Section 1: San Juan Watershed-Based Plan

Scope and purpose of this document

The San Juan River arises in Colorado, flows south into New Mexico, then back across the southwest corner of Colorado and into Utah where it ultimately joins the Colorado River at Lake Powell. This area, where the four states of Utah, Colorado, New Mexico, and Arizona come together, is often referred to as the Four Corners region. While the San Juan River itself does not occur within the boundaries of Arizona, some of its tributaries do, including, most notably, Chinle Creek (Figure 1-1). Water flowing in the San Juan enters Lake Powell and from there joins the Colorado River flow.

The Colorado River Basin has been divided into an Upper Basin and a Lower Basin, with the division occurring at Lee's Ferry, just south of the point where the Colorado River enters Arizona from Utah (Harding et al., 1995). The San Juan Watershed is part of the Upper Basin. The watersheds below Lee's Ferry, in the Lower Colorado Basin, are addressed in two separate NEMO watershed-based plans, those for the Colorado-Grand Canyon Watershed and for the Colorado-Lower Gila Watershed.

The purpose of the NEMO San Juan Watershed-Based Plan is to provide information and guidance necessary to identify existing and potential water quality impairments within the watershed and to present management alternatives for responding to these impairments. The ultimate goal is to protect water quality where it meets applicable standards and to restore water quality where it fails to meet these standards.

This watershed-based plan consists of three major elements:

- A characterization of the watershed that includes physical and social information relevant to assessing water quality risks that has been collected from existing data sources. No new field data were collected for this plan. This characterization represents an inventory of natural resources and environmental conditions that affect primarily surface water quality. This information is contained in Section 1 of this document.

- A watershed classification that identifies water quality problems by incorporating and assessing water quality data reported by the Arizona Department of Environmental Quality in its biennial report consolidating water quality reporting requirements under the federal Clean Water Act (ADEQ, 2008). [The ADEQ water quality data and further information for each stream reach and for surface water sampling sites across the state can be found at: www.adeq.state.az.us/environ/water/assessment/ assess.html.] Section 2 of the present document describes the risk evaluation methods used and the results of the watershed classifications.

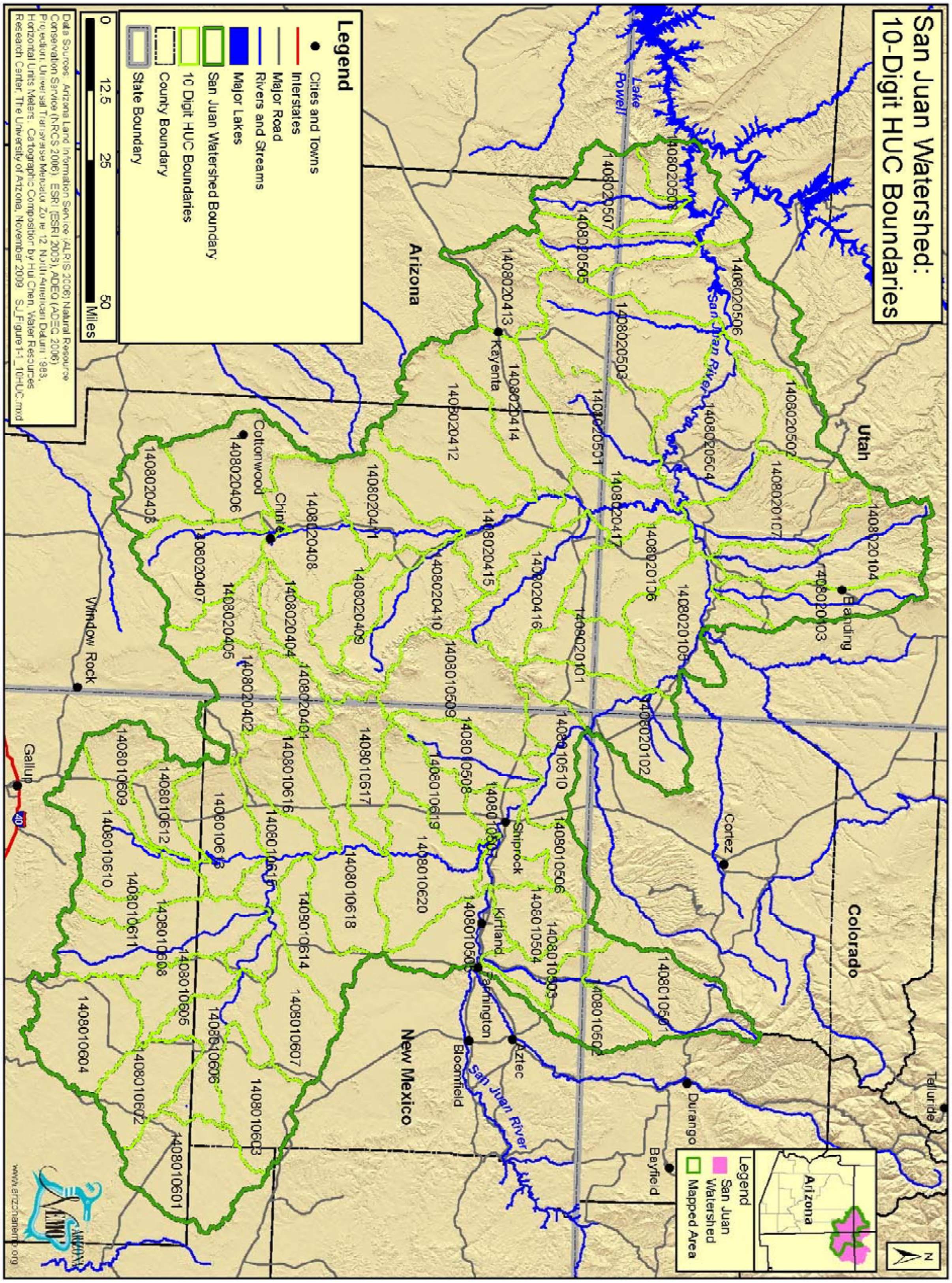

Figure 1-1: 10-Digit HUC Boundaries

- A discussion of management alternatives that may be implemented to achieve and maintain compliance with applicable water quality standards. This information makes up Section 3 of this document.

These watershed management activities are proposed with the understanding that the land-use decision makers and stakeholders within the watershed can select the management measures they feel are most appropriate and revise management activities as conditions within the watershed change. Although these chapters are written based on current information, the tools developed can be used to reevaluate water quality concerns as new information becomes available.

<u>Watershed Information</u>

This section of the plan describes social, physical, and environmental factors that characterize the San Juan Watershed, with particular emphasis on those factors employed in the subwatershed risk classifications that make up Section 2 of the plan.

Internet Mapping Service

Arizona NEMO supports an interactive mapping capability known as Arizona NEMO Internet Mapping Services (IMS) (www.ArizonaNEMO.org/) With this tool it is possible to access maps of all the major watersheds in Arizona and to display various themes such as the locations of towns, roads, and mines; the distribution of soil types and precipitation patterns; land ownership; and other data. The interactive map of the San Juan Watershed can provide useful information to supplement this watershed plan, including stream type and density, location of stream gages, stream flow data, water wells, precipitation and temperature maps, ecoregions, biotic communities, population density, and housing density, which have not been presented within this plan.

Hydrologic Unit Code (HUC) Number

The San Juan Watershed is designated by the U.S. Geological Survey with a six-digit Hydrologic Unit Code (HUC). The United States is divided and sub-divided into successively smaller hydrologic units of surface water drainage features, which are classified into four levels, each identified by a unique hydrologic unit code consisting of two to ten digits: regions (2 digit), sub-regions (4 digit), accounting units (6 digit), cataloging units (8 digit), and 10-digit codes for the level at which monitoring and risk analyses are carried out (Seaber et al., 1987). Table 1-1 contains the names and HUC unit codes used to designate watersheds and subwatersheds in this plan. Their locations are shown in Figure 1-1.

Table 1-1: San Juan 10-Digit HUCs and Subwatershed Areas

HUC	Subwatershed Name	Area (sqmi)
1408010501	Headwaters La Plata River	310
1408010502	McDermott Arroyo-La Plata River	158
1408010503	Barker Arroyo-La Plata River	114
1408010504	Shumway Arroyo	142
1408010505	Ojo Amarillo Canyon-San Juan River	219
1408010506	Salt Creek	125
1408010507	Salt Creek-San Juan River	152
1408010508	Shiprock Wash	181
1408010509	Red Wash	366
1408010510	Salt Creek Wash-San Juan River	183
1408010601	Canada Alemita-Chaco Wash	332
1408010602	Fajada Wash	202
1408010603	Escavada Wash	230
1408010604	Headwaters Kim-me-ni-oli Wash	321
1408010605	Outlet Kim-me-ni-oli Wash	155
1408010606	Kim-me-ni-oli Wash-Chaco River	252
1408010607	De-na-zin Wash	218
1408010608	India Creek	345
1408010609	Figueredo Wash	149
1408010610	Headwaters Coyote Creek	253
1408010611	Standing Rock Wash	121
1408010612	Red Willow Wash	122
1408010613	Outlet Coyote Creek	262
1408010614	Hunter Wash	191
1408010615	Coyote Wash-Chaco River	223
1408010616	Captain Tom Wash	193
1408010617	Sanostee Wash	203
1408010618	Sanostee Wash-Chaco River	322
1408010619	Dead Man's Wash	173
1408010620	Dead Man's Wash-Chaco River	314
1408020101	Tsitah Wash	157
1408020102	Marble Wash-San Juan River	333
1408020103	Recapture Creek	208
1408020104	Cottonwood Wash	353
1408020105	Desert Creek-Lower San Juan River	331
1408020106	Gothic Creek	248
1408020107	Comb Wash-Lower San Juan River	371
1408020401	Wheatfields Creek	96
1408020402	Whiskey Creek	225
1408020403	Pine Springs Wash	176

HUC 10	Subwatershed Name	Area (sqmi)
1408020404	Canyon del Muerto	165
1408020405	Canyon de Chelly	159
1408020406	Cottonwood Wash	289
1408020407	Nazlini Wash	301
1408020408	Black Mountain Wash-Chinle Wash	325
1408020409	Agua Sal Wash	160
1408020410	Lukachukai Creek	286
1408020411	Red Water Wash-Chinle Wash	210
1408020412	Tyende Creek	397
1408020413	Upper Laguna Creek	216
1408020414	Lower Laguna Creek	291
1408020415	Trading Post Wash-Chinle Wash	348
1408020416	Walker Creek	301
1408020417	Chinle Creek	167
1408020502	Grand Gulch	181
1408020503	Oljeto Wash	818
1408020504	Lime Creek-Lower San Juan River	391
1408020505	Nokai Creek	178
1408020506	Copper Canyon-Lower San Juan River	425
1408020507	Piute Creek	233
1408020508	Neskahi Wash-Lower San Juan River	225

Data Sources: GIS data layer "10 digit HUCS" originated by Natural Resources Conservation Service(NRCS), 2006. http://www.nrcs.usda.gov

Social Features

Urban Areas and Population Growth

Ancestral Puebloan (or Anasazi) cultures arose in the Four-Corners region around 700 B.C. and spread to the west, as far as the present-day Lake Mead by A.D. 900 – 1100 (Rohn and Ferguson, 2006). The architectural hallmark of the Ancestral Puebloans was the multi-room pueblo structure. Some of the most well-known and spectacular pueblo ruins occur in the San Juan Watershed. Chaco Canyon in northwest New Mexico contains a remarkable complex of structures begun in the early 900s and abandoned by 1300. Several well preserved Ancestral Puebloan site occur in Arizona along the Chinle Wash and its tributaries. Among the best known are Mummy Cave, Antelope House, and White House, sites within Canyon de Chelly and Canyon del Muerto. Mesa Verde in southwest Colorado, contains spectacular cliff dwellings built between A.D. 1200 and 1300 which mark the culmination of a long history of occupation of the area stretching back to the late 500s (Rohn and Ferguson, 2006).

