ARIZONA NEMO


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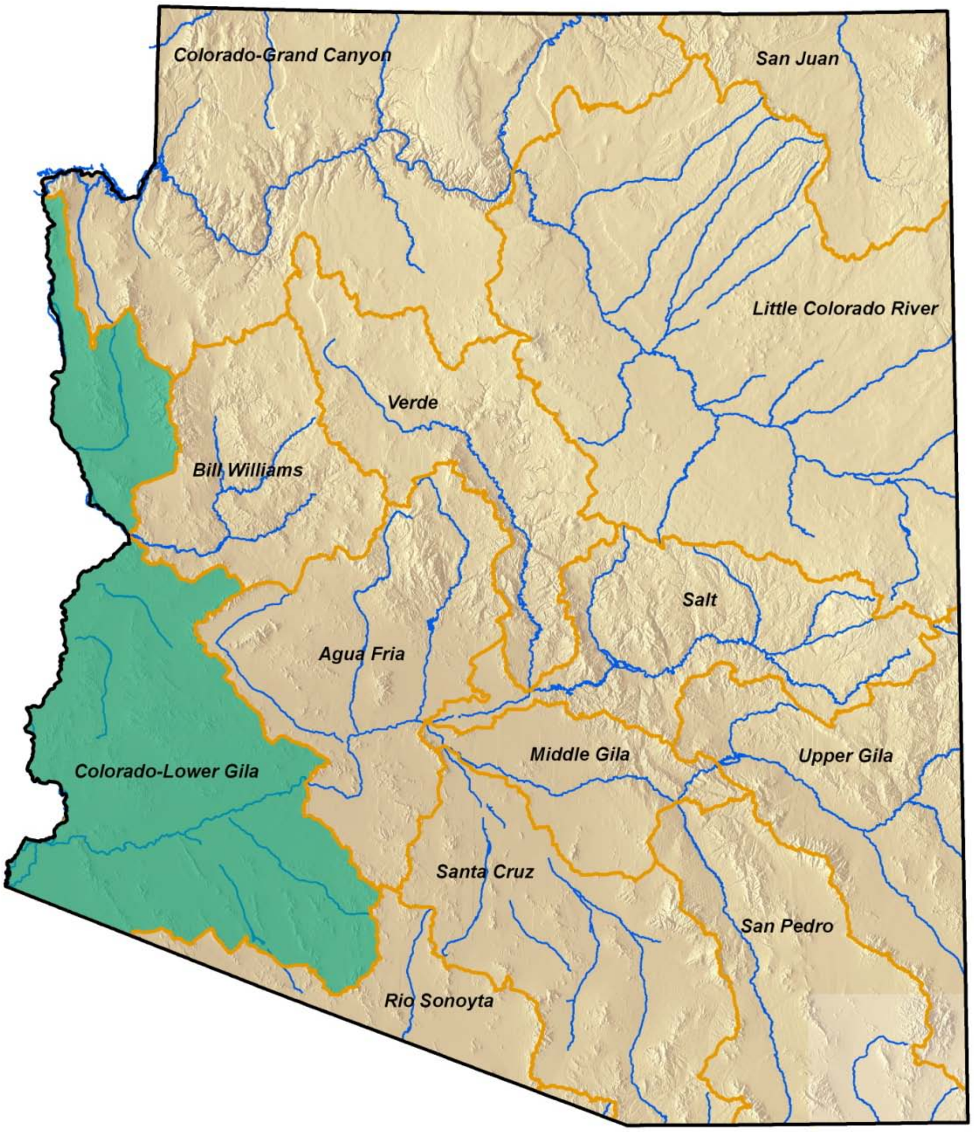
NEMO Watershed-Based Plan
Colorado-Lower Gila Watershed

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Water Resources Research Center

ADEQ
Arizona Department of Environmental Quality

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ARIZONA COOPERATIVE EXTENSION

Acknowledgments

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The NEMO website is www.ArizonaNEMO.org

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NEMO and Nonpoint Source Pollution

The Southwestern United States, including the state of Arizona, is the fastest growing region in the country. Because the region is undergoing rapid development, there is a need to address health and quality of life issues that result from degradation of its water resources.

Water quality problems may originate from both "point" and "nonpoint" sources. The Clean Water Act (CWA) defines "point source" pollution as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged" (33 U.S.C. § 1362(14)).

Although nonpoint source pollution is not defined under the CWA, it is widely understood to be the type of pollution that arises from many dispersed activities over large areas, and is not traceable to any single discrete source. Nonpoint source pollution may originate from many different sources, usually associated with rainfall runoff moving over and through the ground, carrying natural and manmade pollutants into lakes, rivers, streams, wetlands and ground water. It is differentiated from point source pollution in that, for some states such as Arizona, there are no regulatory mechanisms by which to enforce clean up of nonpoint source pollution.

Nonpoint source pollution is the leading cause of water quality degradation across the United States and is the water quality issue that NEMO, the Nonpoint Education for Municipal Officials program, and this watershed-based plan will address.

The National NEMO Network, which now includes 32 educational programs in 31 states, was created in 2000 to educate local land use decision makers about the links between land use and natural resource protection. The goal of the network is to "help communities better protect natural resources while accommodating growth" (nemonet.uconn.edu). One of the hallmarks of the NEMO programs is the use of geospatial technology, such as geographic information systems and remote sensing, to enhance its educational programs.

Nationally, NEMO has been very successful in helping to mitigate nonpoint source pollution. The goal of NEMO is to educate land-use decision makers to take proactive voluntary actions that will mitigate nonpoint source pollution and protect natural resources. In the eastern United States (where the NEMO concept originated), land use authority is concentrated in municipal (village, town and city) government. In Arizona, where nearly 80% of the land is managed by state, tribal and federal entities, land use authorities include county, state and federal agencies, in addition to municipal officials and private citizens.

In partnership with the Arizona Department of Environmental Quality (ADEQ) and the University of Arizona (U of A) Water Resources Research Center, the Arizona Cooperative Extension at the

U of A has initiated the Arizona NEMO program. Arizona NEMO attempts to adapt the NEMO program to the conditions in the semiarid, western United States, where water supply is limited and many natural resource problems are related to the lack of water, as well as water quality.

Working within a watershed template, Arizona NEMO includes comprehensive and integrated watershed planning support, identification and publication of Best Management Practices (BMP), and education on water conservation and riparian water quality restoration. Arizona NEMO maintains a website, www.ArizonaNEMO.org, that contains these watershed based plans, Best Management Practices fact sheets, Internet Mapping Service (IMS), and other educational materials.

