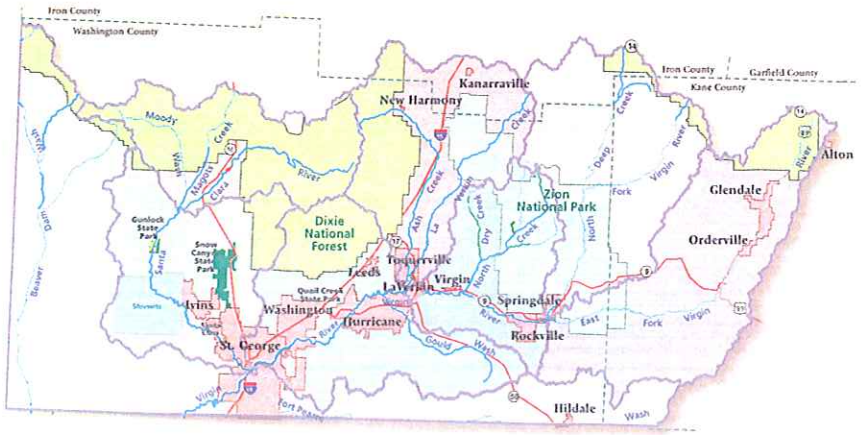
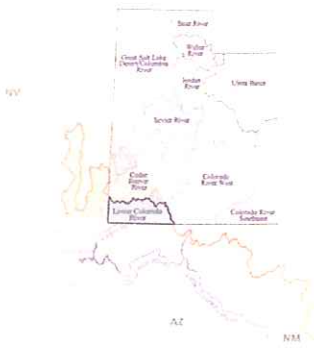
Virgin River Watershed Management Plan

February 2006





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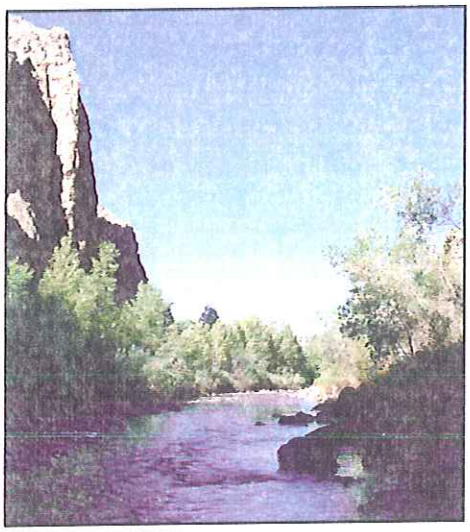
Section One

Watershed Management Planning

The Virgin River Watershed



THE VIRGIN RIVER WATERSHED is an area of land that covers portions of southwest Utah, southeast Nevada, and northwest Arizona (Figure I-1). To trace the Virgin River watershed on a map, you would begin in the southwestern corner of Iron County and trace the watershed boundary in a southeasterly direction into Washington County, through the Dixie National Forest where Moody Wash and Magotsu Creek begin to form the Santa Clara River. Follow the boundary of the Virgin River watershed east along the northern portion of Washington County past Route 18, where it dips south again, and heads north back into Iron County moving east past Kanarraville and Route 16 and past Route 14. Here the watershed boundary begins to dip south again, crossing into Kane County where Deep Creek and the North Fork of the Virgin River have their origin. The boundary rises north to where Routes 14 and 89 intersect, just west of Alton,

What Is a Watershed?

A watershed is a geographic area that drains to a common outlet such as a point on a larger stream, a lake, an underlying aquifer, an estuary, or an ocean. Natural features define the boundaries of a watershed, not political or jurisdictional boundaries. As a result, watershed boundaries may transect portions of cities, counties, and states.

This definition takes into account the waters that flow through an area, as well as the different land uses that surround those waters. These land uses include residential areas, commercial areas, forested land, and agricultural land. In addition, this definition considers the people that live in an area—even if they live in different counties, cities, or states—and the actions and decisions these people make on a daily basis.

and then runs south parallel to Kanab Creek just east of Glendale, Orderville, Mount Carmel and Mount Carmel Junction.

If you wanted to trace the boundaries of the entire Virgin River watershed, you would cross the Nevada and Arizona borders. Given that this plan focuses on the portion of the Virgin River watershed within Utah's boundaries, you can trace the Arizona-Utah border as the southern boundary of the watershed and the Nevada-Utah border as the western boundary of the watershed. However, the watershed itself never stops at these state boundaries; it continues to flow into the Colorado River.

For the purposes of this plan, the Virgin River watershed means the area of land in Iron, Washington, and Kane Counties that drains into the Virgin River. It takes into account all activities that happen within these boundaries and all the people who live, work, and visit this area.

Watershed Management

Everything that happens within the boundaries of a watershed affects the condition of the watershed. Clean, healthy watersheds can support our many uses (e.g., drinking water, agriculture, recreation), as well as the needs of wildlife and their habitat. To ensure watersheds can meet all of these needs, it is important to understand how our actions impact watershed conditions.

There are two important factors that influence the health of a watershed: (1) water quality and (2) water quantity. Both of these factors are linked to activities that take place on the land. When it rains, more than just water flows into the streams and rivers within a watershed. Water that travels over the land picks up pollutants such as debris, dirt, chemicals, and animal waste, and carries these pollutants to nearby waterbodies. These pollutants can cause harm to us at certain levels and make it dangerous or expensive for us to use our water. Not only can these pollutants disrupt our use of local waterbodies, but they can also cause harm to the wildlife that rely on healthy watersheds.

In addition to water quality, land use activities can also impact water quantity within a watershed. Increases in water use, or changes to the natural function of a waterbody, may decrease the amount of water that flows in a stream or river. In watersheds characterized by hot, dry climates, water quantity may be naturally limited. Further impacts on water quantity can result in insufficient flows to support our uses, such as irrigation and drinking water, and to sustain water-dependent wildlife.

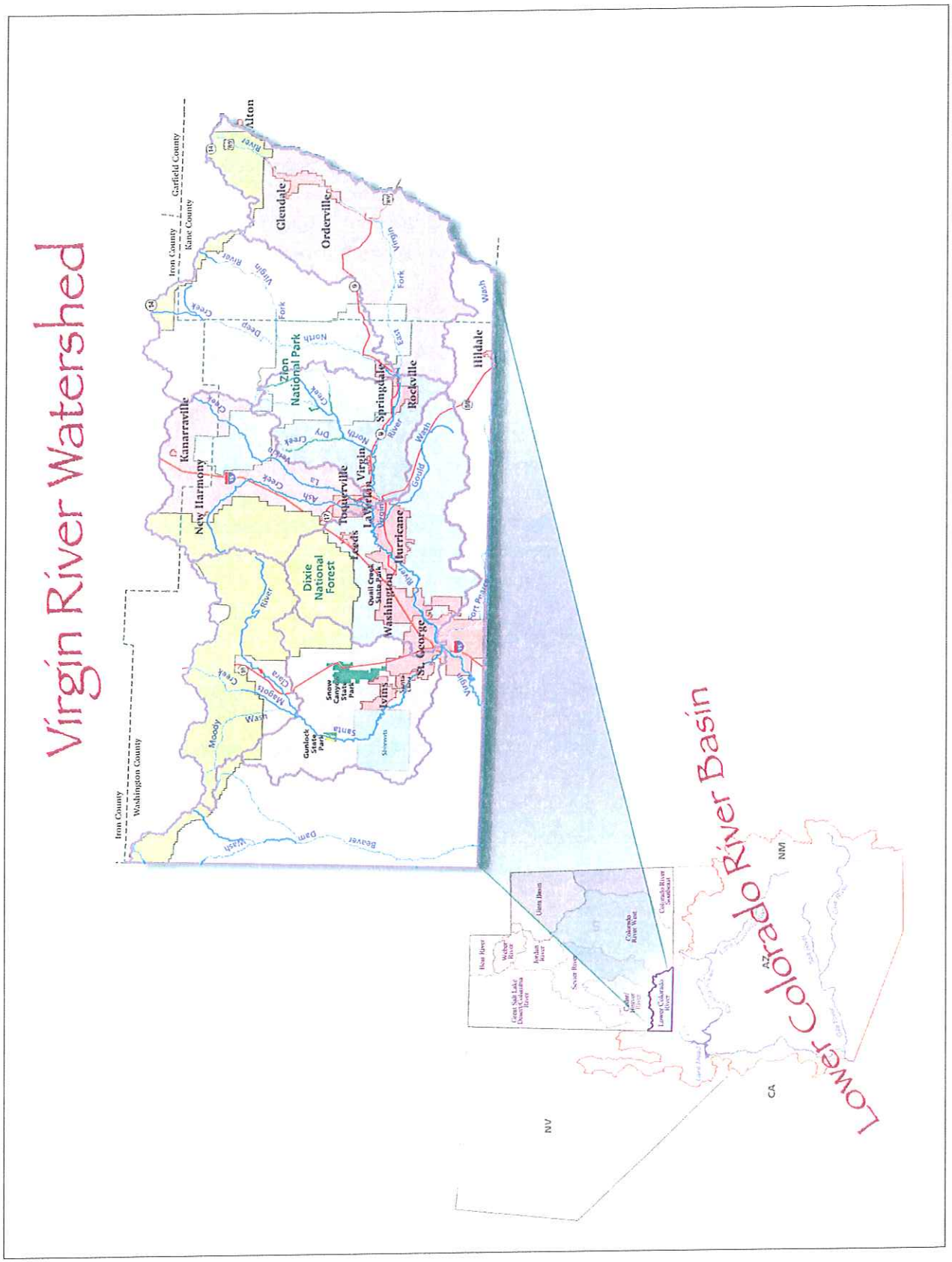


Figure I-1. The Lower Colorado River Watershed in Utah, Nevada, and Arizona with Utah's portion of the Virgin River Watershed

By understanding how a watershed functions and how our decisions impact watershed conditions, we can take action to improve and protect our water resources. There are a wide range of activities that will improve water quality and increase water quantity. Some of these activities may include changing personal behaviors that have a negative impact on the watershed, such as over-watering our lawns, crops, and golf courses or neglecting the maintenance of our septic systems. Other activities may include changing the way we do business, such as improving the management of livestock manure from animal feeding operations or sediment from construction sites.

Watershed Management Planning

By their very nature, watersheds are complex. Embraced within their boundaries is a mix of people with varying political, social, economic, and cultural interests and issues. In some cases, people have conflicting interests and goals related to water. For example, recreational users might want more water in a stream to support fish populations, but farmers need the water for irrigation to grow their crops. In other cases, some people within a watershed may work toward similar goals, but they aren't aware of each other's efforts. As a result, time and money is needlessly spent on duplicative activities while other important issues go unaddressed. Even if water is important to them, many people have never heard the word "watershed" and may not understand how it relates to their everyday lives.

A watershed management plan can address all of these issues; it is a tool for facilitating coordination and cooperation, obtaining funding for projects within the watershed, and educating stakeholders on watershed problems and solutions. Using a variety of data and information, a watershed management plan can answer the following questions:

- Where are we now?
- Where do we want to go?
- How will we get there?
- When will we know that we have arrived?

Watershed management planning is a dynamic process that involves several iterative steps. The first phase, data collection and analysis, consists of identifying goals and objectives, identifying and prioritizing problems, and compiling and analyzing data. The second phase in watershed management planning is decision support. This phase includes developing, evaluating, and selecting management strategies (i.e., best management practices). The third phase, implementation and evaluation, involves applying the selected management strategies and monitoring the effectiveness of these strategies. The information and data generated in each phase feeds into the other

phases of watershed management planning, and stakeholders provide input throughout the entire process.

Most watershed management plans contain the following elements:

- A description of the watershed, including the physical setting, land use, important wildlife species, and a history of the area
- Current watershed conditions (i.e. water quality and water quantity)
- Causes and sources of water quality problems, such as pollutants or changes in land use
- Critical areas within the watershed where the greatest problems are occurring
- Goals for the watershed management plan that are measurable and reflect the stakeholders' vision for the watershed
- Actions or practices that address problems in the critical areas to achieve the goals of the watershed management plan
- A strategy for implementing the actions and practices that includes a schedule, responsible partners, and required resources
- A monitoring plan to track the effectiveness of the actions toward achieving the goals of the watershed management plan
- A strategy for evaluating and adapting the watershed management plan based on monitoring data.

Stakeholders are individuals that impact, and are impacted by, decisions made in a watershed. They have the responsibility for implementing decisions, and have the ability to impede or assist in implementing the decision.

Through the development of a watershed management plan, the people who have a vested interest in the watershed—also referred to as stakeholders—can collaborate to create a vision and a strategy for achieving that vision. Stakeholder participation in the development process is essential because the real challenge of watershed management begins once the initial plan is complete. Watershed management is not about writing a document that sits on a shelf—it is about creating a useful road map for improving watershed conditions over time. Successful implementation of the actions and strategies identified in the watershed management plan will largely depend on the commitment and involvement of stakeholders. Without their support and participation, a watershed management plan will become a static report instead of a dynamic plan for action.

Watershed Management Activities in the Virgin River

This is not the first plan developed for the Virgin River. For years, the Virgin River has been the subject of many studies and plans. Given the interstate nature of the Virgin River watershed, the scope of these past studies and

plans has varied. The purpose of these studies and plans has also varied, influenced by factors such as regulatory requirements and data collection needs. A list of watershed plans and studies preceding this watershed management plan include:

- Planning for Water Quality in the Virgin River System in the State of Utah: A Program for Developing a Comprehensive Water Quality Management Plan. March 1974.
- The Virgin River Basin Study: A Regional Approach to Multi-objective Planning for Water and Related Resources. June 1977.
- Water Quality Phase of 208 Waste Water Quality Management Program. July 1975 to July 1977.
- Virgin River Study. December 1977.
- Washington County Water Management and Conservation Plan. 1993/1994.
- Dixie Resource Area Proposal Resource Management Plan and Final Environmental Impact Statement. September 1998.
- Virgin River Management Plan. June 1999.
- Zion National Park General Management Plan. August 2001.
- Environmental Assessment for the Santa Clara Pipeline. October 2002.

Current Watershed Planning Activities

There are many new studies and planning activities focusing on the Virgin River watershed. Through these current, ongoing efforts, partners and stakeholders are generating new data and information on the Virgin River watershed that are essential to this watershed management plan. Where possible, this watershed management plan will attempt to integrate with these current programs and plans. For example, much of the data and information collected for recent planning activities have informed the development of this watershed management plan. Management practices identified through recent planning activities will also be integrated. The goal is to avoid duplication of effort and to select a suite of complimentary management practices that produce a comprehensive strategy. A description of key recent studies and planning activities is provided below.

Total Maximum Daily Load

Under the Clean Stream Water Act, the State of Utah is required to assess its streams and lakes and establish and maintain water quality standards to protect, restore, and preserve the quality of its waters. All streams are assigned a designated use, these include: drinking water, recreation, fishing and aquatic life, and irrigation/stock watering. The different designated

stream uses are assigned different water quality standards and protections to support the use. When an assessment demonstrates that a waterbody is not meeting water quality standards for a particular parameter or standard, it is categorized as impaired and placed on Utah's section 303(d) list of impaired waters. UDEQ must develop a Total Maximum Daily Load (TMDL) for the pollutant(s) causing the impairment.

A TMDL is a detailed analysis and plan for reducing the pollutants causing the impairment. The analysis characterizes the watershed, identifies sources contributing to the water quality impairment, and determines the amount of pollutants the impaired water body can receive without exceeding water quality standards. A strategy for achieving water quality standards through the TMDL, referred to as an implementation plan, identifies a series of conservation and management practices that can be implemented.

Various segments of the Virgin River are listed on Utah's 2002 section 303(d) list of impaired waters for total dissolved solids, dissolved oxygen, temperature, and total phosphorus. UDEQ, in conjunction with the Washington County Water Conservancy District, initiated the development of TMDLs to address these impairments. The results of that process are described in detail in the *TMDL Water Quality Study of the Virgin River Watershed* (UDEQ 2004) and are also summarized below:

Beaver Dam Wash Temperature Listing

- Remove from 303(d) list because temperature standards are naturally exceeded.

North Creek Total Dissolved Solids Listing

- Remove from 303(d) list because total dissolved solids standards are exceeded because of natural causes.

Santa Clara River Total Dissolved Solids and Temperature Listings

- Remove 303(d) listing for temperature because temperature was found to be well within required standards.
- Implement strategies to reduce dissolved solids to the stream including selenium.

Baker Dam and Gunlock Reservoir Total Phosphorus and Dissolved Oxygen Listings

- Implement strategies to reduce existing loads of total phosphorus in Baker Dam and Gunlock Reservoir.

Virgin River Total Dissolved Solids Listing

- Implement a new total dissolved solids standard due to naturally high total dissolved solids concentrations.

Drinking Water Source Protection Plan

The Virgin River water is diverted for use as drinking water in three areas—Quail Lake, the Quail Lake diversion dam, and at the drinking water intake for Springdale. To ensure that the water is a high quality source of drinking water, UDEQ requires the development of a Drinking Water Source Protection (DWSP) Plan. A DWSP Plan focuses on preventing the contamination of water used as a drinking water supply before it is treated and distributed. High quality source water reduces the need for costly drinking water treatment technologies and contributes to the delivery of safe, clean drinking water to a community.

The purpose of a DWSP Plan is to determine how susceptible the drinking water supply is to potential contamination sources, such as polluted runoff from urban areas and agricultural land, and identify strategies to manage these sources. Key activities for developing a DWSP Plan include:

- Defining source water protection zones based on proximity to the drinking water source.
- Determining how vulnerable a drinking water source is to contamination by identifying potential contaminant sources in each protection zone, as well as assessing the surrounding natural setting and the structural integrity of the drinking water intake.
- Identifying management strategies, such as public education and pollution prevention practices, for the potential contaminant sources posing the greatest risk to the drinking water source.

Storm Water Management Plans

In response to recent federal National Pollutant Discharge Elimination System program storm water requirements, UDEQ issued a Phase II municipal separate storm sewer system (MS4) general permit. Phase II MS4 permit requirements apply to the following cities and towns in the Virgin River watershed:

- St. George
- Santa Clara
- Washington
- Ivins

This permit requires cities to develop a storm water management plan that addresses six minimum control measures and defines measurable goals for tracking success in implementing these measures. The six minimum

control measures, requirements intended to reduce the type and quantity of pollutants contaminating runoff from an urban area, are as follows:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site storm water runoff management
- Post-development storm water management
- Municipal good housekeeping and pollution prevention.

Cities and towns required to develop a storm water management program have a five-year period, beginning on December 9, 2002, to develop and fully implement their programs. Ideally, the management practices selected to fulfill the requirements of the six minimum control measures will integrate with the strategies identified in Section 4 of this version of the Virgin River Watershed Management Plan. Conversely, as storm water management programs take shape and new information becomes available, the Virgin River Watershed Management Plan should reflect this information and storm water management practices.

The Virgin River Watershed Management Plan

The process for developing the Virgin River Watershed Management Plan has depended on sound science and continuous stakeholder involvement. It was initiated in 1998 by the Virgin River Management Plan Coordinating Committee, the group responsible for developing the 1999 Virgin River Management Plan. The purpose was very broad in its scope and included: improved communications for watershed issues, develop information opportunities for the public, provide water resources to meet the county's needs, address habitat improvement for endangered species, improve water quality, etc. The Committee invited representatives from several other stakeholder groups to participate in developing the Virgin River Watershed Management Plan, including Kane County, Dixie National Forest, the Bureau of Land Management, the Natural Resources Conservation Service, Zion National Park, and Dixie Soil Conservation District. This expanded group became known as the Virgin River Watershed Advisory Committee (VRWAC).

During 1999 the VRWAC focused on developing four working groups, obtaining input from the public and defining the mission and scope of the Virgin River Watershed Management Plan. Three public meetings hosted by the VRWAC in St. George, Hurricane, and Orderville gave watershed stakeholders the opportunity to learn about the Virgin River Watershed Management Plan and volunteer to participate on the four work groups

Partners in the Virgin River Watershed Management Planning Process

Washington County Water Conservancy District

Dixie National Forest

Utah Department of Environmental Quality, Division of Water Quality

Bureau of Land Management

City of St. George

Town of Springdale

Washington County

U.S. Natural Resources Conservation Service

Dixie Soil Conservation District

Kane County

LaVerkin Bench Canal Company

Town of Rockville

City of Ivins

Ash Creek Special Service District

Zion National Park

Utah Department of Natural Resources

St. George Washington Canal Company

Iron County

City of Santa Clara

Shivwits Band Paiute Indian Tribe

City of LaVerkin

Five County Association of Governments

City of Hurricane

Kane County Water Conservancy District

U.S. Forest Service

Virgin River Land Preservation Association

People for the USA

City of Washington

Utah Division of Water Resources

Virgin River Program

Utah Division of Water Rights

Partners in boldface are major contributors to the Virgin River Watershed Management Plan

addressing water quality, water quantity, land use and ground water. At this time, the VRWAC composed the following mission statement:

> *We intend to maintain and enhance the water quality and associated natural resources of the Virgin River Watershed in Utah through education, good management practices and voluntary cooperation while respecting property owner rights.*

The VRWAC also established the following objectives:

- Address all impaired waters on the 303d list
- Maintain or improve existing water quality conditions.

Members of the four work groups participated in training sessions on issues related to watershed management, including water quality standards and water quality assessments. During their meetings, work group members also

began the process of identifying problem areas within the watershed and prioritizing these problems. As the process moved forward, the VRWAC realized the challenges associated with developing a watershed management plan relying solely on volunteers. In 2000 several partners participating on the VRWAC provided funding to hire a consultant to develop the watershed management plan through a process that relied upon stakeholder input.

Work on the Virgin River Watershed Management Plan began again in October 2002 with the VRWAC and the consultant hired to facilitate the development of a comprehensive watershed management effort. This comprehensive approach included the development of TMDLs for impaired waters in the Virgin River watershed, the DWSP Plan for the three surface water intakes in the watershed, and the locally-led watershed management plan.

The process to develop this comprehensive watershed management plan builds upon other watershed management planning approaches used by Virgin River stakeholders (e.g., U.S. Forest Service representative from Dixie National Forest) and other watersheds around the country. The process also uses the products (e.g., reports, work group input) developed through the earlier efforts of the VRWAC (Table I-1). The goal of the process has been to generate and integrate the maximum amount of stakeholder input and accurate scientific information to meet the objectives of the VRWAC and the needs of people that reside in the Virgin River Watershed.

Use of the Watershed Management Plan

Catalysts for this plan include the need to meet water quality standards and to provide safe, clean drinking water supplies. In addition to these catalysts, driven by federal and state regulations, stakeholder issues and concerns have significantly shaped the direction of this plan. The Virgin River Watershed Management Plan is intended to be a dynamic, evolving action plan for conserving the Virgin River water resources to meet the needs of the people who live and visit the watershed. This evolution is dependent on watershed stakeholders and partners participating in the VRWAC.

A dynamic and evolving watershed management plan is one that places emphasis on assessing watershed conditions, determining the cause of problems or impairments, and the effectiveness of management strategies. The plan should prioritize problems or needs in the watershed and provide at least conceptual solutions to problems. As watershed stakeholders implement the strategies outlined in this version of the plan, it is essential that the successes of these strategies are monitored and evaluated to determine their effectiveness. Based on monitoring data and other evaluation information, watershed stakeholders and the VRWAC should make adjustments to the watershed management plan, as necessary.

Table I-1. Integration of Existing information into the Virgin River Watershed Management Planning Process

Watershed Management Planning Process	Sources of Information for the Virgin River Watershed Management Plan
Phase I: Data Collection and Analysis	
Identifying goals and objectives	○ Compilation of Stakeholder Key Issues ○ Stakeholder Meetings
Compiling and analyzing data to identify problems	○ Watershed Characterization Report ○ Drinking Water Source Protection Plan Susceptibility Report ○ Stakeholder Meetings
Prioritizing problems	○ Total Maximum Daily Load development ○ Source Water Protection Susceptibility Report ○ Facilitated Meeting
Phase II: Decision Support	
Developing management strategies	○ DWSP Plan Management Strategies Report ○ Total Maximum Daily Load development ○ Washington County Water Conservation Plan ○ VRWAC Input ○ Virgin River Management Plan ○ Virgin River Fisheries Plan
Evaluating management strategies	
Selecting management strategies	
Prepare watershed management planning document	
Phase III: Implementation and Evaluation	
Developing implementation plan and schedule	○ DWSP Plan Management Strategies Report ○ Total Maximum Daily Load Implementation Plan ○ VRWAC Input
Implementing strategies	
Developing evaluation plan	
Conducting evaluation	
Revising watershed management plan	

It is necessary that all watershed partners and stakeholders understand and appreciate that this initial watershed management plan is a very basic conceptual document. It is necessary that updates and additions to the plan occur so that the plan can be a valuable tool in helping to address the problems and needs of the Virgin River watershed. Possible future additions to the management plan could include detailed information regarding: stream water quality and quantity, flood plain management, groundwater resources, water needs and uses, tamarisk mapping and removal, etc.

Virgin River Watershed Management Plan

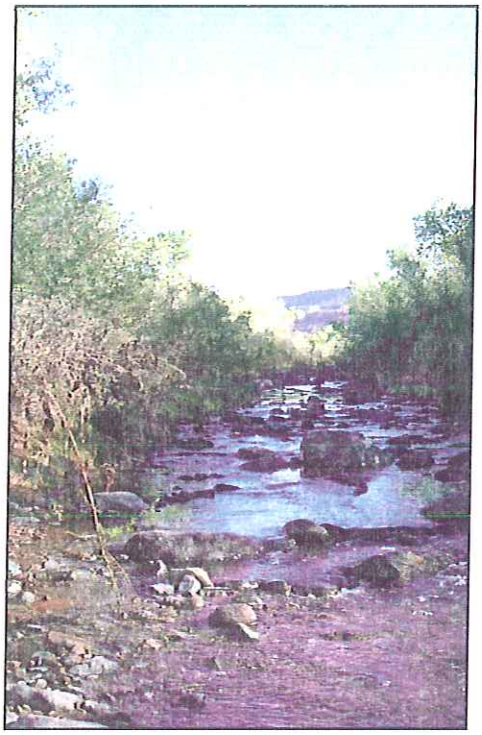
Mission Statement

We intend to maintain and enhance the water quality and associated natural resources of the Virgin River watershed in Utah through education, good management practices and voluntary cooperation while respecting property owner rights. We believe that:

- People can make the world a better place.
- Cooperation and sincere effort are essential to achieve common goals.
- Integrity is essential to all good relationships.
- Knowledge is power.
- When we treat others with consideration we promote good will.
- Private property rights are essential for freedom.
- Multiple use of public lands is a vital principal which must continue.
- Conserving our resources now is essential for future generations.
- Each person is accountable for his/her actions.
- Agriculture is essential to the economic activity of this watershed.
- The benefits of change must be understood to be accepted.
- The decisions used to guide an area are better and more informed when they come through consensus of the people who live in that area.
- And we believe that voluntary action is essential to the success of the Virgin River Watershed Management Plan.

Section Two

Overview of the Virgin River Watershed



WATERSHED BOUNDARIES influence the flow of water over an area of land; they do not typically influence the way we look and think about the land. We are familiar with the political boundaries of areas such as states, counties, cities and towns, school districts, utility districts, private property and federal lands. The boundaries of these areas influence our every day lives by defining the laws that we must follow, the taxes we pay, the schools we can attend, and the services we receive. As a result, thinking on a watershed level requires that we look at familiar boundaries in a different way.

Understanding the characteristics of the Virgin River watershed is the first step in developing a watershed management plan, and to do that, we must understand its unique features and functions. Natural features that affect the characteristics of the Virgin River watershed include soils, climate, topography, plants and

animals, and hydrology. In addition to natural features, human factors such as land use and land ownership also affect the watershed's characteristics. The remainder of this section presents information on both natural features and human factors that characterize the Virgin River watershed.

Natural Features of the Virgin River Watershed

The Virgin River watershed (Figure II-1) is part of the larger Lower Colorado River–Lake Mead watershed, which drains approximately 30,000 square miles of southeast Nevada, northwest Arizona, and southwest Utah. Bounded by the Escalante Desert and the Sevier River watersheds to the north, the Paria River watershed to the east, and Utah's border with Nevada and Arizona to the west and south, the watershed occupies approximately 2,800 square miles of Washington, Kane, and Iron Counties. The majority of the watershed (approximately 76 percent) is in Washington County, while 19 percent is in Kane County and 5 percent is in Iron County.

The principal drainage for the watershed is provided by the Virgin River and its tributaries: the East Fork Virgin River, North Fork Virgin River, North Creek, La Verkin Creek, Ash Creek, Fort Pearce Wash, Santa Clara River, and Beaver Dam Wash.

The information presented in this section has been summarized from the *Virgin River Watershed Management Plan: Watershed Characterization Report* (Tetra Tech 2003). Detailed information and maps related to the Virgin River watershed are available in the report.

Soils

Soil characteristics greatly affect land use decisions and land management practices, and ultimately water quality, in the Virgin River watershed. Soil types throughout the watershed vary greatly from one location to another. For example, soils in the Beaver Dam Wash Watershed Planning Area (WPA) located in the far western portion of the Virgin River watershed generally have higher amounts of salinity and are more erodible than soils in the Upper Virgin River WPA. Salinity and soil erodibility are particularly important to water quality. Soils that are high in salts and easily erodible can contribute to high salinity concentrations and deliver sediment to streams through runoff.

Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. The Virgin River watershed is comprised of very diverse topography that consists of mesas, cliffs, mountain ranges, narrow canyons, and numerous valleys. Mesas are the predominant topologic feature in the southern and eastern

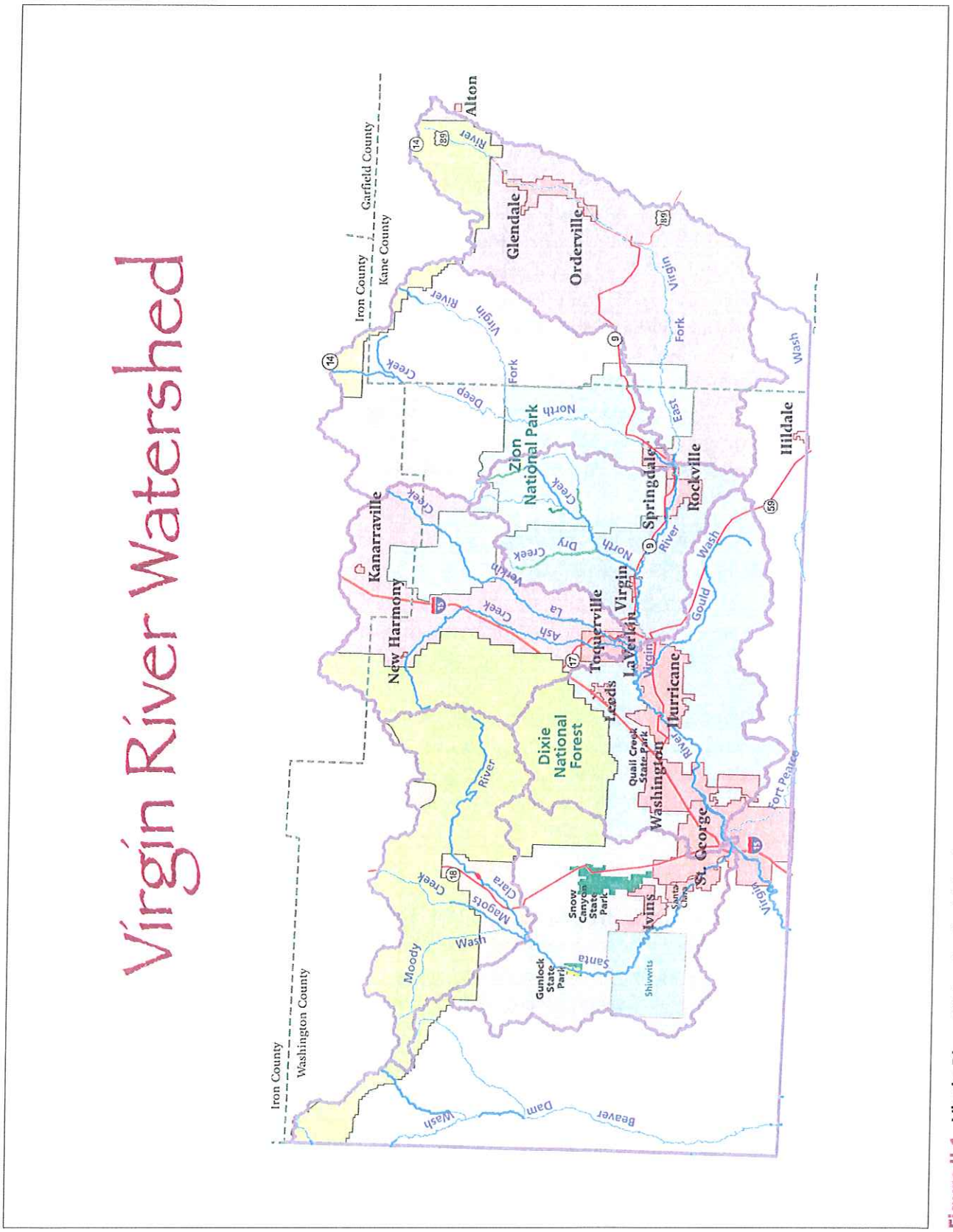


Figure II-1. Virgin River Watershed within the State of Utah

portions of the watershed, and mountainous terrain characterizes the western and northern portions. Elevation ranges from 10,500 feet above sea level in the headwaters of Deep Creek to 2,100 feet where the Virgin River crosses the Utah/Arizona State border.

Climate and Hydrology

Climate in the Virgin River watershed varies greatly and is highly dependent on elevation. Average annual temperatures range from 63.2°F at St. George to 46.1°F at Alton. Some climate stations experience summer temperatures around 100°F, and winter temperatures below zero. The Virgin River watershed has two distinct precipitation seasons. Pacific Northwest frontal systems bring winter and spring precipitation to the watershed in the form of rain at lower elevations and snow at higher elevations. In addition, late summer and early fall thunderstorms bring moisture to the entire basin. Average annual precipitation ranges from 6 to 8 inches annually near St. George and the lower portions of the watershed to approximately 35 inches in the mountains near Pine Valley and the headwaters of the North Fork Virgin River.

Hydrology in the Virgin River watershed is typical of the arid southwest climate. The majority of the watershed is drained by intermittent streams, which only flow during rain or snow melt events and are dry the remainder of the time. Typically, stream flow is the heaviest in late winter and early spring when the Pacific Northwest frontal system brings moisture to the watershed and snow at higher elevations begins to melt. Permanent flow can be observed year round in the Virgin River and its major tributaries. The remaining drainage is made up of artificial canals and ditches predominately used for irrigation purposes. There are also a significant number of diversions and reservoirs throughout the watershed used for diverting and storing water for a variety of purposes including drinking water supplies and agricultural irrigation.

Wildlife

The great diversity in topography, climate, hydrology and land cover results in a very diverse ecosystem with a large variety of wildlife. The area includes small and big game mammals such as Mule Deer that are hunted for sport . Both cold and warm water fish are present including rainbow trout, brown trout, catfish, bass, various panfish and other fish. Some of the fish species native to the Virgin River watershed home include the woundfin minnow, the Virgin River chub, and the Virgin spinedace. The watershed has game birds, waterfowl, migratory birds, raptors and others. Reptiles and amphibians found include snakes, toads, frogs, lizards, tortoises including the mojave desert tortoise—Utah's only native tortoise. These species, as well as other wildlife species living in the Virgin River watershed, depend on the

vegetation located within or adjacent to the Virgin River and its tributaries. Wildlife species use this corridor of vegetation connecting the stream to upland areas, referred to as riparian habitat, as a breeding and feeding ground and migratory routes.

Human Factors

The natural features of the Virgin River watershed have influenced where the first settlers chose to build their homes and plant their crops—eventually shaping future land use decisions, population growth, and other human factors.

The Shivwitts Paiutes were among the early inhabitants of the area and were present when the Mormon pioneers settled the area in the 1850s and 1860s. Early settlers raised cotton, figs, grapes, olives, almonds, and other crops. The area received its name of "Dixie" or Utah's Dixie because of the cotton production and warm climate. Mining was an important part of the local industry and from 1875 to 1880 Silver Reef near Leeds was a booming mining town. Agricultural communities developed along streams or where water could be diverted to suitable lands. The economic base of the area has shifted from its traditional agricultural roots to become dominated by the tourism, education, services, trade and construction industries. Interstate 15 transects the county from the southwest corner to the northeast and connects Las Vegas and California through St. George to Salt Lake City and points northward. Zion National Park attracts about 2.5 million visitors annually from all over the world. Dixie State College has grown to be a respected four-year state college. Many people find the area attractive for retirement because of the warm climate, beautiful scenery, and comfortable lifestyle.

Land Use

Land use and land cover are important in making management decisions in a watershed. How people use the land and the density and locations of various vegetation play an important role in stream stability and water quality as well the viability of wildlife and their habitat.

The break down of major land uses in the watershed by percentage is shown in Figure II-2 and includes shrubland, forest lands, grass lands, and agricultural lands. Shrubland dominates the lower elevations of the watershed while higher elevations are predominately forested. Shrublands and forest lands in

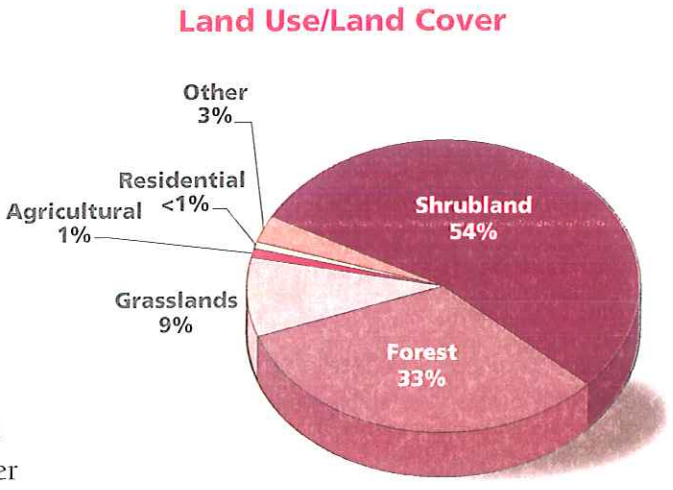


Figure II-2. Percent Land Use/Land Cover in the Virgin River Watershed

the watershed play an important role in controlling the amount of sediment transported to streams in the watershed.

Grasslands are evenly distributed throughout the watershed whereas agricultural areas are mostly located along or near streams. Agriculture is important to the livelihood of people living in the watershed.

Land use and land cover are discussed in more detail for each watershed planning area in Section Three.

Population Growth and Trends

The Virgin River watershed is experiencing rapid population growth. High population growth is a result of the watershed's proximity and accessibility to larger metropolitan areas in surrounding states and its favorable climate conditions. Table II-1 shows the population of the Virgin River watershed by county. Since 1974 and the construction of Interstate 15 to connect St. George with Las Vegas, population in Washington County has increased from approximately 18,000 people to more than 90,000 people in 2000. Population in the three counties that comprise the Virgin River watershed increased by 41,973 people from an estimated 50,050 people in 1990 to 94,023 in 2000. St. George's population increased by 21,161 people (74.24 percent) between 1990 and 2000. Washington County experienced greater population growth than Kane and Iron Counties.

Table II-1. Virgin River watershed population summarized by county.

County	Watershed Population
Washington	88,500
Kane	4,938
Iron	585
Total	94,023

Source: U.S. 2000 Census and GIS analysis.

Urban population centers in the Virgin River watershed are listed by county in Table II-2. The population in Washington County in 2004 is thought to be over 116,000. Most of the watershed's urban population is located in Washington County, with the highest population in the City of St. George (Figure II-3).

Table II-2. Urban population centers in the Virgin River watershed.

Incorporated Cities and Towns	Population	Percent
Washington County		**94.38%**
St. George City	49,663	56.33
Hurricane City	8,250	9.36
Washington City	8,186	9.28
Santa Clara City	4,630	5.25
Ivins Town	4,450	5.05
La Verkin City	3,392	3.85
Hildale Town	1,895	2.15
Toquerville Town	910	1.03
Leeds Town	547	0.62
Springdale Town	457	0.52
Virgin Town	394	0.45
Rockville Town	247	0.28
New Harmony Town	190	0.22
Kane County		**5.27%**
Kanab City	3,564	4.04
Orderville Town	596	0.68
Glendale Town	355	0.40
Alton Town	134	0.15
Iron County		**0.35%**
Kanarraville Town	311	0.35
Total	**88,171**	**100**

Source: U.S. 2000 Census and GIS analysis

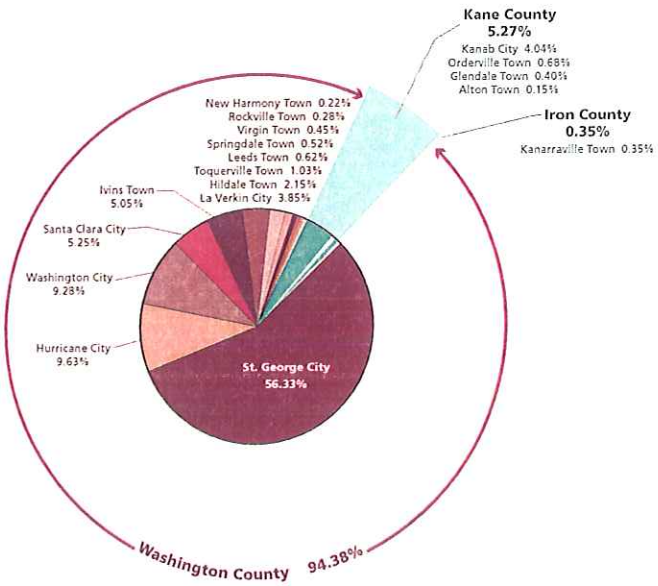


Figure II-3. Distribution of Virgin River Watershed Population by County and Unincorporated Cities and Towns

Land Ownership

Various federal, state, private, and tribal agencies are responsible for managing land throughout the Virgin River watershed (Figure II-4). The U.S. Bureau of Land Management is responsible for managing 780,685 acres (43 percent), while private landowners own 421,314 acres (23 percent). Other land owners/managers include the U.S. Forest Service (Dixie National Forest), National Park Service (Zion National Park), State of Utah, the Shivwits Band of Paiute Indians, and Utah State Parks.

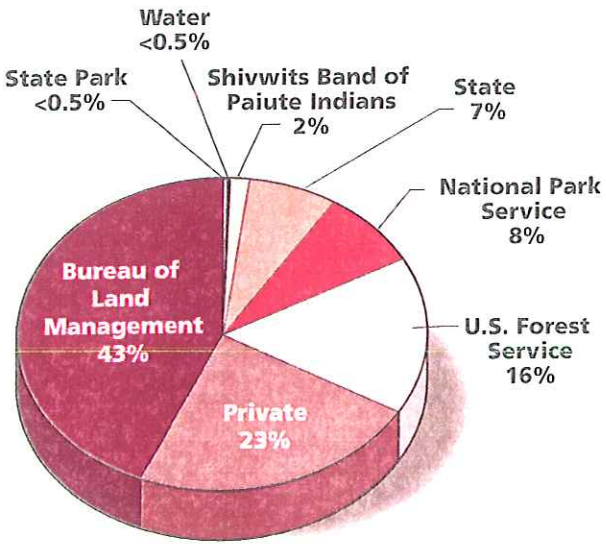


Figure II-4. General land management units in the Virgin River Watershed

Stakeholders

Stakeholders are individuals that affect, and are affected by, decisions made in the watershed. Therefore, stakeholders in the Virgin River watershed include the approximately 94,000 people living in Washington, Kane, and Iron Counties, as well as any people who may live outside of the watershed but work within its boundaries. In addition to people that live and work in the watershed, the definition of stakeholders also encompasses visitors that travel to the Virgin River watershed to enjoy the wide variety of recreational opportunities. The National Park Service estimates that approximately 2.5 million people visit Zion National Park each year!

To understand the human factors that affect the Virgin River watershed, it is necessary to understand the values, concerns, interests, affiliations, and motivations of the watershed's stakeholders.

For the purposes of this initial version of the Virgin River Watershed Management Plan, the stakeholder characterization identifies general categories of stakeholders (Table II-3). In addition, the stakeholder characterization contains a preliminary list of organizations and agencies comprised of watershed stakeholders. It is important to note not all watershed stakeholders are partners in the Virgin River Watershed Management Plan; however these are individuals and organizations that characterize the watershed and may either help or hinder watershed management actions. As with any part of a watershed characterization, stakeholder categories and organizations will change over time; this characterization should be regularly updated.

Table II-3. Virgin River Watershed Management Plan General Stakeholder Characterization

Stakeholder Category	Who Does It Include?	What Do They Care About?
Public landowners	Federal, state, tribal, and local agencies and organizations with land holdings in the watershed	Managing land according to agency mission to meet specific goals
Private landowners	Individuals that own parcels of property within the watershed for personal or business use	Limiting federal, state, and local regulations affecting private property
Federal government	Bureau of Land Management U.S. Natural Resources Conservation Service National Park Service U.S. Forest Service U.S. Fish and Wildlife Service U.S. Environmental Protection Agency	Achieving agency goals and meeting federal regulatory requirements within the agency's purview Establishing partnerships with state and local stakeholders Implementing effective programs
State government	Utah Department of Natural Resources Utah Department of Environmental Quality Utah Division of Water Resources	Achieving agency goals and meeting state and federal regulatory requirements within the agency's purview
Local government	County and city/town departments and commissions responsible for functions that relate to watershed management (e.g., public works, planning commissions, water utilities, parks and recreation)	Providing local citizens with effective and efficient services Improving quality of life for current and future residents within jurisdiction Sustaining local economy
Planning agencies and organizations	County and city/town planning commissions Five County Association of Governments Southwest Utah Planning Authorities Council	Developing and implement planning and zoning ordinances Promoting local development according to local planning goals and objectives
Public health agencies and organizations	Southwest Utah Public Health Department Five County Association of Governments	Protecting and promoting health and safety of residents Providing public health services Conducting regulatory responsibilities (e.g., on-site wastewater permitting)
Residents	Year-round homeowners Seasonal (e.g., cabin, RV parks) residents Renters New home buyers New to the State of Utah New to the Virgin River watershed	Maintaining and improving personal quality of life Increasing property value Paying reasonable mortgage, rent, property taxes Protecting personal property Obtaining quality local services

Table II-3. Virgin River Watershed Management Plan General Stakeholder Characterization (continued)

Stakeholder Category	Who Does It Include?	What Do They Care About?
Tourists	Visitors to the Virgin River watershed that reside elsewhere	Maintaining personal safety Accessing local sights Saving money Obtaining quality services Convenient transportation
Agricultural interests	Local farmers Farm goods suppliers Federal, state, and local agencies addressing agricultural issues (e.g., Dixie Soil Conservation District, extension service, Farm Bureau)	Preserving the ability to farm Tracking federal, state, and local regulation that affects agriculture Educating local farmers on innovative techniques to improve yield and reduce negative impacts on surrounding natural resources
Business interests	Local business owners Chambers of Commerce Five County Association of Governments	Attracting new business to the area Complying with federal, state, and local regulations Generating revenue
Education interests	Students Teachers Local school districts Dixie State College Vocational schools and other training facilities	Providing high quality education Attracting and retaining quality instructors Acquiring funding Achieving state academic goals
Civic groups	Churches Rotary Club 4-H groups Girl and Boy Scouts League of Women Voters (Washington County)	Developing membership Providing services to the community Achieving group goals and objectives
Development interests	County and city/town planning commissions Construction companies Developers	Permitting new developments that meet local requirements Understanding regulations affecting development Generating revenue

Table II-3. Virgin River Watershed Management Plan General Stakeholder Characterization (continued)

Stakeholder Category	Who Does It Include?	What Do They Care About?
Tourism Industry	Hotels Restaurants RV parks and campgrounds Golf courses Wilderness adventure companies (biking, climbing, backpacking, ballooning, etc.) Retail stores Gas stations	Attracting tourists Providing high quality service Generating revenue Complying with applicable federal, state, and local regulations
Recreational enthusiasts	Individuals and businesses that participate in and provide services/equipment that support recreational activities such as: Fishing Hunting Off-highway vehicles Backpacking Camping Boating	Accessing local natural resources for recreational purposes Limiting fees and permitting requirements Ensuring personal safety Generating revenue Maintaining local natural resources to ensure sustained recreational opportunities
Drinking water consumers	Individuals that occupy residences and businesses served by a public water system (i.e., not a privately-owned ground water well)	Obtaining safe drinking water Paying reasonable rates
Non-profit organizations	People for the USA, Grand Canyon Trust, Virgin River Land Preservation Association	Achieving organizational goals and objectives Increasing membership Obtaining funding
Media	Salt Lake Tribune, Daily Spectrum, St. George Magazine, Southwest Utah Magazine, television and radio broadcasters (KCSG, KSL, KUED, KZHK)	Developing unique and interesting stories Meeting deadlines Generating an audience Generating revenue

Section Three

Virgin River Watershed Key Concerns

THE PREVIOUS SECTION painted the big picture of the Virgin River watershed by defining its natural features, characterizing land uses and ownership, and describing the people who affect —and are affected by—the watershed. All of these components acting together over time have influenced the current state of the Virgin River watershed.

This section provides a snapshot of conditions in the Virgin River watershed at this point in time. A snapshot of current conditions is useful in establishing a baseline or a benchmark to measure changes over time and track trends in watershed health. The snapshot consists of a description of water quality and quantity conditions, as well as the conditions of biological communities in the overall watershed. In addition to a description of current conditions, the snapshot provides an explanation of the factors contributing to these conditions.

Water Quality Standards are the yardstick for measuring water quality. They contain the following three components:

- **Beneficial Uses** reflect how we can potentially use the water and how well it supports aquatic life.
- **Criteria**, either narrative or numeric, express the condition of the water necessary to support beneficial uses either as a pollutant concentration or as a statement that waters must be "free from" certain pollutants.
- The **antidegradation policy** describes when the state can allow new or increased discharges of pollutants after demonstrating an important social or economic need.

For purposes of watershed management planning, the Virgin River watershed has been sub-divided into eight watershed planning areas (WPAs). The eight WPAs identified in Figure III-1 include:

- East Fork Virgin River
- North Fork Virgin River
- Upper Virgin River
- Ash Creek/La Verkin Creek
- Lower Virgin River
- Upper Santa Clara River
- Lower Santa Clara River
- Beaver Dam Wash/Fort Pearce Wash.

There is a significant amount of variation within the Virgin River watershed and, as a result, problems experienced in one area of the watershed will differ from problems in another. As part of establishing baseline conditions for the Virgin River watershed, it is necessary to look at what is happening in each of the WPAs. This section identifies and prioritizes key concerns for each of the eight WPAs based on stakeholders input. Information from field visits and other data sources supplement stakeholder input as necessary.

A Snapshot of the Virgin River Watershed: Establishing Overall Baseline Conditions

To establish overall baseline conditions for the watershed, this section will address three factors: (1) water quality, (2) water quantity, and (3) biological health. It is important to remember that this snapshot of the Virgin River watershed reflects currently available data. As new information becomes available, watershed stakeholders and partners should update this section of the Virgin River Watershed Management Plan and, if possible, compare new data against this baseline to determine if watershed conditions are improving or declining.

Water Quality

Water quality is often the primary component for determining the health of a watershed. As the state agency charged with water quality protection, UDEQ regularly monitors waters in the State of Utah for several water quality parameters such as pH, alkalinity, acidity, dissolved metals, turbidity, salinity, bacteria, nutrients, and dissolved oxygen. UDEQ then compares monitoring results to Utah's water quality standards, the goal or target concentrations of specific pollutants in water set to protect certain uses. Designated uses for which the streams are protected include: drinking water, recreational uses including swimming and boating, aquatic wildlife, and agricultural purposes. When monitoring results show that the concentration

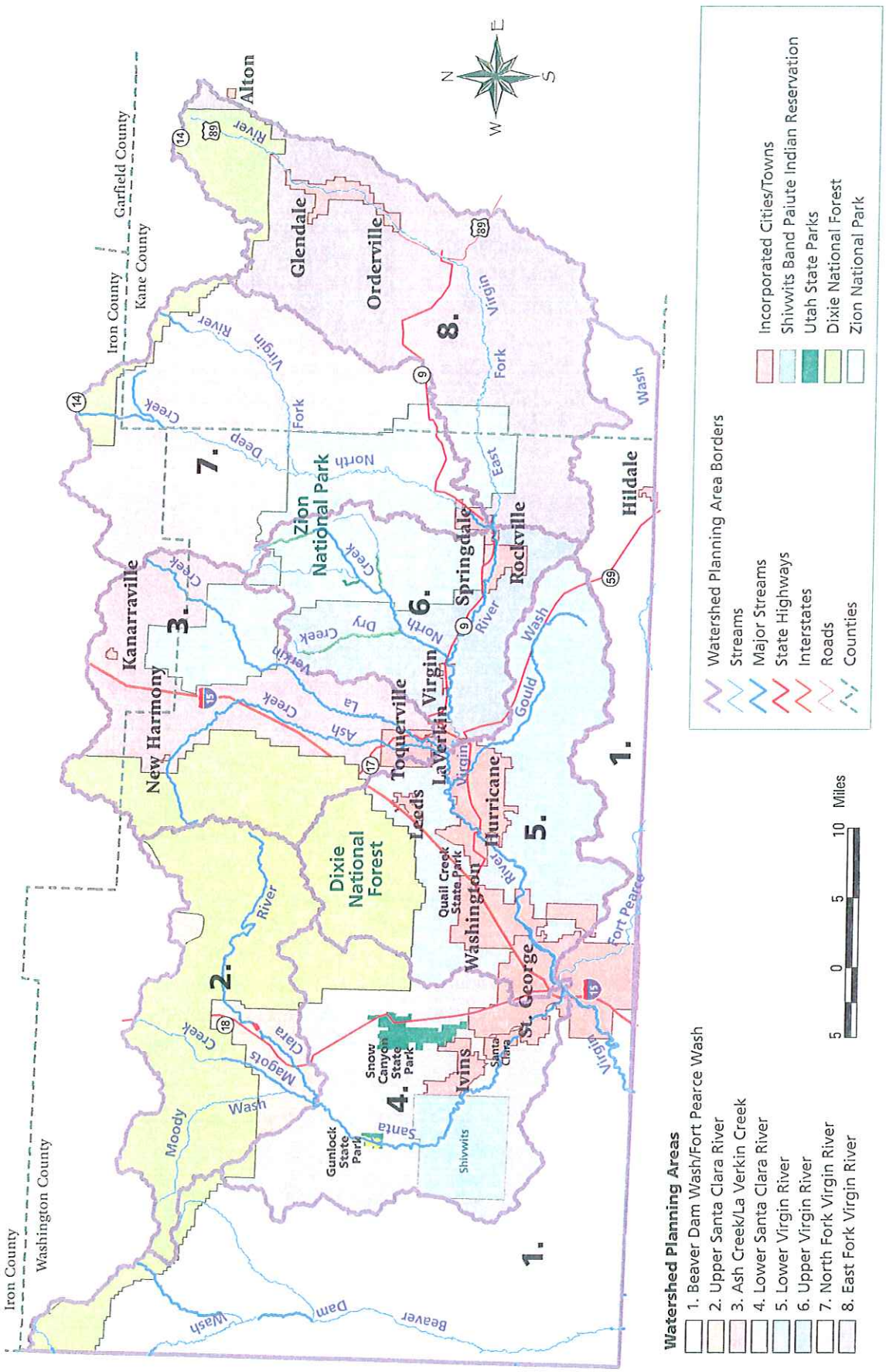


Figure III-1. Virgin River Watershed Planning Areas

of pollutants in a stream, river, or reservoir does not exceed water quality standards, that waterbody is in attainment of water quality standards associated with the particular stream use. The different use classifications have different water quality standards assigned to them to insure that the stream can function as it is intended. Concentrations of pollutants above water quality standards indicate that a waterbody is impaired and belongs on Utah's section 303(d) list of impaired waters.

Time to Review TMDLs

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Once UDEQ calculates the maximum amount, smaller pieces of the TMDL pie (allocations) are allotted to pollutant sources, such as wastewater treatment plants and animal feedlots.

What is Causing Water Quality Impairments in the Virgin River Watershed?

Low Dissolved Oxygen

What Is it? Dissolved oxygen is the term used to describe the form oxygen takes in water. Cold, running water holds more dissolved oxygen than still water or water at high temperatures. Water with organic material tends to have less dissolved oxygen because microorganisms consume oxygen during the decomposition process.

What Causes It? Discharges from wastewater treatment plants, failing on-site septic systems, and feedlots contain organic materials that microorganisms decompose, resulting in low dissolved oxygen.

Why Is It a Problem? Conditions that cause low dissolved oxygen levels (e.g., dense algal growth) can cause water to be unsafe for recreation, or have an unpleasant odor and/or appearance. Low dissolved levels can cause aquatic animals to leave an area, weaken, or die, potentially impacting popular sportfishing species and locally important endangered species.

Temperature

What Is It? Temperature has an important affect on water quality because it influences the rates of biological and chemical processes. Every aquatic species has an optimal temperature range – some survive better in cold water, others survive better in warm water.

What Causes It? Temperature changes occur for a variety of reasons, including removal of streambank vegetation that provides natural shading, impoundments caused by a dam or other barriers that hamper natural flow, runoff from paved areas that absorb heat, and groundwater inflows.

Why Is It a Problem? Water at higher temperatures cannot hold dissolved oxygen as well as cooler water. Warmer water also increases the rate of development and decomposition of aquatic plants.

Total Phosphorus

What Is It? Phosphorus is an essential nutrient for aquatic plants and animals, but at increased levels it can create water quality problems.

What Causes It? Natural sources of phosphorus include soil and rocks. Human sources of phosphorus include failing septic systems, runoff from fertilized lawns and crops, runoff from animal feedlots, and discharges from wastewater treatment plants.

Why Is It a Problem? High concentrations of phosphorus increase the rate of plant growth, causing algae to quickly bloom and decompose. The decomposition process reduces the levels of dissolved oxygen in the water, resulting in negative impacts on aquatic animals.

Total Dissolved Solids

What Is It? Total dissolved solids are particles that will pass through a filter with pores around .002 cm in size, including calcium, nitrate, phosphorus, iron, and sulfur. Total dissolved solids are also an indicator of the level of salinity in a waterbody.

What Causes It? Factors influencing total dissolved solid concentrations include natural geology and runoff from urban and agricultural lands that contain fertilizers, sewage, and sediment.

Why Is It a Problem? Water with high concentrations of total dissolved solids are less suitable for agricultural uses, such as irrigation, and can threaten aquatic life at very high concentrations.

(USEPA 1997)

The streams and water bodies in the Virgin River watershed have different classifications and associated protections. Some select streams or stream reaches are classified as being protected for water supplies (1C). Most of the streams located in the upper portions of the watershed at higher elevations are classified for cold water game fish (3A). Other streams that have warmer water, often in the lower portion of the watershed, are classified warm water game fish (3B). All streams in the watershed have been classified as being protected for both secondary contact recreation such as boating or wading (2B) and agricultural uses (4). In addition, streams flowing through one of the National Forests in Utah are considered high quality and granted a higher level of protection. The following is a table listing the streams in the watershed and their designated uses.

Table III-1.

