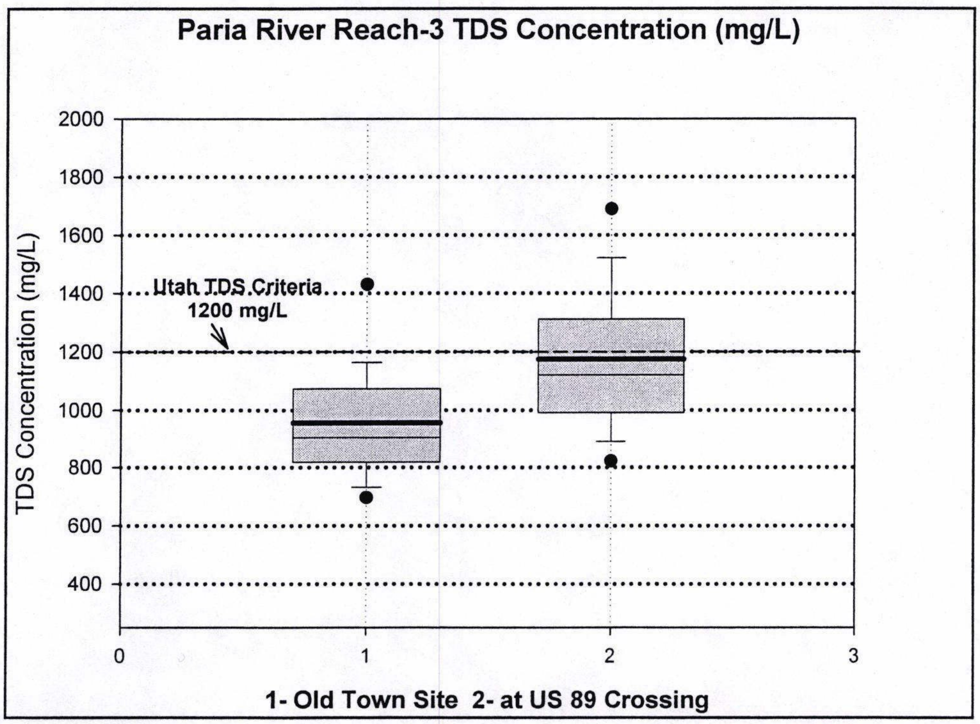

Figure 4-2 Concentration of TDS at Two Stations on Paria River Reach-3 Compared to the Utah Standard for Irrigation of 1,200 mg/L

Statistics for Paria River at US89 Crossing (495185), the station with the highest TDS concentration, are summarized in Table 4-2. We recommend the site-specific criteria be 1,500 mg/L. This will ensure that the site-specific standard is set at an appropriate level that reflects the natural background concentrations of TDS.

Table 4-2
Statistics and Site-Specific Criteria for Paria River Reach-3
Based on Station 495185 - Paria River at US89 Crossing

Statistic	TDS Concentration (mg/L)
Count	132
Mean	1,174
Median	1,121
Min	325
Max	2,564
85th Percentile	1,467
State Criteria	
Irrigation	1,200
Stockwater	2,000
Recommended Site-Specific Criteria	**1,500**

Notes: Data period, February 1976 to July 2002.

5.0 PROJECT IMPLEMENTATION PLANS AND BMPs

The Canyonlands Soil Conservation District (CSCD) is coordinating with local stakeholders and agencies to develop Project Implementation Plans (PIPs) and a coordinated approach to improve water quality within the watershed. The CSCD will establish criteria and select cooperators for implementation of projects. These projects will be designed to minimize land use impacts on water quality in the Paria River and its tributaries.

The overall project goals are to reduce TDS loading in the Paria River watershed by improving irrigation methods and conveyances, stabilizing stream channels and protecting stream banks from erosion. Surface runoff and percolation to the upper aquifers can be reduced or eliminated through gated pipe, sprinkler or drip irrigation methods and/or by delivering irrigation water through lined canals or pipe. Stream bank protection can be facilitated through ditch and canal lining and establishing herbaceous cover along riparian corridors. Much of this work is currently underway in other parts of the State under the auspices of the Salinity Control Program administered by the Department of Interior (Bureau of Reclamation) and the Department of Agriculture (Natural Resources Conservation Service).

The project goals are also intended to inform and educate the community concerning nonpoint source pollution and the importance of managing natural resources within the watershed. To reach these goals, objectives and tasks are defined and a narrative description is provided for each objective and task. At least one task is proposed to accomplish each objective. These tasks may include specific activities such as milestones, outputs and identifying responsible parties.

PIPs designed to reduce TDS concentrations in the Paria River incorporate Best Management Practices (BMPs) to address salt and sediment loading and improve the efficiency of irrigation methods and conveyances, thereby minimizing surface runoff and percolation to the underlying alluvial aquifer. By implementing appropriate BMPs, we hope to encourage adoption and implementation of similar activities to address water quality problems throughout the entire watershed.

PIPs will be implemented throughout the next several years and will include water quality monitoring to evaluate their effectiveness. An evaluation and monitoring plan will also be implemented to document progress in achieving improved water quality conditions, to review effectiveness of BMPs, 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.

Successful projects combine a voluntary approach with cost-share assistance to identify key system components that improve irrigation water management and stream channel stabilization, while allowing management flexibility. A coordination plan is presented to identify the lead project sponsor, describe local support for the projects, describe how the project will coordinate with pertinent 319 and non-319 funded programs, and describe similar activities that are being undertaken elsewhere in the watershed.

No long-term funding is planned for operation or maintenance of these projects. Individual landowners are responsible for operation and maintenance of BMPs throughout the projected life of the practices. Projects will be inspected by the project lead sponsor. The operation and maintenance of the designed systems will be thoroughly explained to the landowner and they will sign a document indicating their understanding and cooperation. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding.

5.1 Statement of Need

The upper segment (Reach 1) of the Paria River is currently not meeting the designated beneficial uses for beneficial use 4 (agriculture) due to excessive TDS concentrations, which are attributed to natural and human sources. The middle reach of the Paria River is not listed as a water quality-limited segment. TDS concentrations in the lower segment (Reach 3) are attributed primarily to natural sources with no known human sources of salinity. This Project Implementation Plan addresses the primary human sources of dissolved solids identified within the TMDL analysis.

Water from the Paria River is used for crop irrigation and stock watering. The small town economies of Tropic, Cannonville and Henrieville in the northern end of the basin rely on agriculture, which is dependent on irrigation from surface waters. Paria River flows are diverted to irrigation canals at numerous points along the river. The area is underlain by saline soils and geologic formations and, as irrigation water is applied, the return flows convey dissolved solids back into the river. Groundwater also contributes to an increase in TDS in some gaining segments of the Paria River.

The intent of the proposed program is to reduce nonpoint source pollution in the Paria River through application of improved irrigation methods and BMPs. By demonstrating these practices to area stakeholders, we hope to encourage them to adopt and implement similar activities to address their own water quality problems. With the support and direction of the CSCD, priority will be given to implementation projects that feature efficient irrigation methods and conveyances that minimize surface runoff and percolation into the underlying alluvial aquifer. Tours of these project sites, news articles and fact sheets will help encourage adoption of these practices elsewhere in the watershed.

5.1.1 Project Water Quality Priority

As required by 26-11-6 of the Utah Code Annotated 1953, waters of the State of Utah are grouped into classes so as to protect State waters against controllable pollution. The designated beneficial uses for the Paria River are secondary contact recreation (Class 2-C), non-game fishery (Class 3C), and agriculture (Class 4). The upper Paria River from its headwaters to the confluence of Rock Springs Creek and the Lower Paria River from its confluence with Cottonwood Creek to the Utah-Arizona border have been identified as impaired due to exceedence of Utah's TDS criteria for protection of agricultural uses (Class 4 waters).

The Paria River is divided into upper, middle, and lower segments. The upper Paria River (Reach-1) has its headwaters in Bryce Canyon National Park and Dixie National Forest then flows south past the small towns of Tropic, Cannonville and Henrieville to the confluence with Rock Springs Creek in the GSENM. The middle Paria River (Reach-2) runs from Rock Springs Creek, south to its confluence with Cottonwood Creek and is entirely within the boundaries of the GSENM. The lower Paria River (Reach-3) flows from Cottonwood Creek south to the Utah-Arizona border. The middle reach of the Paria River has not been designated a 303(d) impaired water for TDS and is not considered by this water quality management plan.

5.1.2 Project Goals

The overall project goals are to reduce nonpoint source TDS loading to the upper and lower Paria River watershed by decreasing the amount of salts entering the watershed from irrigated lands and stream channel erosion, in addition to informing and educating the community concerning nonpoint source pollution and the importance of managing natural resources within the watershed. TDS loading will be addressed through a combination of efficient irrigation and irrigation water management methods, and stream bank protection and channel stabilization techniques. Public education will be addressed by offering tours of demonstration sites and publishing news articles and fact sheets to encourage adoption of these practices elsewhere in the watershed. Specific project goals are as follows:

Goal #1: Reduce TDS and sediment loading to impaired reaches of the Paria River and its tributaries.

Goal #2: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality within the watershed.

Goal #3: Provide administrative services to project sponsors documenting matching contributions, tracking individual project progress, coordinating team efforts, and generating reports and data in a timely manner.

5.1.3 Objectives and Tasks

Goal #1: Reduce TDS and sediment loading to impaired reaches of the Paria River and its tributaries.

Objective 1: Improve irrigation techniques and irrigation water management practices.

Task 1: Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the CSCD cooperatively with the local work group and will be conducted in the early spring of the first contract year.

Task 2: Develop irrigation water management plan using BMPs (irrigation water management, improved irrigation systems and pipelines).

Output - Irrigation water management plans. This will be conducted in spring of the first and third contract years. Design work will be performed by NRCS and CSCD staff.

Task 3: Implement projects.

Output - Implementation will occur between fall of the first and third contract year through spring of the second and fourth contract year. Landowners will implement projects. NRCS and CSCD staff will advise, review and certify project implementation.

Task 4: Monitor according to methods described in Section 5.3.

Output - Water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during spring runoff and once during summer base flows; after project completion -once during spring runoff and once during summer base flow. These data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, DWR, DEQ, USU extension, etc.

Objective 2: Improve stability of the stream channel and minimize stream bank erosion in impaired reaches of the Paria River and its tributaries.

Task 5: Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the CSCD cooperatively with the local work group and will be conducted in the early spring of the first contract year.

Task 6: Develop stream bank protection plans using BMPs (ditch and canal lining, stream channel stabilization and stream bank protection).

Output - Stream bank protection plans. This will be conducted in spring of the first and third contract years. Design work will be performed by NRCS and CSCD staff.

Task 7: Implement projects.

Output - Implementation will occur between fall of the first and third contract years through spring of the second and fourth contract years. Projects will be implemented by landowners and NRCS and CSCD staff will advise, review and certify project implementation.

Task 8: Monitor according to methods described in Section 5.3.

Output - Water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during spring runoff and once during summer base flows; after project completion -once during spring runoff and once during summer base flow. These data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, DWR, DEQ, USU extension, etc.

Objective 3: Enhance the riparian corridor to reduce sediment runoff to the river and its tributaries.

Task 9: Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be led by the CSCD cooperatively with the local work group and will be conducted in the early spring of the first contract year.

Task 10: Develop and riparian improvement plan using BMPs (tree/shrub establishment, establish herbaceous cover).

Output - Riparian improvement plans. This will be conducted in spring of the first and third contract year. Design work will be performed by NRCS and CSCD staff.

Task 11: Implement projects.

Output - Implementation will occur between fall of the first and third contract year through spring of the second and fourth contract years. Projects will be implemented by landowners and NRCS and Canyonlands Soil Conservation District staff will advise, review and certify project implementation.

Task 12: Monitor according to methods described in Section 5.3.

Output - water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during spring runoff and once during summer base flows; after project completion -once during spring runoff and once during summer base flow. This data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, DWR, DEQ, USU extension, etc.

Goal #2: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality within the watershed.

Objective 1: Three tours will be conducted focusing on: 1) irrigation techniques, designs and proper management practices; 2) stable stream channels and stream bank erosion protection; and 3) and enhanced riparian corridors.

Task 13: Conduct improved irrigation technique and management tour.

Output - The tour will be conducted either near project completion or shortly after. USU Extension, UACD, Canyonlands Soil Conservation District staff and landowners will jointly plan this tour.

Task 14: Conduct riparian area/stream bank tour.

Output - The tour will be conducted either near project completion or shortly after. USU Extension, UACD, Canyonlands Soil Conservation District staff and the landowner will jointly plan this tour.

Objective 2: Share general and technical information with producers and area stakeholders.

Task 15: Develop Fact Sheets and Newspaper Articles

Output - Fact Sheet series, Newspaper articles. These products will be completed during implementation of the project and will be disseminated during tours after project completion and other times of the year. USU Extension, UACD, and NRCS will collaborate on the content of these products. USU Extension and UACD will jointly produce and disseminate them.

Goal #3: Provide administrative services to project sponsors documenting matching contributions, tracking individual project progress, coordinating team efforts, and generating reports and data in a timely manner.

Objective 1: Provide administrative services.

Task 16: Track Match and Prepare Reports

Output - Documented matching fund records and prepare Semiannual, Annual and Final reports. UACD staff will coordinate this effort. Completed semiannually, at the end of the first contract year and again at the completion of the project. UACD staff will prepare these products.

The following BMPs are considered for the Paria River Water Quality Management Plan and may be used along with the information and education efforts to improve water quality in the watershed. Numeric codes following each BMP indicate NRCS standards and specification numbers taken from the NRCS Field Office Technical Guide.

1. Irrigation Water Management (449)
2. Irrigation System (442, 443, 444)
3. Pipeline (430)
4. Ditch and Canal Lining (428)
5. Stream Channel Stabilization (584)
6. Stream bank Protection (580)
7. Tree/Shrub Establishment (612)
8. Riparian Herbaceous Cover (390)

All projects will include BMP's and will be planned to the level of a total resource management system in accordance with NRCS standards and specifications.

The following procedures will be used to achieve Project Goals:

1. Isolate water quality problem sources.
2. Select and implement projects for watershed nonpoint source problems.
3. Promote fair and cost effective nonpoint source pollution control.
4. Monitor progress and evaluate economic benefits of implementing water quality improvements.
5. Create a public awareness of water quality concerns and educate the public on how they can protect water quality for themselves and the community. Promote community involvement in project implementation activities by use of volunteer groups.

5.1.4 Permits

All appropriate permits will be secured as needed. Project sponsors will ensure compliance with all local, state, and federal regulations pertaining to project activities such as not disturbing sensitive habitats, not filling or degrading wetlands.

5.1.5 Lead Sponsor

The Canyonlands Soil Conservation District is the lead project sponsor. The CSCD is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint source water pollution. Additionally the CSCD 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 CSCD and individual cooperators to accomplish this work.

5.1.6 Assurance of Project Operation and Maintenance

No long-term funding is planned for operation or maintenance of these projects. Individual landowners are responsible for operation and maintenance of BMPs throughout the projected life of the practices. Projects will be inspected by the project lead sponsor. The operation and maintenance of the designed systems will be thoroughly explained to the landowner and they will sign a document indicating their comprehension. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding.