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Section 1: Colorado-Lower Gila Watershed-Based Plan

Scope and Purpose of this Document

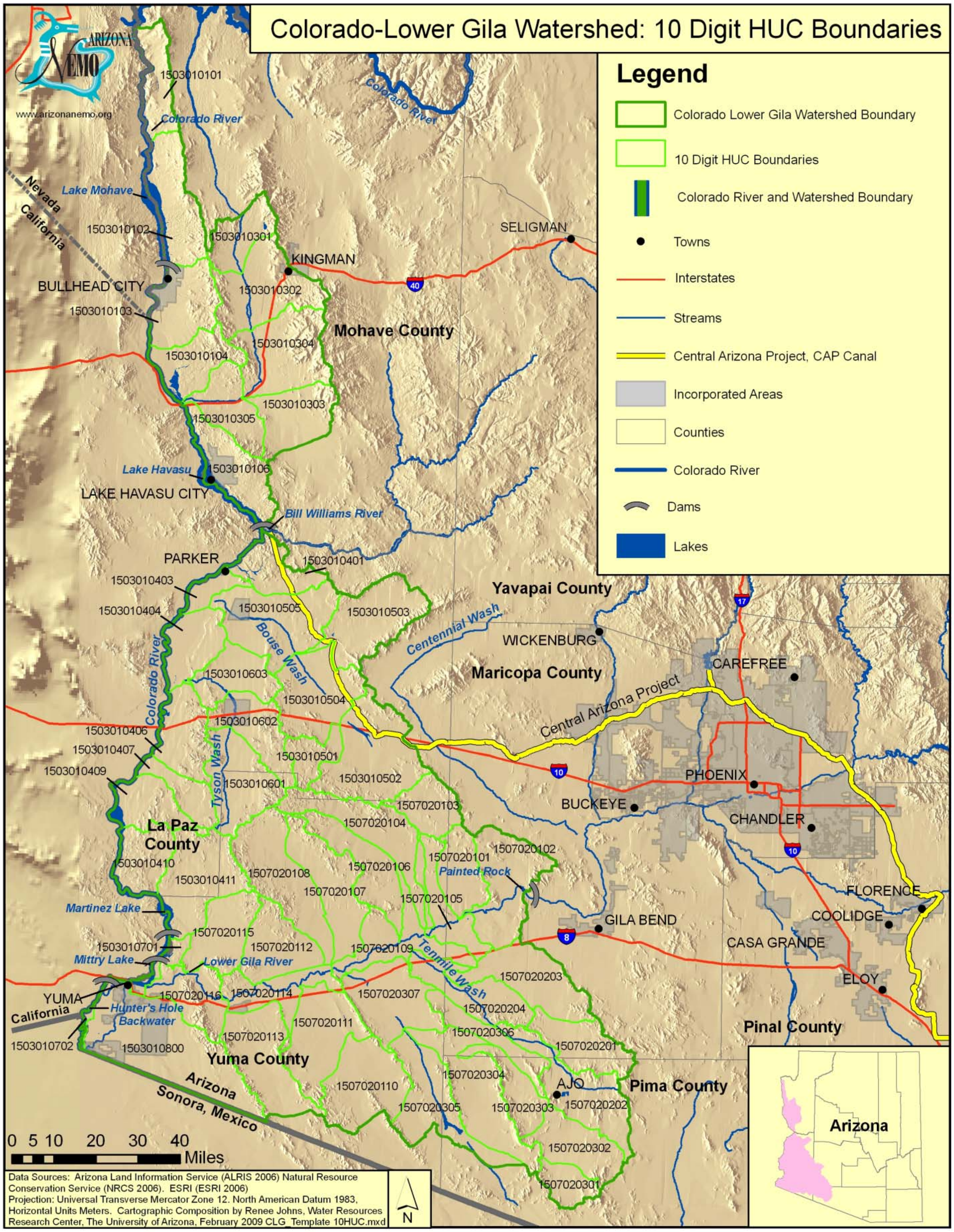
The watershed addressed in this plan consists of the lands in Arizona drained by the Colorado River below Hoover Dam as far south as San Luis on the Arizona-Mexico border and by the Gila River below Painted Rock Dam (Figure 1-1), an area of almost 14,000 square miles. The lower Colorado River forms the boundary between Arizona and California and part of the boundary between Arizona and Nevada. The watershed of the Bill Williams River, a major tributary of the Colorado River, is described in a separate NEMO watershed-based plan (www.ArizonaNEMO.org) and is not included here.

The Colorado River arises in Colorado and flows through Utah before entering Arizona near the town of Page. That part of the Colorado River watershed that lies between the Glen Canyon Dam and Hoover Dam is addressed in the NEMO Colorado-Grand Canyon Watershed-Based Plan. The Gila River arises in New Mexico and flows into Arizona near Duncan. Parts of the Gila River watershed that lie upstream of the Painted Rock Dam are addressed in two previous NEMO plans: The Upper Gila Watershed-Based Plan and the Middle Gila Watershed-Based Plan.

The purpose of the NEMO Colorado-Lower Gila 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:



Colorado-Lower Gila Watershed: 10 Digit HUC Boundaries

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006)
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG_Template 10HUC.mxd

Figure 1-1: 10 Digit HUC Boundaries

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.
- 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.

Watershed Information

This section of the plan describes social, physical, and environmental factors that characterize the Colorado-Lower Gila 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 Colorado-Lower Gila 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, biotic communities, population density, and housing density, which have not been presented within this plan.

Hydrologic Unit Code (HUC) Number

The Colorado-Lower Gila 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: Colorado-Lower Gila Watershed 10-Digit HUCS and Subwatershed Areas

HUC	Subwatershed Name	Area (square miles)
1503010101	Jumbo Wash-Lower Colorado River	183
1503010102	Lower Colorado River-Lake Mohave	291
1503010103	Silver Creek Wash-Lower Colorado River	263
1503010104	Topock Marsh-Lower Colorado River	210
1503010106	Lower Colorado River-Lake Havasu	266
1503010301	Tennessee Wash-Sacramento Wash	167
1503010302	Thirteenmile Wash-Sacramento Wash	357
1503010303	Buck Mountain Wash	241
1503010304	Walnut Creek-Sacramento Wash	359
1503010305	Franconia Wash-Sacramento Wash	209
1503010401	Osborne Wash-Lower Colorado River	175
1503010403	Upper Parker Valley-Lower Colorado River	74
1503010404	Lower Parker Valley-Lower Colorado River	200
1503010406	Ehrenberg Wash-Lower Colorado River	227
1503010407	Mohave Wash-Lower Colorado River	126
1503010409	Gould Wash-Lower Colorado River	181
1503010410	Yuma Wash-Lower Colorado River	188
1503010411	Martinez Lake-Lower Colorado River	354
1503010501	Alamo Wash	114
1503010502	Upper Bouse Wash	434
1503010503	Cunningham Wash	329
1503010504	Middle Bouse Wash	331
1503010505	Lower Bouse Wash	395
1503010601	Upper Tyson Wash	297
1503010602	Middle Tyson Wash	221
1503010603	Lower Tyson Wash	197
1503010701	Picacho Wash-Lower Colorado River	61
1503010702	Lower Colorado River below Morelos Dam	13
1503010800	Yuma Desert Area	632
1507020101	Columbus Wash	180
1507020102	Fourth of July Wash-Lower Gila River	334
1507020103	Clanton Wash	195
1507020104	Baragan Wash	292
1507020105	Nottbusch Wash-Lower Gila River	162
1507020106	Hoodoo Wash	239
1507020107	Yaqui Wash	300
1507020108	Gravel Wash	373
1507020109	Park Valley-Lower Gila River	252
1507020110	Upper Mohawk Wash	336
1507020111	Lower Mohawk Wash	324
1507020112	Big Eye Wash Area	240
1507020113	Coyote Wash Area	333
1507020114	Morgan Wash-Lower Gila River	202
1507020115	Castle Dome Wash	227
1507020116	Fortuna Wash-Lower Gila River	206

HUC	Subwatershed Name	Area (square miles)
1507020201	Upper Midway Wash	220
1507020202	Upper Tenmile Wash	320
1507020203	Lower Midway Wash Area	305
1507020204	Lower Tenmile Wash	230
1507020301	Cherioni Wash	108
1507020302	Cuerda de Lena	229
1507020303	Daniels Arroyo	153
1507020304	Growler Wash	377
1507020305	Upper San Cristobal Wash	323
1507020306	Childs Valley	149
1507020307	Lower San Cristobal Wash	307
Total Watershed	Colorado-Lower Gila Watershed	14,012

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

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Social Features

Urban Areas and Population Growth

The Colorado-Lower Gila Watershed has been inhabited by humans since at least 8000 years ago when hunting and gathering peoples of the Archaic San Diegito culture occupied the area (Cordell, 1997; Reid and Whittlesey, 1997). This area of the Southwest is one of the least known archaeologically, and it is not known just how these early Archaic people are related to later inhabitants of the lower Colorado River area whose culture is known as the Patayan. The Patayan were a pottery-making, agricultural, fishing, and trading people whose earliest ceramics have been dated to A.D. 700 (Reid and Whittlesey, 1997). Among the manifestations of Patayan culture are the spectacular figures of humans and animals that they constructed on the desert pavement near Yuma and elsewhere in the lower Colorado basin (www.blm.gov/az/st/en/prog/recreation/cultural/fisherman.html).