	Designated Uses and Protections					
Stream	1C Drinking (needing treatment)	2B Boating or Wading	3A Cold Water Fish	3B Warm Water Fish	3C Non Game Fish	4 Irrigation or Stock Watering
Beaver Dam Wash from Motoqua to headwaters		X		X		X
Virgin River and its tributaries from state line to Quail Creek Diversion		X		X		X
Santa Clara from Virgin River to Gunlock Reservoir	X	X		X		X
Santa Clara from Gunlock Reservoir to headwaters		X	X			X
Leed's Creek		X	X			X
Quail Creek from Quail Creek Reservoir to headwaters	X	X	X			X
Ash Creek and tributaries from Virgin River to Ash Creek Reservoir		X	X			X
Ash Creek from Ash Creek Reservoir to headwaters		X	X			X
Virgin River and tributaries from Quail Creek Diversion to headwaters except as listed below	X	X			X	X
North Fork Virgin River and tributaries	X	X	X			X
East Fork Virgin River from Glendale to headwaters		X	X			X
Kolob Creek from Virgin River to headwaters		X	X			X

From Utah Administrative Code R317-2, Standards of Quality for Waters of the State.

Recent monitoring by UDEQ demonstrated that various segments of the Virgin River are impaired for total dissolved solids, dissolved oxygen, temperature, and total phosphorus. These waters include Baker Dam and Gunlock Reservoir because of low dissolved oxygen and high levels of phosphorus. Also considered impaired is the Santa Clara River below Gunlock Reservoir because of total dissolved solids in the water. Impaired segments appear on Utah's section 303(d) list and require the development of a Total Maximum Daily Load (TMDL) analysis. The TMDL calculates how much of the impairment causing pollutants must be removed in order for the stream to meet the water quality standards. A TMDL analysis for impaired waters in the watershed was completed and submitted to EPA for approval in 2004.

Several segments have naturally high concentrations of total dissolved solids as a result of naturally occurring hot springs and runoff from rock formations and soils that contain large amounts of soluble minerals. The establishment of a site-specific water quality standard would account for this natural source and remove these segments from the section 303(d) list. Adoption of site-specific criteria for total dissolved solids is being recommended for certain impaired segments as part of the TMDL development process. Other listings for high temperatures were made in error and are being corrected. Under the comprehensive watershed management planning effort for the Virgin River, UDEQ has developed TMDLs for the remaining waterbody/pollutant combinations on the section 303(d) list.

According to UDEQ's monitoring results, water quality in the remaining segments of the Virgin River watershed are meeting water quality standards. This does not mean, however, that all non-impaired waters are in good condition. There may be areas within the watershed that are currently meeting water quality standards, but could easily exceed water quality standards without proactive, preventative measures.

To develop and implement effective action strategies for improving water quality conditions, it is important to understand the various sources of pollutants and the impact they may have on the watershed. The report entitled *TMDL Water Quality Study of the Virgin River* describes the possible sources of pollutants causing water quality impairments. In addition, the Susceptibility Report developed as part of the Drinking Water Source Protection Plan identifies potential contaminant sources within source water protection zones throughout the Virgin River watershed. Significant sources of water quality related problems in the Virgin River watershed could include:

Geology. The natural geology of the Virgin River watershed may act as a natural source of pollutants, such as sediment and salts. Storm water run-

off can erode and collect particles of sediment, depositing it into nearby streams and rivers. Soluble minerals occur naturally in rock formations and soils and as dissolved solids in water in the Virgin River watershed. These 'salts' accumulate in the upper layer of soils as water evaporates. Storm water runoff can carry these accumulated salts to nearby streams and rivers.

Geothermal Activity. Several hot springs exist throughout the Virgin River watershed, including those known as the "Pah Tempe" or La Verkin hot springs. These hot springs discharge large volumes of hot water that has extremely high concentrations of dissolved solids such as chloride, sodium, calcium, magnesium, and sulfate. The Pah Tempe hot spring likely has a greater impact to the water quality and aquatic habitat than any other source of pollution in the watershed.

Improper Livestock Management. Livestock have the potential to impact water quality in several ways. Improper livestock management practices may contribute to erosion and may contribute nutrients to streams and rivers if appropriate management practices are not in place.

Irrigation. Irrigation water can collect nutrients and salts from fields and cycle them back to streams and rivers through ground water and return flows. Irrigation is essential to farming in the Virgin River watershed because of the arid climate.

Erosion. Erosion can be in different forms, including headward erosion at the top of gullies, slope retreat, and downcutting streams. Areas of high relief, steep slopes, uplifted mountains, and weakly cemented rock layers or weakly consolidated sediments are common in the watershed and these are very susceptible to erosion. Erosion can be further exacerbated by sparse vegetative cover that is natural, or caused by improper land management.

Wastewater Disposal. Wastewater disposal methods and technologies, such as lagoons, treatment plants, or individual septic systems, all have the potential to impact water quality through nutrients, dissolved solids, and bacteria, if they are not properly maintained.

Exotic Vegetation. Non-native species of plants may out-compete native species and impact the water quality and habitat in the watershed. Tamarisk, also referred to as salt cedar, is an exotic species of brushy riparian vegetation that has taken over much of the riparian corridor of the Virgin River watershed. Salt Cedar excretes salts as it grows, and it consumes large quantities of water, which results in reduced flows and higher salinity levels. Cheat grass is present in much of the upland areas

and rangelands in the watershed. Recent fires in the watershed were propagated by cheat grass and were likely much larger and widespread than if this exotic were not present.

Stream Alteration. Good water quality conditions are often dependent on the natural shape and function of a stream. Changing the natural stream geomorphology can lead to erosion and a build up of sedimentation downstream. Proper land management and decision making must take place to maintain and improve stream conditions.

Urban Runoff. Runoff from rain events, as well as lawn and golf course irrigation, can pick up pollutants from lawns, streets and sidewalks such as sediment, nutrients, and other chemicals. These pollutants can travel through the storm sewer system and discharge into nearby streams and rivers.

Water Quantity

In the Virgin River watershed, water supply is one of the most challenging and contentious concerns. The health of the watershed, from both an economic and a natural resource standpoint, depends on adequate water supplies. Early settlements in the Virgin River watershed experienced decreases in water quantity due to diversions within the watershed and seasonal low flows (WCWCD 1999). Rapid growth and development in portions of the Virgin River watershed has placed pressure on limited water supplies, raising concerns about the watershed's ability to meet residents' future water demands for (1) municipal and industrial uses; (2) secondary, or landscape, uses; and (3) agricultural irrigation uses

In 1999 the Washington County Water Conservancy District and other federal, state and local sponsors addressed the issue of water supply in the Virgin River watershed through the Virgin River Management Plan. The goal of this plan is to develop an integrated approach to the proper development and management of the Virgin River and its tributaries.

Providing sufficient water resources for Washington County's needs is one of the specific goals of the plan. The plan summarizes current developed water rights and supply, and estimates future water needs. Total current developed water supply, which accounts for municipal, industrial, and landscaping uses, for Washington County is approximately 72,000 acre-feet. Projections indicate that the total water supply needed by 2020 to sustain a medium growth rate will be approximately 118,782 acre-feet. Even with water conservation efforts, that is a water shortage of 55,782 acre-feet (WCWCD 1999). Projected growth through 2038 would require a total of 174,000 acre-feet of water to sustain the county (WCWCD, 2005).

To address the projected water shortage, the Virgin River Management Plan describes potential projects and river management changes that could result in an additional 114,700 acre-feet of water supply. These approaches include: Sand Hollow Reservoir (50,000 AF), Pah Tempe Removal (31,000 AF), Ash Creek (7,000 AF), Gunlock/Ivins Reservoir Pipeline (3,600 AF), Reduction Winter Flows (5,000 AF), Water Conservation (16,000 AF), Water Reuse (22,000 AF), and Wells (11,000 AF) (WCWCD, 1999). The Sand Hollow Reservoir, was dedicated in April 2003 and has increased the storage of the Quail Creek system. The WCWCD is currently pursuing the implementation of a pipeline from Lake Powell to the Sand Hollow Reservoir. This could provide an additional 70,000 AF of water to the Sand Hollow-Quail Creek System and help provide water to meet the growth demands in Washington County.

In addition to increasing water supply, the projects and management strategies identified in the plan have the potential to enhance habitat for native fish species and other wildlife dependent on healthy watershed conditions. A minimum of three cfs are being released from the Quail Creek Diversion Dam to maintain continuous flow conditions in the Virgin River. In the Santa Clara River, three cfs are also being released from Gunlock Reservoir to the river to maintain flow conditions and support native fisheries there. A target release flow set by the Virgin River Program of five cfs at the Washington Fields diversion is an estimate of what might happen there.

Biological Community

To determine conditions of biological communities within the Virgin River watershed, it is necessary to assess vegetation and wildlife that depend on aquatic habitat—directly or indirectly—for survival.

There are many ongoing plans and projects that address biological conditions within the Virgin River watershed. The Virgin River Watershed Management Plan relies on information from these existing plans and projects to establish baseline conditions for the watershed. For this version of the Virgin River Watershed Management Plan, biological conditions focus on research conducted through the Virgin River Resource Management and Recovery Program that focuses on solving water allocation problems while recovering threatened and native fish species.

Habitat

Habitats provide the basic elements that wildlife species need to survive: food, water, shelter and space. The health and diversity of wildlife species in the Virgin River watershed are particularly dependent on habitats found in, and adjacent to, rivers and streams. Areas of vegetation located near and

dependent upon water are referred to as riparian corridors. Healthy riparian corridors that can support abundant populations of fish, birds, and mammals are comprised of dense populations of a variety of trees and plants. Typical riparian corridors in the Virgin River watershed contain a mix of cottonwood, velvet ash, box elder, desert willow, and seepwillow (USFWS, 2000).

A variety of disturbances have affected the riparian corridor in the Virgin River watershed, including drought, water diversions, recreational activities, range management, and invasion of non-native vegetation (USFWS, 2000). Impacts to the riparian corridor from water depletion and invasion of non-native vegetation are related in the Virgin River watershed. As the Virgin River and its streams experience reduced flow, many water-dependent plant species in the riparian corridor are unable to compete with drought-tolerant species, such as Tamarisk. Tamarisk has become the dominant plant species in numerous portions of the Virgin River watershed, replacing native species important to a healthy riparian corridor. Recreational activities and improper livestock management techniques along streambanks may cause impacts to riparian corridor health.

Wildlife

The wildlife of the Virgin River watershed is unique and diverse. The watershed has a diverse topography containing mesas, cliffs, mountain ranges, narrow canyons and valleys. Elevations range from 2,175 feet at the Utah/Arizona state line to above 10,000 feet above sea level in the headwaters of Deep Creek. Land cover includes shrubland (56%), evergreen forest (25%), deciduous forest (9%) and other areas of bare ground, pastureland, mixed forest, etc. (Tetra Tech, 2003). Mammals in the watershed include mule deer, desert big horn sheep, mountain lion, bobcat, striped skunk, badger, foxes, coyote, porcupine, raccoon, beaver, rabbits, chipmunks, squirrels, bats, mice, rats and other mammals. Many raptor species have been observed in the watershed including falcons, osprey, golden eagles, hawks, and owls. Game bird species in the watershed include quail, mourning dove, ring-necked pheasant, and pigeons. Many waterfowl species occur including mallards, ruddy ducks, grebes, Canada geese, and other ducks. Passerine birds and songbirds include hummingbirds, woodpeckers, flickers, swallows wrens, robins, warblers, flycatchers, sandpipers, nuthatches, jays, sparrows, blackbirds, orioles, and others. Reptile and amphibian species include lizards, snakes, toads, frogs, and tortoises. (WCWCD, 1999). Native fish found in the watershed include the woundfin, Virgin spinedace, Virgin River chub, desert sucker, flannelmouth sucker, and speckled dace. Numerous non-native fish species are found including rainbow trout, brown trout, red shiner, green sunfish, and bullhead catfish. Unfortunately, the uniqueness of the species assemblage translates into threatened and endangered species status for

some wildlife inhabiting the watershed, including several fish species, the Southwest Willow Flycatcher and the desert tortoise. Federally listed and proposed threatened and endangered Species in Washington County are listed in the following table (WCWCD, 1999).

Table III-2.

Federally Listed and Proposed Threatened and Endangered Species in Washington County		
Common Name	**Scientific Name**	**Category**
Mojave Desert Tortoise	Gopherus agassizi	Threatened
Bald Eagle	Haliaeetus leucoephalus	Threatened
Mexican Spotted Owl	Strix occidentalis lucida	Threatened
Southwest Willow Flycatcher	Empidomax trailii extimis	Endangered
Woundfin	Plagopterus argentissimus	Endangered
Virgin River Chub	Gila seminuda	Endangered
Virgin Spinedace	Lepidomeda mollispinis mollispinis	*Proposed listing, **withdrawn as a result of listing as State of Utah Conservation Species
Dwarf Bear-Claw Poppy	Arctomecon humilis	Endangered
Siler Pincushion	Pediocactus sileri	Threatened

* Federal Register notice May 18, 1994 (590 FR.25875) proposed listing as threatened.
** Virgin Spinedace Conservation Agreement and Strategy, April 11, 1995.

Several previous studies have been made of the conditions of the fish populations in the Virgin River watershed (Valdez, et al., 1991, Addley and Hardy, 1993; USFWS, 1995). In 2002, the Virgin River Fishes Recovery Plan was established to 1) implement actions to recover, conserve, enhance, and protect native species, and 2) enhance the ability to provide adequate water supplies for sustaining human needs (UDNR, 2002).

The woundfin historically occurred in the Gila River, Arizona; the Moapa (Muddy) River, Nevada; and the Virgin River. The woundfin is presently found in the Virgin River from an area above Lake Mead in Nevada, upstream to the point where the Pah Tempe hot springs enter the River (USFWS, 1994).

The Virgin River Chub historically occurred in the Virgin River from its confluence with the Colorado upstream to the Pah Tempe hot springs. Today it is found in the same river reach in the Virgin River from its mouth to the Pah Tempe hot springs (USFWS, 1994).

The Virgin Spinedace is managed as a conservation species under the Virgin River Spinedace Conservation Agreement. It is found in portions of Beaver Dam Wash, the Santa Clara River including portions of Moody Wash and

Magotsu Creek, lower Ash and La Verkin Creeks, the Virgin River upstream from Pah Tempe hot springs, lower North Creek and the lower portions of the North and East Forks of the Virgin River (Addley and Hardy, 1993 and USFWS, 1995).

The speckled dace is a native fish that is found in most of the tributaries of the Virgin River. The species is not endangered and is found in streams elsewhere in Utah and other western states. Speckled dace are most commonly found in the main stem of the Virgin River above Pah Tempe and in various other tributaries. They can also be found downstream from Pah Tempe in shallow low-gradient riffle habitats with gravel or cobble substrates

Thirteen non-native fish species are found in the Lower Colorado River watershed including rainbow trout, brown trout, red shiner, and black bullhead catfish. Non-native fish can adversely impact native fish by increasing food competition and predation. Red shiner appear to have the greatest potential impact on woundfin through competition for food and habitat and possibly predation of larvae (USFWS, 1995). Where spinedace are found in association with non-native fishes (e.g., trout, bass, and red shiners) there is a distinct likelihood of competition for resources and predation (Addley and Hardy, 1993). The Virgin River Fishes Recovery Plan includes recommendations for addressing the threats posed to native fish species by non-native species (USFWS, 1994).

In addition to sensitive fish species, the Virgin River watershed is home to a threatened population of desert tortoise. The distribution of this species in Utah is limited to the extreme southwest portion of the state, including the Beaver Dam Slope and other areas near St. George. Populations are thought to have declined by as much as 75 percent in Utah. Two plans, the Desert Tortoise Recovery Plan and the Washington County Habitat Conservation Plan, focus on taking steps to ensure that the tortoise does not suffer further population declines (UDWR, 2003).

Stakeholders' Key Concerns in Watershed Planning Areas

Developing a strategic action plan that prioritizes problems and management strategies is necessary for the Virgin River watershed. Such a prioritized, strategic plan will help stakeholders take action in the short-term, and serve as a tool for obtaining the necessary funding to implement the plan over time.

Stakeholders participated in activities to prioritize concerns within the watershed. Stakeholders identified a wide range of concerns during initial

watershed management planning efforts that were organized according to the following categories: water quality, water quantity, living resources, land uses, social considerations, and education. Later in the watershed management planning process, a limited number of stakeholders took a survey to help narrow and prioritize the list of concerns within each category for the watershed. The survey also asked stakeholders to prioritize concerns in each watershed planning area.

Once stakeholders prioritized concerns using the survey, the VRWAC hosted public meetings in St. George and Orderville to further refine and prioritize the list of key concerns. Stakeholders participating in these public meetings broke into small groups and discussed key concerns affecting each of the watershed planning areas. They had the opportunity to describe the problem as they perceived it, and post a "flag" on the watershed map to indicate the approximate geographic location of the area of concern. Through these meetings, stakeholders provided the VRWAC with a spatial representation of the priority concerns in the watershed. The remainder of this section discusses the priority concerns for each watershed planning area based on the results of stakeholder input through the survey and the public meetings held in St. George and Orderville.

Water Quality Problems and Natural Resources

In addition to the stakeholder concerns that were expressed, the Virgin River Watershed Advisory Committee developed a mission statement as explained in Chapter One. The goal and intent of the watershed management plan is *to maintain and enhance the water quality and associated natural resources of the Virgin River Watershed.* To satisfy this goal, it is critical that public concerns be investigated, verified, and translated into real world impacts to the water quality and natural resources of the watershed.

Survey Says. . . . Stakeholders' Top Ranked Issues in the Virgin River Watershed

Water Quality

- Water quality monitoring
- Potential groundwater contamination
- Potential agricultural runoff

Water Quantity

- Stream flow management
- Water conservation
- Water storage

Ground Water

- Potential Septic system impacts
- Groundwater monitoring
- Investigation of groundwater resources in high growth areas

Land Use

- Potential septic system impacts to water quality as a result of high residential densities
- Impacts to riparian habitat
- Growing off-road recreational use

Living Resources

- Threatened and endangered species
- Management of invasive plants and introduced species
- Management of fish species important to the watershed

Social Considerations

- Preservation of quality of life
- Obtaining local input in watershed management planning
- Involvement of public and other organizations throughout the watershed

Public Education and Outreach

- Need for increased water conservation
- Need for understanding natural water quality conditions
- Need for increased understanding of surface and ground water interactions within the watershed

Many of the priority concerns identified may not be on-the-ground identifiable water quality problems or impacts to the watershed. Concerns may be more related with the need to maintain open communications between all of the parties interested in the watershed or concerns with preserving the quality of life that residents enjoy. There are also concerns that impacts to streams or groundwater may be present that have not been investigated or that impacts may take place in the future. These are important issues and must be recognized and considered.

Where impacts to the water quality or natural resources of the watershed can be clearly identified they are listed in the individual watershed planning areas. There are other impacts that are more widespread and are common to many, or all, of the different watershed planning areas, these are listed and described below.

Dissolved Solids

Many areas within the Virgin River watershed have **rock formations** exposed that contain soluble minerals. The minerals include gypsum and different kinds of salt. These minerals dissolve when exposed to water and are then carried down the stream. Soluble minerals dissociate in water into charged ions. Dissolved materials often found in the waters of the watershed include, calcium, magnesium, sodium, potassium, chloride, sulfate, and others.

The rock formations that are much of the problem include the Moenkopi, Chinle, Carmel, Tropic, and Straight Cliffs-Wahweap Formations. The Moenkopi Formation includes layers of sandstone, shale, mudstone, gypsum and calcareous mudstone. It was deposited as an ancient tidal mud flat. It tends to weather into a gentle slope at what is considered the base of the vermillion cliffs of the grand staircase. The formation can be seen near Quail Creek Reservoir. The Chinle Formation includes a resistant layer of coarse sandstone or conglomerate that forms the rim rock at Purgatory and above the town of Rockville. Above that is a thick layer of brightly variegated shale that makes up the Petrified Forest Member of the Chinle Formation. It is not fertile ground and often weathers into badlands. The material is prone to landsliding because it contains clays that swell. The layer often contains abundant mineralized petrified wood remains.

Farther up in the geologic rock layers in the area, is a sequence of rocks that were deposited in a shallow inland sea. These rock formations lie above the massive Navajo sandstone that makes up the impressive cliffs and canyons of Zion National Park and the white cliffs of the grand staircase in southern Utah. The Carmel formation is on top of the thick layers of massive sandstone. It tends to be light brown to tan and forms slopes and small cliffs. It was deposited in a shallow ocean and contains layers of shale, platy

limestone, and sandstone. These rocks are expressed near Mount Carmel on the East Fork of the Virgin River. Above the Carmel Formation is found the Tropic shale and the Straight Cliffs-Wahweap sandstone. These rock layers were also formed in or near the edge of a shallow sea. These rocks contain shale, sandstone, and localized coal seams. The rocks are exhibited near the towns of Orderville and Glendale and form what is referred to as the grey cliffs of the grant staircase.

These and other rock formations to a lesser extent contain minerals that dissolve and enter the Virgin River. These dissolved solids or salts can accumulate in **soils** as water evaporates and leaves the solids behind. Leaching of minerals from underlying bedrock can also form a hardpan or caliche in the soil horizon. This layer consists of accumulated minerals, usually calcite, that was mobilized by water and then precipitated as solid minerals. Salts can also accumulate at or near the surface of the soil. Irrigation with water containing high concentrations of dissolved solids can concentrate salts in the soil and require irrigation beyond the need of plants in order mobilize salts and remove some from the soil through irrigation return flows. The following figure shows the distribution of soil salt concentrations in the watershed. The data represent a weighted average of the maximum salinity reported for the soils in a map unit.

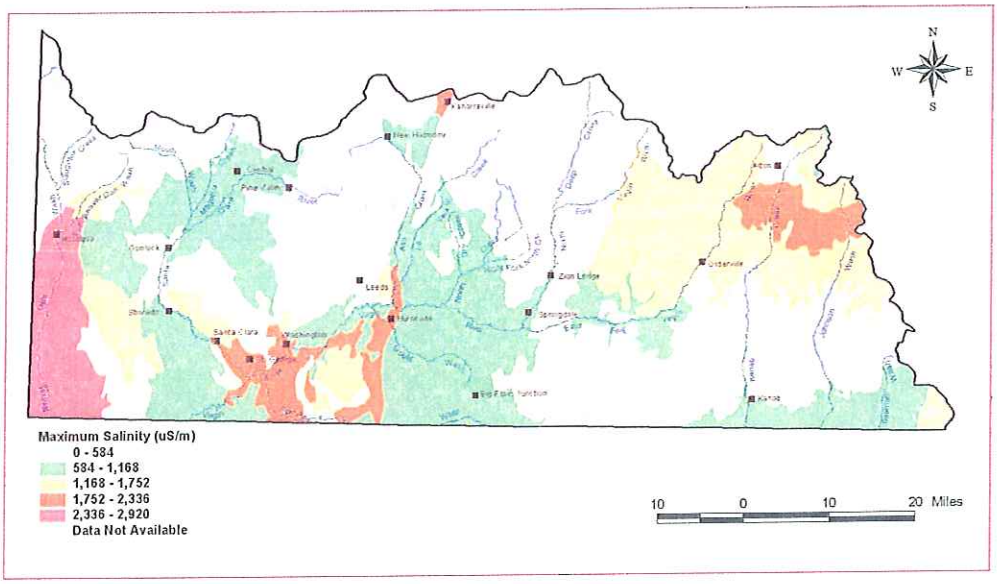


Figure III-2.

Geothermal hot springs are a significant contributor of dissolved solids to the Virgin River. The greatest of these springs is the Pah Tempe or La Verkin hot springs located near the town of La Verkin and upstream from the confluence of La Verkin and Ash Creeks. The hot springs discharge directly to the river and dramatically increase the dissolved solids concentrations and temperature of the river especially under low flow stream conditions. The springs consistently discharge at 11 cfs. The springs discharge from both banks and from the riverbed itself. The Virgin River TMDL demonstrated that background concentrations of dissolved solids combined with concentrations from the Pah Tempe hot springs made it impossible to meet

Table III-3.

Parameter	August 1981			May 1982		
	Virgin River above	Pah Tempe Hot Spring	Virgin River below	Virgin River above	Pah Tempe Hot Spring	Virgin River below
Flow	48	11	45	500	11	515
Temperature (C)	26.5	41.5	30.0	12.5	41.5	13.5
Temperature (F)	79.7	106.7	86.0	54.5	106.7	56.3
pH	8.2	6.8	7.3	7.9	6.7	7.5
Dissolved Calcium (mg/l)	92	820	280	60	880	80
Dissolved Magnesium (mg/l)	30	160	63	14	160	17
Total Hardness as CaCO3 (mg/l)	350	2700	960	210	2900	270
Dissolved Potassium (mg/l)	4.6	150	43	2.4	150	7
Dissolved Sodium (mg/l)	51	2300	580	18	2300	70
Chloride (mg/l)	43	4100	980	17	3600	95
Dissolved Oxygen (mg/l)	6.8	0.5	0.52	9.1	1.1	8.5
Sulfate (mg/l)	230	2100	690	70	2100	120
Total Dissolved Solids (mg/l)	560	9660	2755	280	9840	500
Specific Conductivity (ms/cm @ 25 C)	905	13600	4450	455	1400	800

the state standard of 1,200 mg/l. A site specific total dissolved solids concentration of 2,360 mg/l for the Virgin River from Pah Tempe downstream has been proposed and approved by the EPA as a criterion that represents natural background conditions for the stream.

In addition to the Pah Tempe hot spring, another significant hot spring is located at the town of Veyo. The springs at La Verkin have been developed into a resort and the hot spring at Veyo has been developed into a swimming pool. The Veyo hot spring has much less of an impact on the Santa Clara River than the effect of the Pah Tempe hot spring on the Virgin River. The following table shows a comparison of some of the key water quality constituents, and the water quality of Kolob Creek, Veyo hot spring, Pah Tempe hot spring, sea water, and the water from the Great Salt Lake in Utah. The Pah Tempe water contains dissolved solids concentrations that are much higher than other hot springs found in the area and much higher than the natural headwater streams of the area, but its water is still not as high in dissolved solids as the evaporite basins of the Great Salt lake and the oceans of the world.

Table III-4.

Parameter	Kolob Creek above the Reservoir	Veyo Hot Spring	Pah Tempe Hot Spring*	Sea Water*	Great Salt Lake*
Chloride (mg/l)	3	28	4,000	55,500	54,500
Calcium (mg/l)	82	57	850	1,200	200
Magnesium (mg/l)	15	27	160	3,700	3,300
Potassium (mg/l)	2	4	150	1,100	2,000
Sodium (mg/l)	3	31	2,300	30,800	32,800
Sulfate (mg/l)	30	78	2,100	7,700	7,200

*Utah Geological Survey, PI-39

The problem of dissolved solids and especially salts is further complicated by the presence of **Tamarisk** or Salt Cedar in the watershed. Tamarisk is a woody shrub that was introduced to the United States in the 1830s to stabilize river banks and to shelter areas as a windbreak. Tamarisk has spread across much of the Virgin River's stream banks. It has displaced native trees such as willows, cottonwoods and mesquite. Tamarisk can transpire up to 300 gallons of water per day and can severely limit available water or even dry up a water source. It thrives in saline and nutrient poor soils and actually concentrates salts in the soil by transpiring salty water and eliminating salt through shed leaves. Tamarisk spreads by root, trunk, and branch sprouts as well as up to 500,000 wind-blown seeds that can be produced by each plant. The plant is of very little value to wildlife and is very difficult to eradicate.

William M. Ciesla, Forest Health Mangement International, www.forestryimages.org

Sedimentation

The Virgin River watershed has lands ranging in elevation from over 2,000 to over 10,000 feet above sea level. Many areas are rugged with steep slopes and high relief. Much of the watershed area is covered by **rock layers** that are weakly cemented or weathered and highly susceptible to erosion. The arid climate limits plant growth and most areas are sparsely vegetated. Precipitation comes in two general seasons, winter snows and summer

'monsoon' rains. Summer rains are often localized and intense. This combination of high relief, erodible soils, and intense rains often produces stream flows with high concentrations of sediment and suspended solids.

Sedimentation can also be caused by **earth disturbing activities** such as building construction, road construction, and dirt and gravel road runoff. Activities disturbing the stream banks and affecting their stability are especially damaging to the stream and cause sedimentation. Off highway vehicles, stream crossings and improper land management practices can lead to stream bank instability and excessive erosion and sedimentation. Areas of forestland or rangeland burned by wildfires can be very susceptible to severe erosion. Wildfires can consume tens of thousands of acres in a single fire and can have drastic effects on local and regional streams.

Lack of Stream Flow

A **drought** began in southern Utah and particularly in the Virgin River watershed during the winter of 1998-1999 and has continued through the Summer of 2004. More recently, in the Fall of 2004 through the Spring of 2005, the watershed experienced near-record high precipitation levels. In most areas the precipitation was at least twice the normal amount. At this point in time it is unknown if this was an unusually wet year in the middle of a drought or if the extended drought conditions have come to an end. According to the USGS, droughts in the state normally last an average of about 4 years; the current drought is not unusual for its length, but for its severity. For example, the total annual flow of the Virgin River measured at the town of Virgin was the lowest on record since monitoring began at this site in 1910 (USGS, 2003). Drought generally lessens the amount of water that can be released from storage reservoirs to users downstream. Decreased precipitation leads to decreased recharge to aquifers and decreased surface water availability tends to lead to increased groundwater withdrawals. Dry conditions deplete soil moisture which must be replaced before recharge conditions can return to normal. Also, as the quantity of water in streams decreases the concentration of natural or introduced pollutants increases.

Stream flow in the watershed is used for municipal drinking water (after treatment), irrigation of agriculture lands, watering of stock, habitat for fisheries and other wildlife, and recreation. All these have been impacted by the drought conditions. There are many **stream diversions** in the watershed where water is taken from the stream, mainly for irrigation purposes. The drought has limited the amount of water available for irrigation and limited the amount of water left in the stream after water is diverted.