5.2 Coordination Plan

5.2.1 Lead Project Sponsor

The CSCD 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 CSCD will be responsible for writing the final project report pursuant to EPA and State requirements.

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

5.2.2 Local Support

The CSCD is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the Paria River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The CSCD will establish criteria and select cooperators for implementation of projects. This project will be used to show landowners and cooperators BMPs for minimizing land use impacts on water quality in the Paria River and its tributaries.

5.2.3 Coordination and Linkages

The CSCD anticipates 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

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

5.2.4 Similar Activities

A stream bank stabilization demonstration project on the Paria River near Cannonville was funded with 319 funds in 2001. The project entailed sloping back the vertical stream bank, constructing six rock barbs and planting cottonwood poles. In addition, a canal-lining project for the Tropic Ditch has been proposed and is likely to receive funding in the near future.

5.3 Evaluation and Monitoring Plan

5.3.1 Sampling and Analysis Plan Goals

Monitoring plan goals are to track BMP implementation and effectiveness, and evaluate progress in achieving improved water quality conditions as these nonpoint source controls are implemented. The project lead sponsor has a strong commitment to demonstration of success of these pollution prevention and remediation strategies, but a limited monitoring budget, and therefore the monitoring effort needs to be shared with DWQ and other agency cooperators.

The monitoring goal is divided into two primary objectives:

1) Implementation and effectiveness monitoring to evaluate project BMPs, and
2) Trend monitoring to evaluate success in meeting water quality standards and goals.

The lead sponsor, the CSCD, is the lead entity for carrying out the implementation and effectiveness monitoring. The DWQ is the lead entity for completing trend monitoring.

Implementation monitoring in comparison to effectiveness monitoring focuses on documenting the number and location of practices or implementation projects applied to meet water quality goals. This requires developing an accounting system of practices, or using currently established reporting procedures familiar to the lead sponsor, to track project implementation.

Effectiveness monitoring evaluates whether BMPs were successful at meeting their intended purpose, such as reducing water use, reducing infiltration or reducing bank erosion. Effectiveness monitoring does not require water quality sampling to be effective. Simple methods, as described below, can be used to evaluate BMP effectiveness. Implementation and effectiveness monitoring can be carried out by CSCD staff, volunteers, or associated personnel in the agricultural community.

Trend monitoring involves monitoring change in TDS and other parameters, such as discharge, over time. Detecting trends requires statistical design, commitment to long-term monitoring over time and high sample frequency. Trend monitoring needs to be carried out by an organization, such as DWQ or USGS, with sufficient infrastructure and funding to assure long-term monitoring.

Work activities associated with these objectives include the following:

1) Develop a project specific monitoring plan to evaluate BMP effectiveness as projects are approved for monitoring. Since each project may be comprised of multiple BMPs or multiple land-owners, only general monitoring approaches for effectiveness monitoring are described in this document.
2) Monitor water quality at long-term monitoring sites to demonstrate sustained and overall improvements in water quality. This task will be completed by the DWQ or a team from cooperating agencies.
3) Maintain a common database of all data collected pertaining to the projects. The database will be developed and maintained by lead agency support staff at the Utah Association of Conservation Districts (UACD).
4) Review data and include data summaries in annual reports. This activity will be performed as sub-tasks within tracking and reporting tasks.

5.3.2 Implementation and Effectiveness Monitoring

Implementation and effectiveness monitoring are the responsibility of the CSCD and cooperating agencies such as NRCS, Utah State University Extension, and Utah Department of Agriculture. The monitoring methods therefore focus on those protocols that can be effectively carried out by natural resource staff with an agricultural background.

The Project Implementation Plan identifies three objectives with associated BMPs to achieve Goal #1, reducing TDS and sediment loading to the impaired water quality segments. The general monitoring approach that is appropriate for these objectives is described below. Objective #2 and #3 have been combined since the BMPs used to meet these objectives will be similar or will directly overlap.

Implementation Monitoring

State and federal agricultural organizations affiliated with the CSCD have a number of standard reporting procedures that are used to track management practices. The Soil Conservation District in consultation with these agencies is best suited to determine the tracking and reporting system that works for them. The kinds of information that the system should be capable of tracking are listed in Table 5-1, referenced in the EPA document "Techniques For Tracking, Evaluating, And Reporting The Implementation Of Nonpoint Source Control Measures" (EPA, 1997).

Table 5-1
Example Variables for Tracking BMP implementation

Management Measure	Useful Variables	Less Useful Variables	Appropriate Sampling Unit
Erosion and Sediment Control	•Area on which reduced tillage or terrace systems are installed •Area of runoff diversion systems or filter strips per acre of cropland •Area of highly erodible cropland converted to permanent cover	•Number of approved farm soil and erosion management plans •Number of grassed waterways, grade stabilization structures, filter strips installed	•Field •Acre
Facility Wastewater and Runoff from Confined Animal Facilities	•Quantity and percentage of total facility wastewater and runoff that is collected by a waste storage or treatment system	•Number of manure storage facilities	•Confined animal facility •Animal unit
Nutrient Management	•Number of farms following and acreage covered by approved nutrient management plans •Percent of farmers keeping records and applying nutrients at rates consistent with management recommendations •Quantity and percent reduction in fertilizer applied •Amount of fertilizer and manure spread between spreader calibrations	•Number of farms with approved nutrient management plans	•Farm •Field •Application
Pesticide Management	•Number of farms with complete records of field surveys and pesticide applications following approved pest management plans •Number of pest field surveys performed on a weekly (or other time frame) basis •Quantity and percent reduction in pesticides use	•Number of farms with approved pesticide management plans	•Field •Farm •Application
Grazing Management	•Number of cattle-hours of access to riparian areas per day •Miles of stream from which grazing animals are excluded	•Miles of fence installed	•Stream mile •Animal unit

Effectiveness Monitoring

Where implementation monitoring is designed to answers the questions, "*Were BMPs applied? Where and How Many?*" Effectiveness monitoring should answer the question. "*Were the BMPs effective at reducing pollutant inputs?* Effectiveness monitoring is best carried out by the local sponsor because of their relationship with local growers and producers. Effectiveness monitoring plans should be built into each implementation grant as a necessary part of doing business. Although simple procedures can be used, effectiveness monitoring still requires resources to design the project specific plan, make field measurements, and develop reports.

The general monitoring approach is described below and organized by the Project Implementation Plan objectives listed under Goal # 1, reduction of TDS and sediment loading to impaired reaches (Section 5.1.3). Below each objective are the BMPs that are assumed to meet the objective, and the general monitoring approach which will accomplish effectiveness monitoring. Objective #2 and #3 are grouped together since the monitoring approach needed to evaluate the objective are similar.

Objective 1: Improve irrigation techniques and irrigation water management practices.

Best Management Practices:

1. Irrigation Water Management (449)
2. Irrigation System (442, 443, 444)
3. Pipeline (430)
4. Ditch and Canal Lining (428)

Monitoring Approach:

These BMPs decrease salinity from irrigation by increasing the efficiency of irrigation systems and thereby reducing the volume of surface runoff or infiltration through the saline soils. Implementation and effectiveness monitoring evaluates the quantity of water conserved and the decrease in infiltration using these conservation practices compared to current methods.

A simple monitoring approach is to calculate the quantity of water expected to be saved or the decrease in infiltration that can be expected by applying the BMP to a specific project site. A more quantitative approach is to measure infiltration rates before and after the practice to determine the decrease in infiltration, however, the cost of monitoring becomes more expensive and impractical for project sponsors.

Objective 2: Improve stability of the stream channel and minimize stream bank erosion in impaired reaches of the Paria River and its tributaries.

Objective 3: Enhance the riparian corridor to reduce sediment runoff to the river and its tributaries.

Best Management Practices:

5. Stream Channel Stabilization (584)
6. Stream bank Protection (580)
7. Tree/Shrub Establishment (612)
8. Riparian Herbaceous Cover (390)

Monitoring Approach:

BMPs for stream channel stabilization reduce inputs of sediment and salts by decreasing erosion within the near bank region of the stream channel. Since streambank erosion is a natural process BMPs should emphasize working with natural stream dynamics and avoid the use of hardened structures such as riprap that was used in the past. BMPs generally focus on revegetating streambanks by direct planting of riparian shrubs and forbs or bioengineering methods such as installing willow bundles.

Implementation and effectiveness monitoring will evaluate the success in establishing a riparian buffer and stabilizing the streambank. Planting success is evaluated by using a transect or grid method to count the number of live stems retained over time compared to that planted. Revegetation success for erosion control is evaluated by measuring soil cover, which can be estimated by measuring percent coverage at a portable plot (such as a 3 foot square) and repeating the measurements over time along an established transect. Bank stabilization can be measured by using bank pins to directly measure bank erosion rates, establishing cross-sections that can be accurately resurveyed over time, or by using photopoints.

Details of methods for these approaches can be found in documents such as:

- Bauer, S. B. and Burton, T. A. 1993. Monitoring protocols to evaluate water quality effects of grazing management of western rangeland streams. US EPA Region 10, Water Division, Surface Water Branch. EPA 910/R-93-017.
- Bedell, T. E., and Buckhouse, J. C. 1994. Monitoring primer for rangeland watersheds. US EPA Region 10, EPA 908-R-94-001.
- Harrelson, C. C., Rawlins, C. L., and Potyondy, J.P. 1994. Stream channel reference sites: an illustrated guide to field technique. USDA Forest Service: General Technical Report RM-245.

5.3.3 Trend Monitoring

Trend monitoring is used to answer two primary questions: 1) Are water quality criteria being met; and 2) are TDS concentrations decreasing over time with implementation of BMPs? Since site-specific criteria were recommended as part of this Water Quality Management Plan, a third objective should also be to determine if these revised criteria are appropriate for these river reaches given more data over different climatic regimes.

Trend monitoring for the purposes of this Water Quality Management Plan can be integrated into DWQ's on-going monitoring program by prioritizing critical stations and parameters. Existing monitoring stations established by the DWQ and USGS can meet trend monitoring objectives if samples are collected with sufficient frequency. Generally DWQ currently collects samples at long-term trend monitoring stations once every six weeks (eight times per year) to evaluate trends in water quality.

<u>Sample Locations</u>

The four DWQ monitoring stations listed in Table 5-2 were selected since they provide an initial assessment of background conditions, they are the most data rich stations, and they are generally accessible, which increases the likelihood that the stations can be sampled with a greater frequency. The USGS flow gaging stations can provide long-term continuous flow records;

however, these stations were reinitiated recently in 2002, and therefore are not sufficient to establish flow statistics. Monitoring of flow at the DWQ stations will be required until such time that a quantitative relationship (if any) can be established between the DWQ stations and the USGS gages. Another option (if not already being done) is to request USGS to add TDS monitoring to the parameters measured at the gaging stations.

Table 5-2
Suggested Monitoring Stations for Trend Monitoring

Station ID	Station Name	Sampling Location Rationale	Parameters of Concern	Agency
Paria River Reach-1				
495187	Paria River at U12 crossing	Located in the middle of Reach-1	TDS & Flow	DWQ
495186	Paria River at Kodachrome Basin Road	Located at the bottom of Reach-1	TDS & Flow	DWQ
093381500	Paria River near Cannonville, Utah	Stream flow gaging station in Reach-1.	Flow	USGS
Paria River Reach-3				
599455	Paria River at the Old Town Site	Located upstream of Reach-3.	TDS & Flow	DWQ
495185	Paria River at US89 crossing	Located lower section of Reach-3.	TDS & Flow	DWQ
093381800	Paria River near Kanab, Utah	Stream flow gaging station in Reach-3.	Flow	USGS

Sample Parameters and Frequency

The minimum list of parameters for trend monitoring at these stations is specific conductance (μmho/cm), total dissolved solids (mg/L), and flow (cfs). (Since USGS already monitors discharge continuously at the gaging stations it would be fairly simple to add continuous specific conductance monitoring, which can be used in lieu of TDS sampling. This would create an excellent long-term data record for evaluating trends over time compared to using grab samples.)

If grab samples are used at DWQ stations, sample frequency needs to be increased to a minimum of monthly frequency. The current target of every six weeks is not sufficient to evaluate trends over time.

5.3.4 Data Management, Storage, and Reporting

The data from this project will be maintained in an accessible common database. In addition, water quality and other relevant data will be transferred electronically to the DWQ database. Data will be compiled, analyzed and used in completing progress reports to the State NPS coordinator, DEQ, EPA and others. All water quality monitoring data will be transferred electronically to the DWQ who regularly enter data into the STORET system. These data will be available to all interested parties and organizations. Quality Assurance and Quality Control will be conducted according to the guidelines established in the Utah Water Quality Manual. Only those data that meet QA/QC standards will be entered into the project database.

5.4 Long-Term Funding Plans for Operation and Maintenance

No long-term funding is planned for operation or maintenance of these projects. Maintenance of these projects will be the responsibility of the private landowner. Projects will be inspected by the project lead sponsor, UACD and NRCS staff. The operation and maintenance of the designed systems will be thoroughly explained to the landowner and they will sign a document indicating their understanding and cooperation. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding. We do anticipate increased interest in participation of BMP application and anticipate moving to a watershed-wide implementation phase in the future.

5.5 Public Involvement

There has been public involvement from the inception of the project, through proposal development, review, and submission. The CSCD will select project participants and give oversight to project planning and implementation. This group actively seeks public input into the prioritization of natural resource problems and concerns. We anticipate volunteer help to be provided at many phases of the project.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The Paria River is located in Garfield and Kane Counties in southern Utah and flows from the headwaters in Bryce Canyon National Park and Dixie National Forest through private agricultural lands in the upper reach and south through the BLM administered Grand Staircase-Escalante National Monument (GSENM) into Arizona and the Colorado River below Glen Canyon Dam. The small towns of Tropic, Cannonville and Henrieville at the northern end of the basin are based primarily on an agricultural economy dependent on irrigation from surface waters. Downstream from private lands near Henrieville Wash the river enters GSENM and flows through these primitive public lands for approximately 45 river miles to the Arizona border. The Paria River is situated in a dry desert climate and the majority of surface streams and washes are intermittent. The Paria River is perennial for most but not all of its length through the State of Utah.

The Water Quality Management Plan addresses two distinct reaches of the Paria River. Paria River Reach-1 is the section from the confluence of Rock Springs Creek below the Henrieville to the headwaters of the Paria River. Paria River Reach-3 extends from the Arizona-Utah Border to the confluence with Cottonwood Wash. Utah's Year 2002 303(d) list identifies Paria River Reach-1 and Reach-3 as being impaired due to exceedence of Utah's total dissolved solids (TDS) criteria for protection of agricultural uses, Class-4 waters. The middle section of the river between these two reaches is not listed on the 303(d) list and is not addressed in the Water Quality Management Plan. Based on the evaluation of available information on water quality, soils, rock types and groundwater aquifers we determined that the high TDS concentrations are primarily a natural feature of the desert environment along the Paria River.