By the 1300s, these large building complexes were abandoned for reasons still subject to debate, but the descendents of the Ancestral Puebloans include the modern Pueblo peoples of the southwest. The Hopi now occupy villages atop three mesas to the southwest of the San Juan Watershed in Arizona, but in earlier times they frequented territory near the Four Corners area. Their withdrawal to the mesas may have been driven by loss of lowland agricultural productivity due to drought or to escape raids by other Native American groups (Brew, 1979).

The Navajo are an Athapaskan-speaking people who are thought to have arrived in the Southwest sometime during the last millennium (Cordell, 1997). At the time of Spanish contact, the Navajo occupied a large area in the Four-Corners region, where they were neighbors to several Puebloan groups who had settled the region earlier (Brugge, 1983). Conflicts between the Navajo and Anglo-Americans led to the forced relocation of the Navajo to Fort Sumner (Bosque Redondo) in New Mexico in the mid-1860s. The Navajo were released from Fort Sumner in 1868 and allowed to return to a reservation established for them on the Arizona-New Mexico border. Additions to the Navajo Reservation made in subsequent years included lands in Utah along the south bank of the San Juan River and additional land in northwest Arizona. All of the San Juan Watershed in Arizona is within the Navajo Reservation.

In 1776 a Spanish expedition led by the Franciscan Fathers Escalante and Dominguez crossed a portion of the San Juan Watershed while they were seeking a northern route from Santa Fe, New Mexico, to Monterey, California (Goetzmann and Williams, 1992). Other than this brief crossing, there was no Spanish activity or settlement in this area. Fur trappers from Canada and the United States, however, did travel through the San Juan Watershed on their way to fur trapping areas in the southern Rocky Mountains (Goetzmann and Williams, 1992; http://www.nps.gov/history/history/online_books/blm/co/10/index.htm).

The United States acquired the San Juan Watershed (along with much other western land) from Mexico in 1848 through the Treaty of Guadalupe Hidalgo, which ended the Mexican-American War (Sheridan, 1995).

The largest city in the San Juan Watershed is Farmington, NM, with an estimated 2008 population of 46,328 (http://www.fmtn.org). Settlement at Farmington began in the mid 1870s, and the city was incorporated in 1901. It is primarily a farming and ranching community, but oil and natural gas are also produced. Kirtland, NM, was founded in the early 1880s by Mormon settlers. In 2007 it had an estimated population of 6,645 (http://www.city-data.com/city/Kirtland-New-Mexico.html). Blanding, UT, founded by Mormons in the late 19th century, had an estimated 2008 population of 3,290 (http://www.city-data.com/city/Blanding-Utah.html). Shiprock, NM (2007 estimated population: 8,755; http://www.city-data.com/city/Shiprock-New-Mexico.html); Kayenta, AZ (2007 estimated population: 5,595; http://www.city-data.com/city/Kayenta-Arizona.html); and Chinle, AZ (2007 estimated population: 5,402; http://www.city-data.com/city/Chinle-Arizona.html) are all on the Navajo Reservation.

County Governments and Councils of Governments (COGs)

The San Juan Watershed extends into three Arizona counties (Apache, Navajo, and Coconino); one county in Utah (San Juan); three counties in New Mexico (San Juan, McKinley, and Sandoval; and two counties in Colorado (Montezuma and La Plata) (Figure 1-2).

In 1970, Governor Jack Williams divided Arizona into six planning districts and required all federal programs for planning to conform to the geographic boundaries of those districts. The purpose of this designation was to ensure that cities, towns and counties within each district were able to guide planning efforts in their regions. Each planning district formed a regional Council of Governments (COGs), which provided the central planning mechanism and authority within their region. COGs are non-profit, private corporations, governed by an Executive Board, and owned and operated by the cities, towns and counties in the region.

The San Juan Watershed extends into one Arizona COG (Figure 1-2), the Northern Arizona Council of Governments. It also extends into the Southeastern Utah Association of Local Governments, the Southwest Colorado Council of Governments, and the Northwest New Mexico Council of Governments.

The Northern Arizona Council of Government has prepared a "Water Quality Management Plan for Apache, Navajo, Coconino, and Yavapai Counties" (http://www.nacog.org/planning/waterquality/default.htm).

Other Water-Related Organizations in the San Juan Watershed

The Surface Water Quality Bureau of the New Mexico Environment Department conducted water quality and biological assessments of the San Juan, Animas and La Plata Rivers in 2002, and the results of their surveys were published in *Water Quality Survey Summary for the San Juan River Watershed 2002* (ftp://ftp.nmenv.state.nm.us/www/swqb/MAS/Surveys/SanJuanStudySummary.pdf). The report contains data on nutrient level, pH, fecal coliform, and other water quality parameters for tributaries and reaches of the San Juan River within New Mexico.

The New Mexico Department of Game and Fish developed a management plan for the San Juan River (*Management Plan for the San Juan River, 2004-2008*; (http://www.wildlife.state.nm.us/recreation/fishing/ documents/ SanJuanRiverManagementPlan.pdf) that focuses primarily on recreational fishing. Also addressing fishing in the San Juan was the *San Juan River Trout Fishery Monitoring Plan: Fish Health Assessment*, produced by the New Mexico Cooperative Fish and Wildlife Research Unit for the U.S. Bureau of Reclamations (http://www.usbr.gov/uc/envdocs/eis/navajo/pdfs/feis-vol2/Append_M.pdf).

The New Mexico Office of the State Engineer has produced the *San Juan Regional Water Plan*, focusing on watersheds in New Mexico (http://www.ose.state.nm.us/isc_regional_plans2.html)
The goals of the Plan are to:

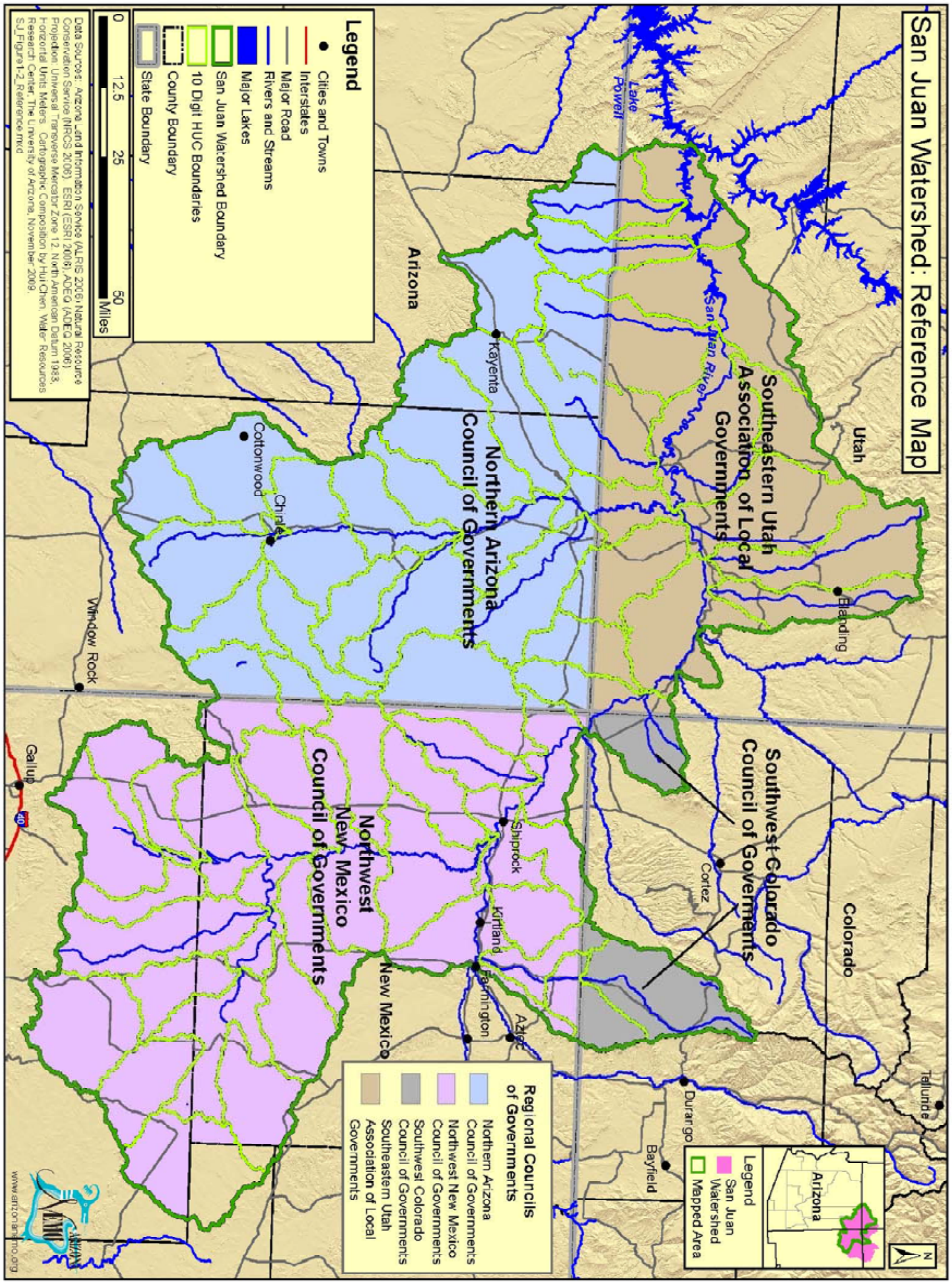

Figure 1-2: Reference Map

- Identify existing and future water demands;
- Identify water supplies for the basin;
- Determine needs to be met by considered alternatives; and,
- Develop implementable alternatives to meet water needs, including conservation methods.

The San Juan Citizens Alliance is a community stakeholder group established for the protection and management of the San Juan River (http://www.sanjuancitizens.org/riverprotection/quality.shtml). It has membership from Colorado, New Mexico, and Ute tribes with reservation land in the watershed.

Land Ownership

Land ownership information for the San Juan Watershed area was provided by the Arizona State Land Department, Arizona Land Resource Information System (ALRIS) (www.land.state.az.us/alris/index.html).

More than three-quarters of the San Juan Watershed is on Navajo tribal lands. Another six percent is private and state land, and the rest is under the jurisdiction of several federal agencies (Figure 1-3, Table 1-2). Land ownership is one of the variables used in the classification of subwatersheds into categories of susceptibility to water quality problems in Section 2 of this plan.