Numerous reservoirs are present throughout the watershed including Kolob Reservoir on the North Fork, Ash Creek Reservoir, and Baker Dam

and Gunlock Reservoir on the Santa Clara River. In addition, Quail Creek Reservoir and Sand Hollow Reservoir are two off river storage basins. The development and management of these reservoirs have aided to lessen the impact of the drought on the river system. The reservoirs have also allowed for the release of water to the stream to help maintain flows critical to native fish species.

Other factors also contribute to increase the severity of the drought. As mentioned above, **Tamarisk** dominates the flood plain of the river from the Hurricane area down through Washington, St. George, and downstream beyond Bloomington. Tamarisk can consume large quantities of water. Other native flood plain species such as willow or cottonwood also consume large quantities of water, but Tamarisk is more effective at capturing and consuming water under drought conditions when water table conditions are lower. **Urban storm runoff** can also allow precipitation to be intercepted by impervious surfaces and sent directly to the stream or to sewage treatment facilities without the option of allowing water to infiltrate the ground and recharge groundwater and provide baseflow to streams.

Nutrients

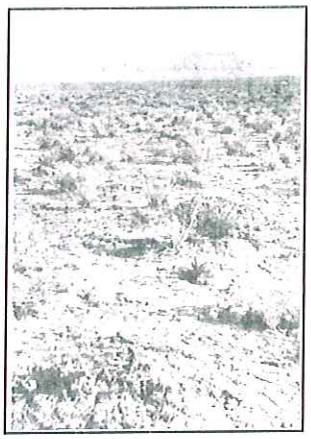
Nutrients in the groundwater and streams are a type of pollution that impacts aquatic life and can cause health problems. Nutrients originate from fertilizers, leachate from septic systems or sewage treatment systems, manure from livestock, and other sources. Nutrients can be found in urban runoff or groundwater as the result of excessive fertilizing on golf courses, residential lawns, or farmed lands. Excessive levels of nutrients in water can be caused by malfunctioning residential septic systems or by the discharge of waste water sources. Livestock grazing and animal feeding operations that are directly on streams or near streams without sufficient management controls may also contribute to the problem. Nutrients often attach to soil particles and it has been found that streambank erosion can contribute to nutrient loading of a stream or water body.

In streams and other water bodies, the nutrients, generally phosphorus, cause algae growth and can lead to algal blooms, especially during the warmer summer months. After the algae experiences a large growth phase it dies back. Bacteria feed on the dead algae and consume oxygen from the water. Low dissolved oxygen in the water body can lead to massive fish kills. Cattle have also been found to have been killed by drinking water containing toxins associated with the bacteria feeding upon the algae. Another common cause of fish kills in streams in the watershed is runoff from areas recently burned by wildfire. The burned ash material has a high biological

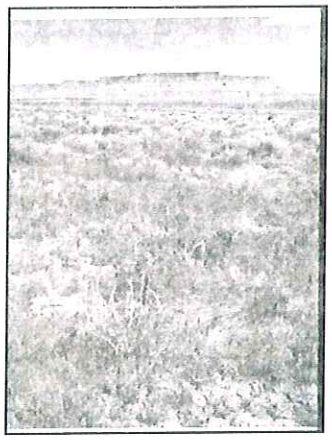
demand that consumes dissolved oxygen in the stream and may cause widespread fish kills.

Healthy Land

Healthy rangelands and forests are critical to maintaining a healthy watershed. Proper land management allows for sustainable forage and cover for wildlife and livestock. It is well recognized that the western rangelands were stocked above carrying capacity and severely overgrazed in the late 1800s and early 1900s. Misuse of this dry environment resulted in the Taylor Grazing Act in 1934. In the State of Utah livestock use dropped from 1,748,270 animal unit months (AUMs) in 1940 to 868,163 AUMs in the 1995/96 grazing year on public lands. Grazing of livestock has dramatically decreased to sustainable levels and the land has recovered (BLM, 1998). The following repeat photographs from 1910 and 1993 were taken in Washington, County, south of Hurricane and show changes in vegetation over time. The BLM attributes the improvements to proper range management.



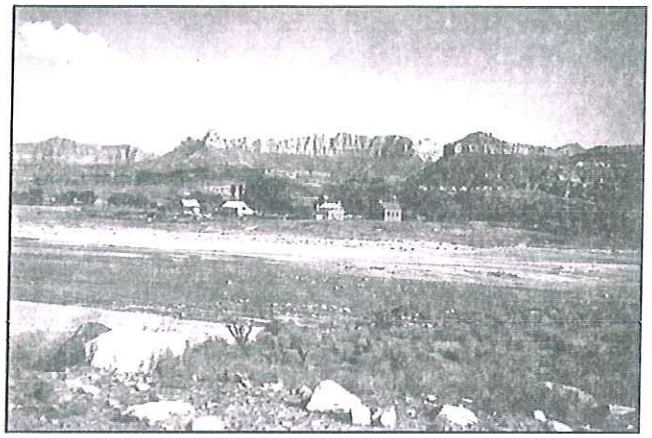
1910, *Anderson (USGS)*



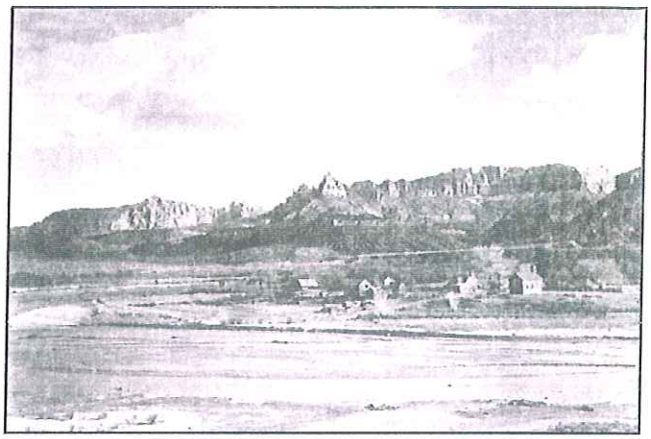
1995, *Earl Hindley (BLM)*

Over the last decades there have been changes to the composition of our forests and rangelands. Through natural plant succession the percent of the landscape composed of evergreen trees has increased while quaking aspen lands have decreased. The same is true for vegetation in lower elevations, pinyon and juniper trees have taken over land that was previously dominated by sage brush and grasses. The change in cover types is much less desirable for both wildlife habitat and livestock use. This is largely due to fire suppression efforts as part of our land management. Also contributing is a decrease in logging and almost no more chaining of pinyon/juniper stands.

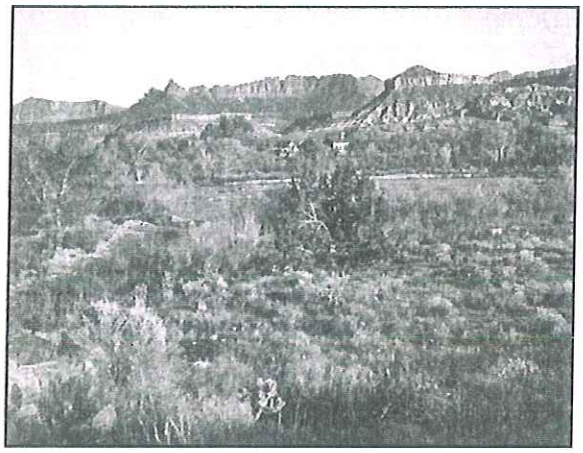
Many exotic plant species were introduced during the colonization of the western United States. Tamarisk, Russian Olive, Russian Thistle, and Cheat grass are a few of the common non-native plant species that have become firmly established in the watershed. These plants can be a nuisance, can outcompete more desirable plants, can become a fire hazard, and can be much less desirable forage and habitat for both native animals and livestock. The dense stands of Tamarisk have become a serious fire hazard to communities as the vegetation has taken over and communities have developed near



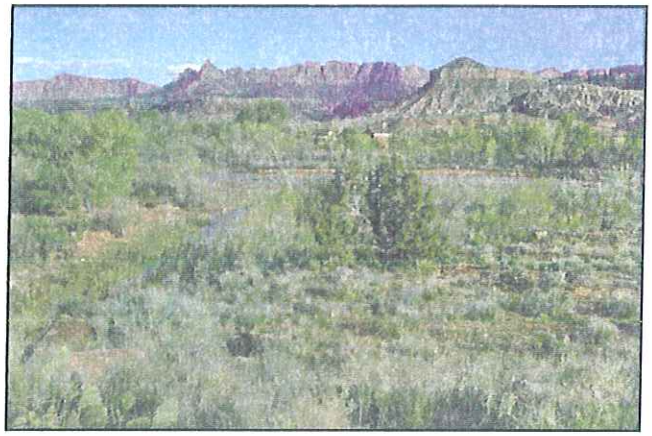
1906, *by W.T. Lee*



1941, *by Grant (BLM)*



1993, *by E. Hindley*



1993, *by E. Hindley*

floodplain areas. Cheat grass has increased the severity and magnitude of recent wildfires in the watershed.

The above repeat photographs were taken of the Virgin River and the town of Grafton looking south with Coalpits Wash to the left. In 1906 it appears the desert landscape consisted of sparse rabbitbrush and cholla. In 1941 there is little change in the wide shallow stream channel and little change in the vegetation although some willow may be present. The development of some agriculture can be seen on the lateral bar developing on the far streambank. In 1993, there is cholla, curlygrass, annual grasses, juniper and some rabbitbrush. The riparian streambank includes cottonwood, coyote willow, rushes, Russian Olive, Seepwillow, arowweed and rubber rabbit brush. One can see that the channel has evolved into a narrower stream with a defined floodplain terrace. Changes may be the result of decreased livestock use locally allowing vegetation to become reestablished and less erosion upstream making for a decreased sediment load to the stream.

Healthy Fish and Animals

Wildlife is important to the function of the watershed and to the residents of the area. Fishing and hunting are some of the most popular outdoor activities. There are also opportunities for wildlife and bird watching as well as camping, hiking and just spending time in nature. Preserving native fish populations is a part of the management plan for the watershed.

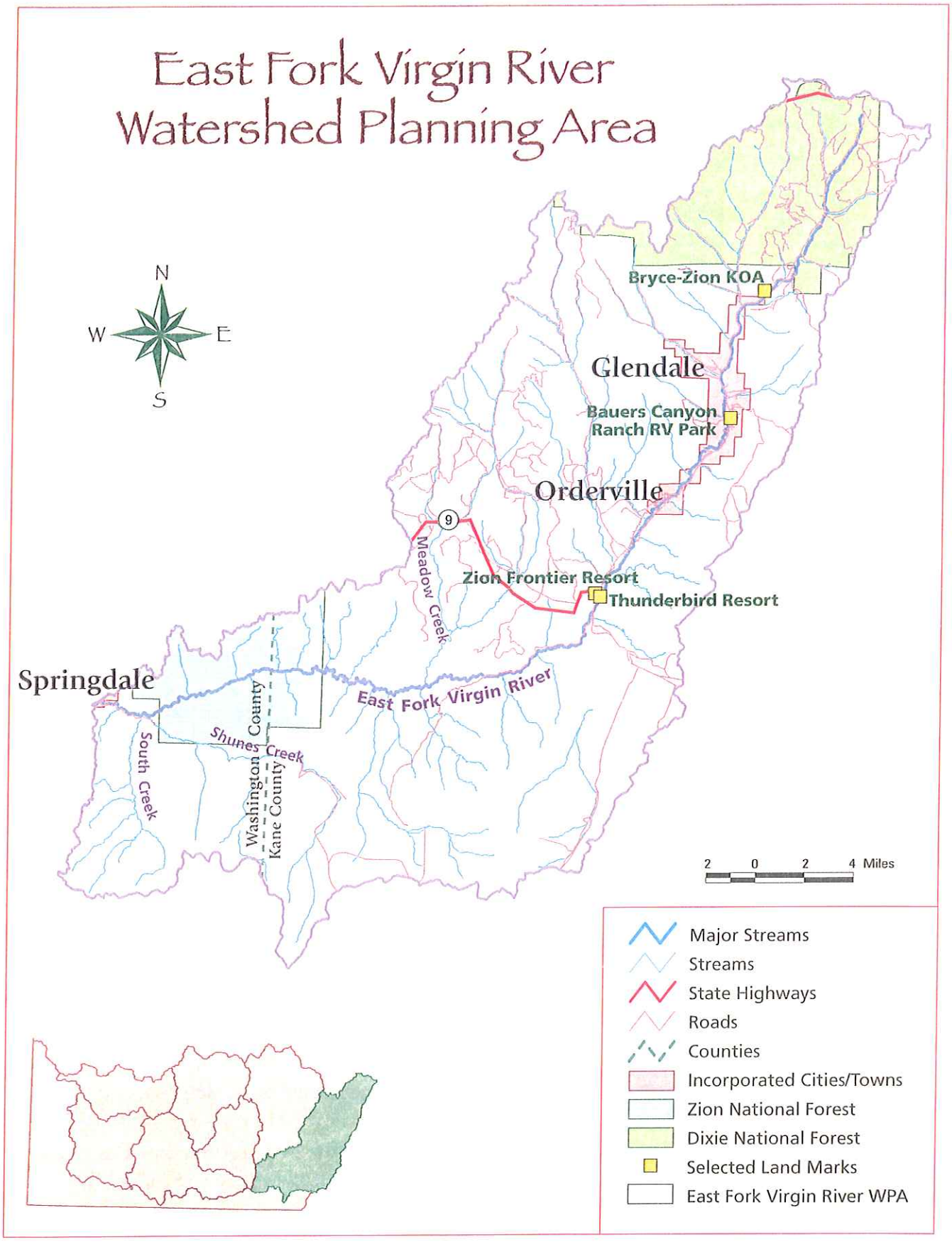
The Virgin River Management and Recovery Program works in the watershed to restore and maintain woundfin, Virgin River chub, Virgin spinedace and other native fishes. The program is a cooperative effort of the Washington County Water Conservancy District, Utah Division of Wildlife Resources, the BLM, the National Park Service, and other partners to monitor the distribution and population of fishes, the stream habitat, and to take steps to improve conditions for the fish.

Watershed Planning Area: East Fork Virgin River

The East Fork Virgin River WPA drains the eastern portion of the Virgin River watershed and includes drainage to the East Fork Virgin River from its confluence with the Virgin River and North Fork Virgin River at the Town of Springdale to its headwaters near the Town of Alton. The majority of the East Fork Virgin River WPA is located in Kane County and includes the communities of Orderville, Glendale, Mt. Carmel, and Mt. Carmel Junction. Precipitation and elevation in the WPA range from 10 to 12 inches at 3,600 feet near Springdale to more than 20 inches annually at 8,000 feet in the headwaters northwest of Glendale. This area is considered the headwaters of the watershed. Water temperatures are cooler and the East Fork supports trout populations above Glendale. The lower portion of the stream is protected for warm water fishes and is habitat for Virgin spinedace. The population is sparse and anthropogenic impacts are limited. Much of the area consists of poorly cemented shale that contains soluble minerals. As a result, the East Fork of the Virgin River is has naturally high concentrations of dissolved solids and sediment in the water.

Various landowners hold title to portions of the East Fork Virgin River WPA including a small area of Zion National Park directly to the east of Springdale. The Bureau of Land Management administers large areas of land throughout the lower and middle portions of the WPA along with scattered parcels of State owned land. The U.S. Forest Service administers the portion of Dixie National Forest, located in the upper reaches and the headwaters of the East Fork Virgin River. A portion of land in this WPA is also privately owned.

A diversity of land use/land cover is present in the East Fork Virgin River WPA and mostly includes shrubland, forestland, and grassland. An even dis-


East Fork Virgin River
Watershed Planning Area
N
W
E
S
Bryce-Zion KOA
Glendale
Bauers Canyon
Ranch RV Park
Orderville
9
Meadow Creek
Zion Frontier Resort
Thunderbird Resort
Springdale
East Fork Virgin River
Shunes Creek
South Creek
Washington County
Kane County
2 0 2 4 Miles
Major Streams
Streams
State Highways
Roads
Counties
Incorporated Cities/Towns
Zion National Forest
Dixie National Forest
Selected Land Marks
East Fork Virgin River WPA

tribution of shrubland mixed with grassland and forestland makes up the lower and middle portions of the WPA from Springdale to Glendale, while forestland dominates the upper portions of the WPA. Additionally a significant amount of agricultural land is located along the East Fork Virgin River in Orderville and Glendale.

What Are Stakeholders' Key Concerns?

Six key concerns for this WPA emerged as priorities to stakeholders: (1) improving the health of the riparian corridor; (2) stream flow management; (3) erosion control; (4) maintaining and improving threatened and endangered fish species; (5) pinyon and juniper tree management; and (6) improving wastewater disposal and septic systems.

Riparian Corridor Health

The East Fork of the Virgin River including Muddy Creek was heavily grazed by livestock in the distant past. The extent of livestock grazing has been drastically reduced, although grazing within the riparian corridor is still present in the East Fork Virgin River. This area of the watershed contains steep slopes and soils that are very susceptible to erosion. Improper land management in the distant past has probably contributed to streambank instability and erosion. The vegetation within the riparian corridor is considered healthy and consists largely of native willow and cottonwood.

Stream Flow Management

Stakeholders within the East Fork Virgin River WPA rely on water for irrigation and livestock to sustain agricultural activities. Stakeholders are interested in identifying opportunities for storing water in the WPA to support agricultural activities. In addition, stakeholders are interested in researching opportunities for tapping into groundwater resources that may exist within the WPA.

Erosion Control

Stream bank erosion occurs in portions of the WPA due to perceived improper livestock management practices in the riparian corridor. In addition, channel incision in Muddy Creek produces conditions for high stream bank erosion. Erosive shale is also present along the East Fork of the Virgin River, leading to widespread natural erosion and high levels of dissolved solids.

Threatened and Endangered Species

Native fish species, including speckled dace and desert sucker, populate the lower portion of the East Fork of the Virgin River. Irrigation diversions in the upper portions of the East Fork reduce flows; further downstream, springs and irrigation return flows provide sufficient flow to support native fish species.

Pinyon-Juniper Management

Pinyon and juniper are native vegetation in the East Fork Virgin River WPA. These tree species spread over time and take over rangeland that is valuable to both livestock grazing and wildlife forage and habitat. These species can be considered nuisance species because they have the ability to outcompete other important and desirable native species. Fire suppression activities and a decrease in "chaining" on federal lands have contributed to a great increase in this less desirable land cover type.

Wastewater Disposal and Septic Systems

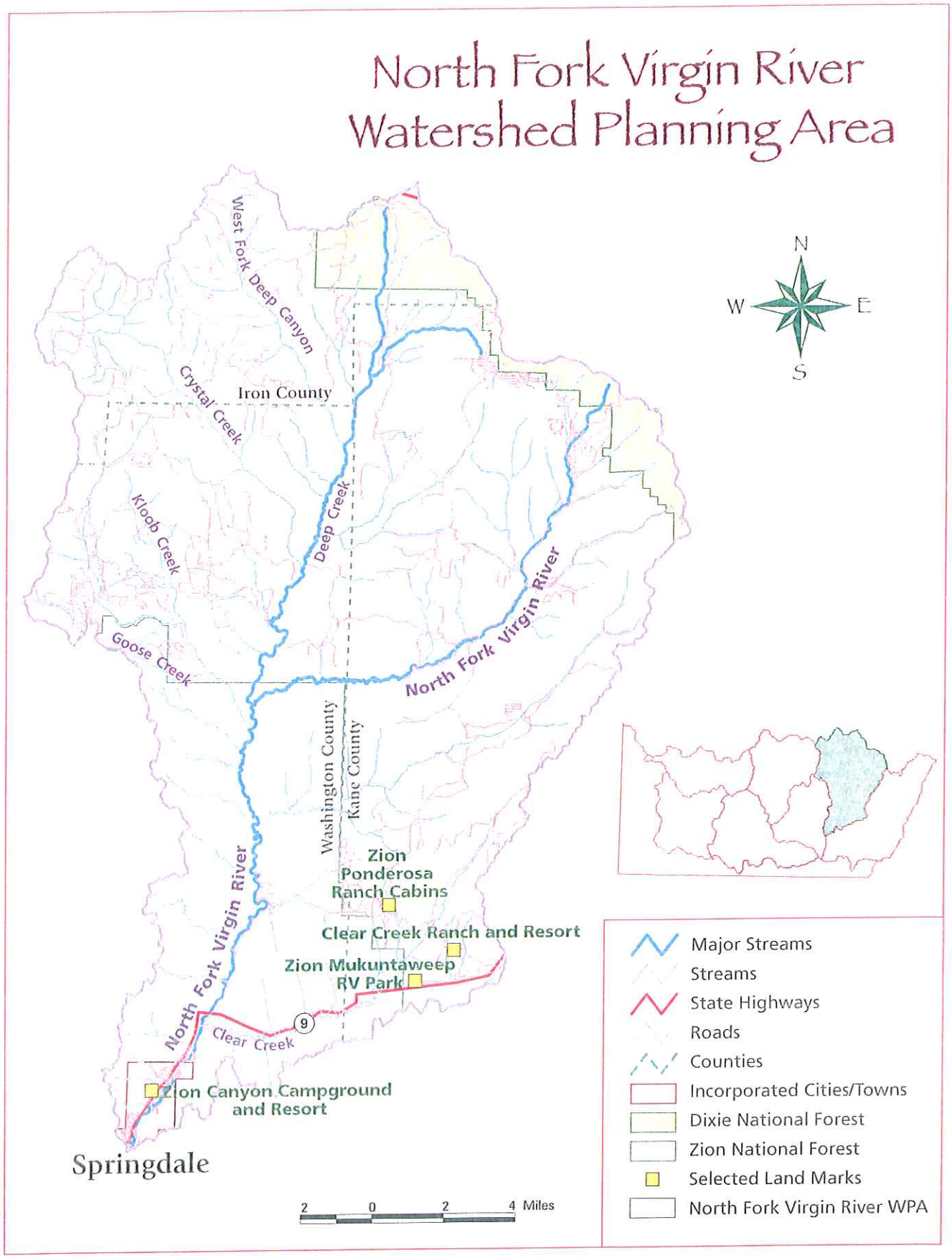
Residents in the East Fork Virgin River WPA rely on a combination of wastewater disposal methods. Orderville is the largest community in the area and it is served by a waste water treatment facility. Septic system use is common in other areas of the Virgin River watershed. Residents of Mt. Carmel and Mt. Carmel Junction, as well as RV campgrounds throughout this WPA, rely on septic systems as a method of wastewater disposal. When septic systems are not functioning properly they can lead to groundwater and stream pollution.

Watershed Planning Area: North Fork Virgin River

The North Fork Virgin River WPA is located in the northeastern portion of the Virgin River watershed and shares boundaries with the North Creek WPA, the Ash Creek/La Verkin Creek WPA, and the East Fork Virgin River WPA. The WPA encompasses the area drained by the North Fork Virgin River and its tributaries and extends north from Springdale to include portions of Washington, Iron, and Kane Counties. The entrance to Zion National Park is located northeast of Springdale and accounts for a large portion of the WPA. Average annual precipitation ranges from approximately 10 to 12 inches at the North Fork confluence with the Virgin River (elevation 3,500 feet) to more than 32 inches in areas where elevation exceeds 10,000 feet.

A variety of land ownership is present in the WPA including the National Park Service, the Bureau of Land Management, the U.S. Forest Service, State and private lands. Zion National Park occupies the lower portion of the WPA and extends from the Springdale upstream to the confluence of Deep Creek and North Fork Virgin River. The Bureau of Land Management administers scattered areas of land adjacent to Zion National Park along Deep Creek and the North Fork Virgin River. Private lands combined with the Dixie National Forest along the northeast border of the WPA account for the majority of ownership in the headwaters region.

Land use/land cover for the WPA is primarily forestland as a result of the higher elevations. Grassland is distributed throughout the WPA in localized areas. In the lower portion of the WPA, notably in Zion Nation Park, there is


North Fork Virgin River
Watershed Planning Area
N
W
E
S
West Fork Deep Canyon
Crystal Creek
Iron County
Kloab Creek
Deep Creek
Goose Creek
North Fork Virgin River
Washington County
Kane County
North Fork Virgin River
Zion
Ponderosa
Ranch Cabins
Clear Creek Ranch and Resort
Zion Mukuntaweep
RV Park
9
Clear Creek
Zion Canyon Campground
and Resort
Springdale
2 0 2 4 Miles
Major Streams
Streams
State Highways
Roads
Counties
Incorporated Cities/Towns
Dixie National Forest
Zion National Forest
Selected Land Marks
North Fork Virgin River WPA

a significant amount of exposed rock. In addition, smaller areas of agricultural land are located in and around Springdale.

What Are Stakeholders' Key Concerns?

Stakeholders identified four key concerns as priorities for the North Fork Virgin River WPA: (1) Natural Stream Function; (2) maintaining and improving threatened and endangered species; (3) wastewater disposal; and (4) recreation.

Natural Stream Function

The North Fork of the Virgin River and Deep Creek originate in Dixie National Forest, flowing through Zion National Park in narrow canyons. Flow is dependent upon winter snow melt and rain events, and flash flooding is common in the North Fork during heavy rain events. The natural flow of the river has been affected by its natural shape and function. Levees and riverbank-protection structures are located throughout the North Fork of the Virgin River in the lower Zion Canyon to prevent the river from using the floodplain. These structures, installed in the 1920s and 1930s, affect the health of the riparian corridor and aquatic wildlife (NPS, 2001).

Threatened and Endangered Species

The North Fork Virgin River WPA provides potential habitat for the endangered woundfin minnow, the Virgin River chub, as well as the endangered bald eagle and the threatened Mexican spotted owl (NPS, 1993 and 2001). The woundfin minnow has not been found in the river system above the Pah Tempe hot springs. The historic and current upstream distribution limit of the Virgin River Chub is a short distance above the Pah Tempe hot springs in the Virgin River. According to the Virgin Spinedace Conservation Agreement and Strategy, populations of the sensitive Virgin spinedace are located in the North Fork of the Virgin River. Although not endangered, the Zion snail is endemic to the seeps and hanging gardens of Zion Canyon and Orderville canyon along the North Fork of the Virgin (UDWR, 2004).

Wastewater Disposal

Springdale operates a small wastewater treatment facility that is located in Rockville and discharges to the Virgin River below the confluence of the North and East Forks of the Virgin River. Wastewater from residential and commercial areas in Springdale flows to this facility for treatment. In addition, the Springdale wastewater treatment facility also handles wastewater from Zion National Park visitors' facilities. Only a small number of septic systems are located in Springdale.

Wastewater disposal is an issue for campers and hikers exploring Zion National Park. The National Park Service educates hikers on proper wastewater disposal methods.

Recreation

Many hikers and backpackers use the North Fork Virgin River WPA for recreational purposes. The Zion Narrow is a popular area that attracts a large number of hikers each year. Other areas within the North Fork are used for hunting, fishing, sightseeing, and off-highway vehicle use.

Watershed Planning Area: Upper Virgin River

The Upper Virgin River WPA is drained by a combination of the North Creek and the Virgin River. Located entirely in Washington County, the WPA includes the cities of Rockville and Virgin, as well as small portions of Springdale, La Verkin, and Hurricane. Zion National Park makes up the northeastern portion of the Upper Virgin River WPA.

Land ownership in the Upper Virgin River WPA is evenly distributed among the Bureau of Land Management, privately-owned, and the State of Utah. The National Park Service manages Zion National Park in the northeast section of the Upper Virgin River WPA.

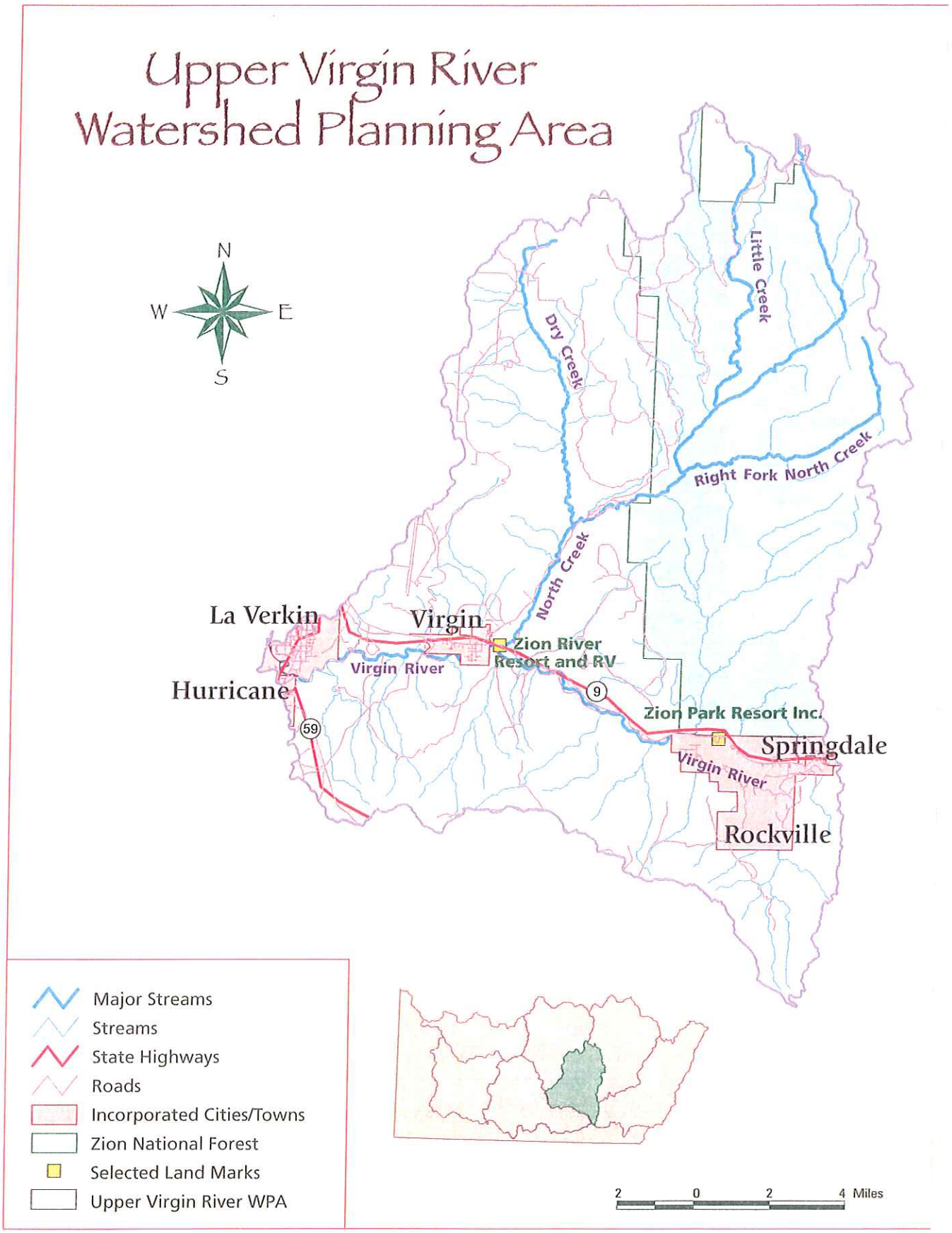
Land use/land cover is similar to other WPAs and is dominated by shrubland, forestland, grassland, and barren land. The approximately 3,000 acres of agricultural land is located adjacent to major hydrological features.