The people of the Patayan culture are the likely ancestors of native Yuman-speaking peoples who lived in the Colorado-Lower Gila Watershed at the time of the first European exploration of the area in the 1700s. Among these native groups were the Mohave, Quechan, Cocopah, Halchidhoma, and Cocomaricopa. Subsequent event resulted in the joining of the Halchidhoma and Cocomaricopa to form the Maricopas, who departed from the lower Colorado region, moving up the Gila River to live near the Pima (Akimel O’odham) people. In addition, the Chemehuevi, a Paiute group, migrated from central California to the lower Colorado River valley (Cordell, 1997, Griffin-Pierce, 2000).

Another Native American group, the Hia C-ed O’odham, a Piman-speaking people, also live within the area of the Colorado-Lower Gila Watershed. These people, sometimes referred to as “Sand People,” have traditionally led a nomadic way of life, moving throughout “El Gran Desierto” in southwest Arizona and Baja California, *gathering wild plants and hunting small game (Griffin-Pierce, 2000).*

The first European to explore the lower Colorado River and describe its native inhabitants was the Spaniard Hernando Alarcón, in 1540 (California Digital Library, 2009). In 1774, Juan Bautista de Anza led an expedition from Tubac to San Francisco Bay, crossing the Colorado River near Yuma. Spanish attempts to control the lower Colorado were ended when the Quechans drove them out in 1781 (Sheridan, 1995).

The United States acquired most of the Colorado-Lower Gila Watershed through the Treaty of Guadalupe Hidalgo that ended the Mexican-American War in 1848, and the south bank of the Gila River in 1853 through the Gadsden Purchase (Sheridan, 1995).

Thousands of Americans crossed the Colorado River near the Gila River confluence during the California Gold Rush of 1849-50. The first American occupation of the area was the establishment of Fort Yuma in 1852, on the California side of the river (Sheridan, 1995). Steamboat traffic up the Colorado River from the Gulf of California began in that year, and water traffic up the Colorado was the major freight transportation route to Arizona until the completion of the Southern Pacific Railroad in 1881 (Lingenfelter, 1978; Sheridan, 1995).

Across the Colorado from Fort Yuma, on the Arizona side, several small communities were established that, in 1873, became the city of Yuma (Woznicki, 1968). Yuma served as a river crossing point, a steamboat stop, a railroad terminus, a supply depot for Fort Yuma, and a site for the Territorial Prison (Woznicki, 1968; Crowe and Brinckerhoff, 1976).

River and overland transportation have been responsible for the founding of many of the towns and cities in the Colorado-Lower Gila Watershed. Quartzsite was founded in 1867 as a stage coach stop near the site of a privately built fort, Fort Tyson (www.ci.quartzsite.az.us/about/; http://jeff.scott.tripod.com/quartzsite.html). Ehrenberg, on the Colorado River north of Yuma, and Bullhead City (formerly Hardyville, began as a steamboat landings in the 1800s (Sheridan, 1995).

Kingman was founded in 1882 as a railroad stop (Malach, 1980), as was Parker in 1909 (www.ci.parker.az.us/history.php).

Wellton was founded in 1878 as a watering facility for the Southern Pacific Railroad (www.town.wellton.az.us/about.htm). Somerton was established in 1898 as a farming community (www.cityofsomerton.com). San Luis began in 1930 as a U.S. port of entry into Mexico (www.cityofsanluis.org). Wellton, Somerton, and San Luis are all now part of the Yuma metropolitan area.

Ajo began in 1916 as a copper mining community, a planned development of the Calumet and Arizona Mining Company (Johns and Strittmatter Inc., 1995).

Lake Havasu City was a planned residential community and tourism resort that was started in 1964 (Wildfang, 2005).

Six communities in the Colorado-Lower Gila Watershed have populations greater than 10,000 (estimated as of July 1, 2008): Yuma (90,041), Lake Havasu City (56,553), Bullhead City (40,868), Kingman (27,817), San Luis (24,909), and Somerton (12,364) (US Census Bureau, 2009). Of these communities, greatest population growth has occurred in Lake Havasu City (an increase of more than 14,000 people since July 1, 2000) and Yuma (more than 11,000 since July 1, 2000); if the whole Yuma metropolitan area is considered, population growth since July 2000 was more than 25,000.

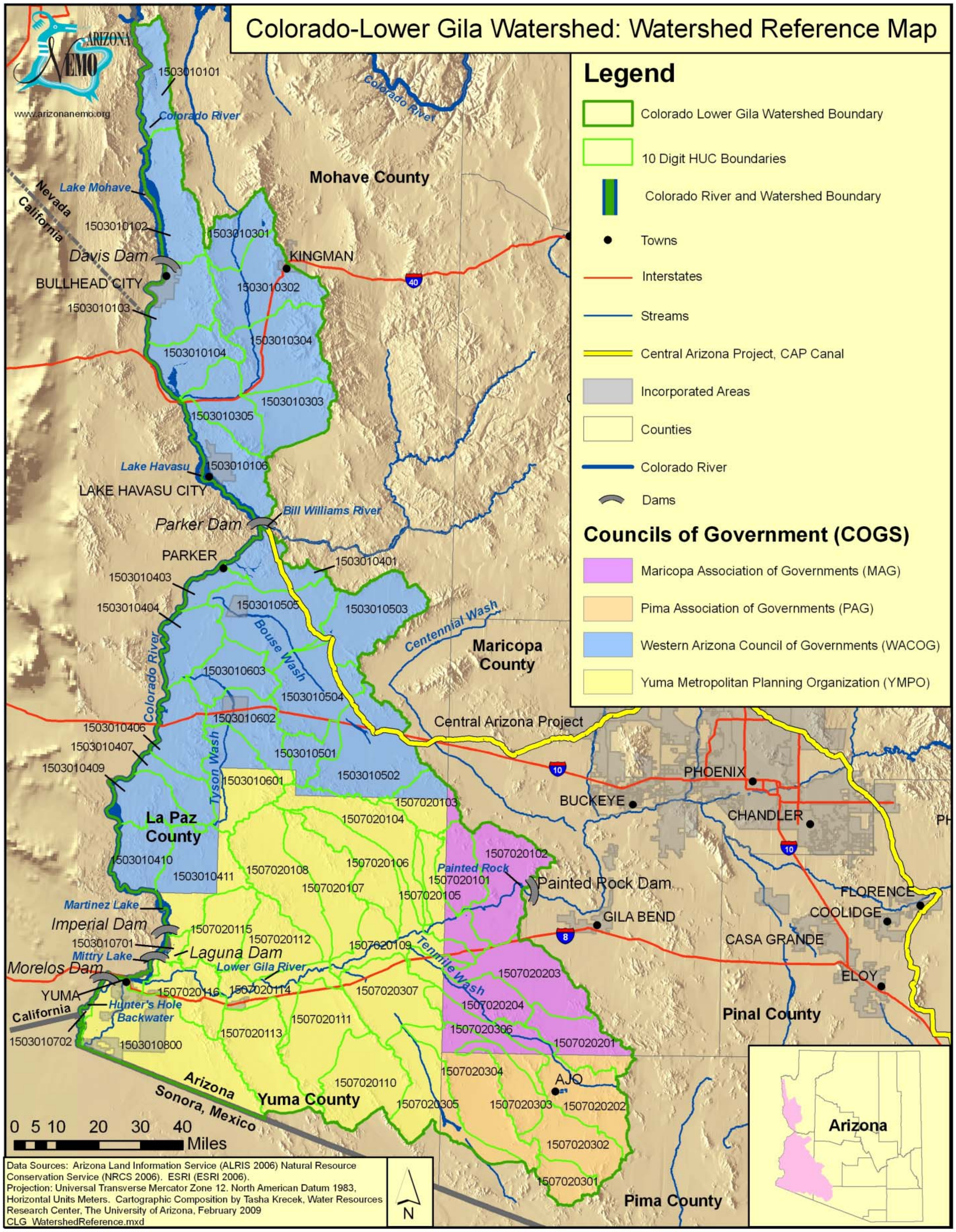
Yuma experienced its greatest rate of growth in the 1960s, and is still growing vigorously. It has become "a popular destination for retirement or second-home owners because of the geography and the warm weather that the city receives year-round" (www.yuma.com/population.php). Lake Havasu City has also become a popular retirement community and tourism destination that has experienced significant population growth in recent years.