In Paria River Reach-1 irrigated lands occur; however, the evaluation of water quality patterns has led us to conclude that exceedence of TDS criteria are primarily due to natural sources. No specific TDS load could be associated with irrigation practices. The Paria River Reach-3 is entirely contained within the Grand Staircase-Escalante National Monument and because of the remoteness and limited uses (primitive recreational activities), no human causes of impairment could be identified that contribute to TDS loading. Although illicit off road vehicle use should be addressed through continued public education and enforcement before it becomes a significant problem. For these reasons, site-specific criteria as provided for by the Standards of Water Quality for the Waters of the State (Utah) were recommended for the two listed reaches (Table 6-1).

Table 6-1
Recommended Site-Specific Criteria for TDS in the Paria River

Waterbody ID	Waterbody Name	Waterbody Description	HUC Unit	TDS Site-Specific Criteria (mg/L)
UT14070007-001	Paria River Reach-1	Paria River from confluence of Rock Springs Creek to headwaters	14070007	2,500
UT14070007-005	Paria River Reach-3	Paria River from Arizona-Utah Border to confluence of Cottonwood Wash	14070007	1,500

Although no specific TDS loading were attributed to human sources, the Canyonlands Soil Conservation District (CSCD) is taking the lead to reduce the possible sources of TDS loading from agricultural activities. The CSCD will coordinate with local stakeholders and agencies to develop Project Implementation Plans to improve water quality within the watershed. The CSCD has identified specific practices from the NRCS Field Office Technical Guide to reduce potential sources of salinity and sediments that change irrigation practices, provide streambank protection, and enhance the riparian vegetation along the river and tributaries.

An evaluation and monitoring program describes implementation, effectiveness and trend monitoring to evaluate success in implementing BMPs and in reducing the concentration of TDS in the Paria River. The monitoring plan identifies implantation and effectiveness monitoring procedures that can be completed by the Conservation District and affiliated agencies. The plan also describes the suggested approach for DWQ to measure trends in TDS concentrations over the long term.

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Appendix 1

List of Contributors

Governmental and non-governmental entities, and the Canyonlands Soil Conservation District assisted in contributing essential watershed information and data, and helped with the preparation of the Watershed Water Quality Management Plan. These groups consisted of the following individuals:

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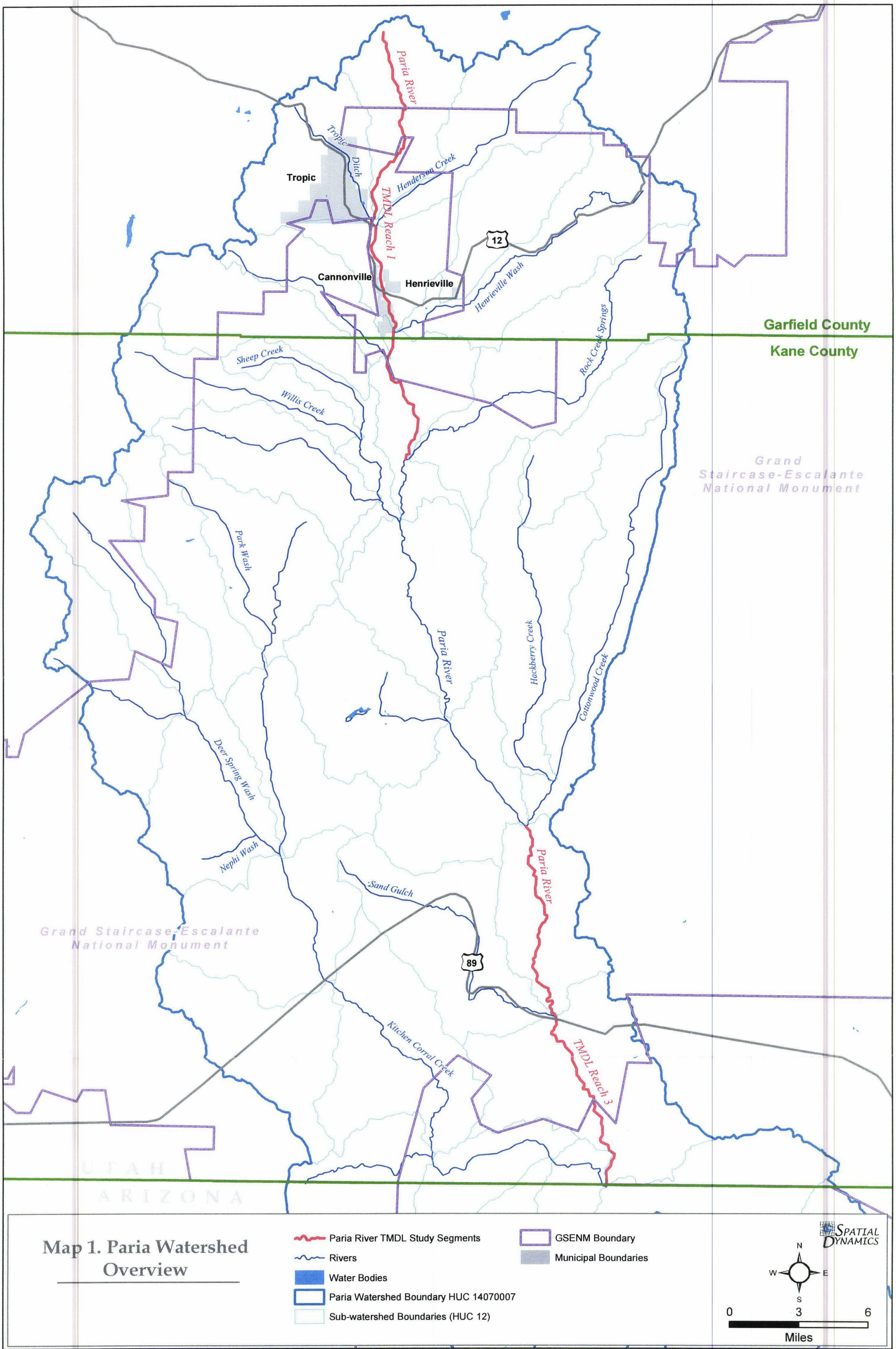
Paria River
Tropic
Tropic Ditch
Henderson Creek
TMDL Reach 1
12
Cannonville
Henrieville
Henrieville Wash
Rock Creek Springs
Garfield County
Kane County
Sheep Creek
Willis Creek
Grand Staircase-Escalante National Monument
Park Wash
Paria River
Hackberry Creek
Cottonwood Creek
Deer Spring Wash
Nephi Wash
Sand Gulch
Paria River
Grand Staircase-Escalante National Monument
89
Kitchen Corral Creek
TMDL Reach 3
UTAH
ARIZONA
Map 1. Paria Watershed Overview
Paria River TMDL Study Segments
Rivers
Water Bodies
Paria Watershed Boundary HUC 14070007
Sub-watershed Boundaries (HUC 12)
GSENM Boundary
Municipal Boundaries
Spatial Dynamics
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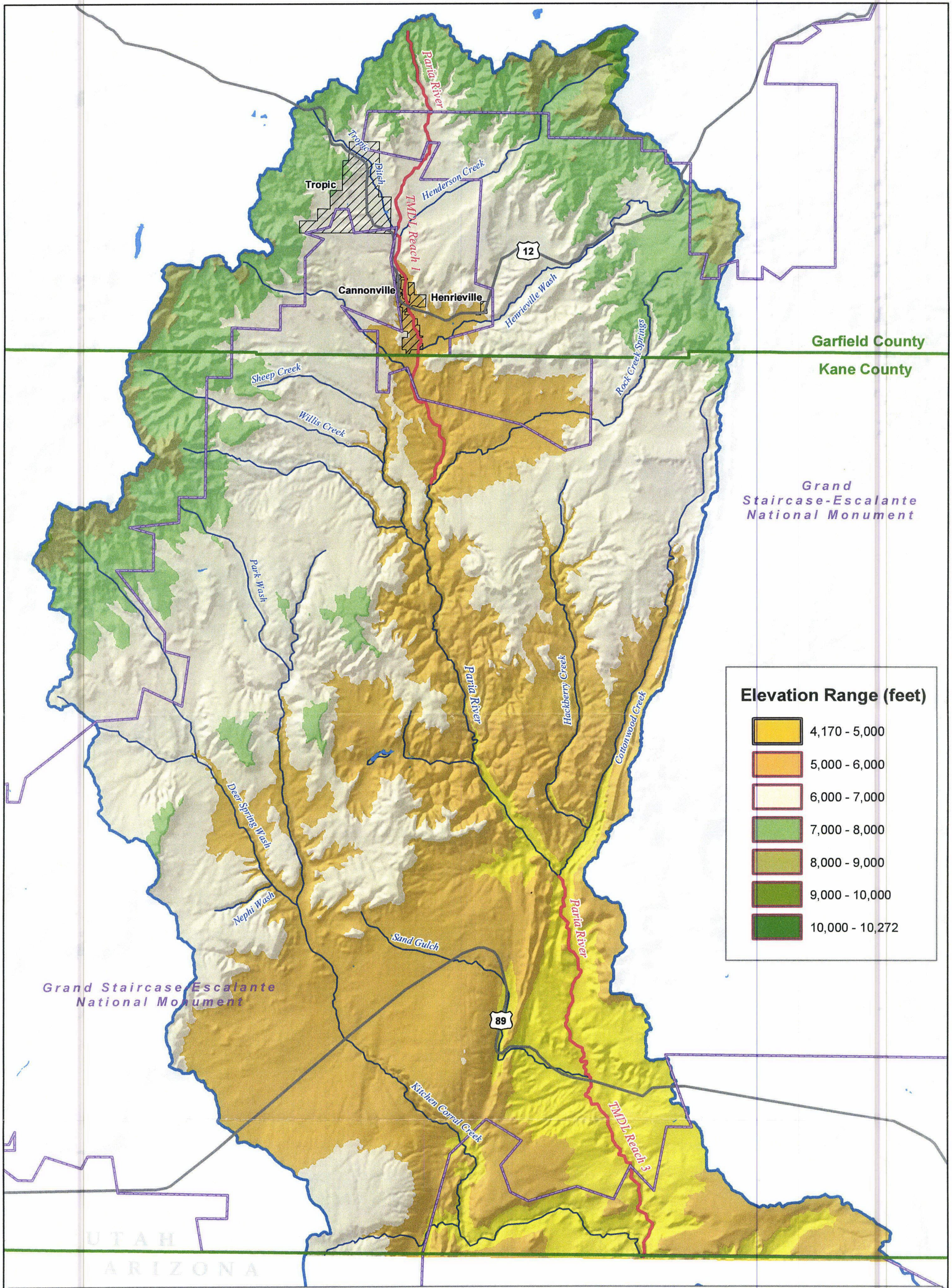
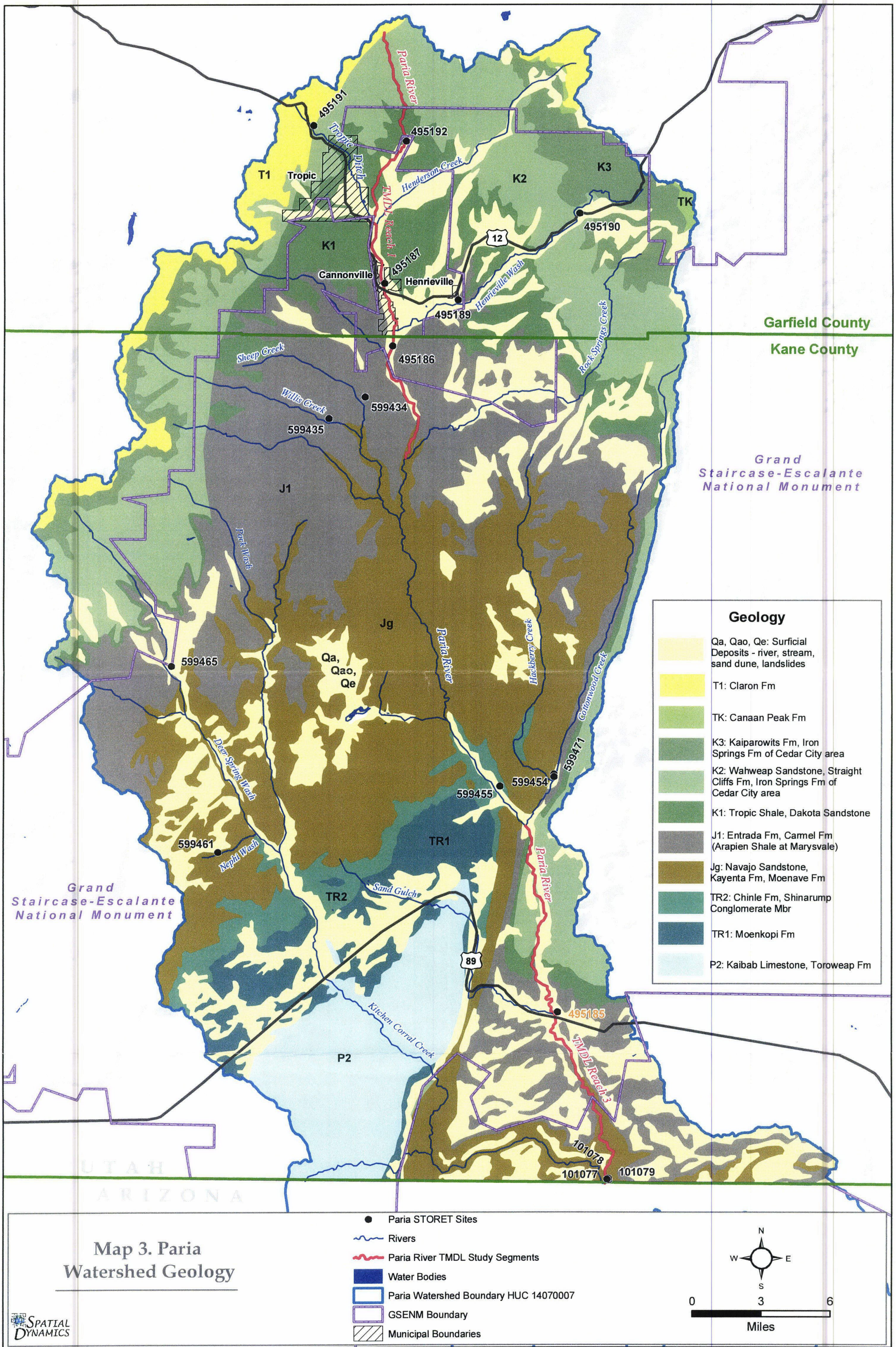
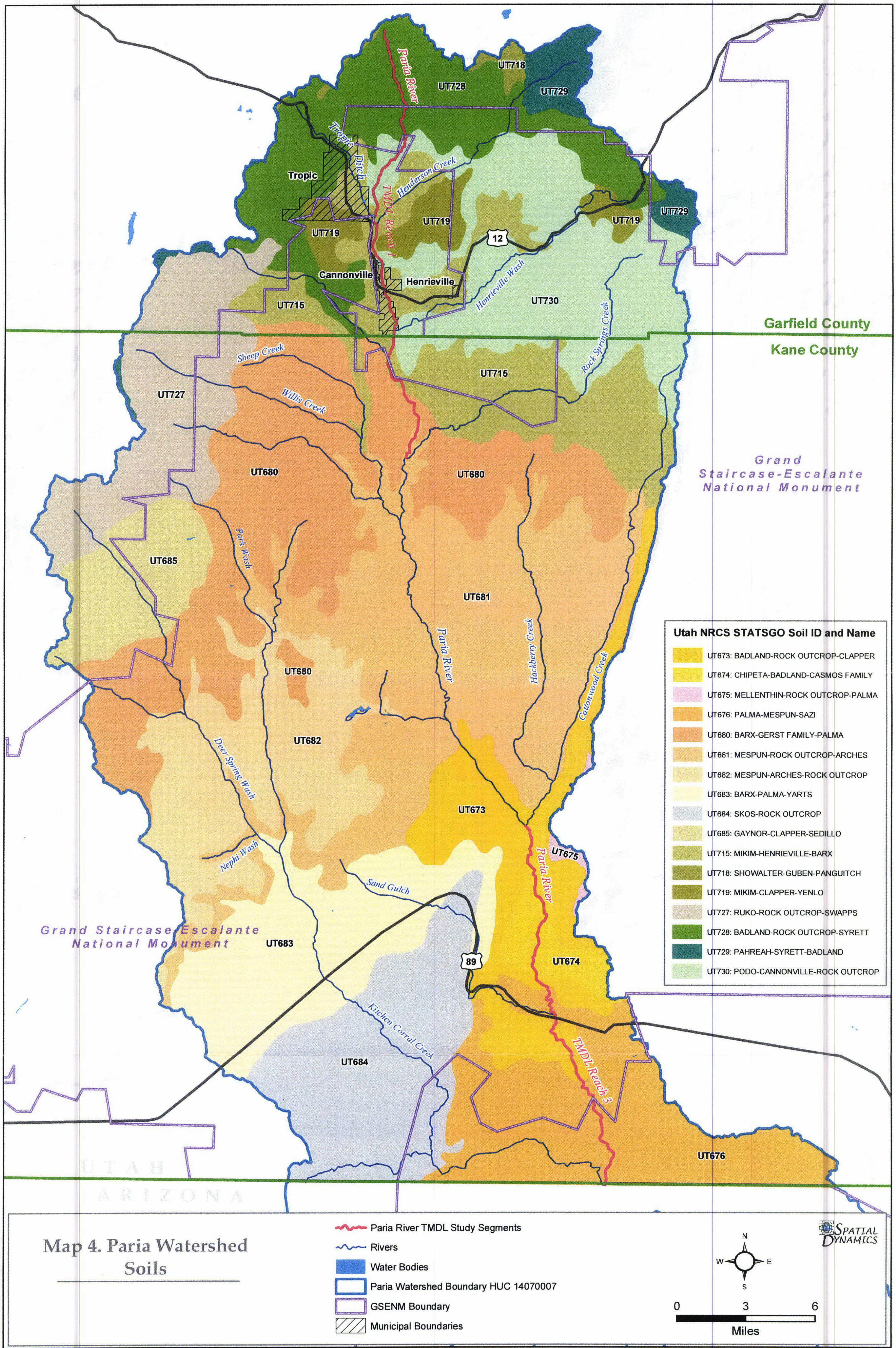