What Are Stakeholders' Key Concerns?

Stakeholders identified five key concerns as priorities in the Upper Virgin River WPA: (1) riparian corridor health; (2) natural erosion; (3) threatened and endangered species; and (4) wastewater disposal and septic systems.

Riparian Corridor Health

The health of the riparian corridor varies throughout the Upper Virgin River WPA. North Creek, which originates in Zion National Park and is a main tributary to the Virgin River, contains robust and largely native vegetation. From the Quail Creek Reservoir Pipeline Diversion to the confluence with the North and East Forks of the Virgin River, vegetation along the Virgin River is a mixture of native willows, cottonwoods, and ash, as well as dense thickets of exotic Russian olive and salt cedar. Lands adjacent to the river also support agricultural activities. Eliminating exotic species and protecting the existing native vegetation are key concerns to stakeholders.


Upper Virgin River
Watershed Planning Area
N
W
E
S
Little Creek
Dry Creek
Right Fork North Creek
North Creek
La Verkin
Virgin
Zion River
Resort and RV
Virgin River
Hurricane
9
59
Zion Park Resort Inc.
Springdale
Virgin River
Rockville
Major Streams
Streams
State Highways
Roads
Incorporated Cities/Towns
Zion National Forest
Selected Land Marks
Upper Virgin River WPA
2 0 2 4 Miles

Natural Erosion

Geology in the Upper Virgin River WPA includes formations of highly-erosive shale that can be eroded as a result of rain events, contributing sediment to the Virgin River. Erosion associated with human activities is also concern in the Upper Virgin River WPA.

Threatened and Endangered Species

A variety of wildlife species inhabit the Upper Virgin River WPA. The Virgin River flowing through the WPA supports populations of Virgin spinedace and other important aquatic life. Stream flow management and the maintenance of flow in the river is important to Stakeholders. A constant flow of three cfs is released from the Quail Creek diversion to support populations of native fish. Stakeholders identified protection of threatened and endangered species as a key concern.

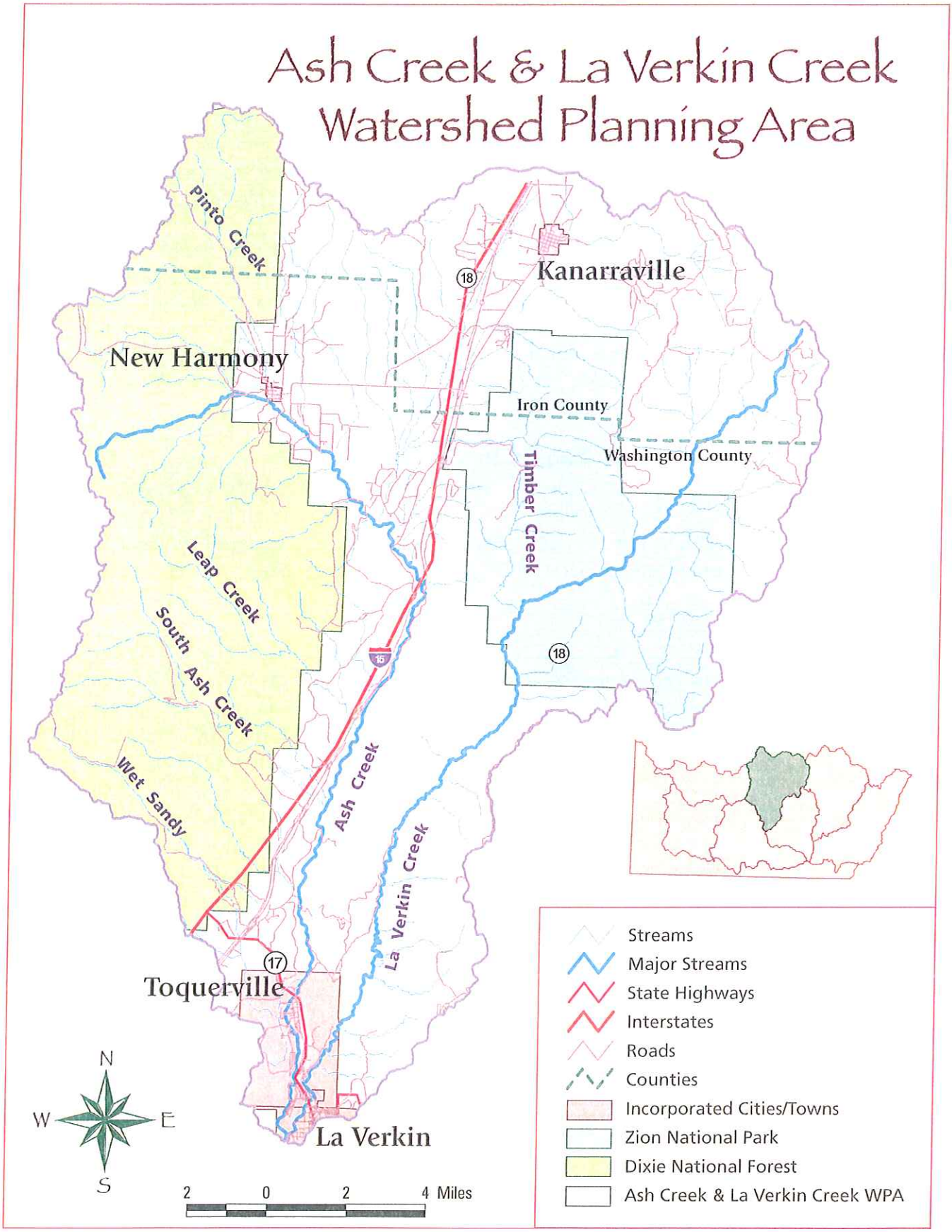
Wastewater Disposal and Septic Systems

Wastewater disposal practices in this WPA include septic systems and wastewater lagoons. Estimates indicate that approximately 200 septic systems are located in Virgin and Rockville (WCWCD, 1997). In addition to these residential areas, the Upper Virgin River WPA also contains RV campgrounds that rely upon septic systems to handle wastewater disposal. The City of Rockville uses a wastewater lagoon adjacent to the Virgin River. In Zion National Park, the National Park Service educates hikers on proper wastewater disposal methods. Stakeholders identified existing and future impacts of wastewater treatment on ground and surface water as a key concern.

Watershed Planning Area: Ash Creek/La Verkin Creek

The Ash Creek/La Verkin Creek WPA includes the drainage of Ash and La Verkin Creeks from their headwaters to the confluence with the Virgin River in La Verkin. Bounded by the Pine Valley Mountains on the west and the North Fork Virgin River and North Creek WPAs on the east, the Ash Creek/La Verkin Creek WPA covers 198,000 acres in Iron and Washington Counties. The communities of Kanarraville, New Harmony, Toquerville and La Verkin are located in this WPA.

Ash and La Verkin Creeks drain distinct areas even though they are located within the same WPA. La Verkin Creek originates above Zion National Park, flows through the northwestern corner of the park and continues through lands administered by the Bureau of Land Management. The lower reaches of La Verkin Creek flow through private lands and enter the Virgin River below Pah Tempe Springs. Three waterfalls occur within the La Verkin Creek portion of this WPA.


Ash Creek & La Verkin Creek
Watershed Planning Area
Pinto Creek
Kanarraville
New Harmony
Iron County
Washington County
Timber Creek
Leap Creek
South Ash Creek
Wet Sandy
Ash Creek
La Verkin Creek
Toquerville
La Verkin
N
W
E
S
2 0 2 4 Miles
Streams
Major Streams
State Highways
Interstates
Roads
Counties
Incorporated Cities/Towns
Zion National Park
Dixie National Forest
Ash Creek & La Verkin Creek WPA

Kanarra Creek, beginning in Zion National Park, joins with North Ash Creek, beginning in Dixie National Forest, to form Ash Creek. Both Kanarra Creek and North Ash Creek flow through private lands and, as Ash Creek, flow through lands administered by the Bureau of Land Management. In addition to federally administered lands and privately owned lands, the State of Utah also manages land within the Ash Creek/La Verkin Creek WPA.

Distribution of land use/land cover in the Ash Creek/La Verkin Creek WPA changes with increasing elevation. The lower elevation regions are classified as shrubland that gradually transition into forestland as elevation increases. Grasslands are also distributed throughout the WPA, while agricultural areas are concentrated along the lower portion of Ash Creek and the headwaters region near New Harmony and Kanarraville. Interstate 15 transects the WPA.

What Are Stakeholders' Key Concerns?

Five key concerns for the Ash Creek/La Verkin Creek WPA emerged as priorities to stakeholders: (1) maintenance of year round flow; (2) riparian corridor health; (3) wastewater disposal and septic systems; (4) threatened and endangered species; and (5) vegetation management.

Maintenance of Year Round Flow

Water quantity is a concern in the Ash Creek/La Verkin Creek WPA, as it is throughout much of the Virgin River watershed. The Ash Creek Reservoir is present on North Ash Creek, but it leaks and generally does not impound water. The exception has been 2005 with the high runoff that filled the reservoir to capacity and it held water through the summer and fall of the year. The runoff in 2005 was so unusually high that the ephemeral Quichapa Lake appeared in the closed basin of Cedar Valley west of Hamilton's Fort. Spring snow melts and thunderstorms from Pine Valley Mountain tributaries on the west side of Ash Creek can occasionally contribute flow to the stream, otherwise the stream is usually dry from the reservoir downstream to the Toquerville springs. La Verkin Creek is thought to have perennial flow from at least Smith Creek downstream to the Virgin River. Diversions on the lower end of the stream often take all of the stream flow during low flow conditions.

Riparian Corridor Health

The health of riparian vegetation varies between Ash Creek and La Verkin Creek. In portions of Ash Creek, very little riparian vegetation exists due to a lack of water (VRMP, 1999). This is in contrast to La Verkin Creek, which is characterized by dense and diverse vegetation. Problems associated with the health of the riparian corridor in this WPA stem from recent large scale

wild fires on Pine Valley Mountain and stream channelization on the lower end of La Verkin Creek.

Wastewater Disposal and Septic Systems

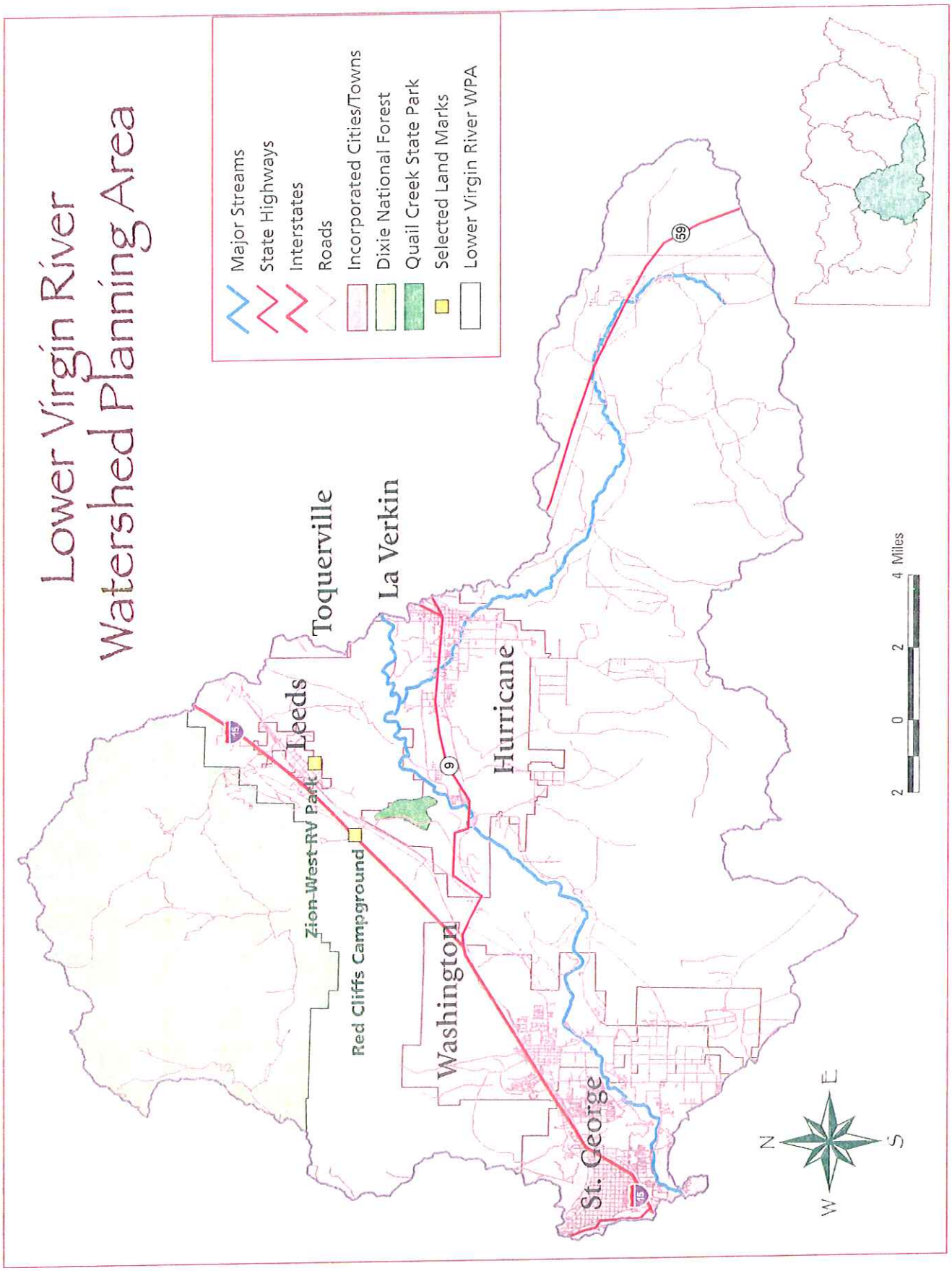
In this WPA, communities rely on septic systems and wastewater lagoons for wastewater disposal. The communities of La Verkin and Toquerville have public sewer system, which include the RV and campgrounds in those communities. The smaller communities of Anderson Junction, New Harmony, Kanarraville and Pintura rely on private septic systems for waste water treatment. Septic systems, if not properly installed and maintained, have the potential to pollute both ground and surface water resources. In areas where the Water District provides water to communities, such as La Verkin, Toquerville, and Virgin, the water supply agreements limit septic system densities to prevent impacts to groundwater.

Threatened and Endangered Species

Ash Creek is typically dry for twelve miles from Ash Creek Reservoir downstream to Toquerville Springs. Spring snow melts and storm flows from Leap Creek, South Ash Creek, and Wet Sandy can contribute surface flow of water to Ash Creek. Virgin spinedace were historically found in the lower 2.5 mile portion of Ash Creek (Addley and Hardy, 1993). The historic spinedace distribution on Ash Creek was limited to the lower portion of the stream from its mouth up to the Toquerville Springs. Virgin spinedace are currently found in the lower portions of both Ash and La Verkin Creeks. La Verkin Creek has perennial flow but goes dry under low flow conditions as a result of water diversions. Three significant waterfalls are present on the stream that act as barriers for spinedace. One is in the headwaters and located in Zion National Park. The other falls referred to as "Twin Falls" and "Chute Falls" are located 9.8 and 7.4 miles from the Virgin River. No spinedace are found above Chute Falls, the lowest water fall and fish barrier.

Vegetation Management

In addition to non-native salt cedar, this WPA requires management of native vegetation, particularly juniper trees. Juniper trees can dominate an area and choke out other important types of vegetation. Areas that contain dense juniper stands are at risk for wildfire, may experience a decrease in wildlife diversity, and provide less forage for wildlife and cattle. In the Ash Creek/La Verkin Creek WPA, a dense stand of juniper poses a wildfire risk to the communities of New Harmony and Harmony Heights. Fires during the summer of 2005 threatened many homes in these areas. In some cases the fire burned within feet of the homes. These communities are situated west of Interstate 15, which runs parallel to Ash Creek.


Lower Virgin River
Watershed Planning Area
Major Streams
State Highways
Interstates
Roads
Incorporated Cities/Towns
Dixie National Forest
Quail Creek State Park
Selected Land Marks
Lower Virgin River WPA
Toquerville
La Verkin
Hurricane
Leeds
Zion West RV Park
Red Cliffs Campground
Washington
St. George
15
9
59
2 0 2 4 Miles
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Watershed Planning Area: Lower Virgin River

The Lower Virgin River WPA, beginning at the confluence of the Santa Clara River with the Virgin River and extending east to the Ash Creek/La Verkin Creek confluence, incorporates all areas drained by Quail Creek, Leeds Creek, and Gould Wash, the Washington Fields region, and the municipalities of Leeds, Hurricane, Washington, and portions of St. George. Located entirely in Washington County, the Lower Virgin River WPA shares borders with the Fort Pearce Wash drainage, the Lower and Upper Santa Clara WPA, the Ash Creek/La Verkin Creek WPA, and the Upper Virgin River WPA.

Land ownership throughout the WPA is dominated by BLM land with smaller portions private ownership distributed throughout Leeds, Hurricane, Washington, and St. George. The Dixie National Forest manages the majority of land in the WPA north of Leeds. In addition, State owned land is distributed throughout the WPA and includes the Quail Creek and Sand Hollow State Parks.

Land use/land cover in the Lower Virgin River WPA consists of shrubland, grassland, forested land, barren land, and agricultural land. Shrubland dominates land cover at lower elevations and transitions to forestland as elevations begin to exceed 4,900 feet. Agriculture land is particularly important in this WPA near Hurricane and Washington and includes a complex system of diversions and canals utilizing water from the Virgin River for irrigation. Small areas of residential and commercial land cover are observed near Hurricane and Washington.

What Are Stakeholders' Key Concerns?

For the Lower Virgin River WPA, stakeholders identified a wide variety of concerns with five receiving priority rankings. Key concerns in the Lower Virgin River WPA include: (1) floodplain management; (2) wastewater disposal; (3) threatened and endangered species; (4) ground water monitoring; and (5) water quality monitoring.

Floodplain Management

The floodplain of the Virgin River is the area of the riparian corridor that is flooded when the river swells due to heavy rain and winter snow melt. Responsible management of the floodplain includes limiting development in this area to provide the Virgin River the space it needs to flow naturally without causing flood damage. Flooding occurs in the Lower Virgin River WPA, particularly in St. George, as a result of heavy rain and winter snow melt. In addition to flash flooding due to natural weather conditions, flooding has also occurred in this area due to a breach of the Quail Creek Dike. Floodplain management efforts are necessary to direct development away

from the floodplain and to areas that are not likely to experience flooding. The St. George area including the city of Washington are rapidly growing and much of the expansion and growth has been near the floodplain. Tamarisk dominates the floodplain and may limit natural stream flow and function under low and higher flow conditions. The dense vegetation found in the floodplain and adjacent to residential areas is also a great fire hazard.

Wastewater Disposal

Both wastewater treatment plants and septic systems handle wastewater disposal in the Lower Virgin River WPA. The St. George Regional Wastewater Treatment Facility located in the southwest corner of Bloomington, near the confluence of the Santa Clara River and the Virgin River, treats wastewater from St. George, Washington and Bloomington. The facility is designed to use tertiary treatment, including disinfection through the use of ultraviolet light, to ensure that treated wastewater will not degrade water quality.

The Ash Creek Special Services District serves Hurricane, Toquerville, and La Verkin with a public sewer system that uses treatment lagoons located west of Hurricane in the area where S.R. 9 crosses the Virgin River. Although the Regional Wastewater Treatment Facility treats the wastewater from most of the surrounding communities, the area still contains a significant number of septic systems. In areas where the Water District provides water to communities, water supply agreements limit septic system densities to prevent impacts to groundwater quality.

Threatened and Endangered Species

The Lower Virgin River WPA contains important habitat for several endangered and threatened native fish species, including the Virgin River chub, the woundfin minnow, and the Virgin spinedace. In addition, the threatened desert tortoise—Utah's only native tortoise—inhabit this WPA. Stakeholders identified protection of these species as a key concern for the WPA. The Virgin River Program (VRP) with its partners is actively working to reestablish these native fish species to their historic distribution. The VRP in conjunction with the WCWCD have established a three cfs release from the Quail Creek diversion to help maintain continuous flow of water in the Virgin River. A target of five cfs below the Washington Fields diversion is also being pursued. The VRP is also aggressively addressing invasive fish species such as the Red Shiner that feeds on sensitive native fish populations of woundfin in this segment of the river. Other efforts are underway to better understand the habitat and limiting factors in the stream that affect native fish populations.

Water Quality Monitoring

A segment of the Virgin River in this WPA is listed on Utah's section 303(d) list for total dissolved solids. The high dissolved solids concentrations observed in this stream segment are primarily caused by the highly mineralized Pah Tempe hot springs water and soluble minerals in the water from natural soils and rock layers. A TMDL was completed for the watershed. The TMDL recommended that a site specific total dissolved solids concentration standard be developed for the Virgin River below Pah Tempe.

Watershed Planning Area: Upper Santa Clara River

The Upper Santa Clara WPA occupies approximately 157,230 acres in the northern portion of Washington County and includes drainage from Magotsu Creek, Moody Wash, and the Santa Clara River to the point where Moody Wash drains into the Santa Clara River. The WPA also includes Baker Dam Reservoir and Pine View Reservoir, which are located along the Santa Clara River in the Pine Valley Region.

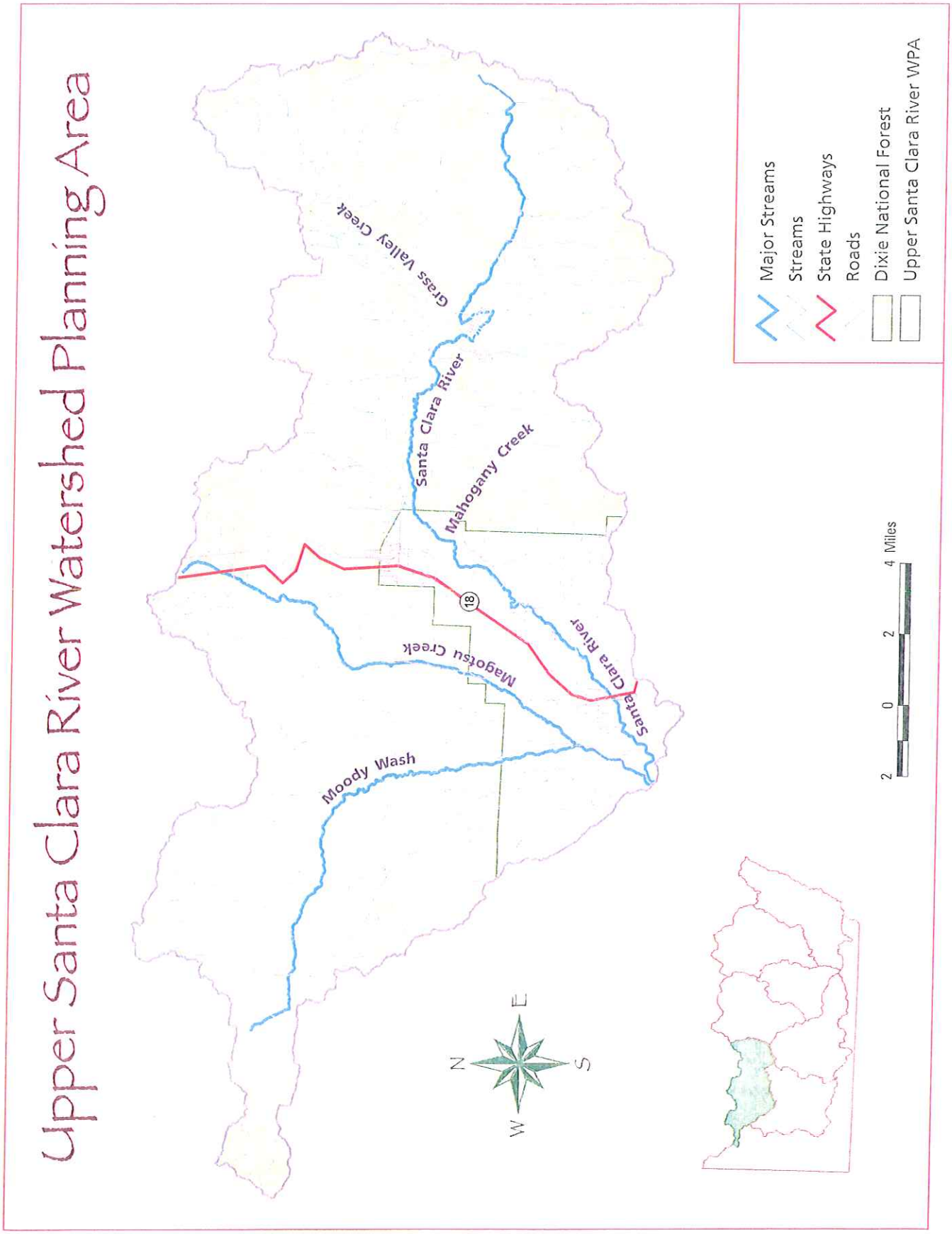
Topography in the Upper Santa Clara WPA ranges from approximately 4,300 feet in the lower portion of the WPA to more than 9,800 feet in the Pine Valley Mountains. Similarly, precipitation ranges from 12 to 14 inches annually in the lower reaches to more than 32 inches annually in the Santa Clara River Headwaters.

Vegetation in the Upper Santa Clara WPA is dominated by juniper-pinyon, oak, and spruce-fur in the forested regions and mountain shrub, sagebrush, and blackbrush elsewhere. Agricultural areas account for approximately 3,400 acres in the WPA.

The U.S. Forest Service and the Bureau of Land Management administer the majority of land in the Upper Santa Clara WPA, with only small portions of privately owned land scattered along the major drainages. Shrubland, grassland, and forestland dominate land use/land cover in this WPA, with land cover distribution changing from predominately shrubland at lower elevations to forestland in higher elevations. There are also significant areas of agricultural land located along Santa Clara River and Magotsu Creek.

What Are Stakeholders' Key Concerns?

Four key concerns emerged as priorities to stakeholders for this WPA as a result of the survey and public meetings: (1) riparian corridor health; (2) runoff storage through reservoirs; (3) wastewater disposal and septic systems; and (4) native species.


Upper Santa Clara River Watershed Planning Area
Grass Valley Creek
Santa Clara River
Mahogany Creek
18
Magotsu Creek
Santa Clara River
Moody Wash
N
E
S
W
Major Streams
Streams
State Highways
Roads
Dixie National Forest
Upper Santa Clara River WPA
2
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Riparian Corridor Health

The health of the riparian corridor in Upper Santa Clara WPA varies. In the Pine Valley Mountains, localized stream bank erosion is a concern. Riparian vegetation is robust and largely native from Pine Valley to Baker Reservoir and from Baker Reservoir to the town of Veyo. Native species also dominate riparian vegetation from Veyo to Moody Wash and Magotsu Creek.

Runoff Storage Through Reservoirs

Two reservoirs are located in the Upper Santa Clara WPA. The Pine Valley Reservoir is a small reservoir located in Dixie National Forest. Baker Dam Reservoir is surrounded by Dixie National Forest and land administered by the Bureau of Land Management, located on the lower slope of Pine Valley Mountains. Stakeholders expressed an interest in increasing reservoir storage for water supply use in addition to current recreation uses.