County Governments and Councils of Governments (COGs)

The Colorado–Lower Gila Watershed occupies parts of five Arizona counties, Maricopa, Pima, Yuma, La Paz, and Mohave (Figure 1-2). These counties have agencies involved in environmental and water quality issues within their jurisdictions. Yuma, La Paz, and Mohave Counties are the Designated Planning Agencies (DPAs) for water quality planning within the Colorado-Lower Gila Watershed (http://www.azdeq.gov/environ/water/watershed/ regional.html).

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 Colorado–Lower Gila Watershed extends into parts of three COGs (Figure 1.2), the Maricopa Association of Governments (MAG) that includes Maricopa County, the Pima Association of Governments (PAG) that includes Pima County, and the Western Arizona Council of Governments (WACOG) that includes Yuma, La Paz, and Mohave Counties. Water quality planning for the Colorado-Lower Gila Watershed, however, is carried out at the county level (see above).



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006).
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Tasha Krecek, Water Resources Research Center, The University of Arizona, February 2009
CLG_WatershedReference.mxd

Figure 1-2: Watershed Reference Ma

Water Management Organizations in the Colorado-Lower Gila Watershed

U.S. Bureau of Reclamation

The Colorado River below Hoover Dam is a vitally important water resource for Arizona, California, and Nevada. The US Bureau of Reclamation has constructed a number of dams and diversions along the this stretch of the Colorado River to manage water flow for flood control, power generation, and to provide water for agriculture, industry, and residential use (www.usbr.gov/lc/).

- Hoover Dam, built between 1931 and 1936, is at the northernmost boundary of the Colorado-Lower Gila Watershed.
- Below Hoover Dam is Davis Dam, completed in 1951 and located a few miles upstream of Bullhead City, AZ. This dam was built to regulate the delivery of Colorado River water to Mexico. The Dam also generates electrical power, and its reservoir, Lake Mohave, is a recreation area.
- Parker Dam, completed in 1938, is further downstream near the town of Parker, AZ. The reservoir created by Parker Dam, Lake Havasu, backs up behind the dam some 45 miles and covers an area of 32 square miles. It is from Lake Havasu that the Metropolitan Water District pumps Colorado River water nearly 250 miles to metropolitan Los Angeles and the Central Arizona Project (CAP) pumps water to Arizona.
- The Palo Verde Diversion Dam, completed in 1957, is located about 10 miles north of Ehrenberg, AZ. This dam diverts Colorado River water into the Palo Verde Canal for use as irrigation water in the Palo Verde Irrigation District in California.
- Imperial Dam, north of Yuma, diverts Colorado River water into three canals that provide irrigation water to California and Arizona. The Dam was completed in 1940.
- Some five miles below the Imperial Dam is the Laguna Dam, originally constructed in 1905 for the diversion of irrigation water, a function that the more recently constructed Imperial Dam has largely taken over. The Laguna Dam was one of the first projects undertaken by the US Bureau of Reclamation.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers, as part of its flood control mission, built the Painted Rock Dam on the Gila River about 30 miles northwest of Gila Bend. This dam marks the upstream limit of the Lower Gila River and is the eastern boundary of the Colorado-Lower Gila Watershed. It is used for impounding and regulating the release of floodwaters originating upstream (www.welton-mohawk.org/history.html).

Central Arizona Project

The Central Arizona Project (CAP) was originally formed in 1948 to facilitate Arizona's access to water from the

Colorado River in accordance with its allotment through the Colorado River Compact (www.cap-az.com/). Funding for the series of canals that deliver CAP water to Arizona municipalities, irrigation districts, and Indian tribes was approved by Congress in 1968, and construction began in 1973. The CAP canal system begins at Lake Havasu and, 336 miles later, reaches Tucson.

Land Ownership

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

Nearly 80% of the Colorado-Lower Gila Watershed is owned by the federal government, primarily under the control of the Bureau of Land Management, the Department of Defense, and the U.S. Fish and Wildlife Service. Arizona state lands make up about 6% of the watershed, and Native American lands comprise about 4% in three reservations. The rest of the watershed (approximately 11%) is privately owned (Figure 1-3; Table 1-2).

Table 1-2: Colorado-Lower Gila Watershed Land Ownership (area in square miles) (part 1 of 2)

Subwatershed	BLM	Bureau of Reclamation	US Forest Service	Game and Fish	Indian Reservation	Military Lands
Jumbo Wash-Lower Colorado River 1503010101	17	-	-	-	-	-
Lower Colorado River-Lake Mohave 1503010102	147	1	-	-	-	-
Silver Creek Wash-Lower Colorado River 1503010103	140	5	-	<1	20	-
Topock Marsh-Lower Colorado River 1503010104	139	-	-	1	17	-
Lower Colorado River-Lake Havasu 1503010106	131	-	-	-	-	-
Tennessee Wash-Sacramento Wash 1503010301	85	-	-	-	-	-
Thirteenmile Wash-Sacramento Wash 1503010302	166	-	-	1	-	-
Buck Mountain Wash 1503010303	50	-	-	-	-	-