Table 1-2: San Juan Watershed Land Ownership (area in square miles)

Subwatershed	Bureau of Land Management (BLM)	Bureau of Reclamation (BOR)	Indian Reservation	National Park Service	Private	State	Regional Park	US Forest Service (USFS)
Headwaters La Plata River 1408010501	10	0	35	0	211	13	0	41
McDermott Arroyo-La Plata River 1408010502	25	1	86	0	41	4	0	0
Barker Arroyo-La Plata River 1408010503	36	0	46	0	25	6	0	0
Shumway Arroyo 1408010504	30	0	89	0	19	3	0	0
Ojo Amarillo Canyon-San Juan River 1408010505	39	0	133	0	38	8	0	0
Salt Creek 1408010506	0	0	125	0	0	0	0	0

Subwatershed	Bureau of Land Management (BLM)	Bureau of Reclamation (BOR)	Indian Reservation	National Park Service	Private	State	Regional Park	US Forest Service (USFS)
Salt Creek-San Juan River 1408010507	11	0	131	0	9	1	0	0
Shiprock Wash 1408010508	0	0	181	0	0	0	0	0
Red Wash 1408010509	0	0	365	0	0	0	0	0
Salt Creek Wash-San Juan River 1408010510	0	0	182	0	0	0	0	0
Canada Alemita-Chaco Wash 1408010601	127	0	166	0	9	28	0	0
Fajada Wash 1408010602	4	0	165	3	11	20	0	0
Escavada Wash 1408010603	124	0	91	3	3	9	0	0
Headwaters Kim-me-ni-oli Wash 1408010604	19	0	182	0	90	30	0	0
Outlet Kim-me-ni-oli Wash 1408010605	8	0	132	3	0	12	0	0
Kim-me-ni-oli Wash-Chaco River 1408010606	26	0	161	45	1	20	0	0
De-na-zin Wash 1408010607	127	0	62	0	3	26	0	0
India Creek 1408010608	12	0	322	0	1	10	0	0
Figueredo Wash 1408010609	0	0	149	0	0	0	0	0
Headwaters Coyote Creek 1408010610	0	0	252	0	0	1	0	0
Standing Rock Wash 1408010611	0	0	121	0	0	0	0	0
Red Willow Wash 1408010612	0	0	122	0	0	0	0	0

Subwatershed	Bureau of Land Management (BLM)	Bureau of Reclamation (BOR)	Indian Reservation	National Park Service	Private	State	Regional Park	US Forest Service (USFS)
Outlet Coyote Creek 1408010613	0	0	262	0	0	0	0	0
Hunter Wash 1408010614	32	0	158	0	0	1	0	0
Coyote Wash-Chaco River 1408010615	11	0	208	0	0	4	0	0
Captain Tom Wash 1408010616	0	0	193	0	0	0	0	0
Sanostee Wash 1408010617	0	0	203	0	0	0	0	0
Sanostee Wash-Chaco River 1408010618	0	0	322	0	0	0	0	0
Dead Man's Wash 1408010619	0	0	173	0	0	0	0	0
Dead Man's Wash-Chaco River 1408010620	0	0	314	0	0	0	0	0
Tsitah Wash 1408020101	0	0	156	0	0	0	0	0
Marble Wash-San Juan River 1408020102	0	0	331	0	2	0	0	0
Recapture Creek 1408020103	98	0	20	0	39	13	0	38
Cottonwood Wash 1408020104	156	0	6	0	26	29	0	134
Desert Creek-Lower San Juan River 1408020105	26	0	293	0	4	7	0	0
Gothic Creek 1408020106	0	0	247	0	1	0	0	0
Comb Wash-Lower San Juan River 1408020107	292	0	11	0	5	31	0	30
Wheatfields Creek 1408020401	0	0	92	4	0	0	0	0
Whiskey Creek 1408020402	0	0	216	9	0	0	0	0

Subwatershed	Bureau of Land Management (BLM)	Bureau of Reclamation (BOR)	Indian Reservation	National Park Service	Private	State	Regional Park	US Forest Service (USFS)
Pine Springs Wash 1408020403	0	0	176	0	0	0	0	0
Canyon del Muerto 1408020404	0	0	111	54	0	0	0	0
Canyon de Chelly 1408020405	0	0	93	65	0	0	0	0
Cottonwood Wash 1408020406	0	0	287	0	0	0	0	0
Nazlini Wash 1408020407	0	0	298	2	0	0	0	0
Black Mountain Wash-Chinle Wash 1408020408	0	0	314	10	0	0	0	0
Agua Sal Wash 1408020409	0	0	159	0	0	0	0	0
Lukachukai Creek 1408020410	0	0	286	0	0	0	0	0
Red Water Wash-Chinle Wash 1408020411	0	0	210	0	0	0	0	0
Tyende Creek 1408020412	0	0	395	0	0	0	0	0
Upper Laguna Creek 1408020413	0	0	214	0	0	0	0	0
Lower Laguna Creek 1408020414	0	0	290	0	0	0	0	0
Trading Post Wash-Chinle Wash 1408020415	0	0	346	0	0	0	0	0
Walker Creek 1408020416	0	0	300	0	0	0	0	0
Chinle Creek 1408020417	0	0	166	0	1	0	0	0
Grand Gulch 1408020502	164	0	0	2	0	8	0	6
Oljeto Wash 1408020503	0	0	813	0	5	0	0	0
Lime Creek-Lower San Juan River 1408020504	213	0	113	38	4	22	0	0

Subwatershed	Bureau of Land Management (BLM)	Bureau of Reclamation (BOR)	Indian Reservation	National Park Service	Private	State	Regional Park	US Forest Service (USFS)
Nokai Creek 1408020505	0	0	175	1	0	0	0	0
Copper Canyon-Lower San Juan River 1408020506	169	0	193	44	1	16	0	0
Piute Creek 1408020507	0	0	228	1	0	0	0	0
Neskahi Wash-Lower San Juan River 1408020508	19	0	123	79	0	2	0	0

Data Sources: GIS data layer "ownership", Arizona State Land Department, Arizona Land Resource Information System (ALRIS), October 27, 2007 http://www.land.state.az.us/alris/index.html; GIS data layer "SGID_U024_LandOwnership", Utah GIS Data Portal, 2006; GIS data layer "nm_own", BLM, 2004; GIS data layer "landowner_colorado", BLM, 2006.

Land Use

Figure 1-4 shows the distribution of land use categories within the San Juan Watershed based on data from the Southwest Regional Gap Analysis Project (earth.gis.usu.edu/swgap/swregap_landcover_report.pdf).

Virtually all of the San Juan Watershed considered in this plan is classified as forest, range, or barren land. There are agricultural areas near Blanding, Utah, and Farmington, New Mexico, and in some parts of the watershed lying in southwest Colorado.

Human use levels are used in the categorization of subwatersheds into different levels of susceptibility to water quality problems in Section 2 of this plan. A component of human use is the land cover category "impervious surface," which includes such features as roads, parking lots, sidewalks, rooftops, and other impervious urban features. Impervious surfaces are indicators of more intensive land use, and water infiltration into the soils and subsurface aquifers is near zero (http://calval.cr.usgs.gov/JACIE_files/JACIE04/files/2Sohl11.pdf).