Wastewater Disposal and Septic Systems

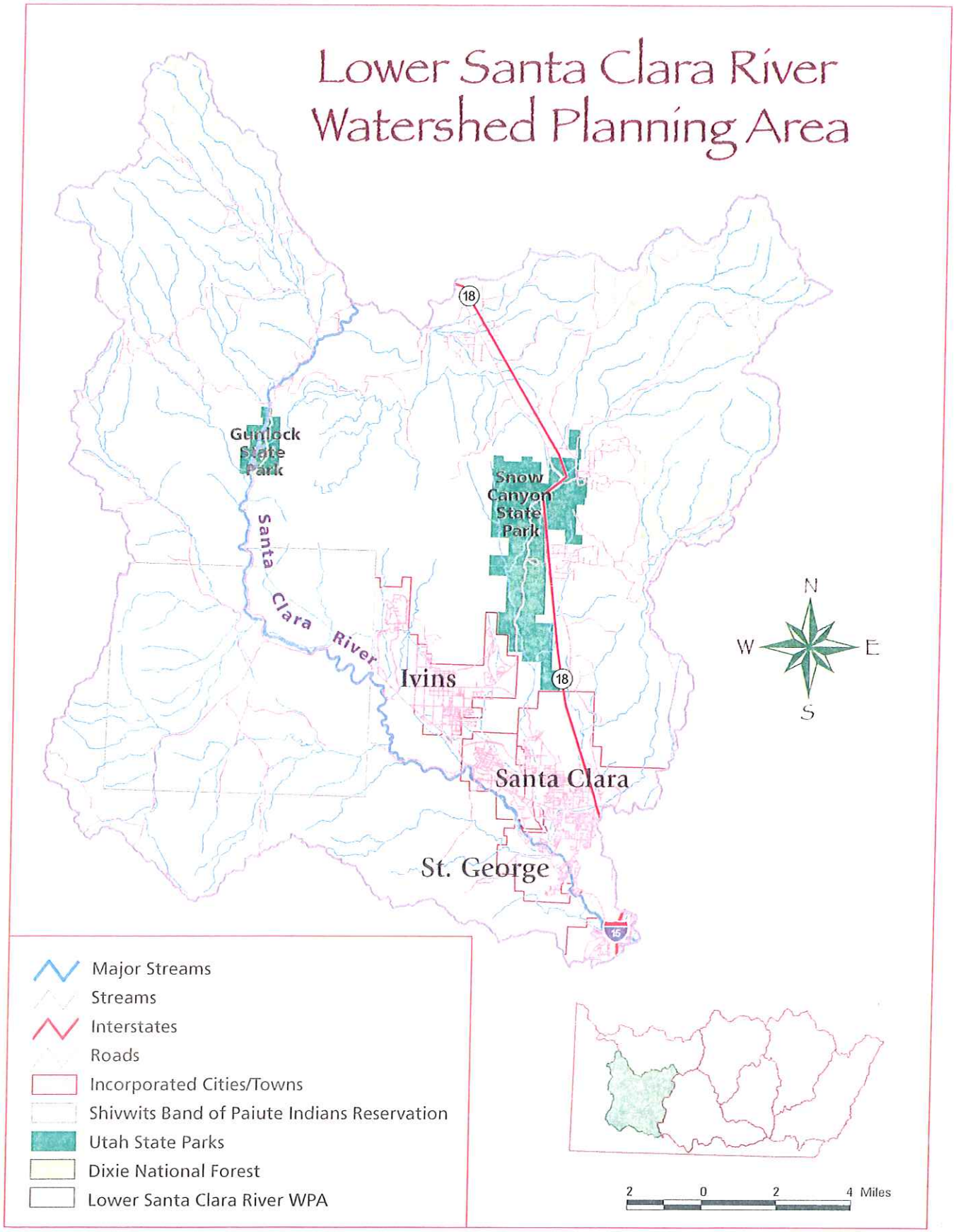
The community of Brookside is located along the stream channel below Baker Dam Reservoir. Housing is relatively dense and the cumulative impact of individual septic systems on water quality is undocumented. The cool climate of Pine Valley is leading to the development of an increasing number of seasonal homes, also reliant upon individual septic systems for wastewater disposal. Septic systems have the potential to cause water quality impacts to both surface and ground water at high densities and without proper installation and maintenance. Stakeholders believe that addressing septic systems is key to protecting both surface and ground water resources.

Native Species

The Upper Santa Clara River WPA contains stretches of habitat occupied by the Virgin spinedace, a sensitive native fish species. Virgin spinedace historically occupied an estimated 3.1 miles of habitat in Magotsu Creek; by 1993, the amount of occupied habitat was estimated at 0.6 miles, an 81 percent decrease in estimated occupied habitat (USFWS, 1995). The Virgin Spinedace Conservation Agreement and Strategy identifies several non-native aquatic species that occupy Virgin spinedace habitat in the Upper Santa Clara WPA (USFWS, 1995).

Watershed Planning Area: Lower Santa Clara River

The Lower Santa Clara WPA includes the area draining to the Santa Clara River between its confluence with the Virgin River and the confluence with Magotsu Creek. Bounded by the Beaver Dam Wash/Fort Pearce Wash WPA on the west and south, the Upper Santa Clara WPA to the north, and the


Lower Santa Clara River
Watershed Planning Area
Gunlock State Park
Snow Canyon State Park
Santa Clara River
Ivins
Santa Clara
St. George
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Major Streams
Streams
Interstates
Roads
Incorporated Cities/Towns
Shivwits Band of Paiute Indians Reservation
Utah State Parks
Dixie National Forest
Lower Santa Clara River WPA
2 0 2 4 Miles

Lower Virgin River WPA on the east, the Lower Santa Clara WPA is located entirely in Washington County.

Land holdings in the WPA include the Bureau of Land Management, State, private, national forest, and tribal lands. The cities of St. George, Santa Clara, and Ivins make up the majority of private land holdings and are located in the lower portion of the WPA along the Santa Clara River. The Shivwits Band of Paiute Indians Reservation is located almost entirely in the Lower Santa Clara WPA just to the west of Ivins. State managed land includes Gunlock State Park surrounding Gunlock Reservoir and Snow Canyon State Park adjacent to Ivins.

Land use/land cover in the Lower Santa Clara WPA is characterized predominately as shrubland and grassland with some forestland in the higher elevations. A large area of exposed rock extends from St. George through Ivins into the area surrounding Snow Canyon State Park. Areas of commercial and residential land uses are concentrated in and around St. George.

What Are Stakeholders' Key Concerns?

Five key concerns emerged as priorities to stakeholders for this WPA as a result of the survey and public meetings. Key concerns in the Lower Santa Clara River WPA include: (1) riparian corridor health; (2) maintenance of year round flow conditions; (3) increased off-highway vehicle recreational activity; (4) native species; and (5) water quality monitoring.

Riparian Corridor Health

As with the Upper Santa Clara WPA, the health of the riparian corridor varies throughout the Lower Santa Clara WPA. From the confluence of Moody Wash and Magotsu Creek with the Santa Clara to Gunlock Dam, riparian vegetation is primarily native coyote willow, desert willow, and cottonwood. Some stream banks are stable and well vegetated, and others show signs of erosion. From Gunlock Dam to Ivins, vegetation is a mixture of native species and exotic species. Some salt cedar thickets inhabit the riparian corridor from Ivins to the confluence with the Virgin River, although the stream channel is stable and well vegetated with native species.

Maintenance of Year Round Flow Conditions

Historically the Santa Clara River has experienced a wide range of flow conditions. Isolated rain storms in the watershed can produce flash floods that are capable of scouring the stream and removing riparian vegetation. The stream below the town of Gunlock historically went dry nearly every year. Gunlock Reservoir was constructed in 1970 for irrigation water and flood control. Diversions and Gunlock Reservoir alter natural flow conditions

within the Lower Santa Clara WPA. The river below Gunlock Dam often ran dry during the winter when releases for irrigation were stopped. The recently completed Santa Clara Pipeline Project provides a three cfs flow in the Santa Clara River below Gunlock Reservoir. The VRP is also leasing, on a short-term lease, an additional two cfs of flow from the Shivwitts Indian Tribe that is being released to the stream.

Increased Off-Highway Vehicle Activity

Several areas within this WPA provide recreational opportunities, including Gunlock State Park and Snow Canyon State Park. Off-highway vehicles are allowed on public lands where signs indicate it is permitted. Heavy recreation, which includes off-highway vehicle use, occurs along stream banks and is a potential threat to the health of the riparian corridor, as well as a factor in stream bank erosion and sediment loading to streams (VRMP 1999). Stakeholders believe it is important to work with others and take steps to manage off-highway vehicle activity.

Native Species

Historically this WPA has provided habitat for populations of Virgin spinedace, a threatened native fish species. Virgin spinedace are not present in certain portions of this WPA due to the lack of water resulting from irrigation and the historical dry nature of the lower portion of the stream. Stakeholders expressed an interest in addressing concerns related to threatened and endangered species in the Lower Santa Clara WPA.

Water Quality Monitoring

The Santa Clara River from Gunlock Reservoir to the confluence with the Virgin River is considered by the state of Utah to be impaired because of excessive temperature and concentrations of dissolved solids and selenium. Baker Dam and Gunlock Reservoirs are also considered impaired and listed on Utah's section 303(d) list. The two reservoirs are considered impaired because of phosphorous and low levels of dissolved oxygen in the water. The TMDL that addresses the impairment recommends that the lower Santa Clara be delisted for temperature. Recent monitoring has shown that temperature is not a problem. While the reservoirs are considered to be impaired, the impairment is very marginal. The TMDL recommends that Baker Dam be delisted for low dissolved oxygen and that strategies be implemented upstream to address phosphorous. Monitoring of these impaired waters is a priority to track progress toward meeting water quality standards through the implementation of the TMDL.

Watershed Planning Area: Beaver Dam Wash/Fort Pearce Wash

The Beaver Dam Wash/Fort Pearce Wash WPA is located along Utah's border with Nevada and Arizona and occupies 411,537 acres in Washington and Kane Counties. Drainage for the western portion of the WPA is provided by the Beaver Dam Wash, which originates in Utah and flows south through portions of Nevada and Utah before discharging into Arizona. Fort Pearce Wash originates in Arizona and flows north into Utah to its confluence with the Virgin River at St. George. The Virgin River from St. George to the State of Utah border also constitutes a portion of this WPA.

Land use/land cover distribution in the Beaver Dam Wash/Fort Pearce Wash WPA is consistent with the entire Virgin River watershed; shrubland, forested land, and grasslands account for the majority of land area and shrubland and forested densities change with elevation. There is also a significant amount of exposed rock, predominately near the lower reaches of the Beaver Dam Wash and Fort Pearce Wash. Agricultural land is lacking in this portion of the Virgin River watershed; this is most likely due to the absence of persistent stream flow in both the Beaver Dam Wash and the Fort Pearce Wash.

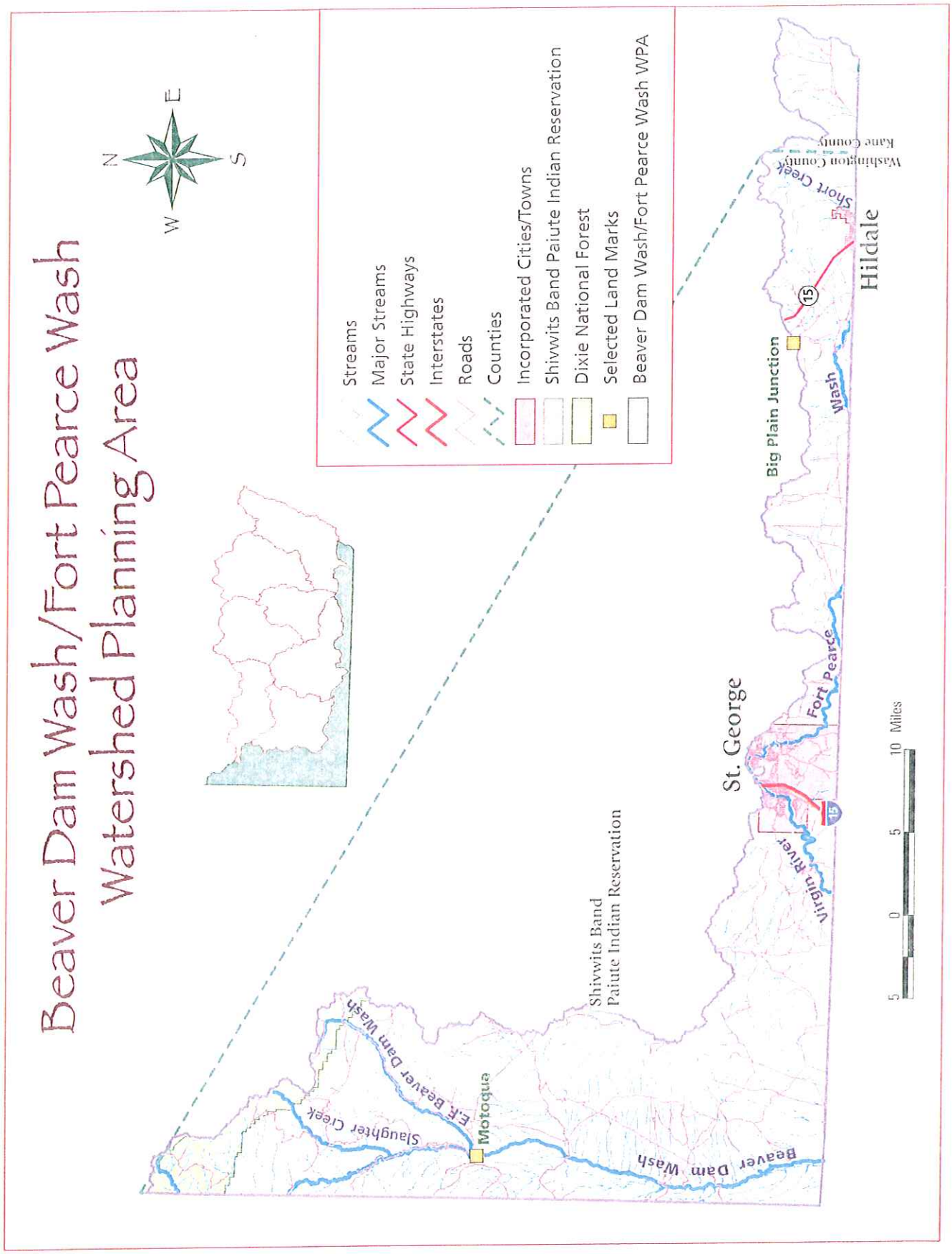
The Bureau of Land Management administers the majority of land in this WPA, approximately 315,100 acres. The principal land use is as rangeland. Other significant landowners in this area include the State of Utah (43,300 acres), private land holders (29,800 acres), and the U.S. Forest Service (19,200 acres), the agency responsible for administering lands in the Dixie National Forest. A small portion of land, approximately 131 acres, falls under the jurisdiction of the Shivwits Band of Paiute Indians.

What are Stakeholders' Key Concerns?

Stakeholders identified two priority concerns: (1) water quality monitoring and (2) threatened and endangered species.

Water Quality Monitoring

Monitoring data are the driving factor behind the development of water quality standards, as well as determining if water quality impairments exist. On occasion, water quality standards are inappropriately applied to a waterbody and additional monitoring data are required to demonstrate that a waterbody is not impaired when measured against appropriate water quality standards. This is the case for temperature issues in the Beaver Dam Wash and explains why water quality monitoring is a key concern for this WPA. UDEQ collected extensive temperature data during the summer of 2002 that was used to de-list this impairment.


Beaver Dam Wash/Fort Pearce Wash
Watershed Planning Area
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Streams
Major Streams
State Highways
Interstates
Roads
Counties
Incorporated Cities/Towns
Shivwits Band Paiute Indian Reservation
Dixie National Forest
Selected Land Marks
Beaver Dam Wash/Fort Pearce Wash WPA
Shivwits Band
Paiute Indian Reservation
Motoqua
E.F. Beaver Dam Wash
Slaughter Creek
Beaver Dam Wash
St. George
Virgin River
Fort Pearce
Wash
Big Plain Junction
Short Creek
Hildale
Washington County
Kane County
15
15
5 0 5 10 Miles

Threatened and Endangered Species

Four native fish species inhabit the Beaver Dam Wash: the speckled dace, desert sucker, woundfin minnow, and Virgin spinedace. The populations of Virgin spinedace occur in reduced abundance near Motoqua in this area.

In addition, this WPA is home to the threatened desert tortoise, the peregrine falcon, chuckwalla, Gila monster, lowland leopard frog, relict leopard frog, and the Arizona toad.

Watershed-Wide Key Concerns

Stakeholders identified many key concerns that apply throughout the watershed. These key concerns include topics under the categories of ground water, social considerations, and public education and outreach. These key concerns are not limited to one particular watershed planning area, although the approaches to address them may require site-specific strategies.

Ground Water

Although surface water diverted from the Virgin River provides drinking water to several communities in the Virgin River watershed, ground water from public water supply wells is a primary source of the watershed's drinking water supply. As areas in the Virgin River watershed become more populated, there is more pressure on the quantity and quality of ground water resources. Like surface water, supplies of ground water are limited. High-growth areas in the watershed are placing a greater demand on these limited supplies, creating a need for groundwater research and a better understanding of available resources.

In addition to water quantity, ground water quality is also a key concern in the Virgin River watershed. Although hidden underground, ground water resources are just as vulnerable to activities on the land as surface water resources. The difference between ground water and surface water, however, is that the land area influencing ground water quality—also referred to as the recharge zone—is less understood than the land area influencing surface water quality. Ground water contamination due to failing septic systems are of particular concern in the Virgin River watershed.

Social Considerations

Stakeholders raised a number of key concerns that relate to developing and implementing the Virgin River Watershed Management Plan. Preserving the quality of life in the Virgin River watershed is a significant concern to stakeholders; the watershed management plan has to strike a balance among the varied concerns and characteristics that make the Virgin River watershed a special place to live. The mission statement for the Virgin River Watershed

Recharging Ground Water Supplies in the Virgin River Watershed

How do our ground water supplies replenish after we tap into them? Just like surface water, storm water runoff, snow melt, and irrigation absorbed by the ground will help to recharge ground water supplies. Ground water aquifers also fill up again from infiltration of streamflow or subsurface inflow from surrounding areas. Surface water and ground water are both important to the health of the Virgin River watershed!

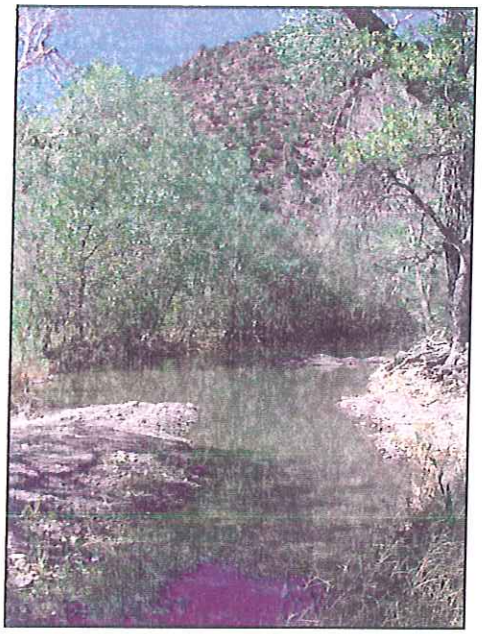
Management Plan reflects the stakeholders' values and the factors that contribute to their quality of life.

Through the development process, stakeholders emphasized the importance of having local control over the Virgin River Watershed Management Plan and the opportunity to participate. Stakeholder involvement is key to any watershed management planning process because, ultimately, stakeholders will have the responsibility for putting the plan into action. Without support from local stakeholders, watershed management plans are just reports that collect dust on a shelf. If stakeholders play an active role in creating a watershed management plan, they have a vested interest in making the plan a reality. For stakeholders in the Virgin River watershed, it is a matter of deciding for themselves—rather than being told—the best course of action to improve watershed conditions.

Public Education and Outreach

More often than not, problems in a watershed are due to a lack of awareness rather than a lack of concern. Stakeholders in the Virgin River watershed know this basic fact and feel that public education and outreach is a key concern to address. Topics for public education and outreach identified by stakeholders include water conservation, natural watershed conditions, and the interaction between surface and ground water. Key concerns in each of the watershed planning areas are also useful in identifying public education and outreach topics. By raising watershed awareness and providing information on potential solutions, residents within the Virgin River watershed may take action to ensure that the Virgin River can provide safe, clean water supplies for drinking and recreation.

Section Four
Strategic Action Plan



STRATEGIC ACTION PLANS are comprised of a suite of activities and management practices selected to target specific problems in the watershed. In addition to describing activities and management practices, strategic action plans contain a schedule for implementation and evaluation, a list of responsible stakeholders, and potential sources of funding. The goal is to ensure that activities and management practices cover the range of critical areas and key issues in the watershed. In some cases, existing plans and programs will address critical areas and key issues; the strategic action plan will simply acknowledge these existing efforts. In other cases, critical areas and key issues will require new activities and management practices. The strategic action plan will describe these new efforts and provide a roadmap.

This section provides the information stakeholders will need to develop a strategic action

What is a Strategic Action Plan?

A strategic action plan focuses on actions to improve conditions in the Virgin River watershed. It is the core of the overall watershed management plan and the roadmap for future watershed management activities. Look at the definition for each word in the name "strategic action plan" and see how it relates to the Virgin River watershed.

Strategic: Important or essential in relation to a plan of action

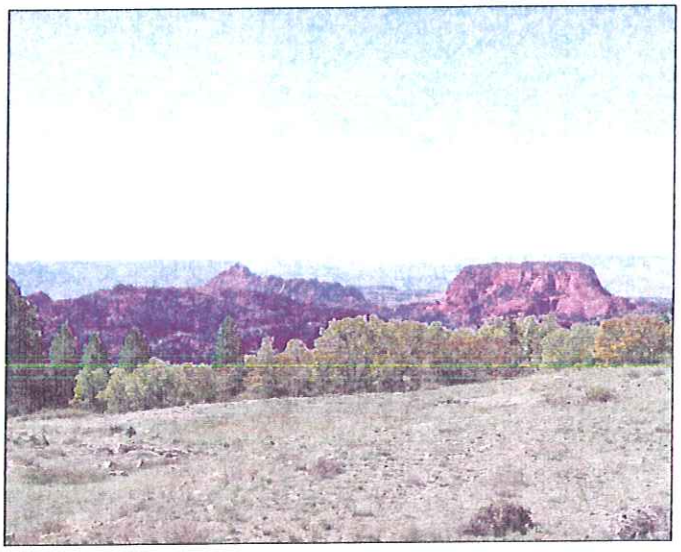
- For the Virgin River, the focus is on watershed priorities and identifying ongoing efforts throughout the watershed to avoid reinventing the wheel.

Action: Organized activity to accomplish an objective

- For the Virgin River, the focus is on identifying activities and management practices that will effectively address problems in the watershed and track success of the activities and practices over time.

Plan: A scheme, program, or method worked out beforehand for the accomplishment of an objective

- For the Virgin River, the focus is on creating a schedule for each activity, identify roles and responsibilities, and develop an approach for evaluating progress.



plan for the Virgin River watershed. Stakeholders unfamiliar with activities and management practices used to address watershed problems might be interested in the overview of common watershed management practices. Following the description of watershed management practices, this section briefly discusses considerations for identifying and selecting appropriate activities and management practices. The remainder of this section focuses on crafting the strategic action plan by describing recommended activities and management practices for the Virgin River watershed and providing a worksheet for documenting details of the plan (e.g., schedule, roles and responsibilities, funding).

Selecting Appropriate Watershed Management Practices

A wide array of watershed management practices and activities exist to reduce pollutants and address pollutant sources. Management practices and activities, often referred to as best management practices (BMPs), vary in cost, technical requirements, and risk. Structural management practices are solutions that might require an investment in new infrastructure, professional technical assistance, and operation and maintenance. This category includes a range of practices such as bioengineering practices to reduce stream bank erosion, installation of efficient irrigation systems, and construction of waste storage or treatment lagoons. Unlike structural management practices, non-structural management practices focus on changes in behavior, policies, and regulations to reduce pollutants and address pollutant sources. For example, non-structural management practices might involve adopting storm water ordinances, updating local zoning ordinances to maintain open space, or conducting a watershed public outreach campaign on septic system maintenance. The most effective strategic action plan will integrate a suite of management practices, both structural and non-structural, to address key issues in the Virgin River watershed.

To select appropriate management practices and activities, stakeholders will need the following information: 1) **sites in the watershed** where a problem exists or improvements can be, 2) **how the various sites compare** in severity or impact on the watershed, and 3) **conceptual solutions or best management practices** that can be applied to address the problem. Additional information, such as cost and effectiveness, may also assist stakeholders in selecting acceptable activities and management practices.

An appendix to the *TMDL Water Quality Study of the Virgin River Watershed* contains a manual of management practices and activities recommended through the TMDL development process. The manual provides a fact sheet for each management practice that describes the purpose, the targeted pollutants, estimated time for pollutant reduction, and expected maintenance. Stakeholders may find this resource, and others like it, useful in evaluating and selecting management practices for the Virgin River watershed.

Potential Causes of Stream Impairment

The mission statement of the Virgin River Watershed Advisory Committee in preparing this watershed management plan focuses on maintaining and improving the health of the watershed including the water quality and other natural resources. The causes of stream impairment or changes to the natural resources may be due to natural conditions in the watershed or natural

processes taking place. Or causes may be the direct or indirect result of our society. The mission statement is as follows.

> *We intend to maintain and enhance the water quality and associated natural resources of the Virgin River Watershed in Utah through education, good management practices and voluntary cooperation while respecting property owner rights.*

There are a number of potential problems or potential impacts to our streams and rivers, land and natural resources that are important to address. The problems may be limited in impact and isolated or serious and widespread throughout the watershed. The problems may impact different things including quality of life, livelihood, available drinking water and agricultural water, recreational opportunities, aesthetics, wildlife, growth of our communities, and even our health. This list of problems and potential causes could include the following:

- Excessive Water Temperature
  - Drought, lack of riparian vegetation, geothermal hot springs
- Sedimentation
  - Erosion, fires, natural geology, earth disturbances, improper livestock management, urban runoff
- Stream Flow Alteration/Lack of Stream Flow
  - Drought, tamarisk, diversions, stream alteration
- Dissolved Solids
  - Geothermal hot springs, natural geology, tamarisk, land use practices (irrigation, fertilizers, waste water, etc.), urban runoff
- Nutrients
  - Waste water from septic systems, industry, sewage treatment plants, fertilizers, livestock, urban runoff
- Dissolved selenium
  - Natural geologic sources, irrigation, drought
- Stream and land changes
  - Invasive plants (tamarisk, cheat grass, etc.), natural plant succession, development on flood plains, stream alteration, land management decisions
- Flooding
  - Fire, invasive plants, floodplain modifications, stream channelization
- Wildfires
  - Fire suppression activities, changes in land management strategies, drought

Table IV-1. Summary of Concerns or Problems in Each Subwatershed

	Temperature	Erosion/ Sedimentation	Stream Flow	Dissolved Solids	Nutrients	Stream/Land Changes	Flooding	Wildfires	Native Fishes	Selenium
East Fork		X	X	X	x	X		X	x	
North Fork			X		x	X			X	
Upper Virgin River	X	x	X	X	x	X	X		X	
Ash/La Verkin Creeks			X		x	X	x	X	x	
Lower Virgin River	X	x	X	X	x	X	X	X	X	
Upper Santa Clara River			X		X	x	X	X	x	
Lower Santa Clara River		x	X	X	X	x	x	X	x	X
Ft. Pearce/ Beaver Dam Washes	X		X	X		x	x		x	

Note: X suggests a higher concern or problem and x suggests a lesser concern or problem.

- Water Quantity
  - Drought, storm water runoff, lack of storage, invasive species
- Distribution and populations of native fishes
  - Drought, fires, nutrients, stream barriers, predation, invasive species, temperature, stream alteration, etc.

Recommended Management Practices for the Virgin River Watershed

Selecting the suite of activities and management practices for the Virgin River watershed strategic action plan may seem like an overwhelming task. Keep in mind that a watershed management plan is a dynamic, evolving tool. Stakeholders will initially choose activities and practices that are appropriate based on present information; as new information becomes available over time, the suite of activities and practices are likely to change. This constant cycle of implementing, evaluating, and readjusting is often referred to as adaptive management. In addition to adaptive management, the strategic action plan will also use a phased approach. This means that not all activities and management practices will happen on the same schedule—they

will happen incrementally over time, according to factors such as priority or resource availability.

Provided below is a list and description of recommended activities and management practices to achieve the goals of the Virgin River Watershed Management Plan. This section presents activities and management practices that address 1) watershed-wide issues discussed at the end of Section Three and 2) issues by WPA. Descriptions for each WPA highlight an activity or management practice that relates to an existing plan or program in the watershed, such as a TMDL or DWSP Plan.

Watershed-Wide Issues and Recommended Management Practices

Maintenance of Stream Flow

Available stream water is a universal concern. Stream water is critical for domestic water supplies, irrigation needs, and for wildlife especially native fishes. The settlement of the area and the successful establishment of communities has largely been a function of the availability of water in streams. Communities such as Gunlock were established at the point in the stream where the stream sustained year round flow before going dry downstream. Other towns such as Grafton struggled to get established and failed because of severe flooding, inconsistent stream flows, or other factors.

While the name of the Virgin River suggests cleanliness and purity, the stream has historically been rich in sediment and dissolved solids. Flows in the stream are highly variable and can go from a trickle to a raging torrent and back to a very limited flow in a matter of hours. Many hikers in Zion National Park have been caught unaware by the impact of isolated showers or thunderstorms in the watershed and the dramatic change in flow downstream.

The settlement of the watershed relied on tapping into the available water in the river and its tributaries and using it for agricultural purposes to sustain life and establish communities. Water was first diverted from the river in 1857 in Washington, when that community was first established. By 1902 there were at least 15 diversions with 41 ditches constructed to irrigate 6,548 acres of land between Springdale, Utah and Bunkerville, Nevada (Hansen, 2002).

One of the biggest factors affecting flow in the Virgin River is the protracted drought that has affected the watershed since the winter of 1998-1999. The drought has been significant in its duration and especially poignant in its severity. For example, total annual stream flow at Virgin in 2002 was the

lowest on record since 1910. The following water years of 2003 and 2004 were among the lowest on record.

The 2005 water year was one of the wettest on record for the watershed. During the winter, mountainous areas in the watershed had 200 to 300 percent of normal snow pack for the year. There was flooding in October 2004 that flooded homes in the Washington Fields and elsewhere on the Virgin River. Later on January 9-12, 2005 there was protracted raining that resulted in severe flooding and widespread damage across the area. The Moody Wash and Magotsu Creek drainages were the most severe. In those areas, the rain was warm and melted the record snowpack. This resulted in what is estimated to have been a 50-year flood event at the town of Gunlock, a 25-year event in Santa Clara, and a 20-year event on the Virgin River in Bloomington.