Subwatershed	BLM	Bureau of Reclamation	US Forest Service	Game and Fish	Indian Reservation	Military Lands
Walnut Creek-Sacramento Wash 1503010304	263	-	-	-	-	-
Franconia Wash-Sacramento Wash 1503010305	150	-	-	-	<1	-
Osborne Wash-Lower Colorado River 1503010401	149	<1	-	-	8	-
Upper Parker Valley-Lower Colorado River 1503010403	4.0	-	-	-	68	-
Lower Parker Valley-Lower Colorado River 1503010404	5.0	-	-	-	192	-
Ehrenberg Wash-Lower Colorado River 1503010406	98	-	-	-	44	71
Mohave Wash-Lower Colorado River 1503010407	14	-	-	-	-	108
Gould Wash-Lower Colorado River 1503010409	53	1	-	-	-	97
Yuma Wash-Lower Colorado River 1503010410	71	-	-	-	-	87
Martinez Lake-Lower Colorado River 1503010411	36	-	-	-	-	259
Alamo Wash 1503010501	37	-	-	-	-	-
Upper Bouse Wash 1503010502	321	<1	-	-	-	-
Cunningham Wash 1503010503	191	-	-	-	-	-
Middle Bouse Wash 1503010504	214	-	-	-	-	-
Lower Bouse Wash 1503010505	325	-	-	-	31	-
Upper Tyson Wash 1503010601	128	-	-	-	-	59
Middle Tyson Wash 1503010602	159	-	-	-	-	-
Lower Tyson Wash 1503010603	162	-	-	-	21	-

Subwatershed	BLM	Bureau of Reclamation	US Forest Service	Game and Fish	Indian Reservation	Military Lands
Picacho Wash-Lower Colorado River 1503010701	13	<1	-	-	3	19
Lower Colorado River below Morelos Dam 1503010702	3	<1	-	-	6	-
Yuma Desert Area 1503010800	20	35	-	-	4	386
Columbus Wash 1507020101	111	-	-	-	-	1
Fourth of July Wash-Lower Gila River 1507020102	311	-	-	-	-	<1
Clanton Wash 1507020103	176	-	-	-	-	-
Baragan Wash 1507020104	181	-	-	-	-	16
Nottbusch Wash-Lower Gila River 1507020105	83	-	-	<1	-	1
Hoodoo Wash 1507020106	95	-	-	-	-	63
Yaqui Wash 1507020107	1	-	-	-	-	100
Gravel Wash 1507020108	4	-	-	-	-	70
Park Valley-Lower Gila River 1507020109	89	<1	-	1	-	6
Upper Mohawk Wash 1507020110-	-	-	-	-	-	132
Lower Mohawk Wash 1507020111	1	5	-	-	-	259
Big Eye Wash Area 1507020112	24	1	-	-	-	170
Coyote Wash Area 1507020113	2	4	-	-	-	272
Morgan Wash-Lower Gila River 1507020114	50	18	-	1	-	21
Castle Dome Wash 1507020115	4	-	-	-	-	164
Fortuna Wash-Lower Gila River 1507020116	73	4	-	-	-	48
Upper Midway Wash 1507020201	55	-	-	-	4	161
Upper Tenmile Wash 1507020202	128	-	-	-	99	70
Lower Midway Wash Area 1507020203	31	-	-	-	-	250

Subwatershed	BLM	Bureau of Reclamation	US Forest Service	Game and Fish	Indian Reservation	Military Lands
Lower Tenmile Wash 1507020204	13	-	-	-	-	172
Cherioni Wash 1507020301	0	-	-	-	<1	-
Cuerda de Lena 1507020302	82	-	-	-	62	-
Daniels Arroyo 1507020303	6	-	-	-	-	24
Growler Wash 1507020304	<1	-	-	-	-	146
Upper San Cristobal Wash 1507020305	0	-	-	-	-	97
Childs Valley 1507020306	2	-	-	-	-	113
Lower San Cristobal Wash 1507020307	7	-	-	-	-	241
Lower Colorado Gila Watershed	4,850	74	-	4	577	3,683

Table 1-2: Colorado-Lower Gila Watershed Land Ownership (area in square miles) (part 2 of 2)

Subwatershed	National Fish and Wildlife Refuge	National Park Service	Parks and Recreation	Private Land	State Land
Jumbo Wash-Lower Colorado River 1503010101	-	166	-	<1	-
Lower Colorado River-Lake Mohave 1503010102	-	121	-	19	3
Silver Creek Wash-Lower Colorado River 1503010103	-	3	-	75	21
Topock Marsh-Lower Colorado River 1503010104	21	-	-	24	8
Lower Colorado River-Lake Havasu 1503010106	30	-	27	39	38
Tennessee Wash-Sacramento Wash 1503010301	-	108	-	77	5
Thirteenmile Wash-Sacramento Wash 1503010302	-	69	1	181	7
Buck Mountain Wash 1503010303	-	-	-	141	20
Walnut Creek-Sacramento Wash 1503010304	-	37	-	96	1
Franconia Wash-Sacramento Wash 1503010305	2	10	-	53	4

Subwatershed	National Fish and Wildlife Refuge	National Park Service	Parks and Recreation	Private Land	State Land
Osborne Wash-Lower Colorado River 1503010401	-	-	4	3	11
Upper Parker Valley-Lower Colorado River 1503010403	-	-	-	2	<1
Lower Parker Valley-Lower Colorado River 1503010404	-	-	-	-	3
Ehrenberg Wash-Lower Colorado River 1503010406	-	-	-	3	11
Mohave Wash-Lower Colorado River 1503010407	-	-	-	-	4
Gould Wash-Lower Colorado River 1503010409	17	-	-	9	5
Yuma Wash-Lower Colorado River 1503010410	28	-	-	<1	3
Martinez Lake-Lower Colorado River 1503010411	53	-	-	1	6
Alamo Wash 1503010501	75	-	-	1	2
Upper Bouse Wash 1503010502	68	-	-	14	32
Cunningham Wash 1503010503	-	-	-	2	135
Middle Bouse Wash 1503010504	-	-	-	82	35
Lower Bouse Wash 1503010505	-	-	-	9	30
Upper Tyson Wash 1503010601	106	-	-	4	-
Middle Tyson Wash 1503010602	55	-	-	5	2
Lower Tyson Wash 1503010603	-	-	-	<1	14
Picacho Wash-Lower Colorado River 1503010701	-	-	-	21	3
Lower Colorado River below Morelos Dam 1503010702	-	-	-	2	1
Yuma Desert Area 1503010800	-	-	-	155	32
Columbus Wash 1507020101	-	-	-	28	40
Fourth of July Wash-Lower Gila River 1507020102	-	-	-	9	13
Clanton Wash 1507020103	-	-	-	3	16
Baragan Wash 1507020104	85	-	-	2	9
Nottbusch Wash-Lower Gila River 1507020105	-	-	-	41	37
Hoodoo Wash 1507020106	66	-	-	1	13
Yaqui Wash 1507020107	162	-	-	12	26
Gravel Wash 1507020108	288	-	-	2	9
Park Valley-Lower Gila River 1507020109	-	-	-	92	64
Upper Mohawk Wash 1507020110	204	-	-	-	-
Lower Mohawk Wash 1507020111	31	-	-	19	9
Big Eye Wash Area 1507020112	37	-	-	5	4

Subwatershed	National Fish and Wildlife Refuge	National Park Service	Parks and Recreation	Private Land	State Land
Coyote Wash Area 1507020113	42	-	-	9	5
Morgan Wash-Lower Gila River 1507020114	-	-	-	103	10
Castle Dome Wash 1507020115	54	-	-	3	2
Fortuna Wash-Lower Gila River 1507020116	-	-	-	68	13
Upper Midway Wash 1507020201	-	-	-	-	-
Upper Tenmile Wash 1507020202	1	-	-	17	0.05
Lower Midway Wash Area 1507020203	-	-	-	1	23
Lower Tenmile Wash 1507020204	-	-	-	23	22
Cherioni Wash 1507020301	-	-	-	-	-
Cuerda de Lena 1507020302	13	-	-	1	2
Daniels Arroyo 1507020303	123	-	-	<1	-
Growler Wash 1507020304	194	-	-	-	1
Upper San Cristobal Wash 1507020305	217	-	-	-	-
Childs Valley 1507020306	33	-	-	-	-
Lower San Cristobal Wash 1507020307	-	-	-	31	28
Lower Colorado Gila Watershed	2,002	513	-	1,490	780