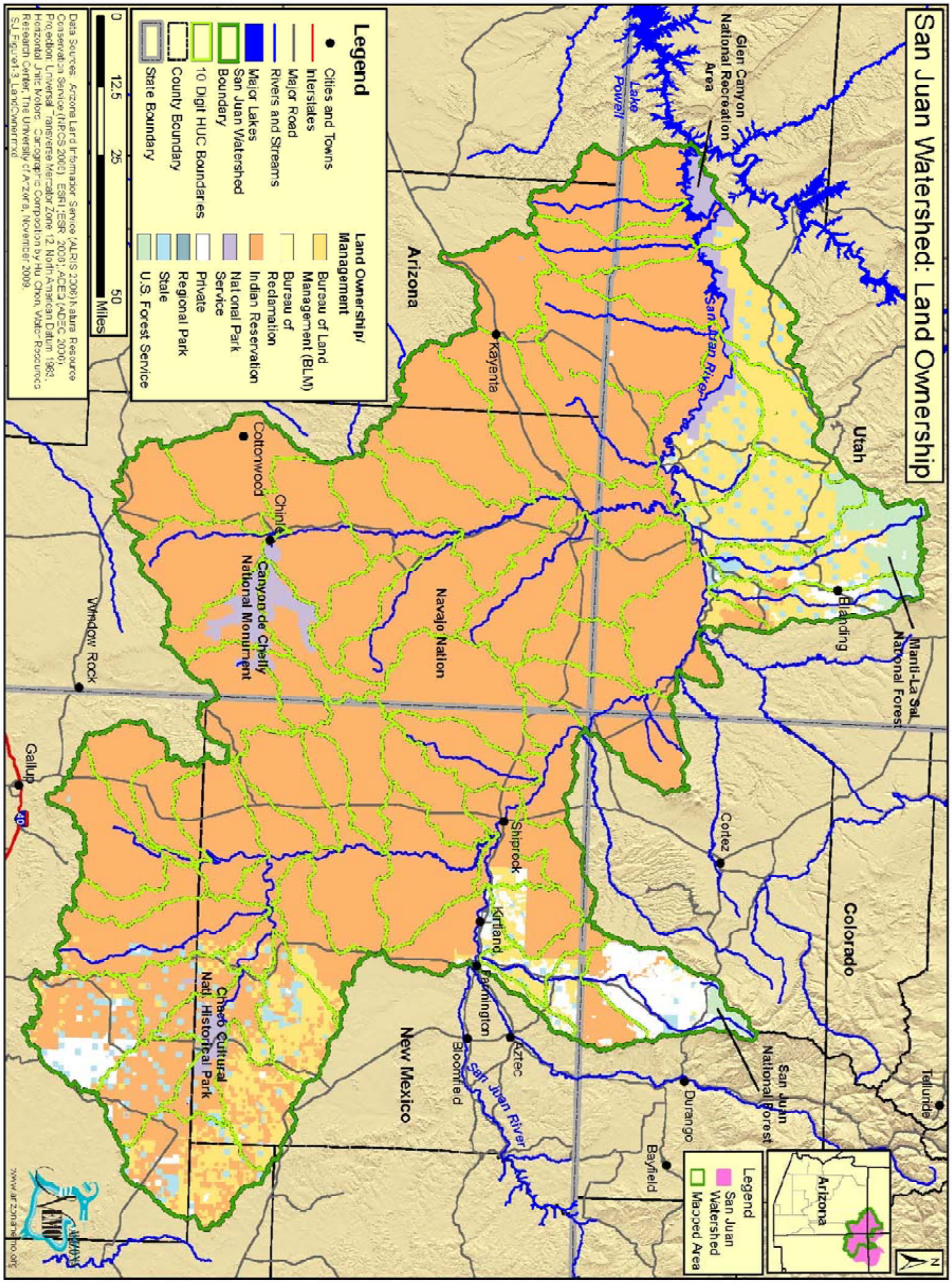

Figure 1-3: Land Ownership

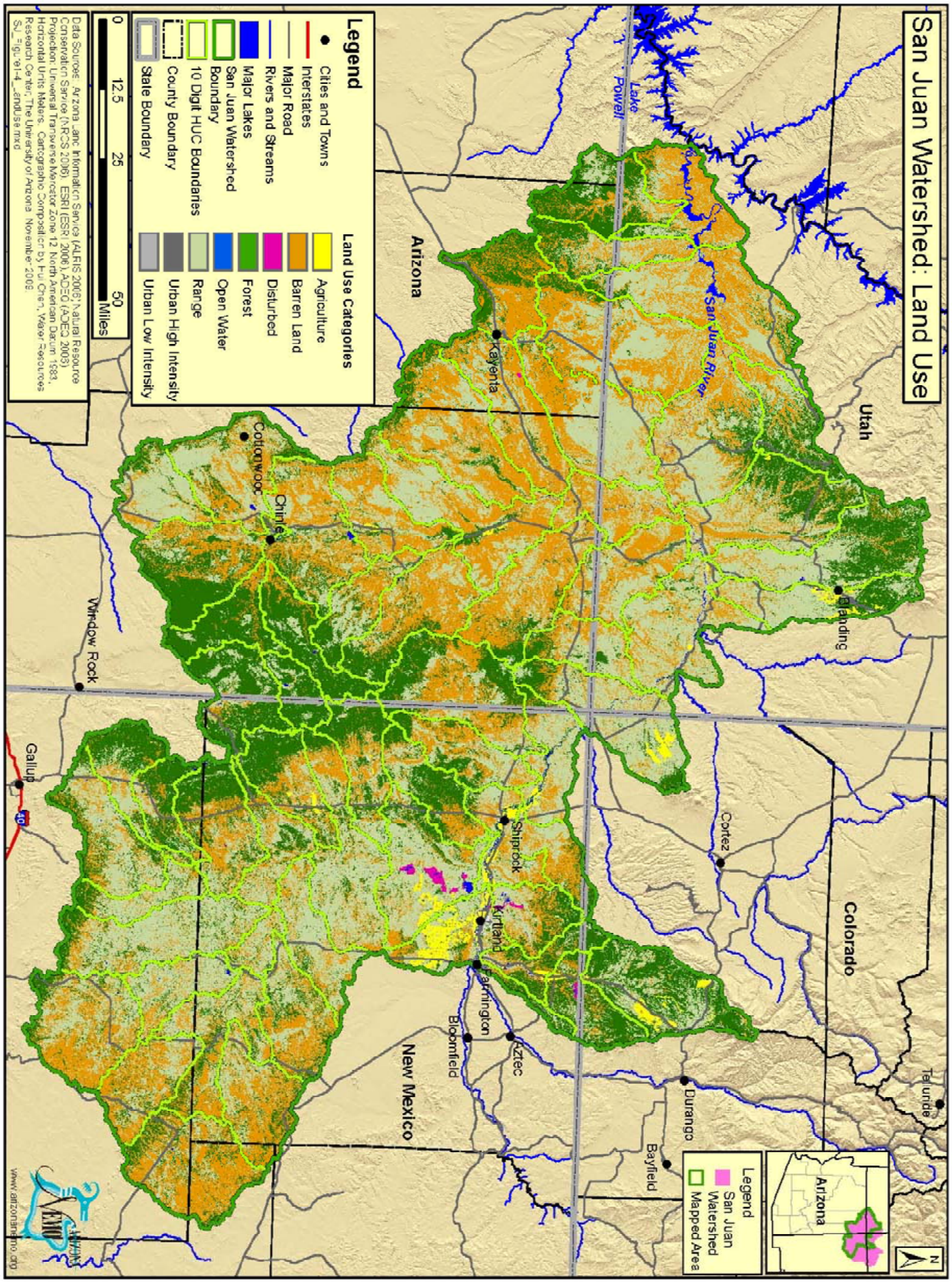

Figure 1-4: Land Use

Physical Features

Watershed Description

The San Juan Watershed includes land in Arizona, New Mexico, Utah, and Colorado drained by the San Juan River and its tributaries. This is an area of more than 15,000 square miles.

Climate

Data from the Western Regional Climate Center (www.wrcc.dri.edu) show a fairly consistent monthly pattern of temperature and precipitation throughout the San Juan Watershed. At the weather stations examined (Chinle and Kayenta, Arizona, Blanding Utah, Farmington, New Mexico, and Mesa Verde, Colorado), average summer high temperatures (July monthly highs) range from 86.7°F at Mesa Verde to 91.2°F at Chinle. Winter (January) average low temperatures range from 13.7°F at Farmington to 17.2°F at Blanding. A map of average annual temperatures throughout the watershed is available on the NEMO web site (www.arizonaNEMO.org).

Annual precipitation at Kayenta averages 7.66 inches, and at Mesa Verde annual precipitation is 18.11 inches. Annual snowfall ranges from 9.2 inches at Farmington to 80.5 inches at Mesa Verde. At Chinle, Kayenta, and Farmington, precipitation occurs primarily during the months of July through October. At Blanding and Mesa Verde, precipitation is more bimodal, with a second peak in precipitation occurring in January.

Topography and Geology

The San Juan Watershed is in the Colorado Plateau physiographic province. Elevations in the watershed range from over 12,000 ft in the San Juan Mountains in Colorado to 3700 ft at Lake Powell. Figure 1-5 is a map of land slope within the San Juan Watershed. Slope is used in calculating such factors as runoff and erosion.

The geology of the Colorado Plateau is described in some detail by Foos (1999: http://www.nature.nps.gov/Geology/education/Foos/plateau.pdf). The Plateau encompasses an area of some 140,000 square miles and extends to the north into Utah and Colorado, to the east into northwestern New Mexico, and across northern Arizona as far as Lake Mead. Foos describes it as "…a high standing crustal block of relatively undeformed rocks surrounded by the highly deformed Rocky Mountains, and Basin and Range Provinces." The oldest rocks forming the Colorado Plateau are of Precambrian age and are exposed at deep parts of the Grand Canyon.

The Colorado Plateau was tectonically stable during the Early Paleozoic (550 – 400 million years before present [BP]), and sediments deposited at that time produced thin sheet-like sedimentary rocks, including the Tapeats Sandstone and the Redwall Limestone. During the Late Paleozoic (400 – 250 million years BP), tectonic uplift produced the ancestral Rocky Mountains as well as the Kaibab and Uncompahgre uplifts in the Colorado Plateau area. During the Mesozoic (250 – 70 million years BP), considerable volumes

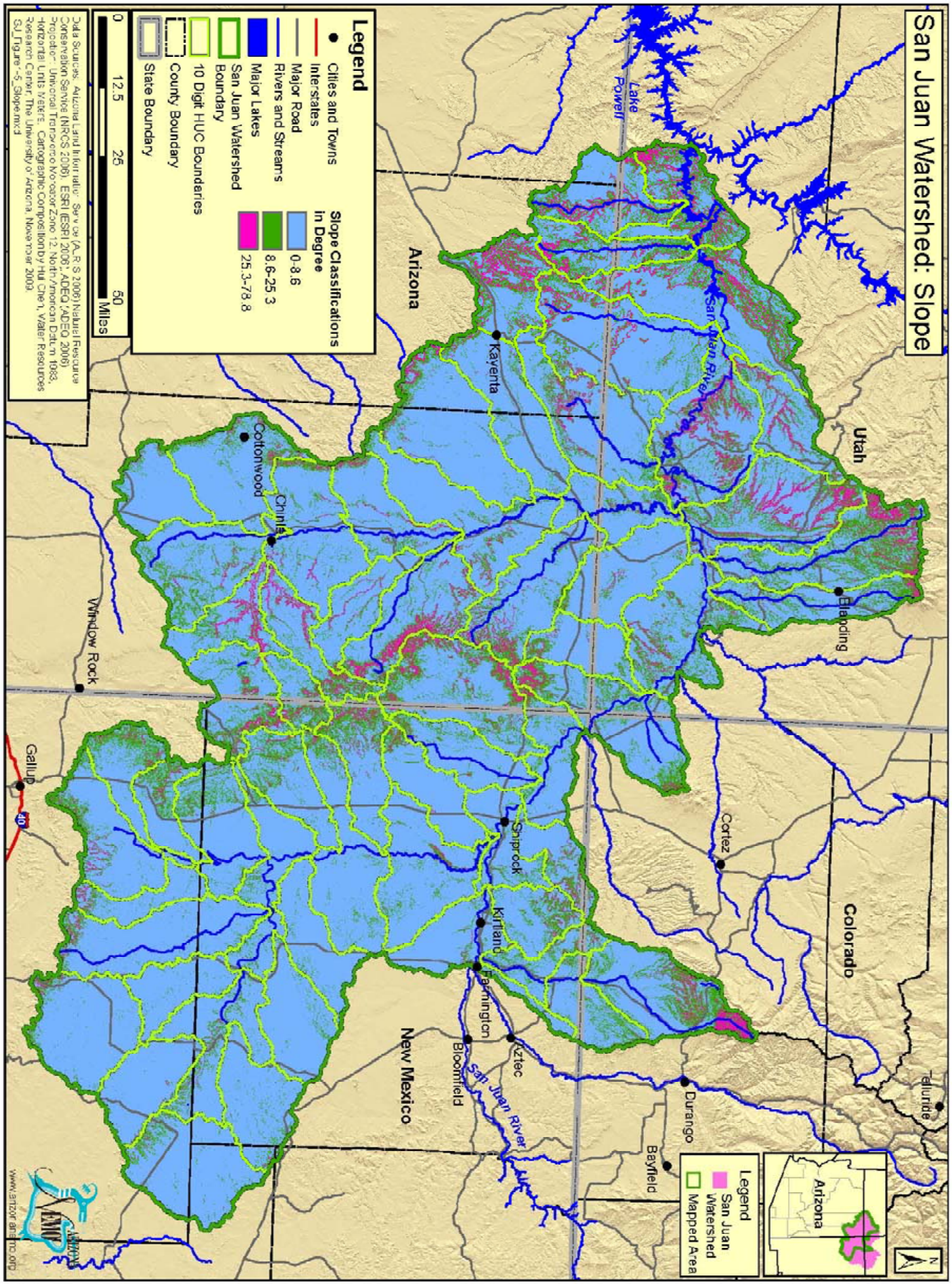

Figure 1-5: Slope

of sediment, some of marine origin, were deposited onto the Colorado Plateau.

A period of major tectonic uplift occurred some 5 million years ago when the Rocky Mountains and the Colorado Plateau were raised 4,000 to 6,000 feet. This uplift resulted in the formation of many of the present-day stream courses which began a period of downcutting and entrenchment, producing the canyon lands of the Four Corners region.

Water Resources

The major lakes and streams of the San Juan Watershed are shown in Figure 1-6 and their sizes are shown in Table 1-3.