Due to the wet fall, all reservoirs on the rivers were full and not able to buffer the effect of the floods. The flooding caused severe damage from Gunlock downstream to Santa Clara and St. George. There was widespread bank erosion due to the duration of the event (over two days), because of a lack of stream channel, the presence of tamarisk, and because of highly erodable soils. Many homes were completely swept away as the soil below them was washed away. Residents observed streambanks being eroded at the rate of eight to ten feet per hour. Roads, bridges, and water, electric, sewer, telephone, and cable lines were damaged or washed away. On average, the Santa Clara River Channel went from 44 feet to 108 feet wide and the river's flood plain increased from an average of 70 feet to 139 feet (WCWCD, 2005). Isolated locations in the river were eroded to be over 700 feet wide. Areas were left with vertical banks that were over 30 feet high.

Farther downstream, there was a great deal of sediment deposited in the Virgin River below the Santa Clara River due to the high sediment load in the Santa Clara and its disproportionately high flow compared to the Virgin River. Areas of the Virgin River near Bloomington experienced over five feet of deposition.

Following the flood disaster, aid was received from FEMA to help restore infrastructure. The NRCS worked through its Emergency Watershed Protection Plan to stabilize streambanks on the Santa Clara and Virgin Rivers and Ash and La Verkin Creeks. Their work generally consisted of large levees constructed of rock rip-rap.

In 1962 the Utah State Legislature created the Washington County Water Conservancy District for the purpose of conserving, developing and stabilizing water supplies so that domestic, irrigation, power, manufacturing, municipal and other beneficial uses are met.

The WCWCD constructed the Quail Creek reservoir in 1985 to help meet the needs of the growing county and its communities. Water for Quail Creek Reservoir is diverted from the Virgin River near the town of Virgin. Water also comes from streams that flow directly into the reservoir, these are Quail Creek and Cottonwood Creek. The irrigation water for Hurricane and La Verkin is now distributed from the Quail Creek pipeline. The old Hurricane and La Verkin diversions and canals have been abandoned.

The newer Sand Hollow reservoir is connected to Quail Creek reservoir with a 66-inch pipeline. The pipeline is equipped with a pump that allows water to be pumped to the higher Sand Hollow reservoir from Quail Creek or water can be gravity fed from Sand Hollow to Quail Creek. The Sand Hollow reservoir has a dual function as both a surface water reservoir and a groundwater recharge basin. The reservoir is designed to allow water to infiltrate into the underlying sandstone aquifer allowing for storage of water underground and retrieval of water through pumping wells.

Water from the reservoirs is primarily stored between the months of November through May. Some irrigation releases are provided in the summer months, but the primary use of the reservoir water is for municipal and industrial needs. The increased storage capacity allows for capture and use of early spring flows that can be used for drinking water, to benefit native fishes in the river and to manage irrigation flows more efficiently. The two large reservoirs also serve as heavily-used recreational areas and support local and migratory wildlife in addition to their primary use for water storage.

Irrigation diversions along the Virgin River and its tributaries have been in place for almost 150 years now. These diversions allowed for the establishment of our communities, and the canal system they created continue to serve valuable purposes in providing secondary water systems to agricultural and, increasingly, residential users, thereby supporting the local economy as well as water conservation. These diversions altered the flow regime of the river and at times of the year have been largely responsible for the river going dry in sections. In recent years many irrigation pipelines have been constructed to replace leaky ditches and canals. This often results in a savings of water that can have a measurable environmental benefit.

The Santa Clara pipeline was completed in the summer of 2004. The pipeline transports water from Gunlock Reservoir to Ivins Reservoir and then to serve secondary uses in the Cities of Ivins and Santa Clara.

Part of the Santa Clara project includes a release of three cfs at Gunlock reservoir to benefit native fish in the lower Santa Clara River. The Quail Creek diversion releases three cfs to help maintain flow in the Virgin River. A

five cfs release is targeted for the Washington Fields diversion to help maintain continuous and year-round flow in the river.

Recommendations to help maintain continuous and year-round flow

It is important to recognize that the Virgin River is a highly variable system. Flows are extremely flashy and water quality is full of sediment and dissolved solids, largely as a result of natural sources. Drought compounds normal low-flow conditions and makes impacts more pronounced. Even after drought conditions expire, it may take a year or two for natural conditions to become reestablished.

In terms of the biological community and ecosystem, it appears that flow is one of the most critical factors affecting the system. The release of water from the Quail Creek diversion and at Gunlock Reservoir in the lower Santa Clara River has had a very positive effect on the native fishes and the overall system. Efforts should be made to maintain these conditions and to pursue the targeted five cfs release at the Washington Fields diversion.

There may be additional options for release of water in the river or in its tributaries. Nontraditional or creative approaches should be considered and evaluated. Options could include pumping of groundwater, and even treated wastewaters. Efforts to remove tamarisk should result in a net increase of water in the river.

Dissolved Solids

Many of the streams in the watershed are impacted by high levels of dissolved solids. Dissolved solids in water make the water unusable for drinking water without expensive treatment. Dissolved solids in water accumulate in the soil, especially through irrigation. These solids or salts can build up and make crusts that limit soil productivity. High rates of irrigation can be necessary to constantly dissolve and mobilize solids from the soil. The state's standard of 1,200 mg/l for total dissolved solids in streams is exceeded in much of the Virgin River and its tributaries as a result of natural and other influences.

Natural geologic rock formations cause high levels of dissolved solids in the river and some of its tributaries. The East Fork of the Virgin River is one area within the watershed that contains these rocks with soluble minerals that result in high concentrations of dissolved solids in the water.

The greatest single source of dissolved solids in the watershed is the Pah Tempe hot springs. The springs have a concentration of almost 10,000 mg/l

total dissolved solids and contribute a constant flow of eleven cfs to the river. Upstream concentrations of dissolved solids range from 200-600 mg/l.

Dissolved solids can be contributed from other sources. Tamarisk concentrates these materials in the soil on the floodplain where it tends to grow. Irrigation can concentrate soluble minerals in the soil that can be dissolved and released to the stream. Runoff from urban areas including golf courses or areas fertilized can contribute dissolved solids to the stream. Raw waste water or treated waste water from treatment plants can contribute as well.

Recommendations to decrease dissolved solids

Many square miles of land are exposed in the watershed that containing soluble minerals. The natural hydrologic cycle including precipitation, snow melt, and runoff allows clean meteoric water to become impacted by minerals or salts that are easily dissolved in water. In some areas this may be worse because of erosion or stream bank instability. Areas contributing high levels of salinity should be investigated to see if there are places where seeding, revegetation, stream bank stabilization or other land management approaches may improve the land and the water quality.

The hot springs at Pah Tempe, and to a much smaller extent, hot springs elsewhere in the watershed, are very difficult to address. It is thought that the source of the Pah Tempe is hot water rising from depth as a result of a temperature gradient. The water dissolves limestone and gypsum present in the Paleozoic limestone layers it discharges from along the Hurricane fault. Hot water rising from depth may be mixing with cooler and water with less solutes that recharges the spring from the Virgin River or other more local sources.

The TMDL for the watershed recommended a revision that would allow for higher total dissolved solids in the river from a regulatory perspective. From a practical perspective, the dissolved solids still limit uses. Care should be taken to implement best management practices and not use excessive amounts of fertilizers on lawns or golf courses. The use of storm detention basins in urban areas may help to keep dissolved solids from the stream. Removal of tamarisk from the stream banks and flood plains in the watershed will also decrease dissolved solids in the water.

Nutrients

The largest sources of nutrients that are present in the Virgin River and its tributaries result from human and animal waste. This could be from waste directly entering the stream from campers and hikers or from animals. Most of the waste indirectly impacts the stream as a cumulative effect from communities with many on-lot septic systems that may not be constructed or

functioning properly. Or it can be from agricultural areas where nutrients can migrate to the stream through runoff or through the shallow groundwater system. Discharge of treated water from sewage treatment plants contributes a very small amount of nutrients to the stream system, but it is usually a more effective system than individual systems.

Recommendations to reduce nutrient levels

Where it is possible, municipal sewage treatment plants should be implemented. Most of our larger communities have implemented or connected to treatment plants including: Orderville, Springdale, Toquerville, La Verkin, Hurricane, Washington, St. George, Bloomington, and Santa Clara. Where treatment plants are not feasible, home owners should be encouraged to maintain and upgrade their septic system as needed to have a properly functioning on-site treatment system. Communities should be aware of the need for septic system density limitations and take steps to limit the impact on groundwater and streams.

Owners of septic systems located throughout the watershed are subject to on-site wastewater regulations administered by the Southwest Utah Public Health Department. On-site wastewater regulations address proper installation of septic systems; individuals must submit a permit application to the health department for review and, upon approval and installation, contact the health department to conduct a final inspection to verify proper installation. Although proper installation is an important aspect to ensuring septic systems function properly, adequate maintenance is essential. To ensure septic systems function properly throughout the WPA, a program that focuses on septic system inspection, maintenance, and education is recommended as a new management practice.

Livestock management practices are available that can limit the animal waste interaction with streams while still allowing for productive livestock grazing. Options include rotational land management strategies, creating off-stream watering sites, fencing stream bank areas, short duration, etc. Almost all strategies can be implemented in such a way that the number of animals is usually not decreased.

Stream and Land Changes

Both our streams and our lands have experienced changes in the past decades and centuries. Our rangelands are generally in much better condition than in previous decades. We have seen the introduction of invasive species such as tamarisk that have taken over much of the stream corridors. The tamarisk deplete water, worsen water quality by concentrating salts in the soils, create a fire hazard in the flood plain, and make an unnatural and

unhealthy habitat in the riparian stream area. There are many areas where streams have been severely altered, sections have been straightened, and gradients adjusted putting the stream out of natural equilibrium and causing stream instability in the area altered and upstream and downstream from the site.

There is evidence to show that pinyon and juniper trees have taken over land previous occupied by brush and grasses that are more valuable to wildlife and livestock. The same is true for spruce and fir trees displacing aspen stands at higher elevations in the watershed. This is largely natural plant succession taking place. The succession cycle is naturally reset by wildfire. Our fire suppression activities are usually effective in preventing large scale devastation to homes, businesses, and private and public lands. The same suppression activities have led to more mature and less valuable lands. Timber harvesting, controlled burning, and chaining of juniper stands have become unpopular or unacceptable land management strategies to many groups or individuals.

In other areas of the watershed, there is great urban and suburban growth taking place. Much of this growth is taking place near streams and in areas where land use changes can have very direct impacts on the streams and land. Development can alter the stream hydrology, increase flooding potential, introduce pollutants, impact wildlife habitat, etc.

Land Use Recommendations

Tamarisk removal should be a high priority activity in the watershed and in those areas where it directly impacts communities. Tamarisk is very difficult to eradicate and efforts will likely require a big initial effort and a dedicated long-term presence. Tamarisk removal is one item that can lead to improvements in many aspects of the watershed's health and function.

Efforts should be made to maintain sound management practices on our rangelands and forest lands. Watershed stakeholders should work together to implement land management strategies, controlled burning, limited fire suppression activities, or other approaches that help to maintain healthy lands and forests.

Stream Recommendations

There area stream segments in the watershed where the streams have been dramatically altered. Some of these can have big impacts on the watershed contributing to stream instability, loss of habitat, increased temperature and other problems. There needs to be further investigation of areas of stream alteration or other impacts to document conditions and impacts and prioritize areas for restoration. Projects that could be targeted include

tamarisk removal and revegetation with native plants, removal of abandoned dams or diversions, stream bank stabilization, natural stream design and reconstruction, etc.

Our watershed residents and governing entities should take steps to manage development to allow for growth in a manner that does not take away from the natural resources that are so valuable to the area. Stormwater planning must also be considered and implemented by local municipalities.

Flooding

Flooding is becoming a big concern for our communities and for the river's health. Prior to the flooding in the winter of 2004 and spring of 2005, there have been a limited number of flood events in the river. This resulted in limited channel capacities, streams that were overgrown with tamarisk, and general conditions that would not accommodate flood flows. Many of our communities are rapidly growing and developing with much of this activity on or near the river's flood plain. Periodic floods scour the channel and help maintain a well functioning hydrologic system. A lack of floods leads to the deposition of sediment and a decreased channel capacity to handle flood waters. Also, the extensive tamarisk stands stabilize floodplain areas, but the dense vegetation may limit the ability of the flood waters to effectively spread across the flood plain.

Flooding Recommendations

Implementation of flood plain mapping and the establishment of flood plain ordinances will help protect life and property and help establish and maintain a healthier river system. Municipalities have the right and responsibility to implement regulations to protect life and property within the watershed. The Water District, the VRP, Washington County, and the cities of St. George, Santa Clara, and Washington are completing master plans for the Santa Clara and Virgin Rivers. These will include a river stability study and an erosion hazard boundary. It is anticipated that the cities will establish ordinances to manage and regulate activities in the river corridor based on the results of the river master plans.

Wildfires

Wildfires in recent years in the Ash Creek and Santa Clara drainages have had severe impacts on the watershed. On the local scale, the fires have burned very hot and limited natural revegetation. Reseeding efforts are costly, difficult, and can be marginally successful. Rain events in these areas have resulted in extreme runoffs of ash-laden water. The black streams of water resulted in dead fish in the Santa Clara River and elsewhere. The increased runoff is also a real threat to local communities. There is a great

potential for large fires in many parts of the watershed that would have dramatic effects on the land and streams.

Recommendations

Fire suppression activities on public land, especially lands administered by the Forest Service and BLM, are well managed and implemented. Where site and current weather conditions allow for it a "let burn" policy may help to regenerate vegetation types and aid in maintaining a healthy land. There may be areas where grazing may be a valuable tool to manage lands and decrease fire potential by removing annual grasses at the end of the season. Prescribed burning, establishing fire breaks and other means should be implemented to prevent and suppress wildfires in order to maintain healthy forests and rangelands.

Native Fishes

The reestablishment of native fishes in the watershed is a concern to many groups and individuals. The Virgin River chub and the woundfin are both listed endangered species. The Virgin Spinedace is managed as a conservation species. The Virgin River Resource and Recovery Program has been established to address these fish species.

The Virgin River chub and woundfin are mainly found in the main stem of the river up to Pah Tempe. The spinedace is generally found in the tributary streams and in the Virgin River above Pah Tempe. These native fishes are well adapted to warm water that is sediment rich. Many local biologists in the Virgin River Program believe that some measure of sediment and turbidity is critical to survival of the fish by helping to limit predation.

Stream flows may impact fish and fish recovery partners have expressed interest in maintaining year round flow in the river. Current studies are attempting to determine if there are short duration periods during the year, especially in the hot summer months, when stream flows are low and temperatures are high that could stress fish or cause fish mortality. In the summer of 2004, the WCWCD released additional flow from Kolob reservoir to supplement stream flows with the intent of minimizing stresses on fish during crucial periods. More typical, non-drought winter precipitation and summer rains will help the fish and likely reduce some of the stresses placed on them.

Many diversions have been constructed in the past for irrigation water. Some of these diversions create a barrier for upstream fish passage and may be the cause of decreased fish populations in upstream locations.

One of the greatest concerns relating to the recovery of native fishes is the presence of competing and predatory fish including Red Shiner and Bass. Large populations of Red Shiner are found in the lower portion of the watershed below the Utah state line. The Virgin River Program has made eradication of the Red Shiner a high priority. Most believe that reestablishment of these native species in the presence of the Red Shiner is a losing if not hopeless battle. Fish barriers have been established to prevent the upstream movement of the Red Shiner. Currently it is believed that the Red Shiner has been successfully removed from the river above the Washington Fields diversion.

Another potential impact to the fish in the river is the Quail Creek diversion located downstream from the town of Virgin. The diversion was constructed in 1985 as part of the Quail Creek Reservoir project. The diversion captures water where it is piped to Quail Creek Reservoir and further to Sand Hollow Reservoir. Sediment accumulates behind the diversion structure. Periodically the gate must be raised to allow the release of accumulated sediment. A sediment management plan is in place with a protocol for determining conditions when sluicing will not have a deleterious impact on the aquatic life downstream. The Quail Creek system also allows flow management options to enhance flows at critical times.

The VRP is actively assessing stream habitat, determining baseline populations, determining limiting factors, maintaining fish in refugia, and conducting periodic stockings. The Utah Division of Wildlife Resources (UDWR) has been conducting quarterly full pass fish assessments to characterize the river from Washington Fields diversion to Pah Tempe.

Recommendations for Recovery of Native Fishes

Recovery efforts should be coordinated through the Virgin River Program to insure that efforts are not duplicated and that work can be focused in an effective means. Baseline conditions for the Virgin spinedace, Virgin River chub, and woundfin have been established and should be kept in mind as recovery targets. Efforts should continue to remove the Red Shiner from the river and limit is introduction. Prevention methods for the Red Shiner and other unwanted species may involve placing barriers and control structures, eradication, public education, and continued monitoring and assessment.

It appears that the release of water from the Quail Creek diversion and at Gunlock Reservoir have both had very positive impacts on the woundfin and spinedace respectively based on informal presentations by the UDWR and others. Implementation of the targeted five cfs release at the Washington Fields diversion will likely also have a measurable improvement

on the fishes. Other opportunities for water releases should be investigated and pursued.

Continued study of baseline conditions and limiting factors may improve understanding of the dynamics of the river system and the needs of the native fishes. However, it may be necessary to implement some adaptive measures based on the best professional judgment of local biologists and fishery experts in order to see changes and make informed decisions for the future.

Ground Water

Many residents living in the Virgin River watershed rely on ground water to supply water to their homes and businesses. Ground water is a resource that is often out of sight, out of mind; however, maintaining ground water quality and quantity is a watershed-wide issue and everyone has a role to play. Residents that may rely on surface water for drinking water supplies should get involved because land in their community might filter rain and snowmelt, allowing ground water supplies to replenish over time.

Recommended Management Practices to Protect Groundwater and Understand Groundwater Resources

To maintain the quality and quantity of ground water supplies, stakeholders in the Virgin River watershed require information about the location of ground water supplies and actions they can take to protect their supplies into the future. Management practices for maintaining ground water quality and quantity focus on collecting and sharing information with stakeholders to encourage informed decisions. Recommended management practices include the following:

- ***Septic System Education, Inspection, and Maintenance Program.*** The first recommended management practice is to develop a program that focuses on septic system education and maintenance. Failing septic systems have the potential to contaminate ground water supplies with nutrients, bacteria, and other harmful pollutants. Proper installation of septic systems falls under the jurisdiction of the Southwest Utah Public Health Department, responsible for enforcing the 2001 Onsite Wastewater Regulations. However, there are no regulations to ensure proper operation and maintenance of permitted septic systems. Once the Southwest Utah Public Health Department approves a septic system permit application and oversees proper installation, it is up to the owner to know when and how to conduct the required maintenance. A septic system education and maintenance program would ensure that septic system owners receive the necessary information on maintenance activities. In

addition to education, the program could include an inspection component. Stakeholders should examine options for septic system inspection and maintenance programs to determine if the program would work best on a voluntary-basis or through a local ordinance.

- ***Ground Water Mapping and Monitoring.*** Stakeholders raised the need for ground water mapping and monitoring to identify the location and condition of culinary water supplies in high-growth areas. Based on stakeholders' input, ground water mapping and monitoring are recommended management practices. Not only will these management practices provide residents with information pertinent to maintaining existing ground water rights, but these practices will also help watershed stakeholders better understand the recharge zones for ground water supplies and make land use decisions that consider the potential impact to ground water.

  To aid in addressing groundwater needs, the WCWCD, in conjunction with the Utah Division of Water Rights has completed a classification petition for the Navajo/Kayenta and Upper Ash Creek aquifers. The report outlines the geologic setting of the aquifers, documents groundwater flow, describes groundwater quality, and delineates potential contaminant sources.

  Additional groundwater investigation of individual water supplies is being done by the U.S. Geological Survey under contract with the WCWCD and St. George City. Age dating and investigation of localized naturally-occurring dissolved arsenic is being investigated. Determining the age of the water helps refine the understanding of groundwater recharge mechanisms and groundwater flow paths.

- ***Water Conservation.*** Several watershed partners within the Virgin River watershed participate in water conservation activities. However, visits to the watershed revealed residents over-watering their lawns and other water intensive practices. Observations send a clear signal that existing water conservation efforts require renewed attention from partners within the watershed. The recommended management practice to address water conservation is to develop and implement a water conservation campaign that ties into strategies for watershed stakeholder involvement and outreach (see below). Water conservation requires a change in attitude and a change in behavior; to achieve these changes, stakeholders must first be aware of the problem surrounding excessive water use and understand the steps they can take to conserve water. More than awareness and education, however, stakeholders will need an incentive to motivate them to conserve

water. The research necessary to develop stakeholder involvement and outreach strategies will reveal the values and concerns of stakeholders and help watershed partners create effective incentives for water conservation.

In addition to water conservation, water reuse is an important part of sound water management in the area. St. George City is implementing a program of reusing treated waste water for limited contact purposes such as watering golf courses and irrigation of agricultural lands. There are plans for this to be increased to decrease some of the demand on our drinking water supplies.

Social Considerations

Any plan that affects the lives and actions of community residents should have local input and local control. Given that the Virgin River Watershed Management Plan will affect numerous communities in Washington, Kane, and Iron Counties, invitations to participate in the process have gone out to residents on several occasions. Many residents have made the effort to participate, but it appears that a majority of residents in the Virgin River Watershed are not aware of the opportunity to get involved. Stakeholders throughout the watershed may respond to the call to participate in watershed activities if more innovative opportunities for involvement are made available.

Recommendations to address Social Considerations

- The development of a stakeholder involvement strategy is recommended as the management practice for addressing social considerations throughout the watershed. A stakeholder involvement strategy identifies meaningful ways for community residents to participate in watershed activities, based on their existing interests, concerns, and values.

Watershed-wide issues to address through a stakeholder involvement strategy include 1) a better general understanding of the Virgin River watershed and what actions stakeholders can take everyday to ensure it is healthy and 2) the relationship between land use decision and water quality and quantity.

Public Education and Outreach

Landowners can make a difference in the Virgin River watershed by making informed decisions and taking positive actions. Therefore, many of the solutions will require motivation and commitments from landowners to adopt recommended management practices. The goal of watershed education and outreach is to develop a message that will increase awareness and, ultimately, motivate a change in behavior.

Plan to educate and reach out to the public

To ensure that education and outreach activities achieve this goal, development and implementation of an information and education (I&E) strategy for the Virgin River watershed is recommended as the primary public education and outreach management practice. An I&E strategy is a road map for developing and implementing effective outreach activities. The focus of the strategy is getting to know stakeholders—the overall target audience —and tailoring outreach activities to reflect their values, concerns, existing level of awareness, and preferred communication channels. Using this information, an I&E strategy aids in crafting messages and identifying outreach formats appropriate for each target audience. Through the development and implementation of an I&E strategy, watershed partners can efficiently use local resources to raise awareness and motivate participation.

Watershed-wide issues to address through an I&E strategy for the Virgin River watershed include 1) a general overview of the Virgin River watershed to raise awareness, 2) the relationship of surface water and ground water in the Virgin River watershed, and 3) water conservation. In addition to watershed-wide issues, an I&E strategy could also address issues specific to certain WPAs where education and outreach are recommended as management practices. For example, septic system education and outreach is recommended in WPAs where stakeholders listed wastewater disposal and septic systems as a key issue. The I&E strategy for the Virgin River watershed could include activities to specifically address the issue of proper septic system installation and maintenance for landowners that rely on septic systems for wastewater disposal.

Recommended Activities and Management Practices for Key Issues and Concerns by Watershed Planning Area

A variety of problems and issues affect each WPA in the Virgin River watershed. The list of key concerns identified by stakeholders for each WPA serves as the basis for the strategic action plan. Recommended activities and management practices for key issues in each WPA are described below.-

East Fork Virgin River

Key concerns in the East Fork Virgin River WPA include: (1) riparian corridor health; (2) maintenance of minimum flow/lack of water storage; (3) erosion control; (4) threatened and endangered species; (5) pinyon-juniper tree land management; and (6) wastewater disposal and septic systems.

The East Fork Virgin River WPA experiences significant recreational use due to Zion National Park. The park boundaries extend from the North Fork drainage on the west side of the park into the southwest corner of the East Fork drainage. Other areas of the East Fork drainage, outside the park support tourist-related commercial activities, as well as agricultural and residential land uses. The Dixie National Forest encompasses the northern-most portion of the WPA, including the headwaters of the East Fork of the Virgin River.

Plans that contain management practices in the East Fork Virgin River WPA include the Zion National Park General Management Plan, the Zion National Park Water Rights Settlement Agreement, and the Dixie National Forest Land and Resource Management Plan. Other management practices include temporary limitations on off-highway vehicle use in Parunuweap Canyon by the Bureau of Land Management. Management practices in each plan have the potential to affect issues in this WPA.

With the exception of erosion control, the key concerns listed above are addressed previously in this chapter's Watershed-wide Issues and Recommended Management Practices section. Much of the area draining to the East Fork of the Virgin River includes soils that are naturally highly susceptible to erosion. There are other areas however, that contain unstable stream banks and contribute high levels of sediment because of natural rocks and soils and also because of past land management practices.

Stream Bank Stabilization

Muddy Creek, which flows to the East Fork near the town of Mt. Carmel, is an area where further investigation and ultimate implementation of stream bank stabilization practices may improve overall watershed conditions. There are also sections of the East Fork where stream bank stability conditions could be improved. Best management practices that may be appropriate to help improve stream bank stability include: removal of nonnative tree species, seeding, pole/post plantings, land management techniques, stream bank fencing, and the use of erosion control fabric. Additional information regarding these BMPs is found in the Appendix.

North Fork Virgin River

Key concerns in the North Fork Virgin River WPA include: (1) maintenance of minimum flow; (2) threatened and endangered species; (3) wastewater disposal and septic system density; and (4) recreation.

As discussed in the previous section, the North Fork Virgin River drainage basin is in a portion of the watershed that experiences significant recreational use both within and outside of Zion National Park. Livestock grazing

is part of the local industry in this area of the watershed and seasonal cabins are common. Waters upstream of the Springdale diversion in Zion National Park provide a source of drinking water for Springdale residents and visitors.

Plans that contain management practices in the North Fork Virgin River WPA include the DWSP Plan, the Zion National Park General Management Plan, and the Zion National Park Water Rights Settlement Agreement. Management practices contained in each plan have the potential to address key issues in this WPA. Other plans include the UDEQ wastewater discharge permit, local on-site wastewater regulations, and a temporary limitation on off-highway vehicle use in the North Fork Wilderness Study Area by the Bureau of Land Management.

In addition to the Watershed-wide Issues and Recommended Management Practices stated above, there is site-specific information regarding issues in the watershed. These issues include: maintenance of minimum flow, threatened and endangered species, wastewater disposal and recreation.

Maintenance of Minimum Flow

Signed in 1996, the Zion National Park Water Rights Settlement Agreement addresses water rights issues among the National Park Service, the three county water conservancy districts within the Virgin River watershed, and the State of Utah. The Agreement prevents the construction of reservoirs on Deep Creek and the North Fork upstream of Zion National Park. In addition, the Agreement requires the Conservancy District, the National Park Service, and the State of Utah to consult on flood control proposals that would affect this area. To further ensure minimum flows in Deep Creek and the North Fork, the Agreement also sets limits on the amount of water that new depletions and diversions can deplete from both surface and ground water sources.

Natural flows have changed in the North Fork due to changes in the floodplain. The Zion National Park General Management Plan refers to the development of a river management plan for the North Fork. Through the river management plan, the National Park Service intends to conduct a number of activities that will restore the natural conditions. One activity is to evaluate different techniques for removing levees and riverbank protection structures, and the effects of removing these structures on visitor's access and park infrastructure (NPS, 2001).

Threatened and Endangered Species

To address populations of threatened and endangered species within and around the boundaries of Zion National Park, the National Park Service describes a series of practices and policies intended to protect surrounding

natural resources. Populations of the threatened Mexican spotted owl occur in the side canyons off the main Zion Canyon, located in this WPA. The National Park Service ensures Zion National Park can provide the public with recreational opportunities while supporting this threatened species by enforcing trail closures and prohibiting facility construction from March 1 through August 31—the breeding/nesting period for the Mexican spotted owl. In addition, the National Park Service will not designate new camping sites in Mexican spotted owl territories (NPS, 2001).

Efforts by the National Park Service to protect downstream populations of Virgin spinedace include using erosion and sediment controls to prevent runoff from construction sites and scheduling construction activities to avoid spawning season. The Virgin Spinedace Conservation Strategy identifies the management of non-indigenous fish species in the North Fork of the Virgin River as a management strategy to improve conditions for Virgin Spinedace populations.

Wastewater Disposal and Septic System Density

Management practices for wastewater disposal in this WPA vary according to method. The small wastewater treatment facility operated by Springdale falls under the regulatory jurisdiction of UDEQ's Utah Pollutant Discharge Elimination System permit program. The permit requires treated wastewater discharging from the plant to meet established pollution effluent; the plant operator takes regular samples to ensure the discharge does not exceed permit limits.

Wastewater disposal is also an issue for campers and hikers exploring Zion National Park. To address this issue, the National Park Service has established a human waste disposal program for overnight visitors in the Virgin Narrows (i.e., the North Fork). Individuals associated with an overnight permit receive a disposal bag referred to as Restop 2. Using a special blend of polymers, this bag within a bag contains and breaks down waste turning it into a deodorized gel safe for disposal in trash and landfills (NPS, 2001).

Recreation

Within the boundaries of Zion National Park, the National Park Service policies in place to ensure that Zion National Park maintains its wilderness character and can support wilderness experiences for visitors in years to come. Policies include a limit of 12 people per group hiking in the backcountry and a prohibition on the use of campfires. In addition, the National Park Service educates visitors on how to prevent water pollution; this is important for the North Fork since the river is the trail in this WPA.

Outside the boundaries of Zion National Park, recreational activities occur on lands administered by the Bureau of Land Management and on privately-owned lands. Guidelines for recreational activities on public lands ask users to pack out wastes, camp in a campground if one is available, camp away from water sources, avoid leaving human waste near water sources, and protect live vegetation. In August 2000, BLM published an emergency travel limitation order that restricts the use of off-highway vehicles in the BLM Wilderness Study Areas in the North Fork Virgin River WPA. BLM issued the restriction due to increasing off-highway vehicle use off inventoried ways causing impacts to the surrounding wilderness (BLM, 2000).