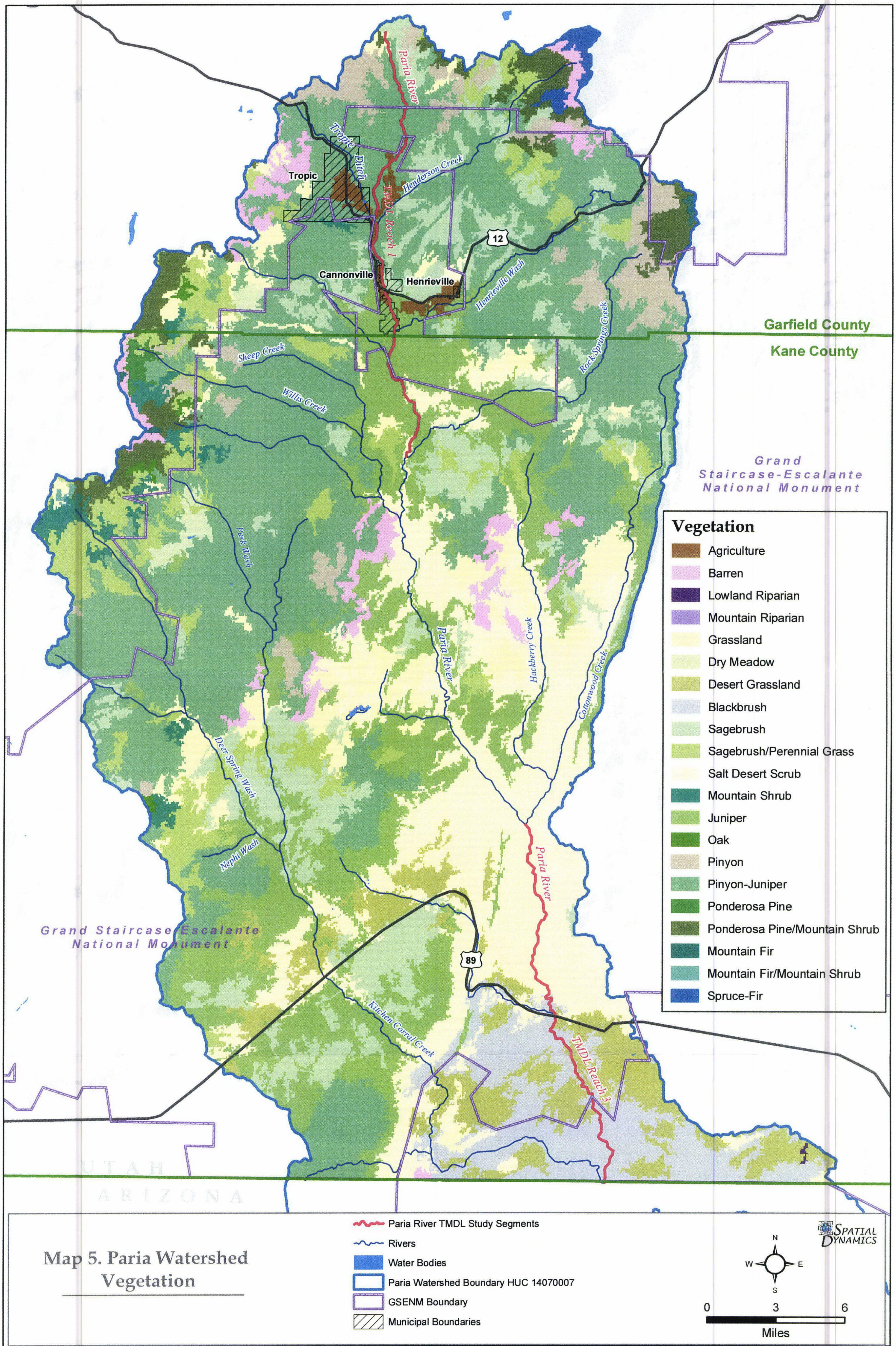
Map 2. Paria Watershed General Topography



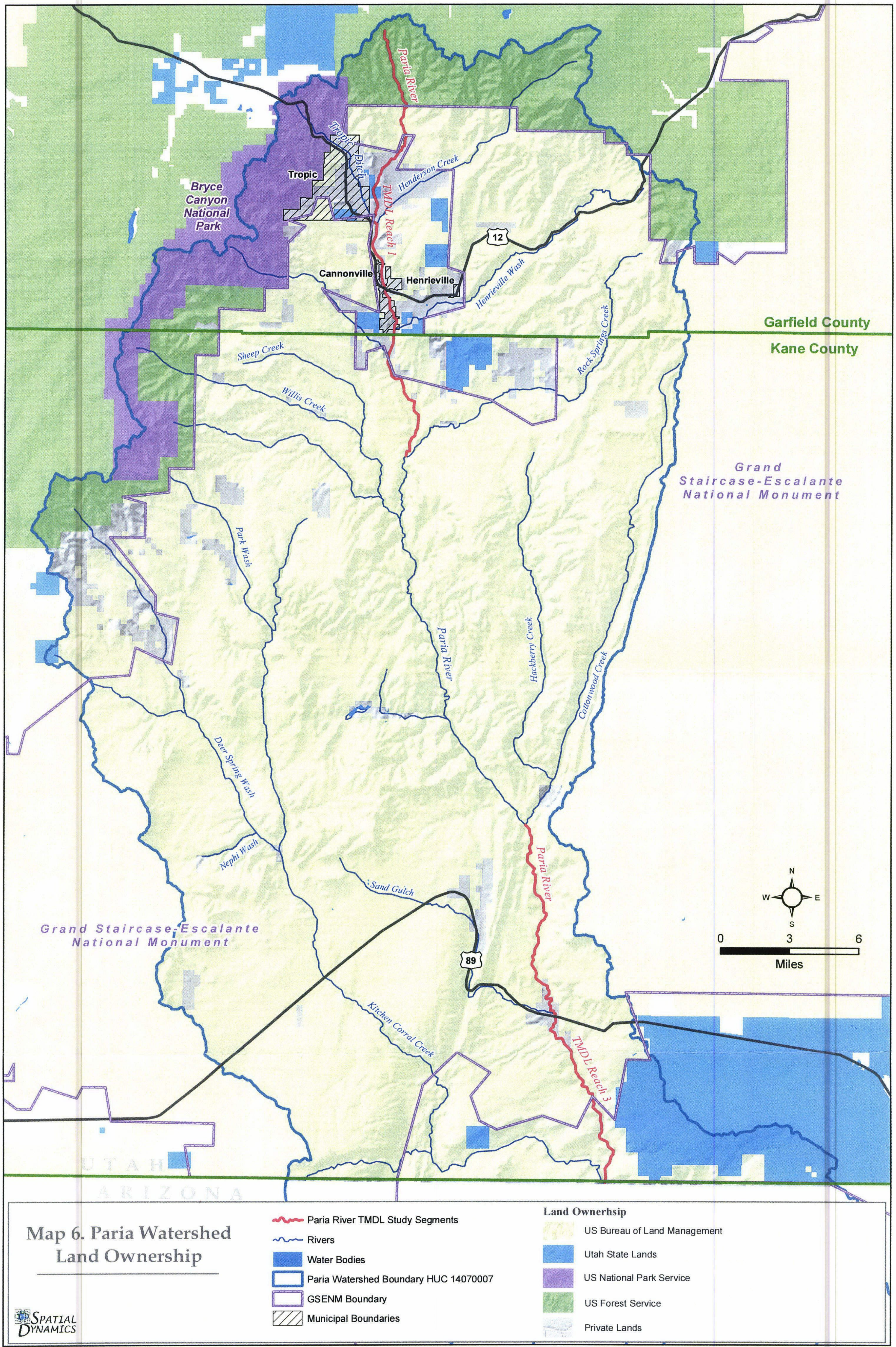
Map 3. Paria Watershed Geology



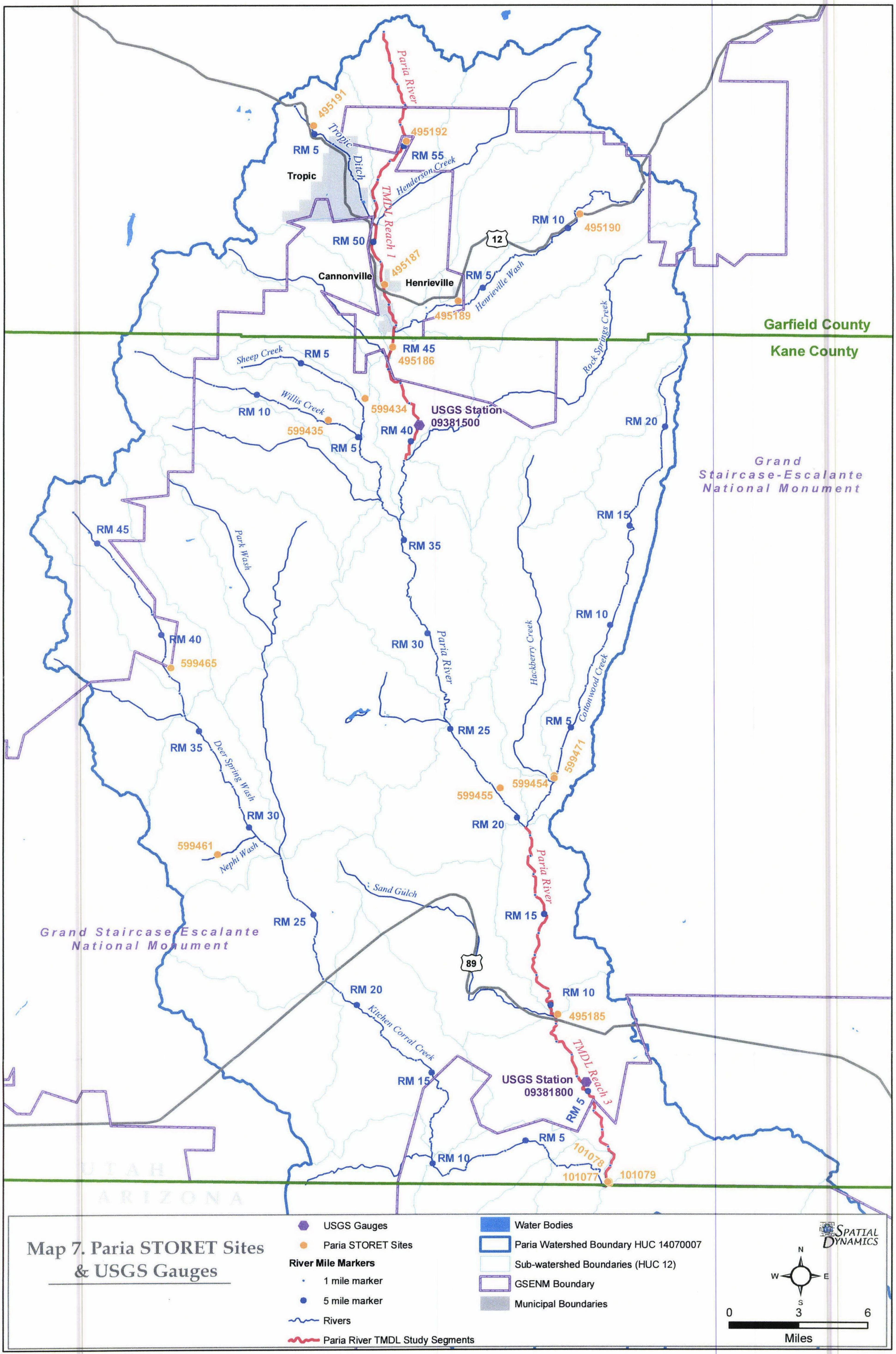
Map 4. Paria Watershed Soils



Map 5. Paria Watershed Vegetation



Map 6. Paria Watershed Land Ownership



Map 7. Paria STORET Sites & USGS Gauges

495191
TROPIC DITCH @ U12 XING

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	09/17/97	504	182	370		175	10	est
	10/31/97	17.6	242	492		9.3	1	est
	11/18/97	6.8	240	488		4.79	1	est
	01/20/98	20.8	236	750		20.3	0.4	est
	02/26/98	17.6	240	475		11.6	1	est
	03/31/98	192	260	459		151	2	est
	04/30/98	4340	224			5120	2	est
	04/30/98		**267.2**	389				
	05/19/98	236	228	454		182	13	measured
	06/09/98	114	210	427		111	15.6	measured
	07/23/02						0	measured
	08/28/02						0	measured
	09/25/02		194	335		1.94	8.7	measured
	11/25/02						0	measured
	12/30/02						0	measured
Number		9	11	10	0	10	14	
Mean		605.42	229.39	463.90	#DIV/0!	578.69	3.91	
Median		114	236	456.5	#NUM!	65.65	1	
Standard Deviation		1409.67	25.89	113.47	#DIV/0!	1597.40	5.45	
Minimum		6.8	182	335	0	1.94	0	
Maximum		4340	267.243	750	0	5120	15.6	
Number > Criteria (1200 mg/L)			0					
Percent Exceedence			0.0%					