Table 1-3: San Juan Watershed Major Lakes and Streams (part 1 of 2)

Lake Name	Subwatershed	Area in Acres	Elevation in Feet	Dam Name (if known)
Bass Lake	Headwaters Coyote Creek	8	6247	
Becenti Lake	Headwaters Kim-me-ni-oli Wash	8	6381	
Bekihatso	Cottonwood Wash	179	5761	
Berland Lake	Captain Tom Wash	8	8862	
Big Gap Reservoir	Dead Man's Wash	19	5646	
Big Lake	Lukachukai Creek	27	8753	
Black Lake	De-na-zin Wash	105	6112	
Black Lake	Whiskey Creek	111	7270	
Blanding City Reservoir #4	Cottonwood Wash Recapture Creek	32	6602	
Blue Rock Tank	Barker Arroyo-La Plata River	6	5856	
Calladito Lakes	Canada Alemita-Chaco Wash	10	6654	
Captain Tom Reservoir	Captain Tom Wash	72	5666	
Castillo Lake	Canada Alemita-Chaco Wash	68	6532	
Castillo, Laguna	Headwaters Kim-me-ni-oli Wash	28	6732	
Chuska Lake	Red Willow Wash	83	6289	
Dry Lake	Oljeto Wash	87	5322	
Fence Lake	Fajada Wash	24	6604	
Flat Lake	Outlet Kim-me-ni-oli Wash	20	6191	
Fluted Rock Lake	Canyon de Chelly	12	7657	
Juans Lake	Outlet Kim-me-ni-oli Wash	339	5886	
Lake Powell	Neskahi Wash-Lower San Juan River	20434	3701	

Lake Name	Subwatershed	Area in Acres	Elevation in Feet	Dam Name (if known)
	Nokai Creek			
	Copper Canyon-Lower San Juan River			
	Piute Creek			
	Neskahi Wash-Lower San Juan River			
	Piute Creek			
Little White Cone Lake	Whiskey Creek	32	7605	
Long Lake	Outlet Coyote Creek	150	8947	
Many Farms Lake	Black Mountain Wash-Chinle Wash	1604	5315	
Milk Lake	India Creek	11	6198	
Morgan Lake	Dead Man's Wash-Chaco River	1259	5328	
Mosquito Tank	Canada Alemita-Chaco Wash	12	6719	
Orphan Annie Tank	Headwaters Kim-me-ni-oli Wash	34	6864	
Recapture Reservoir	Recapture Creek	265	6070	
Round Rock Reservoir	Lukachukai Creek	54	5522	Round Rock Dam
Tanner Lake	De-na-zin Wash	17	5899	
Tanner Lake	Canada Alemita-Chaco Wash	69	6558	
Toadlena Lake	Wheatfields Creek	38	9045	
Tocito Lake	Sanostee Wash	132	5528	
Todacheene Lake	Whiskey Creek	9	8763	
Toh De Niihe	Cottonwood Wash	122	5630	
Tolani	Pine Springs Wash	129	5961	
Tsaile Lake	Canyon del Muerto	260	7031	Tsaile Dam
Turkey Reservoir	Canyon de Chelly	13	7352	
Walker Creek Reservoir	Walker Creek	28	4980	
Wheatfields Lake	Wheatfields Creek	218	7293	Wheatfield Dam
Whiskey Lake	Red Willow Wash	136	8885	
Youngs Lake	Shumway Arroyo	42	5331	

Data Sources: GIS data layer "Lakes"; GIS data layer "assessed_lakes_06"; GIS data layer "water_body"; GIS data layer "Assessed_Lakes"; GIS data layer "SGID_U500_Lakes"; GIS data layer "305b_lakes"; GIS data layer "co_wb_2008_303d_072408".

Table 1-3: San Juan Watershed Major Lakes and Streams (part 2 or 2).

Stream Name	Length in Miles	Subwatershed
Agua Sal Creek	41	Lukachukai Creek
		Agua Sal Wash
Balakai Wash	24	Cottonwood Wash
Black Mountain Wash	21	Black Mountain Wash-Chinle Wash
Black Rock Canyon	19	Canyon del Muerto
Blackhorse Creek	4	Red Wash
Canyon De Chelly	27	Canyon de Chelly
		Whiskey Creek
		Black Mountain Wash-Chinle Wash
Canyon Del Muerto	21	Canyon del Muerto
		Black Mountain Wash-Chinle Wash
		Canyon del Muerto
Chinle Creek	22	Chinle Creek
		Walker Creek
		Trading Post Wash-Chinle Wash
Chinle Wash	95	Trading Post Wash-Chinle Wash
		Red Water Wash-Chinle Wash
		Black Mountain Wash-Chinle Wash
Cottonwood Wash	38	Nazlini Wash
		Cottonwood Wash
Cove Wash	14	Red Wash
Coyote Wash	12	Whiskey Creek
Gypsum Creek	14	Oljeto Wash
Laguna Creek	59	Chinle Creek
		Lower Laguna Creek
		Upper Laguna Creek
Lukachukai Creek	17	Lukachukai Creek
Lukachukai Wash	31	Lukachukai Creek
		Trading Post Wash-Chinle Wash
Nakai Canyon	18	Nokai Creek
Nazlini Wash	40	Nazlini Wash
		Black Mountain Wash-Chinle Wash
Neskahi Wash	1	Neskahi Wash-Lower San Juan River
Oljeio Wash	12	Oljeto Wash
Plute Creek	20	Piute Creek
Red Wash	4	Red Wash
Sanostee Wash	1	Sanostee Wash

Stream Name	Length in Miles	Subwatershed
Tsaile Creek	29	Canyon del Muerto
Tsegi Canyon	22	Upper Laguna Creek
Tyende Creek	47	Tyende Creek
		Trading Post Wash-Chinle Wash
Walker Creek	47	Walker Creek
Whiskey Creek	8	Whiskey Creek
Cherry Creek	23	Headwaters La Plata River
Cowboy Wash	20	Marble Wash-San Juan River
Johnny Pond Arroyo	14	Headwaters La Plata River
Marble Wash	13	Marble Wash-San Juan River
Mariano Wash	16	Marble Wash-San Juan River
McDermott Arroyo	15	McDermott Arroyo-La Plata River
Plata River, La	41	Headwaters La Plata River
San Juan Arroyo	10	Headwaters La Plata River
Captain Tom Wash	35	Captain Tom Wash
		Sanostee Wash-Chaco River
Chaco River	106	Coyote Wash-Chaco River
		Dead Man's Wash-Chaco River
		De-na-zin Wash
		Kim-me-ni-oli Wash-Chaco River
		Salt Creek-San Juan River
		Sanostee Wash
		Sanostee Wash-Chaco River
Chaco Wash	52	Canada Alemita-Chaco Wash
		Kim-me-ni-oli Wash-Chaco River
Coyote Wash	50	Coyote Wash-Chaco River
		Figueredo Wash
		Headwaters Coyote Creek
		Outlet Coyote Creek
		Whiskey Creek
Dead Mans Wash	33	Dead Man's Wash
		Dead Man's Wash-Chaco River
Escavada Wash	35	Escavada Wash
		Kim-me-ni-oli Wash-Chaco River
Hunter Wash	47	Coyote Wash-Chaco River
		Hunter Wash
		Sanostee Wash-Chaco River
Indian Creek	50	Coyote Wash-Chaco River
		India Creek

Stream Name	Length in Miles	Subwatershed
Kim-me-ni-oli Wash	42	Headwaters Kim-me-ni-oli Wash
		Outlet Kim-me-ni-oli Wash
Little Shiprock Wash	30	Shiprock Wash
Red Willow Wash	33	Red Willow Wash
Salt Creek Wash	30	Salt Creek
		Salt Creek Wash-San Juan River
San Juan River	64	Marble Wash-San Juan River
		Ojo Amarillo Canyon-San Juan River
		Salt Creek Wash-San Juan River
		Salt Creek-San Juan River
Sanostee Wash	39	Dead Man's Wash-Chaco River
		Sanostee Wash
Shiprock Wash	32	Salt Creek Wash-San Juan River
		Shiprock Wash
Tocito Wash	43	Outlet Coyote Creek
		Red Willow Wash
		Sanostee Wash
Butler Wash	37	Comb Wash-Lower San Juan River
Chinle Creek	70	Chinle Creek
Comb Wash	38	Comb Wash-Lower San Juan River
Cottonwood Wash	35	Cottonwood Wash
Recapture Creek	50	Recapture Creek
		Desert Creek-Lower San Juan River
		Recapture Creek
San Juan River	39	Lime Creek-Lower San Juan River

Data Sources: GIS data layer "azstreams"; GIS data layer "SGID_U100_StreamTIGER2000"; GIS data layer "nw_streams"; GIS data layer "SJ_Rivers".

Lakes and Reservoirs

The portion of Lake Powell that is contained within the San Juan Watershed covers 20,434 acres, and is by far the largest standing water body in the Watershed. Both Many Farms Lake, north of Chinle, Arizona, and Morgan Lake, southwest of Kirtland, New Mexico, are larger than 1,000 acres, but the other lakes in the San Juan Watershed are all less than 400 acres in extent.

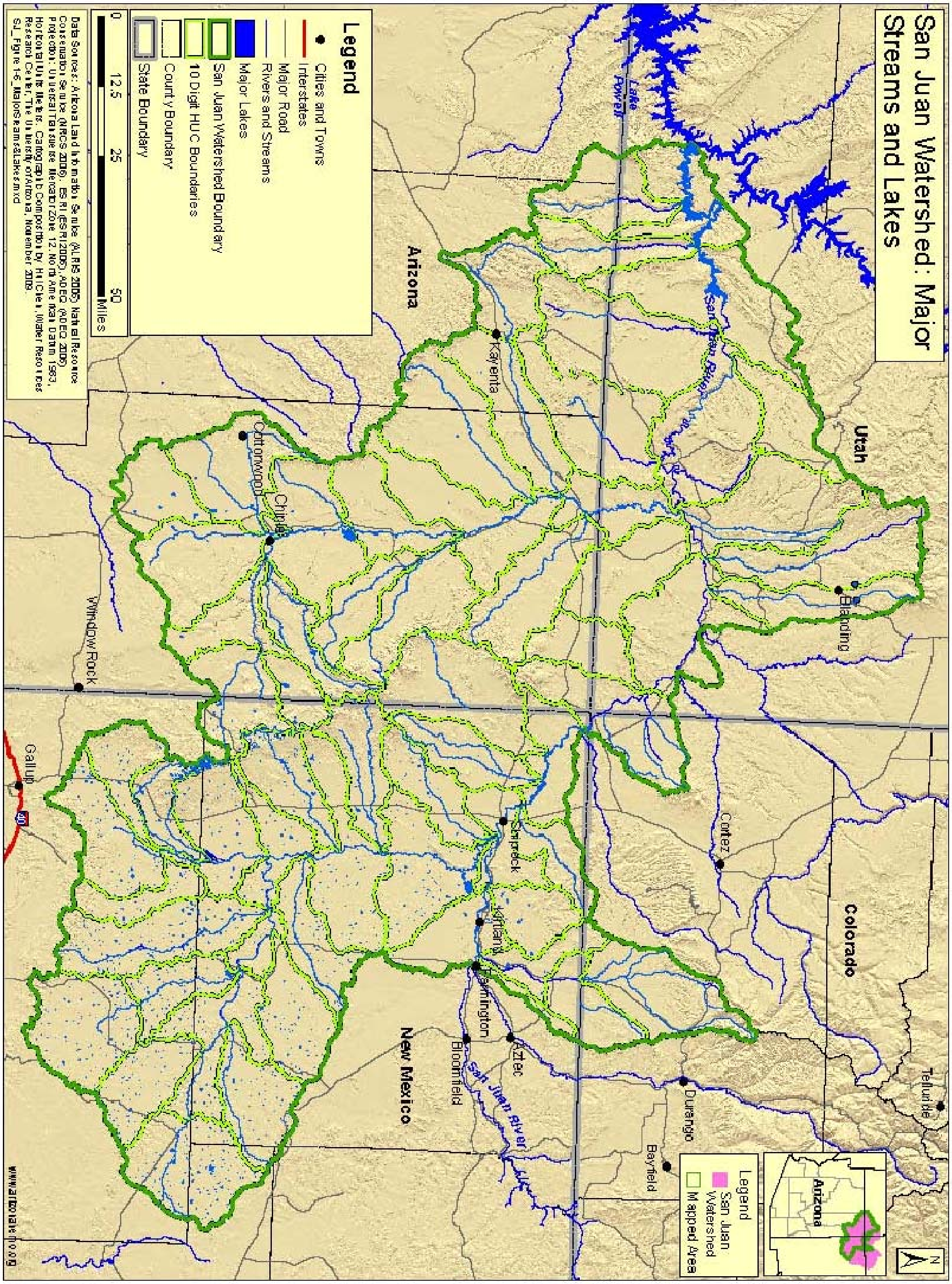

Figure 1-6: Major Streams and Lakes

Streams

The San Juan Watershed contains a total of 1,850 miles of major streams that are of three types: perennial, intermittent and ephemeral.