An education effort to provide information on drinking water source protection is recommended to help protect the water quality at the Springdale intake.

Upper Virgin River

Key concerns in the Upper Virgin River WPA include: (1) riparian corridor health; (2) maintenance of natural flow conditions; (3) natural erosion; (4) threatened and endangered species; and (5) wastewater disposal and septic systems.

Pah Tempe Hot Springs

Probably the greatest single source or impact to the watershed is the Pah Tempe or La Verkin hot springs. These discharge to the river in Timpoweap Canyon east of the town of La Verkin. The springs deliver water that is much warmer than the natural stream temperature and the spring water contains very high levels of dissolved solids that make the water unsuitable for almost all uses.

The U.S. Bureau of Reclamation, as part of the Colorado River Water Quality Improvement Program investigated the possibility of desalinization of the hot springs water in 1973 (U.S. Bureau of Reclamation). The plans involved a dam on the Virgin River where stream water would be collected and bypassed and the remaining hot springs could be collected and treated. The spring water would be pumped to a desalinization plant. There the water would be treated to reduce dissolved calcium in the water, cooled and filtered. The main treatment and removal of dissolved solids would take place through reverse osmosis technology. This involves the use of a semipermeable membrane that allows water to pass through, but dissolved solids can not. A concentrated brine solution would be discharged to a very large evaporation pond for disposal. Approximately 3.5 cfs would be lost to through cooling of the water and through waste water evaporation. The project was estimated to cost over $20 million in 1973 with annual equivalent operation,

maintenance and replacement costs of the unit to be $1,759,000 for the 100-year period of analysis.

In 1974, Congress enacted the Colorado River Basin Salinity Control Act, directing the Department of the Interior to complete planning reports on salinity control. The Bureau of Reclamation completed a Concluding Report (Bureau of Reclamation, 1981) on desalinization of the La Verkin Springs in 1981. The report concluded that while the project was acceptable and had the support of the local communities and technology existed to treat the water, its effectiveness was questionable. A downstream salinity reduction was not certain because of downstream irrigation on gypsiferous soils and farther downstream in the Virgin River gorge, a portion of the river percolates underground and later discharges as the Littlefield Springs. Also, other projects in the Colorado River System were found to be more cost effective in salinity reduction.

During the investigation, other alternatives were examined, but found to not be as viable as the desalinization plant that was proposed. Total evaporation of the water with spring flows piped to the Fort Pierce or the Sand Hollow and Grassy Valley areas were considered. A higher recovery desalting process was considered, but the costs were unacceptably high. Injection of the total spring flow and the brine from the desalting plant into deep wells in the Purgatory Flat area was considered. The costs were reasonable, but there was not a high level of confidence that the fluids would remain in the area where they were injected. The water was also considered for mixing with coal mined from the Alton coal fields allowing transport as a slurry. Use of the water for cooling water in the then proposed Warner Valley power plant was also considered. These uses were not practical because of excessive cost in the case of the coal slurry project, and because of regulatory concerns at the proposed power plant. Lastly, pumping and intercepting the groundwater supplying the hot springs with a well field pumping system was considered, but abandoned because of the high estimated annual costs, the fact that a substantial amount of river water would be captured, and the fact that the Pah Tempe Resort has a right to the nonconsumptive use of a portion of the flow from the springs.

Later in 1983 the Bureau of Reclamation reinitiated the study after it was suggested that total evaporation of the hot springs water could be done more economically (Bureau of Reclamation, 1984). Hydrologic studies were updated, geologic studies were initiated and costs from previous work were indexed to 1983. The WCWCD initiated construction of the Quail Creek Reservoir in November 1983, which allowed for the storage of river water and the potential release of flows to offset losses due to evaporation. The 1984 report investigated various salinity reduction variations of three

main approaches including: 1) desalinization of the water, 2) total evaporation of the water, and 3) total evaporation of the water utilizing the Quail Creek Diversion structure. Variations on these approaches involved the use of natural soil liners in ponds and the use of synthetic liners. The report concluded that the project was not cost effective and recommended that the studies be discontinued until technological or other factors warranted further reconsideration.

The hot springs have been investigated through the years, primarily in the context of removing salt from the stream. Since past investigations by the Bureau of Reclamation, new membranes have been developed that make reverse osmosis treatment more cost effective. It may be worthwhile to revisit desalinization of the water. There may be circumstances where it may be determined that high stream temperatures during summer periods cause impacts to native fish populations. This could be cause to consider treating the hot springs to reduce the temperature and not addressing the dissolved solids. Other options of dealing with the hot springs could involve capturing the water and piping it to a point downstream where it could be used to generate power or serve some other purpose while moving the point of first impact farther downstream.

Recommended management practices specific to the Upper Virgin River include land and livestock management practices to establish and maintain healthy lands and riparian corridors. There area areas of tamarisk where removal would improve the health of the stream and the watershed. Education efforts should target riparian landowners, tourists, construction activities, agricultural landowners and homeowners. It is also recommended that work be done to help manage floodplain areas. Mapping of the 100-year floodplain, working with local property owners, purchasing property or acquiring easements, and establishing local floodplain ordinances are all recommended steps to maintain the health of the stream corridor.

Ash Creek/La Verkin Creek

Key concerns identified in the Ash Creek/La Verkin Creek WPA include: (1) maintenance of natural flow conditions; (2) riparian corridor health; (3) wastewater disposal and septic systems; (4) threatened and endangered species; and (5) vegetation management.

Although Ash Creek and La Verkin Creek are part of one WPA, the problems vary between the two creeks. Both streams lie in the northern portion of the watershed and have tributary streams in Iron County. The streams parallel each other with Ash Creek being located along I-15 between Pine Valley

Mountain and the Hurricane Fault. La Verkin Creek is located to the east on the east side of Black Ridge.

Ash Creek receives flow primarily from tributary streams on the eastern side of Pine Valley Mountains. As stated in Section 3, this stream flows to the leaky Ash Creek Reservoir and most of the year the stream flow disappears underground and rarely flows on the surface from Ash Creek Reservoir to Toquerville. It is a perennial stream from Toquerville Springs to its mouth near La Verkin.

La Verkin Creek forms in the higher elevations of the Kolob Plateau in the Kolob Canyon portion of Zion National Park. The stream flows to the south and its mouth is at the Virgin River. Ash Creek and La Verkin Creek flow to the Virgin River at the same point.

Stakeholders have expressed concerns about maintenance of flow in the streams. Ash Creek goes dry and sinks underground below Ash Creek Reservoir. Some diversions are in place on tributaries to Ash Creek that provide irrigation water to Anderson Junction and Pintura. La Verkin has continuous flow, but irrigation diversions near its mouth often cause the stream go dry during the growing season.

Portions of the Ash Creek watershed have experienced severe wildfires during the past decade. This has resulted in excessive runoff, erosion, and possible impacts to the fishery because of ash-laden sediment. Management of lands in the watershed to prevent widespread wildfires is important to the health of the watershed.

Maintenance of Natural Flow Conditions

To improve flow conditions altered by irrigation diversions, the open ditches that serve as diversions on South Ash Creek, and Wet Sandy could be replaced with pipelines that join with the Ash Creek Reservoir pipeline. The Washington County Water Conservancy District completed the Toquerville Secondary Water Supply project and the Leap Creek project, which replaced open ditches with pipelines, saving water in the process. Other recommended management practices that address flow in La Verkin Creek include protecting the scenic, recreational, and hydrologic values and studying the feasibility of removing or modifying existing diversions.

Salt cedar, an exotic species located in the Ash Creek/La Verkin Creek WPA, also has the potential to affect flow conditions. The extent of salt cedar is much more limited in these areas. Where it occurs in the WPA, it should be removed, with the intent of improving both flow conditions and riparian corridor health, discussed below in more detail.

Riparian Corridor Health

Efforts to manage the 100-year floodplain will benefit riparian corridor health. The 100-year floodplain has been mapped for the lower portions of both Ash and La Verkin Creeks. Local municipalities should be encouraged to implement floodplain management ordinances and work with private property owners to avoid harmful activities, such as construction of structures which alter the flow of water, from occurring in the floodplain. The Virgin River Management Plan recommends purchasing property or acquiring easements to help direct development away from the floodplain.

Areas of the Ash Creek corridor need to be evaluated to determine if alternative land management strategies would be more appropriate. Land on the flanks of Pine Valley Mountain has thick vegetation buildup that will likely result in detrimental wildfires. Livestock grazing, controlled burns, and other management practices may be appropriate to manage these lands.

Wastewater Disposal and Septic Systems

The Ash Creek/La Verkin Creek WPA contains septic systems subject to on-site wastewater regulations administered by the Southwest Utah Public Health Department. Outreach focusing on septic system maintenance should target residents in the Ash Creek/La Verkin Creek.

Threatened and Endangered Species

Recommended management practices to address flow conditions and riparian corridor health will also benefit threatened and endangered species in the Ash Creek/La Verkin Creek WPA. The Virgin Spinedace Conservation Strategy identifies management strategies for Ash and La Verkin Creeks. Management strategies include the re-introduction of Virgin Spinedace, habitat enhancement, and non-indigenous fish management.

Vegetation Management

In addition to removing non-native salt cedar, vegetative management practices include livestock grazing and prescribed burning of flat sagebrush and pinyon-juniper by the Bureau of Land Management to reduce wildfire risk. The BLM has conducted some prescribed burning activities in the Ash Creek Corridor in the past years.

Lower Virgin River

Key issues in the Lower Virgin River WPA include: (1) floodplain management; (2) wastewater disposal and septic systems; (3) threatened and endangered species; (4) ground water monitoring; and (5) water quality monitoring.

The Virgin River from Pah Tempe to the state line is listed on Utah's section 303(d) list of impaired waters and considered impaired because of excessive concentrations of dissolved solids in the water. A TMDL was completed, which calculates the amount of pollution that must be removed in order for the stream to meet water quality standards. As part of the TMDL process, a site-specific standard for total dissolved solids is proposed for adoption for the Virgin River. Potential Sources of total dissolved solids identified through the TMDL development process include:

- Natural sources (Pah Tempe Hot Springs)
- Exotic vegetation (Tamarisk)
- Saline irrigation return flows from fields
- Urban storm water runoff
- Animal or human waste water
- Construction disturbances
- Natural hill slope erosion.

Connections exist among key concerns identified by stakeholders and the sources causing water quality impairments in the Lower Virgin River WPA. As a result, many of the management practices recommended in the TMDL report have the potential to improve water quality conditions and address key issues.

The TMDL, the DWSP Plan and the Virgin River Management Plan provide some recommended management practices for the Lower Virgin River WPA. Other existing practices include those related to local floodplain management zoning ordinances and the Dixie National Forest resource management plan. Communities subject to NPDES Phase II municipal separate storm sewer system permits including, St. George, Washington, and Bloomington must develop storm water management plans; information from these plans may contain management practices relevant to key issues in the Lower Virgin River WPA and should be added as it becomes available. No new management practices are recommended to address key issues in this WPA at this time.

Floodplain Management

Floodplain management is a focus of many plans and projects in the Lower Virgin River WPA. Under the TMDL, recommended management practices to stabilize stream banks and improve vegetation in the floodplain include removing exotic species, establishing new vegetation, and preventing erosion. The TMDL also recommends stream channel stabilization management practices; in the Lower Virgin River WPA, stream channel stabilization might include floodplain widening.

Under the DWSP Plan, education activities might indirectly assist with floodplain management efforts in the Lower Virgin River WPA. Education focuses on preventing impacts to the floodplain rather than correcting existing impacts—the focus of the TMDL. By educating landowners with property in or near the floodplain, landowners will have the information they need to prevent harmful activities from taking place in the floodplain and promote improved floodplain management efforts from private property owners. Several communities in the Lower Virgin River WPA will undertake storm water management planning to meet the new Phase II storm water permit requirements. Storm water management activities have the potential to reduce the amount of debris carried through the municipal separate storm sewer system, allowing the system to carry more storm water and prevent flash flooding.

Recommended management practices under the Virgin River Management Plan also address floodplain management. Recommendations include mapping the 100-year floodplain, working with and assisting private property owners to protect the riparian corridor from development, as well as purchasing property or acquiring easements as necessary. Several communities, such as the City of St. George, have strong local floodplain management ordinances in place that require all proposed development to go through a review and approval process.

Wastewater Disposal and Septic Systems

The Regional Wastewater Treatment Facility located in the southwest corner of Bloomington, near the confluence of the Santa Clara River and the Virgin River, is subject to Utah Pollutant Discharge Elimination System permit requirements. The permit, issued by UDEQ, sets permit limits for the wastewater treatment plant to ensure that the discharge will not cause a water quality standards violation.

Septic systems in the Lower Virgin River WPA, however, are subject to installation requirements administered by the Southwest Utah Public Health Department. Although regulations exist to ensure proper installation of septic systems, the regulations do not address proper maintenance over time. As a result, septic systems might fail due to lack of regular maintenance. The DWSP Plan recommends conducting education activities that focus on homeowners' activities that may affect drinking water supplies; septic system maintenance may be a message included in education efforts.

Threatened and Endangered Species

To address threatened and endangered species, the Virgin River Management Plan recommends several management practices expected to

improve flow conditions and riparian corridor health. Recommended management practices include returning flows of water to the river at the Quail Creek diversion throughout the year, implementing measures to reduce or remove the impact of La Verkin (Pah Tempe) hot springs on water quality, and developing a recreation plan and trail with an interpretative plan to educate users of the trail about values of the river, wetlands, and floodplain.

Efforts are in place to improve conditions for threatened and endangered species in the Lower Virgin River WPA. Through the Habitat Conservation Plan for the threatened desert tortoise, Washington County and the Bureau of Land Management are undertaking several recovery actions. Under the Habitat Conservation Plan, partners developed the Red Cliffs Desert Reserve intended to provide habitat to support populations of the desert tortoise. The U.S. Forest Service monitors threatened and endangered species located within the boundaries of the Dixie National Forest under the Forest Land Management Plan.

Water Quality Monitoring

UDEQ will continue to monitor the water quality in the Virgin River watershed over the next several years as part of its ongoing watershed monitoring program. Data collected through the watershed monitoring program will allow for the periodic re-evaluation of the implementation strategies, milestones, and goals identified in the TMDL, as well as the Virgin River Watershed Management Plan.

In addition to the ongoing watershed monitoring program, the TMDL suggests collecting various other data to allow for a more complete assessment of water quality conditions. Suggested monitoring activities include:

- Conduct photo monitoring to make future comparisons of changes in geomorphology, streambanks, riparian conditions, flow levels, and salt crusts.
- Obtain and analyze aerial photos to monitor the riparian corridor health, the composition of the vegetation in the riparian corridor, the amount of invasive salt cedar, and to track geomorphic changes over time.
- Install bank erosion pins, and follow-up measurements of the pin, to track stream bank erosion over time for areas of the watershed with the most severe bank erosion problems.
- Install scour chains downstream of in-stream disturbances would allow for tracking of deposition and scour and the net gain or loss of sediment in the stream bottoms.
- Collect additional stream channel cross sections at certain sites to track channel morphology changes over time.

- Select permanent follow-up monitoring sites based on the location of future implementation projects to establish simple trend analysis, and gauge BMP effectiveness.

Upper Santa Clara River

Key concerns identified in the Upper Santa Clara WPA include: (1) riparian corridor health; (2) runoff storage through reservoirs; (3) wastewater disposal and septic systems; and (4) threatened and endangered species.

The Santa Clara River from Gunlock Reservoir to the confluence with the Virgin River is listed on Utah's section 303(d) list of impaired waters and requires TMDLs for total dissolved solids, temperature and Selenium. The TMDL development process revealed that several of the sources of the impairments are located in the Upper Santa Clara River WPA, including:

- Selenium:
  - Natural sources
  - Irrigation return flows
  - Stormwater
- Total Dissolved Solids
  - Stormwater
- Irrigation return flows
- Stream bank erosion/Land Erosion

Riparian Corridor Health

Maintaining the health of the riparian corridor in the Upper Santa Clara WPA focuses on preventing stream bank erosion, particularly in the Pine Valley Mountains, and ensuring that the stream can flow unencumbered. Management practices recommended under the TMDL address the various causes for stream bank erosion, including improper land management, widening of the stream channel, and sparse vegetation. Practices such as livestock management, fencing, exotic removal, seeding, pole/post plantings, and stream channel stabilization have the potential to address these causes.

In addition to the TMDL, the Virgin River Management Plan addresses riparian corridor health in this WPA. Recommended management practices include mapping the 100-year floodplain and working with private property owners to ensure development does not occur in the riparian corridor. Purchasing property or acquiring easements to direct development out of the floodplain is also a recommended management practice under this plan. To address the downstream problem of sand and gravel accumulating in the stream channel, the plan also recommends a study to identify the upstream source.

Runoff Storage Through Reservoirs

Capturing and storing stream runoff is important in the Santa Clara drainage. Baker Dam and Gunlock Reservoir are on stream reservoirs. Baker Dam has limited capacity and Gunlock is a much larger reservoir. Lower in the watershed is the Ivins Reservoir. These are irrigation reservoirs located off the stream and supplied with water by the Santa Clara pipeline that was constructed in 2004.

Wastewater Disposal and Septic Systems

Septic systems are a source of pollutants in the Upper Santa Clara River WPA. Owners of septic systems located throughout the WPA are subject to on-site wastewater regulations administered by the Southwest Utah Public Health Department. On-site wastewater regulations address proper installation of septic systems; individuals must submit a permit application to the health department for review and, upon approval and installation, contact the health department to conduct a final inspection to verify proper installation. Although proper installation is an important aspect to ensuring septic systems function properly, adequate maintenance is essential. To address the problem of failing septic systems, the TMDL recommends that landowners conduct regular septic system maintenance. In addition, a new recommended practice is the development of outreach materials and activities that target users of septic systems to increase awareness on the problems associated with failing septic systems and educate users on proper maintenance activities. This recommended management practice could be addressed through watershed-wide I&E strategy.

Threatened and Endangered Species

The recommended management practices intended to improve riparian corridor health under the Virgin River Management Plan and the Virgin River Resource Management and Recovery Program are also intended to improve conditions to support threatened and endangered species. Riparian habitat serves as breeding and feeding grounds for several threatened and endangered species; therefore, improving the riparian habitat will also benefit species that rely on the vegetation in the riparian corridor. In addition, recommended management practices under the TMDL that focus on preventing stream bank erosion and maintaining the natural hydrology of the stream channel will protect riparian habitat and benefit threatened and endangered species.

Lower Santa Clara River

Key concerns in the Lower Santa Clara River WPA include: (1) riparian corridor health; (2) maintenance of natural flow conditions; (3) increased off-

highway recreational activity; (4) threatened and endangered species; and (5) water quality monitoring.

Activities conducted under the Virgin River Management Plan and the Virgin River Resource Management and Recovery Program will help to address key concerns in the Lower Santa Clara River WPA. These activities focus on improving habitat for endangered and threatened wildlife species while allowing for water development.

Riparian Corridor Health

Erosion, exotic vegetation, and stream bank erosion are the primary factors affecting riparian corridor health in the Lower Santa Clara River WPA and the focus of management practices recommended under the TMDL. Practices recommended to improve the health of the riparian corridor in the Upper Santa Clara River WPA—animal management, fencing, exotic removal, seeding, pole/post plantings, and stream channel stabilization —are also the recommended management practices in the Lower Santa Clara River WPA. From the confluence of Moody Wash and Magotsu Creek with the Santa Clara to Gunlock Dam, management practices should focus on areas that show signs of stream bank erosion. From Gunlock Dam to the confluence with the Virgin River, exotic species removal and seeding have the potential to improve riparian corridor health.

Several recommended management practices under the Virgin River Management Plan have the potential to improve riparian corridor health. Development in the floodplain near the confluence of the Santa Clara River with the Virgin River diminishes the health of the riparian corridor. The Virgin River Management Plan recommends working with private property owners to prevent activities, such as development, in the floodplain that could harm riparian habitat. To direct development outside of the floodplain, the Plan recommends developing and enforcing zoning, purchasing property, or acquiring easements. Other recommendations under the Plan include establishing a Special Recreation Management Area to rotate recreation along floodplain and reduce OHV activity (see discussion below) and working with the Bureau of Land Management to develop and implement a land management program from the Gunlock Reservoir Dam to the Winsor Diversion.

Maintenance of Year Round Stream Flow

Alterations to the hydrology of the Santa Clara River have affected the natural flows of the river. The Virgin Spinedace Conservation Agreement contains a provision to return a minimum flow of 3 cubic feet per second of water to the Santa Clara River below Gunlock Reservoir. The Virgin River

Management Plan also recommends restoring native fish habitat by providing year-long water flow below Gunlock Reservoir. In addition, the Plan recommends replacing four water diversions located in the Lower Santa Clara River WPA with a pipeline from Gunlock Reservoir to Ivins Reservoir; the Washington County Water Conservancy District recently completed this pipeline project.

The removal of salt cedar is a recommended management practice that also has the potential to improve the flow of the river in the Lower Santa Clara River WPA. Salt cedar is an exotic species that consumes a significant amount of water. The deep root system of salt cedar enables the species to withstand riparian corridors with lower ground water tables and survive in drought conditions. Native species have difficulty competing with salt cedar; as a result, dense populations of the exotic species take root in riparian corridors and choke out beneficial native species that characterize a healthy riparian corridor. In addition to removing salt cedar seeding and pole/post plantings are recommended to facilitate the growth of native vegetative species. Native species will improve flow conditions because they do not consume large amounts of water like salt cedar.

Increased Off-Highway Vehicle Activity

The Virgin River Management Plan cites heavy recreation and camping use along the river from Gunlock Reservoir Dam to Winsor Diversion. To address the impacts from increased off-highway vehicle activity along stream banks, the Plan recommends that the Bureau of Land Management establish a Special Recreation Management Area that includes rotating recreation along stream banks. From Winsor Diversion to Seep Ditch, the Plan recommends limiting access to existing roads and developing a recreation plan to manage recreational use.

Threatened and Endangered Species

As mentioned above, the Virgin Spinedace Conservation Agreement requires a year-long flow of 3 cubic feet per second below Gunlock Reservoir to support populations of Virgin spinedace. Several of the recommended management practices to maintain minimum flows in the Lower Santa Clara River WPA are intended to restore flows below Gunlock Reservoir and improve conditions for the threatened native fish species.

Water Quality Monitoring

To ensure the success of TMDL implementation, the TMDL includes a discussion on options for monitoring. According to the *TMDL Water Quality Study of the Virgin River Watershed*, UDEQ will continue to monitor the water quality in the Virgin River watershed over the next several years as part of its

ongoing watershed monitoring program. Data collected through the watershed monitoring program will allow for the periodic re-evaluation of the implementation strategies, milestones, and goals identified in the TMDL, as well as the Virgin River Watershed Management Plan.

- In addition to the ongoing watershed monitoring program, the TMDL suggests collecting various other data to allow for a more complete assessment of water quality conditions. Suggested monitoring activities include:
- Conduct photo monitoring to make future comparisons of changes in geomorphology, streambanks, riparian conditions, flow levels, and salt crusts.
- Obtain and analyze aerial photos to monitor the riparian corridor health, the composition of the vegetation in the riparian corridor, the amount of invasive salt cedar, and to track geomorphic changes over time.
- Install bank erosion pins, and follow-up measurements of the pin, to track stream bank erosion over time for areas of the watershed with the most severe bank erosion problems.
- Install scour chains downstream of in-stream disturbances would allow for tracking of deposition and scour and the net gain or loss of sediment in the stream bottoms.
- Collect additional stream channel cross sections at certain sites to track channel morphology changes over time.
- Select permanent follow-up monitoring sites based on the location of future implementation projects to establish simple trend analysis, and gauge BMP effectiveness.

Beaver Dam Wash/Fort Pearce Wash

Key concerns in the Beaver Dam Wash/Fort Pearce Wash WPA include: (1) water quality monitoring and (2) threatened and endangered species.

As discussed in the previous section, the Beaver Dam Wash/Fort Pearce Wash WPA spans the portions of the watershed adjacent to the Arizona and Nevada borders.

Plans that contain management practices in the Beaver Dam Wash/Fort Pearce Wash WPA include the Total Maximum Daily Load, the Dixie National Forest Land and Resource Management Plan, and the Virgin River Spinedace Conservation Agreement and Strategy. Management practices contained in each plan have the potential to address key issues in this WPA.

Water Quality Monitoring

As discussed in Section Three, monitoring data are the driving factor behind the development of water quality standards, as well as determining if water quality impairments exist. According to Appendix A of the *TMDL Water Quality Study of the Virgin River Watershed*, Beaver Dam Wash experiences naturally occurring high water temperatures and that the cold water use designation is inappropriate. To change the designated use for Beaver Dam Wash, additional monitoring data are necessary to demonstrate that high water temperatures are due to natural conditions rather than negative impacts to the watershed.

Summary of Watershed Problems and Concerns

There are many problems and concerns that are shared among the different area or subbasins of the watershed. There are likely concerns or issues that are common to the entire watershed. The following concerns have been identified through stakeholder input that are common to more than one subbasin or watershed planning unit.

- Excessive water temperature
- Sedimentation
- Stream flow alteration/lack of stream flow
- Dissolved solids
- Nutrients
- Dissolved Selenium
- Stream and land changes
- Flooding
- Wildfires
- Water quantity
- Distribution and populations of native fishes

In addition to the problems and concerns that are shared across the watershed, there are other issues that are more specific to local areas. The following table is a summary of concerns expressed during development of the watershed management plan as expressed by stakeholders within the watershed. The table also includes a preliminary assessment of problems and issues needing improvement in the subbasins within the Virgin River watershed.

Table IV-2.

Subbasin	Problem	Need for Improvement	Concern
East Fork of the Virgin River	Erosion on Muddy Creek	Pinyon Juniper Mgt.	Riparian Corridor Health Stream Flow Endangered Species Wastewater Disposal
North Fork of the Virgin River			Stream Flow Threatened/Endangered Species Wastewater Disposal Recreation
Upper Virgin River	Pah Tempe Hot Springs Temperature and Dissolved solids		Riparian Corridor Health Stream Flow Natural Erosion Threatened/Endangered Species Wastewater Disposal
Ash/La Verkin Creeks			Riparian Corridor Health Stream Flow Threatened/Endangered Species Wastewater Disposal Vegetation Management
Lower Virgin River	Floodplain Management Tamarisk Removal		Floodplain Management Threatened/Endangered Species Wastewater Disposal Groundwater Monitoring Water Quality Monitoring
Upper Santa Clara River			Riparian Corridor Health Surface Water Storage Wastewater Disposal Threatened/Endangered Species
Lower Santa Clara River	Tamarisk Removal Floodplain Management	Spinedace conservation	Riparian Corridor Health Stream Flow Off Highway Vehicle Use Threatened/Endangered Species Water Quality Monitoring
Fort Pearce/Beaver Dam Wash	Tamarisk Removal Floodplain Management		Water Quality Monitoring Threatened/Endangered Species

Recommended Projects to address problems and issues in the watershed

The following table summarizes potential projects to address problems and issues identified in the watershed management plan. Many of the projects listed have the potential to improve or address multiple problems or concerns in the watershed. The projects are general in nature and there are

Table IV-3.

Subbasin	Recommended Projects to Address Concerns/Issues
East Fork of the Virgin River	Streambank Stabilization Septic System Education Pinyon and Juniper Tree Removal
North Fork of the Virgin River	Drinking Water Source Protection Education
Upper Virgin River	Proper Land Management Practices Drinking Water Source Protection Education
Ash/La Verkin Creeks	
Lower Virgin River	Establishment of a County Wide Floodplain Ordinance Tamarisk Removal
Upper Santa Clara River	Septic System Educations
Lower Santa Clara River	Development of Off Highway Vehicle Use Plan
Fort Pearce/Beaver Dam Wash	
Virgin River Watershed	Tamarisk Removal (dissolved solids, water quantity, riparian corridor health, flooding, fire, etc.) Floodplain mapping and establishment of an ordinance (flooding, riparian corridor health, fire, etc.) Riparian Education (native species, riparian corridor health, etc.) Streambank Stabilization (solids and dissolved solids reductions, habitat improvement, etc.) Stormwater Management (dissolved solids, selenium, nutrients) Livestock Management Techniques (nutrients) Removal of unused diversions (native species) Eradication of Red Shiner and other Predators Release of water to maintain instream flows (for native fishes) Continued investigation of factors limiting native fishes Further investigation of groundwater resources Water Conservation and Reuse

different approaches or means of accomplishing the project based on site conditions, project partner needs and resources, cost, and interaction with other needs and issues.

Ranking of Projects

Stakeholders will review the watershed management plan and discussed the impacts in the watershed and within specific subbasins. Stakeholders will also review the potential projects or best management practices that could be implemented to address the projects. Some of these projects directly address water quality pollution, stream impairment or impacts to the watershed and its resources. Other projects are intended to prevent problems or further impairment or to better understand the problems of the watershed.

Watershed Management

This watershed management plan is intended to be a first cut at what should be a dynamic document. The document should be updated as additional data and information becomes available to better characterize the watershed and problems that it faces. As new information becomes available, the tactics and approach to address the problems should be revisited to insure that priorities are kept in perspective and efforts can be focused where they will do the most good. Also, as work is done to address problems, conditions in the watershed will change and there will be a need for additional assessment.

Watershed management is a process rather than a piece of paper or a document. To be effective, the process must involve collection of data, assessment of the data, prioritizing and implementing projects to address the problems, and continued data collection, assessment, and implementation. While this plan provides a framework for making decisions and taking steps to address water quality and other watershed problems, it is clear that there is a need for continued efforts to address issues to a greater and more detailed level.

Section Five
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