495192
PARIA R 3 MI NNE OF TROPIC

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	09/17/97						0	measured
	10/31/97						0	measured
	11/18/97						0	measured
	01/20/98						0	measured
	02/26/98						0	measured
	03/31/98						0	measured
	04/30/98	0	420			1.44	0.3	est
	04/30/98		**526.2**	766				
	05/19/98	4.7	416			0.863	0.3	est
	05/19/98		**520.7**	758				
	06/09/98	0	400			0.578		
	06/09/98		**333.9**	486				
Number		3	6	3	0	3	8	
Mean		1.57	436.15	670.00	#DIV/0!	0.96	0.08	
Median		0	418	758	#NUM!	0.863	0	
Standard Deviation		2.71	74.44	159.40	#DIV/0!	0.44	0.14	
Minimum		0	333.882	486	0	0.578	0	
Maximum		4.7	526.242	766	0	1.44	0.3	
Number > Criteria (1200 mg/L)			0					
Percent Exceedence			0.0%					

495187
PARIA R AT U12 XING

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	01/27/81		1202			45	5.2	measured
	01/27/81		**1058.0**	1540				
	09/08/81		**1075.2**	1565			2.8	measured
	11/11/81		**1064.9**	1550			5.6	measured
	01/12/82	371	1110	1416		56		
	09/17/97	1852	890	1307		1716	3	est
	10/31/97	18	1108			1.76	1.2	est
	10/31/97		**414.3**	603				
	11/18/97	34	1114	1579		3.71	2	est
	01/20/98	1314	1226	1647		650	4	est
	02/26/98	100.4	1400	1859		66.1	0.3	est
	03/31/98	1394	1238	1617		1970	4	est
	04/30/98	9280	564			16442	3	est
	04/30/98		**551.0**	802				
	05/19/98	46	562	866		50.4	0.1	est
	06/09/98	11140	612			4895	2	est
	06/09/98		**575.0**	837				
	08/25/98	1668	762	1114		892	5	est
	10/13/98	36.8	1044	1471		7.71	4	est
	04/20/99	1308	686	1059		1178		
	05/22/00						0	measured
	07/03/00						0	measured
	08/13/00	6.8	1130			8.27	0.03	est
	08/13/00		**448.0**	652.1				
	10/06/00	146	1194	1614		105	0.5	est
	11/20/00	467	1206			215	11.6	est
	11/20/00		**451.8**	657.7				
	12/21/00	183.3	1156			82.5	7.8	measured
	12/21/00		**448.3**	652.6				
	01/26/01	676	1256			341	9.7	est
	01/26/01		**1063.5**	1548				
	02/22/01	124	1216	1624		154	2.9	est
	03/19/01	920	1034	1423		972	4.5	est
	04/22/01	986	1056	1430		582	5.4	est
	05/20/01	10800	404			12656	0.65	est
	05/20/01		**395.0**	575				
	07/24/01	24.8	1174			14.2		
	08/27/01						0	measured
	09/16/01						0	measured
	07/23/02	21.2	1078	1456		8.94	0.3	measured
	08/28/02						0	measured
	09/24/02						0	measured
	11/27/02		**1073.8**	1563	0.83		2.77	measured
	12/31/02		**1035.3**	1507	0.8		2.05	measured
Number		24	38	28	2	25	32	
Mean		1788.22	923.05	1269.09	0.82	1724.50	2.83	
Median		419	1060.728	1443	0.815	154	2.41	
Standard Deviation		3390.67	306.51	397.09	0.02	4036.59	2.96	
Minimum		6.8	395.025	575	0.8	1.76	0	
Maximum		11140	1400	1859	0.83	16442	11.6	
Number > Criteria (1200 mg/L)			7					
Percent Exceedence			18.4%					

495190

HENRIEVILLE WASH @ U-12 XING 8 MI E OF CANNONVILLE

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/20/98	215	434	760		195	3	est
	10/13/98	0	352	650		0.586	2	est
	03/31/99	93.5	372	692		61.4	0.6	est
	08/28/00	12	332	602		4.24	2	est
	12/02/00	41.2	396			78.2	5.46	est
	12/02/00		**441.7**	643				
	07/23/01	18.8	352	615	0.32	6.09	2	measured
	08/26/01	10	316			0.799	1.32	measured
	08/26/01		**382.0**	556				
	09/16/01		**414.4**	603.2			1.77	measured
	09/16/01	18	348			2.04		
	11/19/01		388	616.9		1.26	2.2	measured
	12/27/01	16.8	374			15.9		
	12/27/01		**412.2**	600			1.3	measured
	01/30/02	67.6	530			14.4	2.9	measured
	01/30/02		**365.0**	531.3				
	02/11/02	18.4	334	586.2		10.1	2	measured
	03/21/02		**476.1**	693			1.4	measured
	04/30/02	18.4	352	674.8		4.92	0.92	measured
	05/20/02	18	374	623.7		1.39	1.44	measured
	06/19/02		324	575		1.73	1.5	measured
	07/30/02		336	560		1.45	0.84	measured
	08/28/02		**404.6**	589			1.39	measured
	09/24/02		**434.9**	633			1.8	measured
	09/25/02	5.2	366			2.9		
	11/26/02		**415.6**	605	0.31		2.88	measured
	12/30/02		**434.9**	633	0.33			
Number		14	27	21	3	17	20	
Mean		39.49	387.46	621.05	0.32	23.67	1.94	
Median		18.2	374	615	0.32	4.24	1.785	
Standard Deviation		56.59	49.97	52.84	0.01	49.40	1.06	
Minimum		0	316	531.3	0.31	0.586	0.6	
Maximum		215	530	760	0.33	195	5.46	
Number > Criteria (1200 mg/L)			0					
Percent Exceedence			0.0%					

495189
HENRIEVILLE WASH 3 MI E OF CANNONVILLE

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	09/17/97	234.5	749	424		146	4	est
	09/17/97		686					
	10/31/97	55.2	629	360		32.7	3	est
	10/31/97		606					
	11/18/97	1508	645	374		607	12	est
	11/18/97		607					
	03/31/98	742	671	420		801	3	est
	03/31/98		285					
	04/30/98	1856	683	418		1585	4	est
	04/30/98		682					
	05/19/98	61.6	741	444		39.1	0.7	est
	05/19/98		721					
	06/09/98	130	1048	700		123	0.8	est
	06/09/98		1043					
	08/20/98	9172	1073	740		5163	3	est
	08/20/98		1070					
	10/13/98	48.4	1357	616		31.7	2	est
	10/13/98		938					
	03/31/99	631	902	500		321	1	est
	03/31/99		861					
	08/26/00		1120				1.1	est
	08/28/00	150	1040	740		68.9		
	11/25/00	95.3	1620	1248		25.9	0.089	est
	11/25/00		653.2					
	07/23/01	8.8	2048	1526	1.09	1.52	0.083	est
	07/23/01		1890					
	08/26/01		1560	1272		1	0.045	measured
	08/26/01		427					
	09/16/01		1861	1388		21.9	0.15	measured
	09/16/01		1650					
	11/19/01	684	637.2	378		326	6.1	measured
	11/19/01		519					
	12/27/01	10	675	400		26.5		
	12/27/01		629				1.5	measured
	01/30/02		621.6				0.9	measured
	01/30/02	48.4	745	590		38.4		
	02/11/02		568.5				11.4	measured
	02/12/02	12	567	346		3856		
	03/21/02		657				4.5	measured
	04/30/02	14	1144	720		4.36	0.05	measured
	04/30/02		1030					
	05/20/02	12	1170	770		0.736	0.03	measured
	05/20/02		1110					
	06/19/02		1142	766		5.59	0.003	measured
	06/19/02		1100					
	09/25/02	106	602	364		113	3.6	est
	09/25/02		539					
	11/27/02		797		0.41		1	measured
	12/31/02		675		0.35			
Number		20	49	23	3	23	25	
Mean		778.96	914.17	674.09	0.62	579.97	2.56	
Median		100.65	745	590	0.41	39.1	1.1	
Standard Deviation		2042.34	399.16	356.31	0.41	1307.00	3.23	
Minimum		8.8	285	346	0.35	0.736	0.0033	
Maximum		9172	2048	1526	1.09	5163	12	
Number > Criteria (1200 mg/L)			7					
Percent Exceedence			14.3%					

495186
Paria R @ Kodachrome Basin Rd Xing

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	10/04/00	87440	914			54380		
	04/04/01		**822.3**	1197	0.6		12	est
	04/04/01	2510	876			3122		
	07/23/01	6	4030	4728	2.59	4.49	0.005	measured
	08/01/01						0	measured
	09/17/01		**2222.4**	3235			0.5	measured
	09/26/01	56	2488			344		
	10/22/01		1592			18.7		
	11/12/01		**926.8**	1349			13.6	measured
	11/17/01	386	904			133		
	12/26/01	6	868			66.3		
	02/28/02	6140	838			902		
	03/25/02	1280	1094			1349		
	04/25/02	1292	2818			2.36		
	07/23/02						0	measured
	08/28/02						0	measured
	09/25/02		3444	3987		1.73	0.022	est
	11/27/02		**1327.3**	1932	1.04		4.02	measured
	12/31/02		**1251.7**	1822	0.97			
Number		9	16	7	4	11	9	
Mean		11012.89	1651.03	2607.14	1.30	5483.96	3.35	
Median		1280	1172.857	1932	1.005	133	0.02178	
Standard Deviation		28726.42	1033.72	1380.82	0.88	16244.67	5.53	
Minimum		6	822.339	1197	0.6	1.73	0	
Maximum		87440	4030	4728	2.59	54380	13.6	
Number > Criteria (1200 mg/L)			8					
Percent Exceedence			50.0%					

599434
SHEEP CK AT SKUTUMPAH RD XING

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/27/98	292.4	1608	2004		285	5	est
	04/20/99	8	1530	2011		6.52		
	07/03/00	63	1780			31.8	0.2	measured
	07/03/00		**1305.3**	1900				
	11/21/00	9.2	1596			2.87	0.029	est
	11/21/00		**450.3**	655.4				
	07/23/01	12.7	1772	2120	1.14	1.21	0.099	est
	08/27/01		1650	1976		1.87	0.078	measured
	09/16/01	12	1720			4.84		
	09/16/01		**1440.0**	2096			0.05	measured
	09/17/01		**1435.8**	2090			0.2	measured
	09/26/01	22.4	1304			30.3		
	10/22/01	12	1658			2.12		
	11/12/01		**1576.0**	2294			0.044	est
	11/17/01		1796			3.88		
	12/26/01	12.4	1734			8.03		
	02/28/02	18	1330			3.36		
	03/25/02		2032			4.82		
	04/25/02	18	2086			4.6		
	07/23/02						0	measured
	08/28/02		**1372.6**	1998			0.2	measured
	09/25/02	6.4	1698	2002		5.8	0.6	measured
	11/27/02		**1407.7**	2049	1.09		0.2	measured
	12/31/02		**1440.0**	2096	1.12		0.3	est
Number		12	23	13	3	15	13	
Mean		40.54	1553.11	1945.49	1.12	26.47	0.54	
Median		12.55	1596	2011	1.12	4.82	0.2	
Standard Deviation		80.73	320.67	398.94	0.03	72.16	1.35	
Minimum		6.4	450.2598	655.4	1.09	1.21	0	
Maximum		292.4	2086	2294	1.14	285	5	
Number > Criteria (1200 mg/L)			22					
Percent Exceedence			95.7%					

599435
WILLIS CK AT SKUTUMPAH RD XING

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	09/21/98	29.2	1512			2.76	2	est
	10/14/98	8	170	1905		0.099	1	est
	06/06/99	22.8	1214	1609		1.44	0.87	measured
	07/03/00	10.8	1470	1910		3.6	0.3	measured
	11/21/00	0	1496			0.506	0.024	measured
	11/21/00		**447.9**	652				
	07/23/02	4	1568	1928		0.794	0.15	measured
	08/28/02		**1342.4**	1954			0.15	measured
	09/25/02		1642	1995		0.269	0.2	measured
	11/27/02		**1282.6**	1867	1		0.2	measured
	12/31/02						0	measured
Number		6	10	8	1	7	10	
Mean		12.47	1214.50	1727.50	1.00	1.35	0.49	
Median		9.4	1406.199	1907.5	1	0.794	0.2	
Standard Deviation		11.28	498.93	450.09	#DIV/0!	1.34	0.63	
Minimum		0	170	652	1	0.099	0	
Maximum		29.2	1642	1995	1	3.6	2	
Number > Criteria (1200 mg/L)			8					
Percent Exceedence			80.0%					