Data Sources: GIS data layer "landownership" originated by Arizona Land Information System, 2006. www.land.stat.az.us/alris

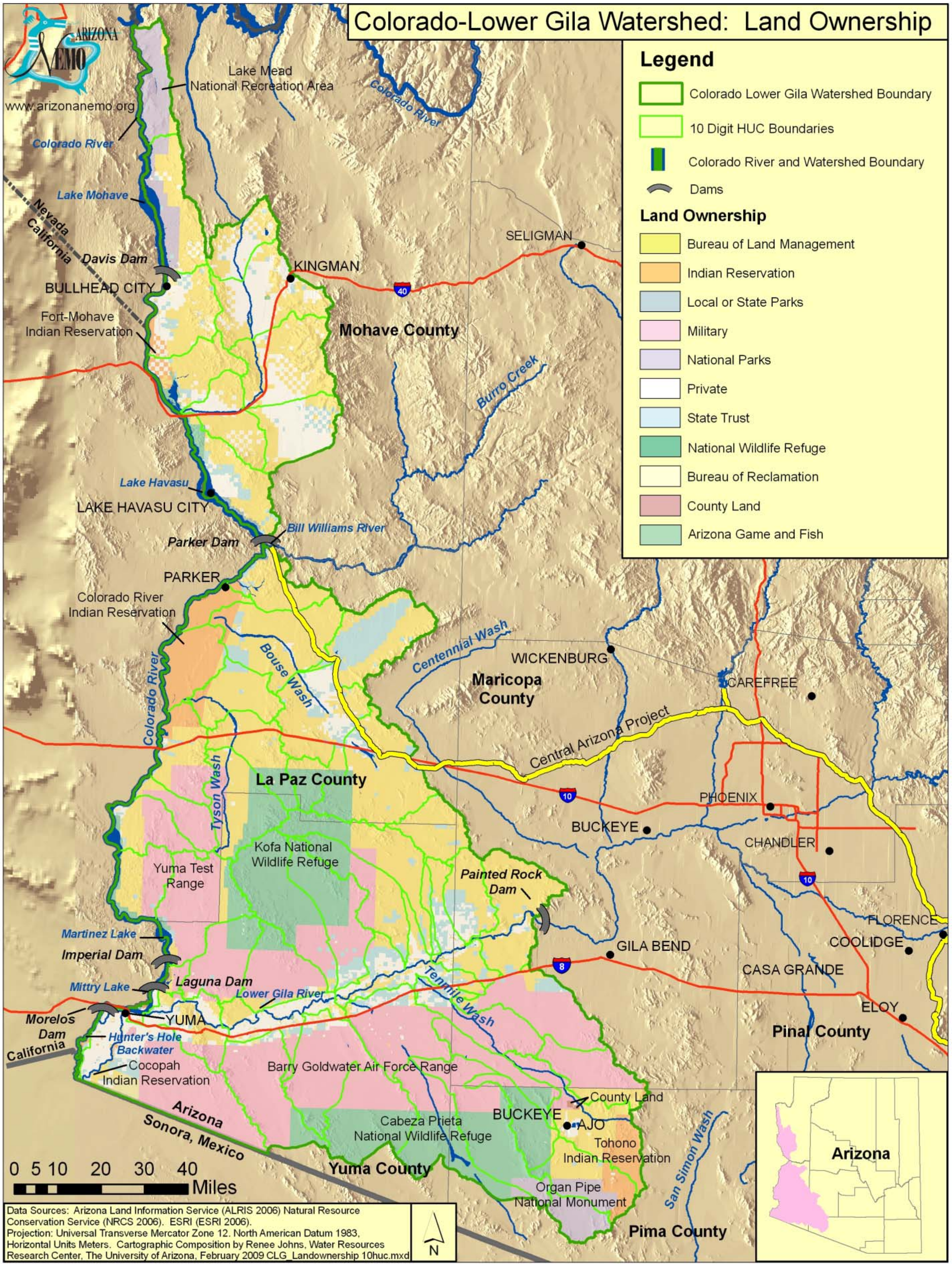
Land ownership is one of the variables used in the classification of subwatersheds into categories of susceptibility to water quality problems in Section 2 of this plan.

Land Use

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

The overwhelmingly dominant land use category in the Colorado-Lower Gila Watershed is rangeland, with agriculture occurring along the Colorado and Gila Rivers and the CAP canals. The two largest urbanized areas are Yuma and Lake Havasu City.

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



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006).
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG_Landownership 10huc.mxd

Figure 1-3: Land Ownership

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).

Physical Features

Watershed Description

The Colorado-Lower Gila Watershed addressed in this plan includes the land within the State of Arizona that is drained by the Colorado River below Hoover Dam and the land drained by the Gila River below Painted Rock Dam. This watershed does not include any areas outside of Arizona. The watershed of the Bill Williams River, a major tributary of the Colorado River is covered in a separate NEMO watershed-based plan and is not included here. The area of the Colorado-Lower Gila Watershed is approximately 14,000 square miles and occupies the extreme west and southwest parts of Arizona (Figure 1-2).

Climate

Data from the Western Regional Climate Center (www.wrcc.dri.edu) show a fairly uniform pattern of temperatures throughout the Colorado-Lower Gila Watershed. With the exception of Kingman, where temperatures are about 10^0 F cooler than the other communities in the watershed, average summer (July monthly average) temperatures are in the 90s and average winter (January Monthly average) temperatures are in the 50s.

Precipitation in the Colorado-Lower Gila Watershed is low, with average rainfall of less than 5 inches per year at locations along the Colorado River (Bullhead City, Lake Havasu City, Parker, and Yuma) and somewhat greater at more westerly upland locations (10 inches per year at Kingman; 8 inches per year at Ajo). Precipitation is seasonally bimodal in the Colorado-Lower Gila Watershed, peaking in January-February and again in August.