- A perennial stream has surface water that flows continuously throughout the year.
- An intermittent stream is a stream or reach of a stream that flows continuously only at certain times of the year, as when it receives water from a seasonal spring or from another source, such as melting spring snow.
- An ephemeral stream is at all times above the elevation of the ground water table, has no base flow, and flows only in direct response to precipitation.

The San Juan River has a length of 103 miles within the San Juan Watershed as defined in this plan.

Groundwater

The Arizona Department of Water Resources has divided the State into seven planning areas (www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/). One of these, the Eastern Plateau Planning Area, includes all of the San Juan Watershed in Arizona. A single groundwater basin, the Little Colorado River Plateau Basin occupies this whole area. Wells tapping this groundwater aquifer supply more than 60% of the water needs for agriculture, municipal, and industrial uses in the Arizona Planning Area.

Soils

Information on soils in the San Juan Watershed (Figure 1-7) comes from the U.S. Department of Agriculture, Natural Resources Conservation Service, State Soil Geographic Database (STATGO) (www.ncgc.nrcs.usda.gov/products/datasets/ statgo). Soil categories are indicative of the texture of the soils and, thus, their susceptibility to erosion. Soil texture is used in the calculation of pollutant risk analyses in Section 2 of this plan. For more information on soil classification, see Appendix A.

Pollutant Transport

Non-point source pollutants are not traceable to a single, discrete source, but are produced by many dispersed activities from many dispersed areas. Non-point source pollutants can occur at a large, landscape scale, such as excess agricultural fertilizer application, or at a small, backyard scale, such as oil leaking from a derelict automobile.

Nonpoint source pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;

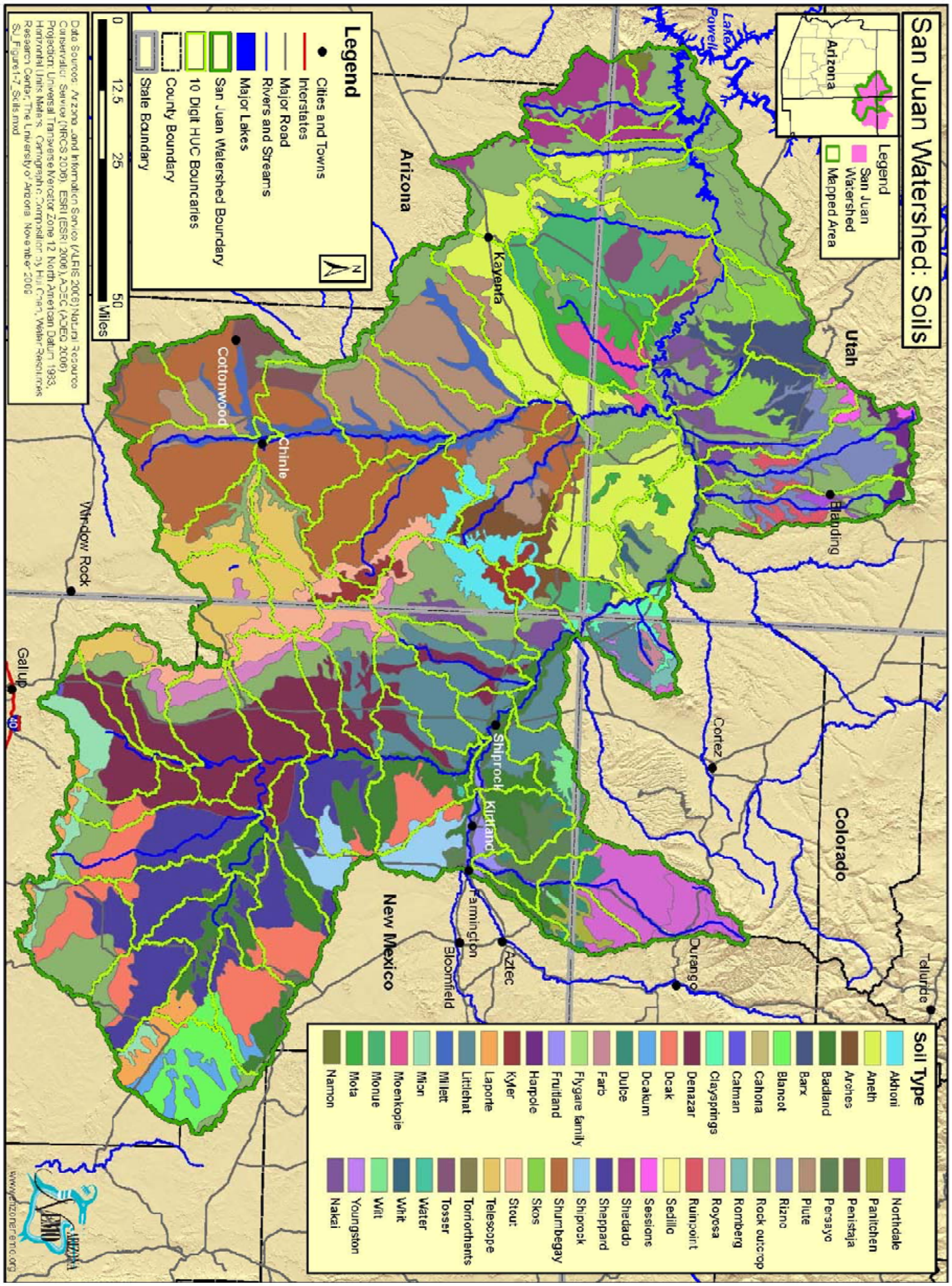

Figure 1-7: Soils

- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;
- Atmospheric deposition and hydromodification are also sources of nonpoint source pollution. (http://www.epa.gov/owow/nps/qa.html).

This Watershed Plan groups non-point source pollutants into four categories: (1) metals, (2) sediment, (3) organics and nutrients, and (4) selenium.

Metals

The metals that are monitored by the Arizona Department of Environmental Quality (ADEQ) are listed on the ADEQ website (www.azdeq.gov/environ/water/assessment/download/2008/g1.pdf). Some 16 metals, including arsenic, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc are monitored. A variety of chemical forms of these metals may be present naturally in bedrock and soils, and they can be exposed and concentrated by mining or other excavation activities. The effects of these metals on natural ecosystems and on humans are discussed below in Section 2.3.1.

Metals from natural and anthropogenic sources can be transported to receiving waters via soil erosion and overland flows resulting from precipitation or through the release of irrigation waters into the environment (Antonius 2008). Brooks and Lohse (2009) note, with regard to the San Pedro Watershed, but true of other watersheds in the Southwest as well, "…sources of metals associated with mines present a potential for episodic metal transport to the riparian system in surface runoff as well as slow transport of mine wastes to the stream in groundwater." Because of their chemical reactivity, metals are especially mobile, and they may also become concentrated in organisms through the process of bioaccumulation.

Factors that are of particular importance in the modeling of pollution from metals are those associated with sources of metals (land use, especially mining and urban development) and those associated with its transport (soil texture, topography, and climate).

Sediment

Sediment, and the turbidity associated with excessive sediment, is the most widespread pollutant found in Arizona streams. It degrades the quality of water for drinking, as habitat for aquatic organisms, and for recreational activities. Sediment accumulation can impair stream flow and silt up storm drains and reservoirs. Sedimentation of streams reflects loss of potentially valuable soils from adjacent areas, potentially reducing land use options.

The principal factors that control soil erosion and sedimentation are the intensity and timing of rainfall events and soil erodibility. The latter is a function of topography, soil texture, land cover, and land use. These relationships can, however, be complex. An increase in impermeable surfaces (paved streets and parking lots, for instance) in urban areas would seem to protect soils from erosion, but, because rain falling on an impermeable surface does not sink into the ground, it accumulates and flows over adjacent land into waterways, increasing sedimentation.

Organics and Nutrients

This pollutant category contains a variety of specific nutrients, such as nitrites and nitrates, ammonia, and phosphorus, as well as environmental indicators of biochemical activity, such as low dissolved oxygen and excessively high (or excessively low) pH, and pathogens, specifically *E. coli*. Potential sources of these pollutants and harmful environmental conditions are urban areas with inadequate wastewater treatment, farms and livestock production facilities, mining wastes that can contribute to low (acidic) pH conditions, and even areas where concentrations of nitrogen-fixing mesquite trees cause increased levels of nitrogen-containing compounds in the soil (Brooks and Lohse, 2009).

As Lewis et al. (2009) point out, "Agrarian practices such as cattle grazing and irrigated agriculture have several impacts on the structure and function of riparian zones, such as increased nutrient loading to the stream." Because desert stream plant communities tend to be nitrogen limited, excess nutrients can lead to algae blooms, and when the algae die and decompose, dissolved oxygen in the water declines, potentially leading to fish kills (Skagen et al., 2008).

The release of excessive nutrients into waters can lead to eutrophication,

> the process of enrichment of water with nutrients, mainly nitrogen and phosphorus compounds, which result in excessive growth of algae and nuisance aquatic plants. It increases the amount of organic matter in the water and also increase pollution as this organic matter grows and then decays. Employing the process of photosynthesis for growth, algae and aquatic plants consume carbon dioxide (thus raising pH) and produce an overabundance of oxygen. At night the algae and plants respire, depleting available dissolved oxygen. This results in large variations in water quality conditions that can be harmful to other aquatic life" (http://www.deq.state.or.us/lab/wqm/wqindex/klamath3.htm)

Runoff and erosion within watersheds can carry soil nutrient and organics into streams and rivers. This transport is especially likely to occur if urban and agricultural activities are occurring within stream-side riparian areas.

Selenium

Selenium is a naturally occurring element whose presence in soils is related to the selenium content of the source rocks from which the soils are derived. Selenium often occurs in association with ores of silver and copper (Wright and Welbourn, 2002), so where these latter ores are abundant it is likely that selenium will be also. Selenium-rich soils that have been disturbed and exposed to erosion, such as by farming activities, can also be sources of selenium to adjacent streams (Zhao 2004).