599455
PARIA R AT OLD TOWN SITE

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/13/98	22690	1156	1562		6172	3.7	measured
	09/16/98	944	866			1358	6.1	measured
	09/16/98		**834.0**	1214				
	11/04/98	119.3	1000	1358		111	30.8	measured
	12/10/98	140.7	1640	2057		97.6	22	est
	01/08/99	324	1154	1560		256	9	measured
	02/04/99		**904.1**	1316			20.2	measured
	03/15/99	136	1028	1406		129	15.8	measured
	04/14/99	98.4	1128	1561		81.8	7.4	measured
	05/10/99	144	1106	1555		56	6.1	measured
	06/01/99	100.8	1050	1454		86.6	5	measured
	07/15/99	35060	980	1430		19212	19.2	measured
	08/17/99	40140	1410	1798		18560	9.8	measured
	09/27/99	267	990	1329		261	18.3	measured
	10/26/99	48	1072	1431		35.9	16.8	measured
	11/16/99	653	1032	1368		202	25.1	measured
	12/13/99	1436	1078	1439		269	25	measured
	01/17/00	384	956	1299		153	22	measured
	02/25/00	1136	904			564	17.9	measured
	02/25/00		**867.0**	1262				
	03/27/00	3712	834	1168		2440	27.9	measured
	04/17/00	61	802	1181		29	5.3	measured
	05/19/00	117	876			49.2	6	measured
	05/19/00		**805.9**	1173				
	06/19/00	71	788	1109	0.58	49.5	3	measured
	07/06/00	258	826		0.56	4.24	2.3	measured
	07/06/00		**738.5**	1075				
	08/16/00	840	740	1041		290	4.3	measured
	09/26/00	24.4	902	1249		16.9	5.82	measured
	10/31/00	13420	954	1324		12392	32	measured
	11/25/00	258	1132	1478		228	12.6	measured
	12/26/00	212	1068	1456		162	6	measured
	01/16/01	73.2	1158	1553		30.4	10.5	measured
	02/24/01	3720	1084	1339	0.71	5287	23.8	measured
	03/26/01	13880	641	1006	0.53	7604	36.3	measured
	04/24/01	2290	880	1266	0.67	3019	16.4	measured
	05/29/01	2690	914	1273	0.67	3847	8.1	measured
	06/18/01		822	1134	0.6	0.714	2.9	measured
	07/30/01	21.2	716	1026	0.54	8.7	3.44	measured
	08/31/01	4	1302			2630		
	09/17/01		**721.4**	1050			4.9	measured
	09/24/01	276	786			50.5		
	10/23/01		1030			32.9		
	11/12/01		**768.1**	1118			11	est
	11/15/01	195	890			134		
	12/28/01	22	584			480		
	01/03/02	10	998			152		
	02/25/02	1170	862			703		
	03/19/02		**845.7**	1231			12.9	measured
	03/19/02	1046	888			599		
	04/24/02	1038	1168			50.2		
	05/28/02	1114	726			25.4		
	07/17/02	48880	1490			8448		
	08/12/02	1228	760	1036		38.7	1.8	measured
Number		44	54	39	8	46	39	
Mean		4555.73	956.59	1325.26	0.61	2095.79	13.27	
Median		300	904.046	1316	0.59	157.5	10.5	
Standard Deviation		11056.48	204.75	221.21	0.07	4474.37	9.47	
Minimum		4	584	1006	0.53	0.714	1.8	
Maximum		48880	1640	2057	0.71	19212	36.3	
Number > Criteria (1200 mg/L)			4					
Percent Exceedence			7.4%					

599471
COTTONWOOD CK AB CNFL/ HACKBERRY CANYNON

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/13/98	1448	286	464		1658	0.004	measured
	10/06/98						0	measured
	11/04/98						0	measured
	12/10/98	15.6	738			13.1	0.022	measured
	12/10/98		**701.4**	1021				
	01/12/99	88	934	1277		61.6	0.132	est
	02/04/99	86.4	254	1227		33.1	0.189	est
	03/15/99	156	644	961		115	0.4	measured
	04/14/99	94.8	676	1041		56.5	0.2	measured
	05/10/99	34	676	1027		88.3	0.2	measured
	06/01/99						0	measured
	08/17/99						0	measured
	10/26/99	307	680	970		111	0.010	measured
	11/16/99	20.4	542			16.1	0.050	measured
	11/16/99		**544.8**	793				
	12/13/99	116	844	1157		70.3	0.023	est
	12/13/99	3180	570			765	2.1	measured
	12/13/99		**532.4**	775				
	01/17/00	396	596			240	0.5	measured
	01/17/00		**608.0**	885				
	02/21/00	240	502			79.5	0.4	measured
	02/21/00		**612.8**	892				
	03/24/00		**634.8**	924			0.5	measured
	03/27/00	198	628			94.2		
	04/17/00	310	580	914		143	0.3	measured
	05/19/00						0	measured
	06/19/00						0	measured
	07/06/00						0	measured
	08/16/00						0	measured
	09/26/00						0	est
	11/21/00						0	est
	01/16/01	12.8	1264	1729		9.28	0.003	est
	02/24/01	58	878	1200	0	38.3		
	03/26/01	148	722	1062	0.56	108	0.3	measured
	04/24/01	118	766		0.51	96.2	0.29	measured
	04/24/01		**667.1**	971				
	05/29/01						0	measured
Number		19	26	19	3	19	29	
Mean		369.84	656.97	1015.26	0.36	199.81	0.19	
Median		118	639.394	971	0.51	88.3	0.022	
Standard Deviation		751.20	194.26	252.62	0.31	390.02	0.40	
Minimum		12.8	254	464	0	9.28	0	
Maximum		3180	1264	1729	0.56	1658	2.1	
Number > Criteria (1200 mg/L)			1					
Percent Exceedence			3.8%					

599454
HACKBERRY CANYON AB CNFL/ COTTONWOOD CK

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/13/98						0	measured
	10/06/98	467	266			422	0.346	measured
	10/06/98		**306.4**	446				
	11/04/98	184	278			150	1.2	measured
	11/04/98		**303.7**	442				
	12/10/98	14.8	272			11	0.5	est
	12/10/98		**305.0**	444				
	01/12/99	29.3	262			30.5	0.286	est
	01/12/99		**308.5**	449				
	02/04/99	151.2	256			77.7	3.7	est
	02/04/99		**304.3**	443				
	03/15/99	30	254			22.3	1	measured
	03/15/99		**310.5**	452				
	04/14/99	74	258	536		29.7	0.4	measured
	05/10/99	180.4	244	490		50.2	0.11	est
	06/01/99						0	measured
	08/17/99	12260	274	447		5343	0.066	measured
	10/27/99	121	278	460		108	0.5	measured
	11/16/99	97.3	272			60	0.8	measured
	11/16/99		**307.8**	448				
	12/13/99	21.6	296			8.47	0.018	est
	12/13/99		**480.9**	700				
	01/17/00	990	218			469	1.6	measured
	01/17/00		**226.0**	329				
	02/21/00	214	272			99.9	1.3	measured
	02/21/00		**311.2**	453				
	03/27/00	169.3	266			58.2	0.7	measured
	03/27/00		**311.9**	454				
	04/17/00	144	296			106	0.3	measured
	04/17/00		**361.4**	526				
	05/19/00	554	246			269	0.3	measured
	05/19/00		**300.9**	438				
	06/19/00						0	measured
	07/06/00						0	measured
	08/16/00						0	measured
	09/26/00	680	254			660	0.066	measured
	09/26/00		**267.9**	390				
	11/21/00	21.3	294			20.6	0.003	measured
	11/21/00		**267.9**	390				
	12/26/00	11.6	274			4.95	0.001	est
	12/26/00		**305.0**	444				
	01/16/01	9.6	286			8	0.002	est
	01/16/01		**318.1**	463				
	02/24/01	12	282		0.22	10.9	0.089	measured
	02/24/01		**305.7**	445				
	03/26/01	111	302	508	0.26	79.6	0.6	measured
	04/24/01	86	264		0.23	71.2	0.33	measured
	04/24/01		**308.5**	449				
	05/29/01						0	measured
Number		24	43	24	3	24	30	
Mean		693.06	287.81	460.25	0.24	340.43	0.47	
Median		116	282	448.5	0.23	65.6	0.293	
Standard Deviation		2475.83	40.74	66.15	0.02	1078.60	0.75	
Minimum		9.6	218	329	0.22	4.95	0	
Maximum		12260	480.9	700	0.26	5343	3.7	
Number > Criteria (1200 mg/L)			0					
Percent Exceedence			0.0%					

495185
PARIA R AT US89 XING

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	02/04/76	2060	974			530		
	04/07/76	935						
	05/12/76	3560	1440			250		
	07/14/76	800						
	10/13/76	305	1124			290		
	12/01/76	155	2348					
	01/18/77	630	1112					
	01/19/77		1138			400		
	03/23/77	15	1370			15	0.1	measured
	05/25/77	9999	1092					
	03/08/78	9999	1522			2550		
	05/10/78	115	1347					
	09/06/78	215	1142			120		
	09/06/78		**893.1**	1300				
	11/14/78	5560	**961.8**	1400				
	01/17/79	37	**1236.6**	1250				
	03/20/79	702	**893.1**			0		
	03/20/79		**961.8**	1400				
	05/16/79	49	1482	1900				
	08/15/79	363	1520			0		
	08/15/79		**1236.6**	1800				
	11/28/79	36	1490			230		
	11/28/79		**893.1**	1300				
	04/10/80	24800	1744	2800		0		
	10/29/80		1618			350	38.6	measured
	01/14/81		1432	1930		12	60	measured
	02/18/81		1486	1775		120		
	04/14/81		1606			19		
	04/14/81		**1312.2**	1910				
	08/18/81	65000	2274			0		
	08/18/81		**1525.1**	2220				
	10/21/81	595	1420			230		
	10/21/81		**1115.0**	1623				
	12/17/81	641	1313			250		
	12/17/81		**1030.5**	1500				
	02/24/82	6630	1238			0	20.4	measured
	02/24/82		**1083.4**	1577				
	04/17/82	20760	1074			0		
	04/17/82		**948.1**	1380				
	05/19/82	214	1710			121		
	05/19/82		**1339.7**	1950				
	09/16/82	3110	1230	1520		980		
	11/09/82	1836	1310			0		
	11/09/82		**518.7**	755				
	01/05/83	717	1492			328	38.8	measured
	01/05/83		**1183.7**	1723				
	03/01/83	30130	1460	1790		0	138.5	measured
	04/26/83	8860	1042			4030		
	04/26/83		**889.7**	1295				
	06/21/83	8610	1100			21000		
	06/21/83		**989.3**	1440				
	08/02/84	26370	1238			0	9	measured
	08/02/84		**1064.9**	1550				
	08/29/84	53290	1318			0	12.2	measured
	08/29/84		**1075.2**	1565				
	04/23/85	3300	1164			350	9.9	measured
	04/23/85		**1018.8**	1483				
	05/22/85	9450	1184			210	24.2	measured
	05/22/85		**829.2**	1207				
	06/25/85						0	measured

08/07/85	20	1340			16	3.1	measured
08/07/85		**1037.4**	1510				
09/04/85	4700	1308			470	7.5	measured
09/04/85		**1192.6**	1736				
10/01/85	272	1244	1561		125	5.6	measured
10/29/85	157	1132			65	14.7	measured
10/29/85		**325.0**	473				
12/03/85	1925	1058			900	20.2	measured
12/03/85		**924.0**	1345				
01/29/86	574	902	1280		0	17.3	measured
03/12/86	855	1220			290	12.4	measured
03/12/86		**1016.8**	1480				
04/22/86	2500	1080			560	10.9	measured
04/22/86		**885.5**	1289				
07/08/86						0	measured
08/19/86	9999	918			0	0.4	measured
08/19/86		**778.4**	1133				
10/01/86	981	1036			320	2.1	measured
10/01/86		**856.7**	1247				
11/12/86	450	1216			250	9.2	measured
11/12/86		**1031.2**	1501				
02/03/87	1456	1198	1555		800	13.9	measured
03/18/87	4055	1176	1510		375	73	measured
04/29/87	43	1414	1742		20	0.4	measured
06/24/87						0	measured
09/15/87	1143	1168	1602		160	2.8	measured
11/10/87	985	1140			800	13	measured
11/10/87		**909.6**	1324				
01/26/88						0	measured
03/07/88	644	1046	1377		490	20	measured
06/01/88	206	1204			140	4.2	measured
06/01/88		**1081.3**	1574				
08/13/98	1220	1068	1476		1800	1.1	measured
09/16/98	1732	1168	1438		3721	7.5	measured
10/06/98	110	978	1389		87.2	13.8	measured
10/06/98	177.3	1194	1618		150	9	measured
11/06/98	348	1126	1522		324	17.7	measured
12/10/98	194.7	1494	1902		157	2.9	est
01/12/99	708	922	1295		708	28.5	measured
02/04/99	462	900	1263		549	21.9	measured
03/15/99	339	1084	1462		343	5	measured
04/14/99	224	1300	1774		141	8.1	measured
05/10/99	936	1306	1725		610	2.8	measured
06/01/99	320	1420	2020		362	0.5	measured
07/15/99	9260	896	1255		19564	28.9	measured
08/17/99	65580	1678	2002		52208	19.3	measured
09/27/99	553	1010	1352		259	9.4	measured
10/26/99	128	1204	1553		118	10.7	measured
11/16/99	578	1100	1437		290	33.6	measured
12/13/99	1528	1268	1594		810	6.8	measured
12/13/99	8844	1162	1521		1320	25	est
01/17/00	640	1008	1307		331	19.8	measured
02/21/00	528	1038	1391		272	17.7	measured
03/27/00	11820	822	1218		7654	17.8	measured
04/17/00	75	1100	1538		9.73	2.8	measured
05/19/00						0	measured
06/19/00						0	measured
07/06/00						0	measured
08/16/00	14980	1090	1438		8402		
09/26/00	89	1570	2021		84.8	1.8	measured
10/31/00	23440	1110	1491		6034	101.6	measured
11/21/00	302	1278	1649		306	4.8	measured
12/26/00	246	1118	1527		227	4.4	measured
01/12/01	668	870	1216		558	22.9	measured
02/19/01	920	1000	1366	0.72	1248	19.8	measured
03/26/01	8260	836	1218	0.64	10720	53.2	measured

	04/24/01	458	1056	1457	0.77	220	16.5	measured
	05/30/01	186	1170	1597	0.85	178	1.8	measured
	07/30/01						0	measured
	08/31/01	4	2564			11440		
	09/17/01		**801.7**	1167			1.15	measured
	09/24/01	54	898			89.6		
	10/23/01		1586			23.8		
	11/12/01		**819.6**	1193			11.7	est
	11/15/01	422	952			236		
	12/28/01	22	542			1668		
	01/03/02	12	998			487		
	02/25/02	1290	1034			3972		
	03/19/02		**891.0**	1297			10	measured
	03/19/02	1198	976			612		
	04/24/02	1220	1716			59.9		
46	07/17/02	5660	1480			7048		
	08/12/02						0	measured
Number		95	132	81	4	92	72	
Mean		5226.83	1174.20	1509.52	0.75	1995.30	15.87	
Median		708	1121	1491	0.745	281	9.65	
Standard Deviation		11908.86	307.99	307.50	0.09	6389.55	22.95	
Minimum		4	324.951	473	0.64	0	0	
Maximum		65580	2564	2800	0.85	52208	138.5	
Number > Criteria (1200 mg/L)			49					
Percent Exceedence			37.1%					