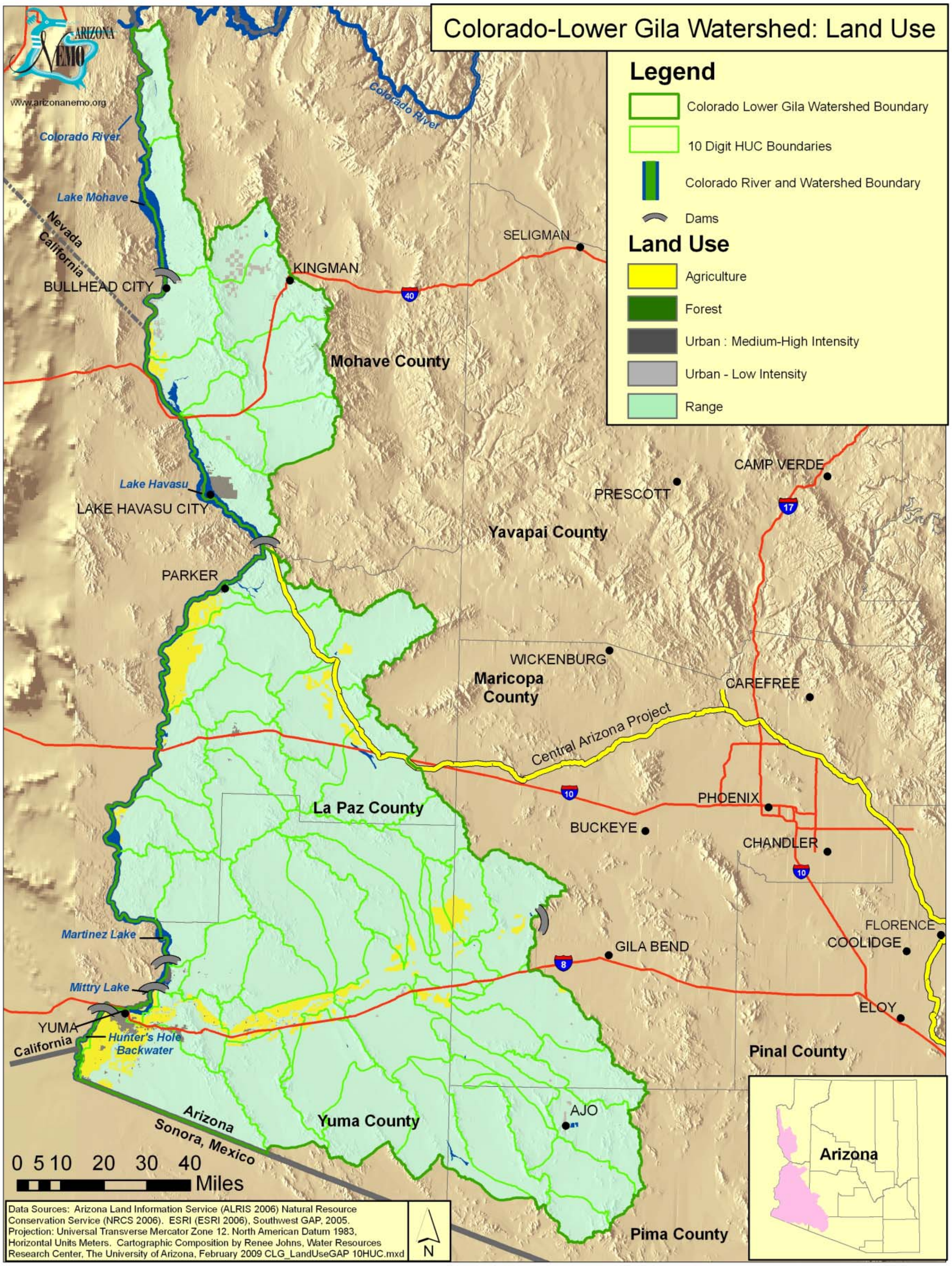
A map of average annual temperature and precipitation throughout the watershed is available on the NEMO web site (www.arizonaNEMO.org/).

Topography and Geology

Elevations within the Colorado-Lower Gila Watershed range from 7,148 ft at Mt. Tipton in the Cerbat Mountains north of Kingman (Kingman itself is at 3,340 ft) to 134 ft at San Luis just south of Yuma on the Arizona-Sonora border (Benchmark Maps, 2004).

Figure 1-5 is a map of land slope within the Colorado-Lower Gila Watershed. Slope is used in calculating such factors as runoff and erosion.

The Colorado-Lower Gila Watershed is within the Basin and Range Province of the southwestern U.S. and northwestern Mexico. The Basin and Range Province was formed from 28 to 12 million years ago as the Baja California portion of the Earth's Pacific Oceanic tectonic plate began diverging from the continental plate, stretching the continental plate. As the earth's crust was stretched, blocks of crust fractured and dropped in a pattern of valley basins and high peak ranges.



Colorado-Lower Gila Watershed: Land Use

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest GAP, 2005. Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG_LandUseGAP 10HUC.mxd

Figure 1-4: Land Use

The Colorado River has its headwaters in the Rocky Mountains of Colorado. It flows into Utah where it is joined by tributaries from Wyoming and continues across the southeastern corner of Utah, entering Arizona at Page. The Colorado River then turns to the west and winds its way through the Grand Canyon until it reaches Hoover Dam where it turns and flows south along the western border of Arizona. Its channel ultimately joins the Sea of Cortez.

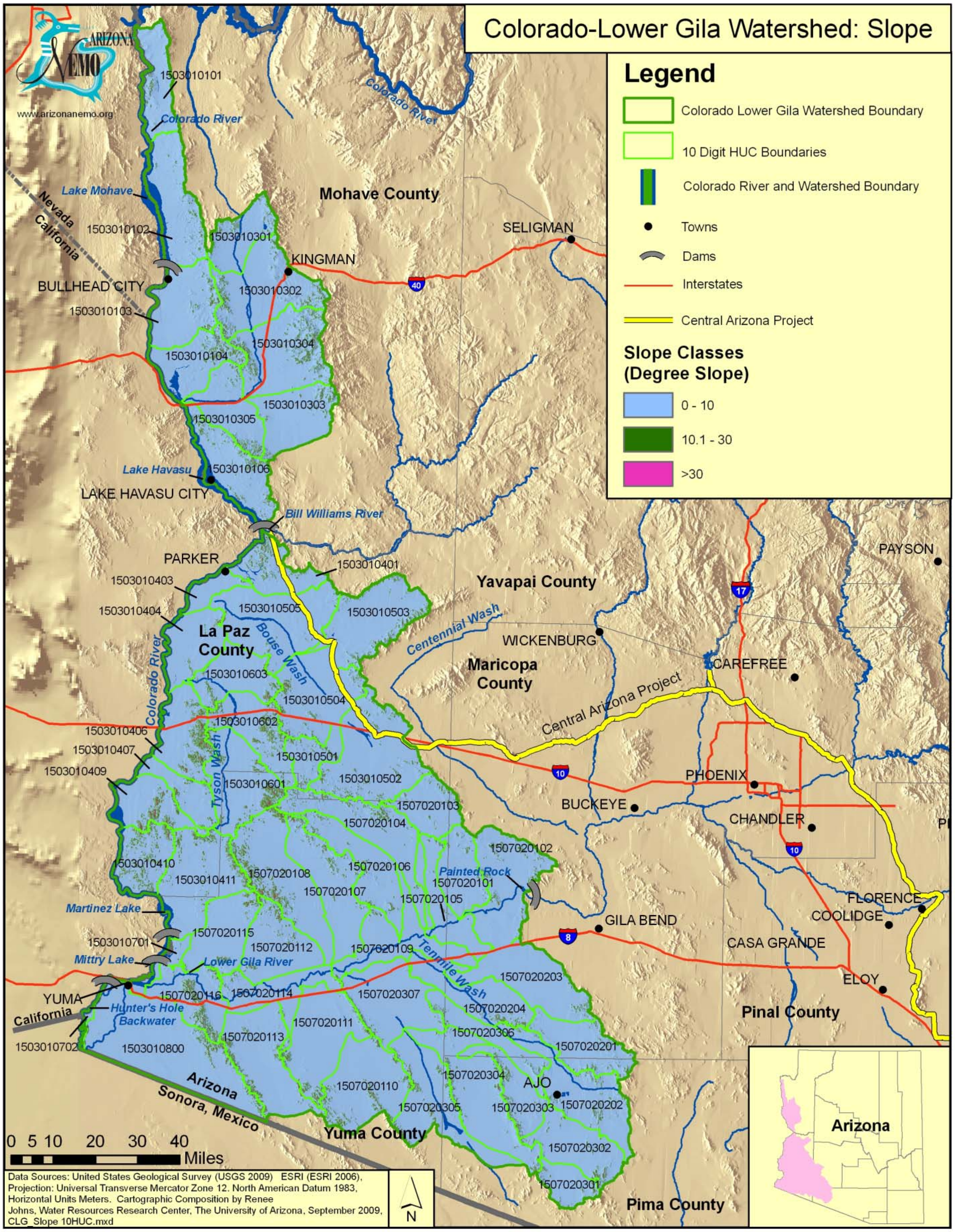
The Colorado has not always flowed in this path, however. Luchitta (1984, 1990) has proposed a scenario that derives the present course of the Colorado as the result of the joining of what were once two separate drainage systems. The first system is the Rocky Mountain drainage to the north, which flowed more or less along the present course of the Colorado River until it reached a point somewhere in the area of the Kanab, Uinkaret, or Shivwits Plateaus where it ended in a lake or some other interior drainage feature. This ancestral Colorado River did not connect with the ocean until after the Sea of Cortez opened about 5.5 million years ago.