Transport of selenium to streams takes place when soils containing selenium are exposed to episodic precipitation. Runoff water in which selenium has been dissolved can flow into receiving waters or the selenium-rich soil itself can be eroded and transported to the receiving waters where the selenium is released to the aquatic environment. Selenium is also concentrated when water used in flood irrigation evaporates as well as in water behind dams. Once in the water, selenium accumulates in fish tissue and can be passed on to other wildlife that feed on fish (Wright and Welbourne, 2009).

General Transport Pathways

The sources of the various pollutants discussed above include their natural presence in the soil, release by urban activities, industrial release (particularly mining), and release through agricultural and stock raising activities. The transport of these pollutants to stream waters is primarily through surface runoff and soil erosion resulting from rainfall. These transport processes depend on the timing and magnitude of precipitation events, topographic slope, and soil erodibility, which itself depends upon soil texture, land cover, and land use practices.

Vegetation

The San Juan Watershed lies principally in the Colorado Plateau Semidesert Province (as defined by Bailey's Ecoregion classification [nationalatlas.gov/mld/ecoregp.html; www.fs.fed.us/land/ecosysmgmt/]).

At lower elevations, arid grasses with interspersed xeric shrubs predominate. Sagebrush (*Artemesia* spp.) dominates over wide areas. Yucca (*Yucca* spp.) and several species of cactus are also common. In the higher woodland zone, the dominant tree species are two-needle pinyon pine (*Pinus edulis*) and several species of juniper (*Juniperus* spp.). Higher yet, in the montane zone, ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) are the dominant forest trees.

Webb et al. (2007:72) note that "…the extensive stands of riparian vegetation along the San Juan makes this river unusual in the region and a valued resource." Species dominating riparian communities along the San Juan include Fremont cottonwood (*Populus fremontii*), coyote willow (*Salix exigua*), tamarisk (*Tamarix* spp.), and Russian olive (*Elaeagnus angustifolia*). The establishment of new riparian vegetation has occurred as the San Juan has experienced channel narrowing during recent decades.

Southwest Regional GAP Vegetation Cover

Vegetation cover is one of the variables used in the SWAT (Soil and Water Assessment Tool) modeling application to calculate runoff and erosion in the subwatersheds within the San Juan Watershed. The data for this are derived from the Southwest Regional Gap Analysis Project (Lowry et al., 2005; fws-nmcfwru.nmsu.edu/swregap/), a multi-state (Arizona, Colorado, Nevada, New Mexico, and Utah) land-cover mapping project based on Landsat ETM+ remote sensing imagery, a digital elevation model (DEM), and field survey data. Vegetation groups for the San Juan Watershed are shown in Figure 1-8.

Invasive species are becoming an increasing threat to Arizona's natural ecosystems. Among the species of concern are plants, such as buffelgrass, saltcedar, and hydrilla, and animals, including the cactus moth and the European starling. In 2005, Governor Janet Napolitano established the Arizona Invasive Species Advisory Council which developed the Arizona Invasive Species Management, published in June 2008 (http://www.azgovernor.gov/ais/). Further information on invasive species in Arizona is available from the U.S. Department of Agriculture National Invasive Species Information Center (http://www.invasivespeciesinfo.gov/unitedstates/az.shtml).

Water Quality Assessments

The Arizona Department of Environmental Quality (ADEQ) carries out a program of water quality monitoring and assessment in fulfillment of Clean Water Act requirements (Figure 1-9). This program, which is described in detail on the ADEQ website (www.azdeq.gov/environ/water/assessment/index.html), consists of periodic field sampling and both field and laboratory testing of surface waters for a range of physical characteristics, chemical constituents, and bacterial concentrations.

A comprehensive water quality assessment report is completed every two years on the status of ambient surface water and groundwater quality. The report contains a list of Arizona's impaired surface waters and those that are not meeting standards. It fulfills requirements of the federal Clean Water Act sections 305(b) (assessments), 303(d) (impaired water identification), 314 (status of lake water quality), and 319 (identification of nonpoint source impacts on water quality). Information concerning this program and the latest assessment and impaired waters list can be found at ADEQ's website: http://www.azdeq.gov/environ/water/assessment/assess.html.

Monitoring data from all readily available sources are used for assessments, including data from volunteer monitoring groups, grantees doing effectiveness monitoring, other agencies, and permitted dischargers. ADEQ works with outside monitoring entities to assure that all data used is scientifically defensible and meets Arizona's credible data requirements.

As indicated in the Standards Development sub-section above, a lake or stream reach can have between two to six designated uses. Each designated use is assessed based on the number of times surface water quality standards were exceeded. If sufficient exceedances, then the designated use is "impaired or not attaining." If sufficient core parameters samples were collected, then the designate use would be assessed as "attaining." Once each designed use has been assessed, then the surface water is assessed as being in one of the following five categories:

Assessment Categories

Category Number	Category	Description
1	Attaining All Uses	All uses were assessed as "attaining uses", all core parameters monitored
2	Attaining Some Uses	At least one designed use was assessed as "attaining," and no designated uses were not attaining or impaired
3	Inconclusive or Not Assessed	Insufficient samples or core parameters to assess *any* designated uses
4	Not Attaining	One or more designated use is not attaining, but a TMDL is *not* needed
5	Impaired	One or more designated use is not attaining, and a TMDL is needed

A surface water would be placed in category 4 instead of category 5 if a TMDL has been adopted and strategies to reduce loading are being implemented or if other actions are being taken so that standards will be met in the near future. Note that this 5-year NPS Plan establishes a number of new strategies in Chapter 3 that when implemented are intended to result in delisting impairments listed for waters in category 4 and 5.

Impaired and Not Attaining Waters Lists

Surface waters are reassessed every two years, and the list of impaired and not attaining surface waters is revised. Rather than including lists and maps in this plan that would be rapidly outdated, the current assessment report, list of impaired waters, and maps can be accessed at ADEQ's website: http://www.azdeq.gov/environ/water/assessment/index.html

Information concerning the status of TMDLs can also be found at this site.

Because all of the subwatersheds within the San Juan Watershed are on Native American lands or in states other than Arizona, no water quality assessments were carried out by ADEQ.

Natural Resources with Special Protection

Included within the "natural resources with special protection" category are wilderness areas managed by the Bureau of Land Management (BLM), the Fish and Wildlife Service, the Forest Service, and the National Park Service, critical habitats for endangered species, Areas of Critical Environmental Concern designated by BLM, Unique Waters designated by the