599465
DEER SPRING WASH BL DEER SPR RANCH

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	09/25/98	28.4	802	1259		7.75	0.050	measured
	03/10/99	36	792	1223		29.4	0.396	measured
	05/13/99	8	770	1214		1.21	0.3	measured
	06/01/99	8.8	774	1216		1.16	0.2	measured
	08/10/99	39.6	882	1224		23.9	0.2	measured
	10/25/99	5.6	792	1201		1.33	0.3	measured
	03/20/00	0	810			1.36	0.4	measured
	03/20/00		**826.5**	1203				
	06/13/00	0	972	1299		0.561	0.013	measured
	08/08/00	13.2	716	1195		2.79	0.305	measured
	10/21/00	86.4	800	1222		11.8	0.178	measured
	03/16/01		**887.6**	1292			0.25	measured
	03/16/01	44.4	840			13.7	0.248	measured
	05/21/01	6.4	994	1418	0.75	0.952	0.019	measured
	06/19/01	26.4	1078	1598	0.86	4.71	0.014	measured
	07/10/01	33280	556		0.35	1760	8.3	est
	07/10/01		**491.2**	715				
	08/20/01	170	866			156		
	09/17/01		**827.8**	1205			0.055	est
	09/17/01	72	832			12.9		
	10/23/01	24	900			3.21		
	11/12/01		**979.7**	1426			0.033	est
	11/17/01	8	980			3.26		
	12/28/01	12	754			2.85		
	02/26/02	6.4	1008			2.77		
	03/26/02	12.4	1086			3.3		
	04/25/02	12	874			1.31		
	05/29/02	12	782			1.68		
	07/17/02	32.4	802			5.77		
	08/12/02	14	784			7.32	0.099	measured
	08/12/02		**224.6**	327				
Number		25	31	17	3	25	18	
Mean		1358.34	822.05	1190.41	0.65	82.44	0.63	
Median		13.2	826.461	1222	0.75	3.26	0.2	
Standard Deviation		6650.45	168.82	282.47	0.27	350.84	1.92	
Minimum		0	224.649	327	0.35	0.561	0.0132	
Maximum		33280	1086	1598	0.86	1760	8.3	
Number > Criteria (1200 mg/L)			0					
Percent Exceedence			0.0%					

599461
NEPHI WASH SPRING DEVELOPMENT

	Date	TSS mg/l	Dissolved Solids (mg/l)	Specific Cond (umho/cm)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	08/08/98	17.6	614	1028		12.3	0	measured
	08/08/98	98	560	1190		93.9		
	08/24/99	332	690	1332		166	0.0004	measured
	08/14/00	660	1980			863	0	est
	08/14/00		**1565.0**	2278				
	09/17/01		**1081.3**	1574			0.0001	est
	09/18/01	164	948			177		
	08/16/02	1126	1060	1486		60		
Number		6	8	6	0	6	4	
Mean		399.60	1062.29	1481.33	#DIV/0!	228.70	0.00	
Median		248	1004	1409	#NUM!	129.95	0.000033	
Standard Deviation		422.48	492.83	437.26	#DIV/0!	316.99	0.00	
Minimum		17.6	560	1028	0	12.3	0	
Maximum		1126	1980	2278	0	863	0.000418	
Number > Criteria (1200 mg/L)			2					
Percent Exceedence			25.0%					

101078

CMPAR029.90 (Paria River above confluence with Buckskin Gulch)

	Date	TSS mg/l	Specific Cond (umho/cm)	Predicted TDS (mg/L)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	10/01/98	1132	1257	**864**		335	26.41	measured
	03/03/99	0.9	1682	**1156**		395	0	measured
	05/24/99	4430	1256	**863**		1.6	0	measured
	06/10/99	5260				65.2	0	measured
	11/04/99	228	1523	**1046**		441	3.85	measured
	12/03/99	1039	1544	**1061**		419	5.44	measured
	04/07/00	230	1232	**846**		441	184.92	measured
	04/14/00		1100	**756**				
	05/19/00	59	914	**628**		0.8	0	measured
	06/02/00	37	1265	**869**		10.9	0	measured
	07/28/00	19.5	453	**311**		10.3	0	measured
Number		10	10	10	0	10	10	
Mean		1243.54	1222.60	839.93	#DIV/0!	211.98	22.06	
Median		229	1256.5	863.2155	#NUM!	200.1	0	
Standard Deviation		1952.20	351.40	241.41	#DIV/0!	207.60	57.80	
Minimum		0.9	453	311.211	0	0.8	0	
Maximum		5260	1682	1155.534	0	441	184.92	
Number > Criteria (1200 mg/L)				0				
Percent Exceedence				0.0%				

101079

CMPAR030.00 (Buckskin Gulch above confluence with Paria River)

	Date	TSS mg/l	Specific Cond (umho/cm)	Predicted TDS (mg/L)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	10/01/98	380	583	**401**		19.6	0.049	measured
	03/03/99	12.2	350	**240**		0.9	0.155	measured
	05/24/99	660	306	**210**		1.1	0.042	measured
	06/10/99	560				3.6	0	measured
	11/04/99	223	457	**314**		5.1	0.162	measured
	12/03/99	168	397	**273**		34.5	0.011	measured
	04/07/00	290	253	**174**		4.8	0.177	measured
	04/14/00		310	**213**				
	05/19/00	11.8	321	**221**		6.4	0.053	measured
	06/02/00	9.4	258	**177**		2.5	0.025	measured
	07/28/00	10.1	318	**218**		3.2	0.24	measured
Number		10	10	10	0	10	10	
Mean		232.45	355.30	244.09	#DIV/0!	8.17	0.09	
Median		195.5	319.5	219.4965	#NUM!	4.2	0.051	
Standard Deviation		239.40	100.52	69.06	#DIV/0!	10.69	0.08	
Minimum		9.4	253	173.811	0	0.9	0	
Maximum		660	583	400.521	0	34.5	0.24	
Number > Criteria (1200 mg/L)				0				
Percent Exceedence				0.0%				

101077
CMPAR029.87

	Date	TSS mg/l	Specific Cond (umho/cm)	Predicted TDS (mg/L)	Salinity (ppt)	Turbidity (ntu)	Flow (cfs)	Flow Comment
	03/03/99	47.8	1624	1116		389	0	measured
	05/24/99	900	367	252		4.6	0.3	measured
	06/10/99	1090				77.8	0.16	measured
	11/04/99	946	1526	1048		441	3.46	measured
	12/03/99	912	1410	969		410	11.65	measured
	04/07/00	1212	1043	717		441	97	measured
	04/14/00		460	316				
	05/19/00	17.1	381	262		54.9	0.12	measured
	06/02/00	12.5	1420	976		10	0.18	measured
	07/28/00	13	407	280		47.8	1.55	measured
Number		9	9	9	0	9	9	
Mean		572.27	959.78	659.37	#DIV/0!	208.46	12.71	
Median		900	1043	716.541	#NUM!	77.8	0.3	
Standard Deviation		530.24	550.56	378.24	#DIV/0!	202.72	31.83	
Minimum		12.5	367	252.129	0	4.6	0	
Maximum		1212	1624	1115.688	0	441	97	
Number > Criteria (1200 mg/L)				0				
Percent Exceedence				0.0%				

Appendix 4: Paria River - USGS Gauge Station Flow Summaries.

USGS 09381500 PARIA RIVER NEAR CANNONVILLE, UTAH

Calendar Year Streamflow Statistics for Utah

Kane County, Utah
Hydrologic Unit Code 14070007
Latitude 37°28'52", Longitude 112°01'15" NAD27
Drainage area 198.00 square miles
Gage datum 5,480.00 feet above sea level NGVD29

LOCATION.--Lat 37°28'52", long 112°01'15", in NE14 sec. 20, T. 38 S., R. 2 W., Garfield County, Hydrologic Unit 14070007, Grand Staricase Escalante National Monument, on left bank about 0.5 mi downstream of Little Dry Valley and about 6.5 mi south of Cannonville.

USGS 09381500 PARIA RIVER NEAR CANNONVILLE, UTAH

Monthly Streamflow Statistics

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	6.85	12.8	10.8	3.34	4.80	.19	.61	11.9	2.19	2.75	9.02	9.16
1952	10.1	17.9	29.3	21.1	2.89	3.73	2.52	10.0	9.21	4.09	7.95	18.0
1953	13.2	10.5	8.25	3.00	.44	.043	38.9	37.0	.70	3.70	9.89	6.80
1954	7.71	11.2	15.8	5.56	2.83	.50	1.96	.29	14.8	13.8	5.36	5.09
1955	3.50	4.57	17.8	3.42	.20	.010	12.4	46.4	.057			
2002	6.82	8.13	6.18	1.69	.50	.11	.47	.000	11.0			
Mean of monthly streamflows	8.03	10.9	14.7	6.35	1.94	.76	9.48	17.6	6.33	6.09	8.06	9.76

Peak Stream Flow Data

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1951	Aug. 03, 1951	7.76	2,040
1952	Sep. 21, 1952	7.20	1,400
1953	Jul. 30, 1953	9.35	2,910
1954	Sep. 11, 1954	7.38	1,600
1955	Aug. 16, 1955	9.76	3,260
1959	Aug. 12, 1959	14.32	6,890
1960	Jun. 06, 1960	12.69	5,550
1961	Aug. 03, 1961	12.40	5,320
1962	Sep. 20, 1962	6.89	1,060
1963	Aug. 31, 1963	19.25	11,600

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1964	Jul. 26, 1964	7.52	1,730
1965	Jul. 19, 1965	7.52	1,730
1966	Jul. 24, 1966	8.70	2,460
1967	Jul. 16, 1967	8.23	2,150
1968	Jul. 31, 1968	9.00	2,650
1969	Aug. 19, 1969	11.60	4,680
1970	Sep. 05, 1970	10.88	4,120
1971	Aug. 05, 1971	7.52	1,730
1972	Sep. 19, 1972	9.55	3,100
1973	Aug. 18, 1973	13.78	6,400
1974	Jul. 22, 1974	6.45	1,050

Appendix 5: Paria River Climate Summary

TROPIC, UTAH (428847)

Period of Record Monthly Climate Summary

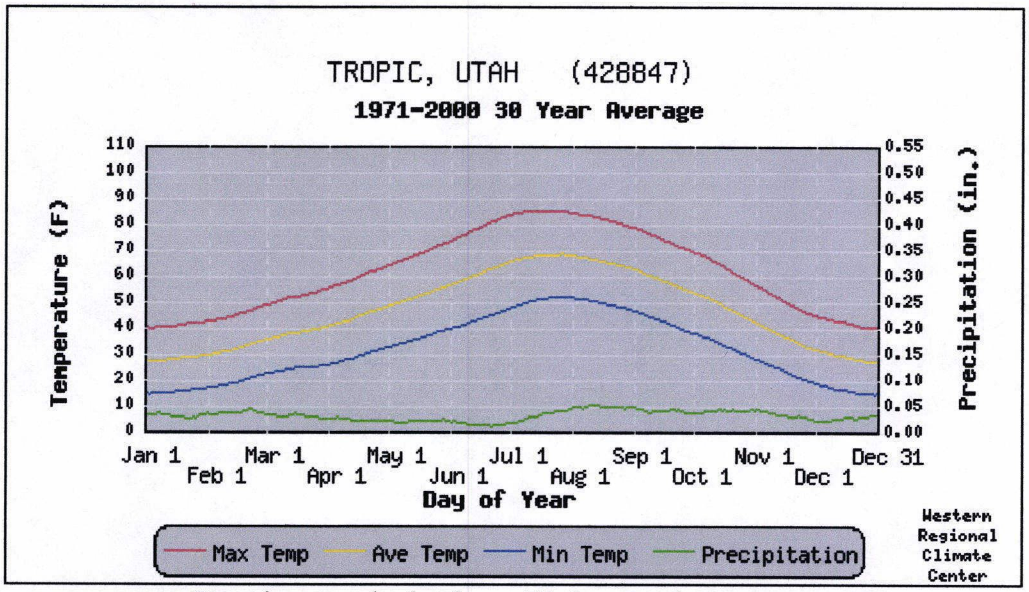
Period of Record : 7/ 1/1948 to 8/31/1999

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	41.4	45.5	52.2	60.5	69.7	79.7	85.4	82.5	75.5	65.3	51.6	43.2	62.7
Average Min. Temperature (F)	15.2	19.1	24.1	29.7	36.8	44.5	51.8	49.9	42.6	33.7	23.5	16.6	32.3
Average Total Precipitation (in.)	1.02	1.02	1.03	0.72	0.70	0.53	1.10	1.81	1.16	1.16	0.94	0.90	12.08
Average Total SnowFall (in.)	8.7	7.6	4.4	1.6	0.2	0.0	0.0	0.0	0.0	0.2	2.2	5.8	30.7
Average Snow Depth (in.)	2	2	1	0	0	0	0	0	0	0	0	1	0

Percent of possible observations for period of record.
Max. Temp.: 94.4% Min. Temp.: 94.6% Precipitation: 95.4% Snowfall: 89.5% Snow Depth: 82.5%
Check Station Metadata or Metadata graphics for more detail about data completeness.

TROPIC, UTAH

1971 - 2000 Temperature and Precipitation



Data is smoothed using a 29 day running average.

- Max. Temp. is the average of all daily maximum temperatures recorded for the day of the year between the years 1971 and 2000.
- Ave. Temp. is the average of all daily average temperatures recorded for the day of the year between the years 1971 and 2000.
- Min. Temp. is the average of all daily minimum temperatures recorded for the day of the year between the years 1971 and 2000.
- Precipitation is the average of all daily total precipitation recorded for the day of the year between the years 1971 and 2000.

TROPIC, UTAH (428847)

1971-2000 Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	41.4	45.8	52.6	60.1	69.1	79.2	85.1	82.2	74.4	63.7	49.1	42.5	62.3
Average Min. Temperature (F)	16.0	19.8	24.8	29.7	36.6	43.9	51.0	49.9	42.8	33.7	23.0	16.6	32.4
Average Total Precipitation (in.)	1.01	1.14	0.99	0.74	0.69	0.50	1.04	1.56	1.28	1.32	1.02	0.87	12.15

Unofficial values based on averages/sums of smoothed daily data. Information is computed from available daily data during the 1971-2000 period. Smoothing, missing data and observation-time changes may cause these 1971-2000 values to differ from official NCDC values. This table is presented for use at locations that don't have official NCDC data. No adjustments are made for missing data or time of observation. Check NCDC normals table for official data.

Western Regional Climate Center, wrcc@dri.edu

Appendix 6

List of Acronyms

BLM	Bureau of Land Management
BMP	Best Management Practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
CSCD	Canyonlands Soil Conservation District
DEQ	Utah Department of Environmental Quality
DWQ	Utah Department of Environmental Quality - Division of Water Quality
DWR	Utah Department of Natural Resources - Division of Water Rights
EPA	United States Environmental Protection Agency
GIS	Geographic Information Systems
GSA	Geological Society of America
GSENM	Grand Staircase Escalante National Monument
mg/L	milligrams per Liter (parts per million)
MSE	Millennium Science & Engineering, Inc.
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
pH	potenz (power) Hydrogen - a measure of acidity and alkalinity
PIP	Project Implementation Plan
SAR	Sodium Absorption Ratio
SC	Specific Conductance (conductivity compensated for temperature)
STATSGO	State Soil Geographic database
STORET	EPA's computerized environmental data STOrage and RETrieval system
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
UAC	Utah Administrative Code
UACD	Utah Association of Conservation Districts
umhos/cm	micro Mhos (the inverse of Ohms) per centimeter - a measure of electrical conductance
USFS	United States Forest Service
USGS	United States Geological Survey
USU	Utah State University
WQMP	Water Quality Management Plan
WQS	Water Quality Standard
WRC	Western Regional Climate center

Responses to comments on the Draft Paria River Watershed Water Quality Management Plan dated February 3, 2005

1) In the upper watershed (Reach 1), the two STORET stations 495187 and 495186 are relatively close together, yet there is quite a change in water quality between them. The document states that this is due "to inputs from a saline aquifer" (p.23); however, the TMDL does not describe this aquifer nor does it provide documentation that the aquifer is the source. Section 1.4.6 (p.13) does briefly discuss hydrogeology and the five primary aquifers, but does not place them in a spatial context (a map of the aquifers would be nice). I do see that agriculture occurs between the two STORET points and I believe this could be a substantial source of the TDS. Furthermore, it may be somewhat difficult to distinguish between natural sources (saline aquifer) and human caused influences. In summary, I believe the statement on page 23 needs to be validated, and I also believe irrigation should be evaluated further as a source of TDS.