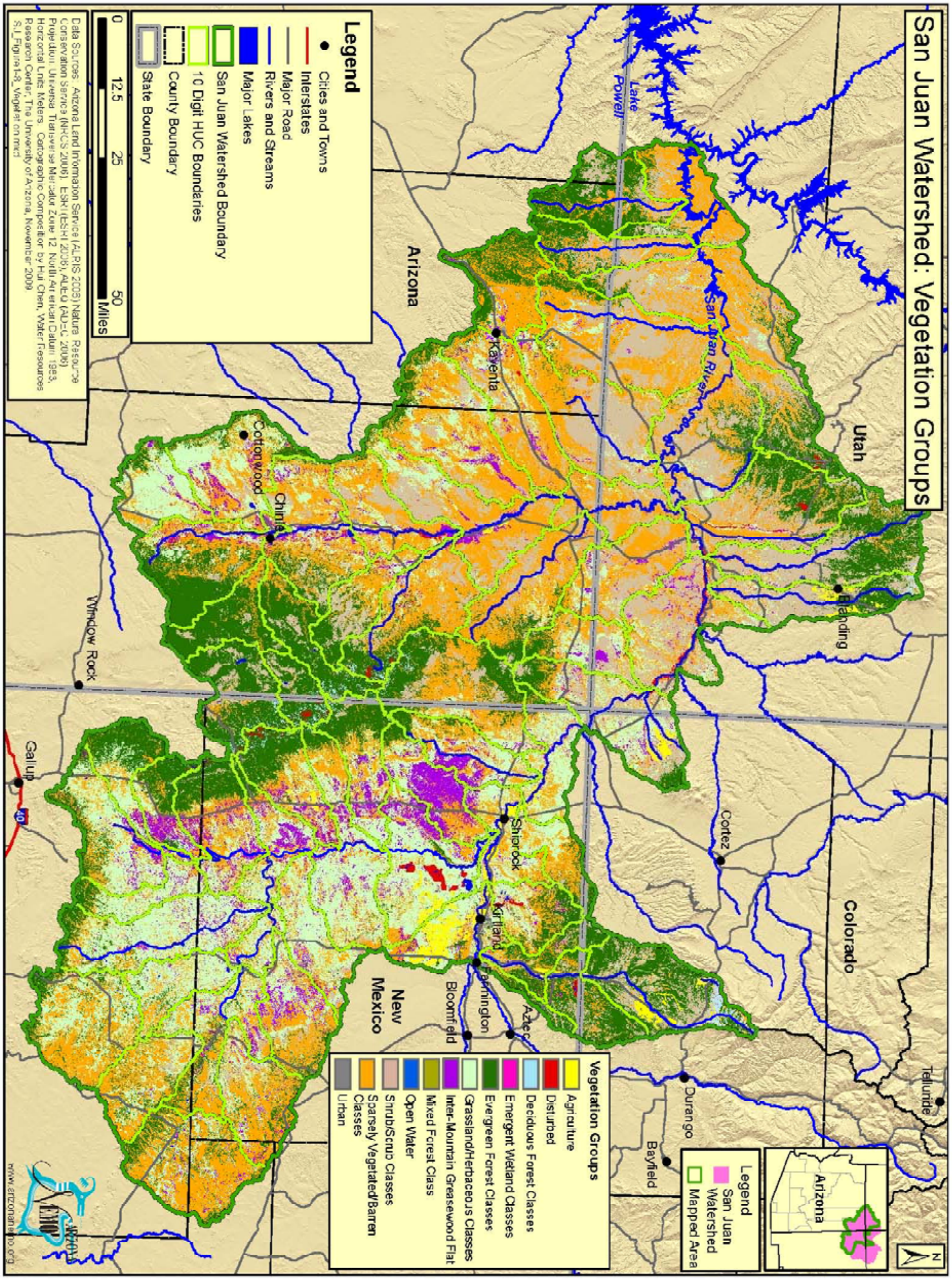

Figure 1-8: Vegetation Groups

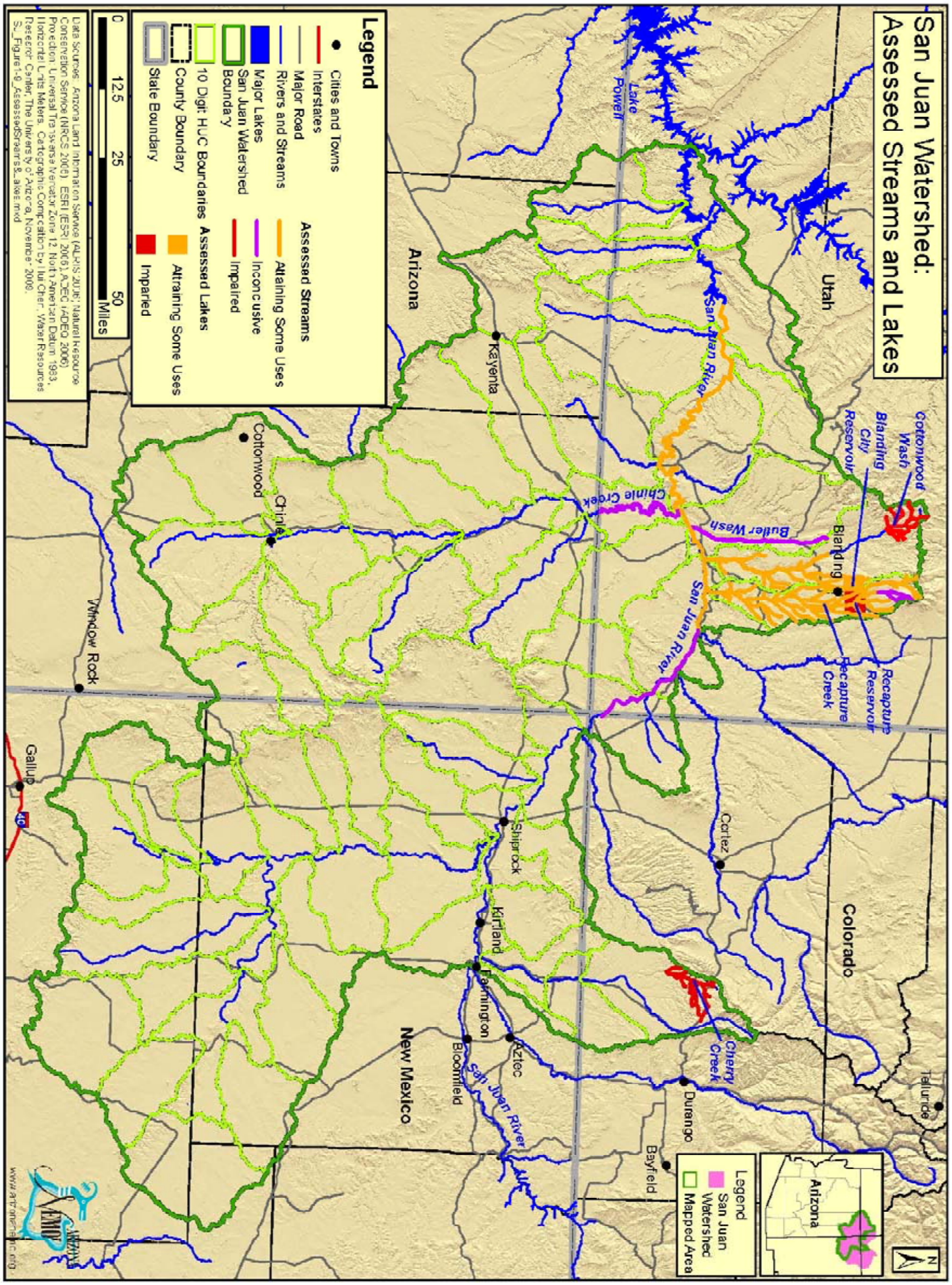

Figure 1-9: Assessed Streams and Lakes

Arizona Department of Environmental Quality, wildlife refuges, and riparian conservation areas.

Natural Resource Areas

The San Juan Watershed has extensive and important natural resources with local, regional, and national significance. Sections 1.3.2, 1.3.3, and 1.3.4 (below) describe outstanding waters, wilderness areas, preserves, riparian areas, and critical habitats for threatened and endangered species that are found within the San Juan Watershed. These areas are mapped in Figures 1-10 and 1-11.

Subwatersheds within the San Juan Watershed in Arizona that contain important natural resource areas are the following:

- Canyon del Muerto, Canyon de Chelly, Wheatfields Creek, and Whiskey Creek subwatersheds all contain portions of Canyon de Chelly National Monument;
- Piute Creek, Nokai Creek, and Oljeto Wash subwatersheds contain streams that drain to Glen Canyon National Recreation Area;
- Several subwatersheds contain critical habitat (or contain streams that drain to critical habitat) for the endangered razorback sucker: Nokai Creek, Copper Canyon-Lower San Juan River, Oljeto Wash, Chinle Creek, Gothic Creek, Tsitah Wash, Marble Wash-San Juan River, and Salt Creek Wash-San Juan River.
- Piute Creek drains to area within the critical habitat of the Endangered Mexican spotted owl.

Outstanding Waters, Wilderness Areas, and Preserves

The only BLM Wilderness area within the San Juan Watershed is the Bisti/De-Na-Zin Wilderness is located in northwest New Mexico, approximately 30 miles south of Farmington. This area of dramatic rock formations is managed by BLM to protect its "naturalness, special features, and opportunities for solitude and primitive types of recreation" (http://www.blm.gov/nm/st/en/prog/wilderness/bisti.html).

The U.S. National Park Service and the Navajo Nation cooperatively manage Canyon de Chelly National Monument, a site of rich natural, cultural, and historical resources in northwest Arizona within the San Juan Watershed (http://www.nps.gov/cach/index.htm).

The Chaco Cultural National Historic Park is located within the San Juan Watershed in northwest New Mexico. This park encompasses nearly 4,000 archaeological sites exemplifying the Chaco culture which dominated the area from the mid 800s to the 1200s. Additionally the park contains grassland, desert scrub, pinyon-juniper woodland, and riparian vegetation communities, which support a rich diversity of plants and animals (http://www.nps.gov/chcu/index.htm).

The Arizona Department of Environmental Quality has designated several stream reaches in Arizona as Outstanding Waters (formerly Unique Waters), which provides them with special protection against long-term degradation. Criteria for designation

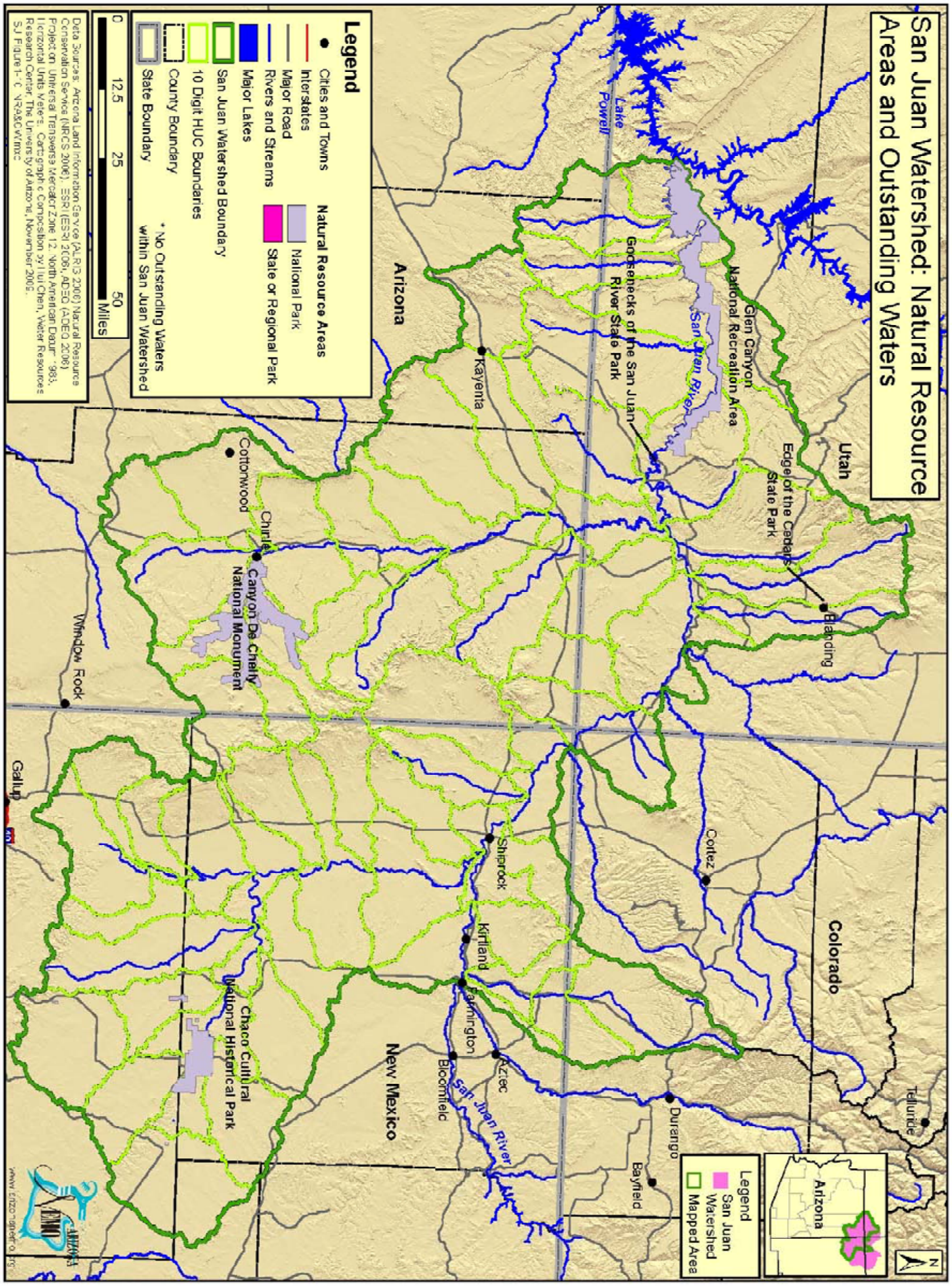

Figure 1-10: Natural Resource Areas and Outstanding Waters

as an Outstanding Waters are specified in the Arizona Administrative Code section R18-11-112 and include:

1) the surface water is a perennial water;
2) the surface water is in a free-flowing condition;
3) the surface water has good water quality;
4) the surface water meets one or both of the following conditions:
   a. the surface water is of exceptional recreational or ecological significance because of its unique attributes, or
   b. threatened or endangered species are known to be associated with the surface water and the existing water quality is essential to the maintenance and propagation of threatened or endangered species or the surface water provides critical habitat for a threatened or endangered species.

None of the designated Outstanding Arizona Waters occurs in the Colorado-Grand Canyon Watershed:

<u>Riparian Areas</u>

Riparian areas are of particular importance in the arid Southwest, where they comprise less than 2% of the total land area (Zaimes 2007). A map of riparian areas within the San Juan Watershed can be found on the Arizona NEMO website (arizonanemo.org). Among the ecosystem

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services provided by riparian areas, Zaimes (2007) lists the following:

1) support animal habitat and enhance fish habitat;
2) filtrate and retain sediments and nutrients from terrestrial upland runoff or out-of-bank floods;
3) reduce chemical inputs from terrestrial uplands by immobilization, storage and transformation;
4) stabilize stream banks and build up new stream banks;
5) store water and recharge subsurface aquifers; and,
6) reduce floodwater runoff.

Webb et al. (2007:72-91) discuss changes that have occurred in the riparian vegetation along the San Juan River. Extreme flooding has been an important factor in controlling the extent of riparian vegetation along the San Juan. It has been hypothesized that overgrazing and drought during the late 1800s reduced rangeland and riparian vegetation, contributing the flood severity. During the 20th century, flood severity has decreased along the river, and riparian vegetation has become more abundant. While much of the increase in riparian vegetation has been as a result of the spread of nonnative tamarisk and Russian olive, cottonwoods and willows have also increased.

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