Response:

"Inputs from a saline aquifer" will be more specifically defined as the shallow alluvial aquifer associated with Henrieville Wash that enters the Paria between stations 495187 (Hwy 12) and 495186 (Kodachrome Rd). Henrieville Wash originates from the "The Blues", an extensive outcrop of highly erodable Tropic Shale that contains high concentrations of salt. During the irrigation season surface flows from Henrieville Creek are put into sprinkler irrigation systems surrounding the community of Henrieville. Some proportion of this irrigation water returns to the downstream channel, primarily through deep percolation into the shallow alluvial aquifer. However, we felt the predominant use of improved irrigation systems in Henrieville minimizes deep percolation to the highest extent practicable so that it is relatively insignificant, particularly in light of the surrounding area's severe hydrologic and geologic environment.

2) For Reach 3, the document states that there are "no known anthropogenic sources of TDS" (p. 23). In looking at the maps, there are two areas of private lands within Reach 3 (one on Sand Gulch and another at Highway 89 and Paria R.) and I was wondering if any activities on these parcels might be considered anthropogenic sources of TDS? Also, are there historic activities (e.g., mining, livestock grazing, roads) within GSENM that could be contributing TDS?

Response:

During a site visit in 2003 we did not observe any anthropogenic activities that would contribute significant loads of TDS to the Paria River.

3) The document cites Moon (1997) and Davies (1997) but does not list them in references. Could I get a copy of these documents?

Response:

The references for these documents have been added.

4) The TMDL recommends site-specific criteria so that the standard "will not cause a future 303(d) listing" (p.24). Conceptually I have difficulty with this reasoning. If the TDS were natural (not to be confused with ambient), then setting a standard relative to natural conditions would be appropriate. But even then the purpose of the standard would not be to avoid future 303(d) listings, though that would be a likely outcome.

Response:

The rationale for establishing site specific standards is not to prohibit future 303d listings as you have commented, this statement has been removed and the site specific standards for the upper and lower reaches have been re-calculated to represent more accurately the natural background concentrations of TDS (1,500 and 2,500 mg/L respectively).

5) For the lower reach, 1,600 mg/L will likely be protective of most aquatic life; however, the site-specific criteria of 3,500 mg/L for the upper reach may affect some sensitive aquatic life.

Response:

See response to comment 4.

6) Appendix 7 (see page 1) was not included with the TMDL.

Response:

The reference to this appendix has been removed.

WESTERN RESOURCE
ADVOCATES

April 15, 2005

Harry Judd
Utah Division of Water Quality
P.O. Box 144870
Salt Lake City, Utah 84114-4870
Via email (hjudd@utah.gov)
and US Mail

Re: Draft Paria River Watershed Water Quality Management Plan and Total Maximum Daily Load (TMDL)

Dear Harry,

Southern Utah Wilderness Alliance, Great Old Broads for Wilderness, Utah Rivers Council, The Grand Canyon Trust, and Utah Council – Trout Unlimited, on whose behalf I make these comments, thank you for this opportunity to address the Draft Paria River Watershed Water Quality Management Plan and Total Maximum Daily Load (TMDL) recently issued to the public by the Utah Division of Water Quality (DAQ). Thank you as well for extending the public comment period to April 15, so that we had more time to consider and respond to the proposed TMDL.

The proposed TMDL represents an important step toward protecting and restoring the beneficial uses of the Paria River. We appreciate the time, effort and analysis that has gone into producing this draft management plan. As an initial matter, it is important to note that, in addition to affecting agricultural uses, excessive total dissolved solids also adversely impact aquatic life, fisheries and native vegetation communities.

We wish to focus your attention on three related issues. Essentially, the TMDL fails to account for and resolve adequately the contribution made to total dissolved solids by: 1) livestock grazing; 2) the use, both legal and illegal, of off-road vehicles and other motorized vehicles; and, 3) road building and route blazing in the Paria River Watershed. Each of these activities functions to destroy vegetation and soil communities, increase soil erosion, and trample and destroy stream banks. These factors all contribute to

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in turn, increases in total dissolved solids (TDS), thereby jeopardizing aquatic life and riparian area dependent species, as well as agriculture. We believe that your failure to address livestock use, motorized vehicle use and road building and route blazing is remiss, as these uses contribute significantly to TDS as well as other water pollution.

More specifically:

The Watershed Plan Fails to Provide Sufficiently For Improvement in Riparian Conditions.

As with the Escalante Plan, DWQ indicates that one of the objectives of the Watershed Management Plan is to "[i]mprove stability of the stream channel and minimize stream bank erosion in impaired reaches of the Paria River and its tributaries." Plan at 31. However, DWQ fails to define sufficiently its methods for accomplishing riparian enhancement through implementation of the Plan. DWQ must define the necessary riparian enhancement projects and provide for assurances of implementation.

Moreover, DWQ fails to recognized that motorized vehicle use **is permitted in the Paria River corridor** and occurs throughout the Paria River Watershed. This activity destroys riparian vegetation and stream banks and stirs up sediments in the river itself as the vehicles repeatedly cross the river. That this activity occurs along the river, as well as throughout the area must be address by the Watershed Plan.

In addition, DWQ fails to recognize the need for additional collaboration with the Bureau of Land Management (BLM). Clearly, BLM land management decisions do not assure improvement of the riparian habitat and cannot be relied on to do so. The Monument Plan has been in effect since 1999. Yet, based on DWQ monitoring in 2003, the Plan has not resulted in sufficient improvements in erosion control and soil stability. Moreover, BLM is several years behind schedule in the completion of a Grazing Management Plan that complies with the Monument Plan and is currently managing livestock grazing under an out-dated, decades-old plan that predates the Monument Plan.

Accordingly, DWQ must define and fund the necessary riparian restoration projects more clearly and provide for clear collaboration with the BLM to assure riparian enhancement. This collaboration should work toward the closure of the Paria River corridor to motorized vehicles.

The Watershed Plan Fails to Consider the Contribution of Grazing, Motorized Vehicle Use and Roads and Route Blazing to TDS.

The Watershed Plan fails to focus on other significant causes of soil erosion which increase the amount of dissolved solids carried by the Paria River. The Watershed Management Plan fails to account for sources of erosion, such as livestock grazing, motorized vehicle travel, and roads and route blazing. Increased sediment loads also lead to scouring of stream channels and the destruction of riparian vegetation, which in turn foster increased dissolved sediment loads.

Motorized vehicle use causes soil erosion by crushing soil communities and loosening surface soils, which are transported to rivers systems by rainwater and snow melt. In addition, this use causes soil compaction, which results in increased soil runoff. As well, soil compaction hinders revegetation by making it more difficult for plant roots to penetrate soils. Also, motorized vehicle use directly damages vegetation, including riparian vegetation, which DWQ acknowledges leads to water quality impairment and an increase in TDS. Roads and blazed routes are also a significant source of sediment. The Watershed Management Plan fails to consider any of the adverse impacts of motorized vehicle use and roads and routes on the excessive TDS of the Paria River.

In addition, the Watershed Management Plan fails to consider the erosive impacts of livestock grazing in uplands and riparian corridors of the Paria River Watershed. Grazing, by removing vegetative cover and trampling soil crusts, increases bare ground. As slope and bare ground percentages increase, erosion increase. Although the erosive forces of livestock grazing are well documented, the Watershed Management Plan lacks sufficient consideration of the potential impacts of livestock grazing on the uplands and in the tributaries on the TDS impairment of the Paria River.

For example, White et al. (1983) found sediment yield 20-fold higher in a grazed watershed when compared to an ungrazed watershed. USDA (1981) reported that topsoil erosion rates from grazed forest and rangeland were 4.2 tons/acre-year and 3.1 tons/acre-year compared to less than 1 ton for healthy forest and range. Packer (1998) documented that loss of soil in Utah and Idaho watersheds through erosion and runoff increased as ground cover decreased. A decrease in ground cover from 40% to 16% resulted in 6 times more runoff and 5.4 times more sediment yield. Trimble and Mendel (1995) estimated that peak storm runoff from a 120 ha basin in Arizona would be 2 to 3 times greater when heavily grazed than when lightly grazed. Lusby (1979) studied grazing systems including removal of livestock from control watersheds in Badger Wash, Colorado. He found that during the period 1953 to 1973, complete exclusion of livestock resulted in over a 40% decrease in runoff and a reduction of 63% in sediment yield.

While the above literature demonstrating the relationship between livestock grazing and erosion rates is certainly instructive, even more telling are those studies that have measured both vegetative cover and erosion rates on both grazed and ungrazed sites in arid regions. For example, Gamougoun et al. (1984) found that the 3-year average of standing biomass in a grazing exclosure in New Mexico was 1,550 kg/ha, whereas a nearby moderately grazed pasture contained a 3-year average of 637 kg/ha of standing biomass. The same study found that the erosion rate (measured as the mean wet sediment production resulting from simulated rainfall) on the ungrazed site was 38 kg/ha, whereas the erosion rate on the moderately grazed site was 153 kg/ha. In a similar study conducted by Meeuwig (1965) in Utah, it was found that combined grass and forb cover on the ungrazed site was 58.4%, whereas forb/grass cover on the grazed site was 49%. The same study found that the erosion rate (measured as the mean wet sediment production resulting from simulated rainfall) on the ungrazed site was 173 lb/acre, whereas the erosion rate on the moderately grazed site was 840 lb/acre.

Accordingly, DWQ must account for and resolve the contributions to excessive TDS in the Paria River made by roads, routes, motorized vehicle use, and livestock grazing in the uplands and tributaries of the Watershed. By failing to do so, DWQ has failed to account for significant causes of the TDS impairment and is overlooking opportunities to address the TDS impairment of the Paria River.

Thank you for your consideration of these comments. Thank you as well for your efforts to protect and restore Utah's waters. Please feel free to call me about this and other matters.

JORO WALKER, Esq.
Director, Utah Office

State of Utah

Department of Environmental Quality

Dianne R. Nielson, Ph.D.
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

JON M. HUNTSMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

Joro Walker
Western Resource Advocates
1473 South 1100 East, Suite F
Salt Lake City, UT 84105

Re: Response to comments on Draft Paria River and Escalante River Watershed Water Quality Management Plans and TMDLs

Dear Joro,

Thank you for your interest and comments on the Paria and Escalante River Water Quality Management Plans (WQMP). I will address comments made on the Paria River WQMP first followed by the Escalante WQMP and simultaneously where appropriate.

The first comment on the Paria WQMP regarding the effects of Total Dissolved Solids (TDS) on aquatic life, fisheries and native vegetation communities is true but actual concentrations in the Paria River are well below the concentrations required to cause toxic effects on plant and animal life by an order of magnitude or more. The water quality standard of 1,200 mg/L TDS is set to protect the most sensitive crops (fruit trees) from the long term, chronic effects of high TDS water and its effects on soil structure and fertility.

In evaluating the sources of TDS and temperature for the Paria and Escalante WQMPs we did not find any direct evidence of TDS or temperature loading related to livestock grazing, off-road vehicle use or road building. As you have pointed out these activities can contribute to increased erosion and loss of riparian vegetation. However, we believe the implementation of current guidelines and management objectives set forth within the GSENM's management plan, such as forage utilization standards and trail designations, are sufficient to minimize the effects of anthropogenic activities on the water quality of the Paria and Escalante Rivers and their tributaries.

In response to the comments on the Paria and Escalante WQMPs failure to sufficiently provide for improvements in riparian condition it must be understood that the WQMPs are intended to serve as long-range planning documents that attempt to identify the types of activities that will lead to water quality improvements and to provide the template language for grant applications that would address site-specific needs. In addition, under current guidelines provided by EPA, TMDLs are not required to provide assurances for implementation of nonpoint source controls.

I was surprised to read in your comments on the Paria WQMP that motorized vehicle use is permitted in the Paria River corridor so I asked James Holland, Hydrologist for the GSENM and he indicated to me that it is not permitted. I am aware that enforcement of OHV restrictions is a significant challenge and will make a recommendation within the WQMP that education and enforcement of OHV regulations remain a high priority.

I agree that additional collaboration between DWQ and BLM is needed on achieving our shared goal of maintaining and improving riparian health and would like to acknowledge the efforts of Joni Vanderbilt and James Holland (GSENM) in helping us to complete these plans. I also need to clarify that there are currently no State monies available to fund water quality projects on federal lands and that Federal land management agencies are in-eligible to receive the federal cost-share grant money the DWQ receives to address non-point source issues.

In response to your comment regarding riparian enhancement within the Escalante WQMP it should be pointed out the creeks that are "… influenced by springs and are characteristically narrower providing longer periods of topographic shade." are a result of natural conditions that cannot be achieved throughout the watershed through management direction. The characteristic narrowness refers to the canyon walls of these creeks, not the width of the creeks themselves. The Escalante WQMP will be revised to more accurately convey this.

The statement within the Escalante WQMP that the "primary potential source of temperature alteration within the public lands is from livestock grazing." is incorrect. What the authors intended to convey was that prior to the retirement of grazing permits along the Escalante River livestock grazing was the most significant land use in that area. More accurately, livestock grazing was one of several factors that contributed to the incidental introduction and establishment of non-native invasive plants such as Russian olive and tamarisk. The non-native vegetation in many areas has since replaced the native flora including cottonwoods and willows that provide more effective stream shading. Therefore the Escalante WQMP will be revised in this section to more accurately convey the mechanisms involved in the decline of cottonwoods and willows and the increasing dominance of Russian olive and tamarisk.

With regards to the effects of upland erosion on the temperature impairment you are correct that streams with high suspended solids concentrations are more prone to absorb heat and scour stream channels. But it is a unique feature of the Escalante River watershed that during periods of intense rainfall when soil erosion occurs is also when flows are highest and stream temperatures are lowest. Obviously soil erosion is not desirable and should be minimized to the extent practicable but there is no direct link between upland erosion and stream temperature.

In our attempt to faithfully characterize the water quality of the Paria and Escalante River Watersheds we found that natural and unalterable conditions preclude the attainment of the 1,200 mg/L TDS standard for the Paria River and the 20°C temperature standard for the Escalante River and have proposed site specific criteria that reflect this. However, we will continue to work with the GSENM to address water quality issues while also recognizing the natural and practical constraints of the watershed's character.

I sincerely appreciate the time and effort you've invested in commenting on the Paria and Escalante WQMP's and believe they will help improve the clarity and focus of these plans. I also welcome further dialogue and increased participation with you on water quality issues within southern Utah and throughout the State. If I can be of further assistance or answer additional questions please feel free to contact me or Carl Adams, our representative directly responsible for the development of the discussed TMDLs.

Sincerely,

Harry Judd
TMDL Manager