Headward erosion of streams draining into the newly opened Gulf of California (which extended as far north as Needles, CA, in the Pliocene, and may have extended to the Lake Mead area in the earlier Miocene) created the lower part of the Grand Canyon and eventually captured the ancestral Colorado River, connecting it to the Sea of Cortez (Nations and Stump, 1996).

The Gila River arises in the in western New Mexico, enters southeastern Arizona near Duncan, then follows a convoluted course westward, passing south of Phoenix, then southwest past Gila Bend, and finally joining the Colorado River at Yuma. The Lower Gila Watershed, as defined in this plan, begins at the Painted Rock Dam northwest of Gila Bend and continues downstream. Two previous NEMO Watershed-Based Plans address the Upper Gila and Middle Gila Watersheds. Most of the surface geology of the Colorado-Lower Gila Watershed consists of relatively recent Tertiary and Quaternary deposits. Exceptions are the Cerbat and Hualapai Mountains north and south of Kingman which consist largely of Proterozoic granites (Kamilli and Richard, 1998), approximately 1.7 billion years old (Duebendorfer et al., 2001). Surface deposits along the Lower Gila River are primarily Middle Pleistocene and Holocene sands and gravels with a large area of Late Pliocene or Early Pleistocene basalt forming the Sentinel lava field south of the Gila River about 20 miles west of Gila Bend (Chronic, 1983; Kamilli and Smith, 1998).

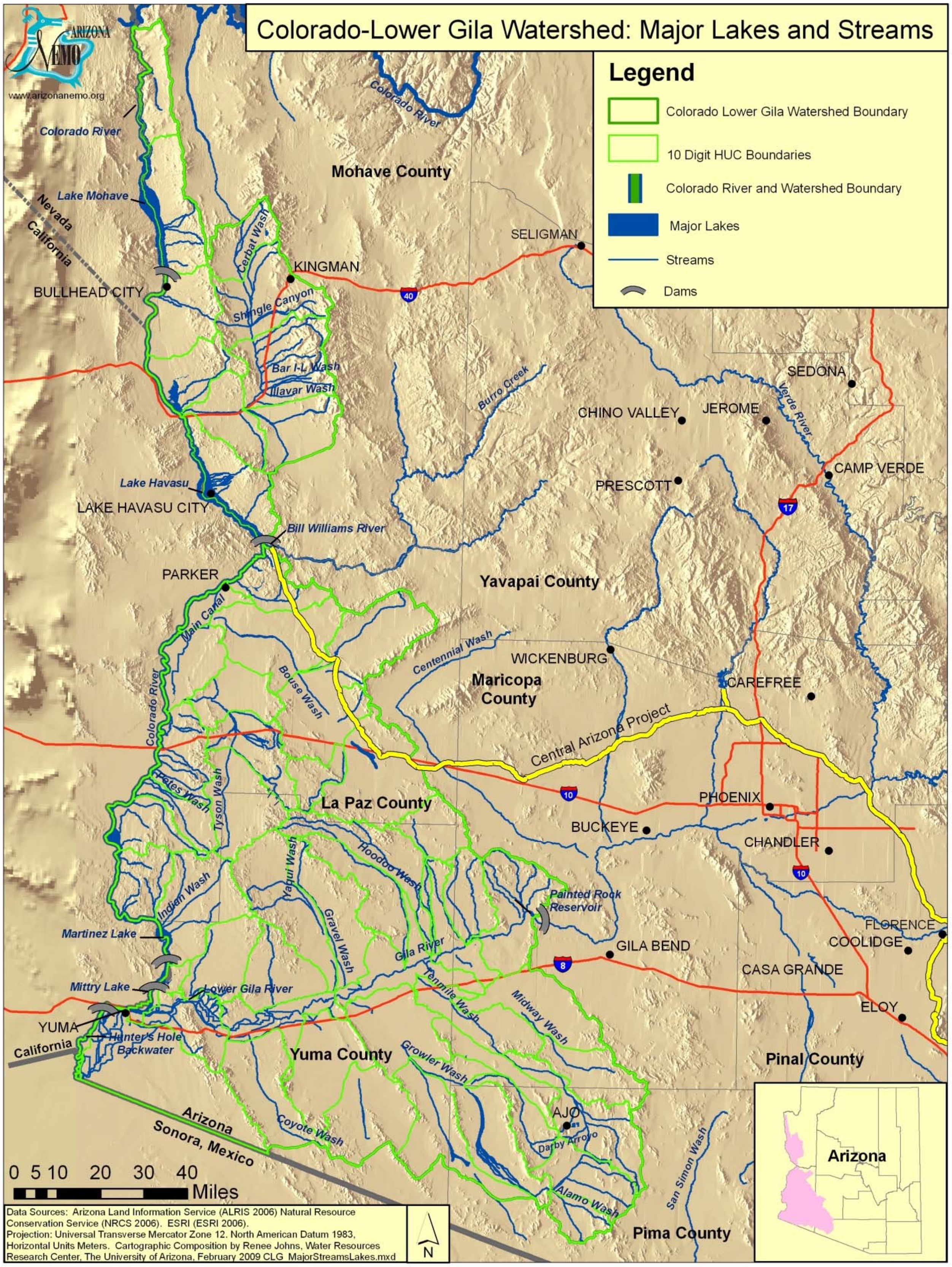
Water Resources

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



Data Sources: United States Geological Survey (USGS 2009) ESRI (ESRI 2006),
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983,
Horizontal Units Meters. Cartographic Composition by Renee
Johns, Water Resources Research Center, The University of Arizona, September 2009,
CLG_Slope 10HUC.mxd

Figure 1-5: Slope



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006).
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG MajorStreamsLakes.mxd

Figure 1-6: Major Lakes and Streams

Table 1-3: Colorado-Lower Gila Watershed Major Lakes and Streams (part 1 of 2)

Stream Name	LENGTH (miles)	Subwatershed
A Canal	11	1503010800
Alamo Wash	38	1503010501
B Canal	10	1503010800
Bar I-L Wash	15	1503010304
Baragan Wash	17	1507020104
Beal Ditch	1	1503010104
Bennett Wash	2	1507020116
Big Eye Wash	24	1507020112
Big Granite Wash	10	1503010503, 1503010504
Bill Williams River	0	1503010106
Black Rock Wash	18	1503010304
Bouse Wash	50	1503010505, 1503010504
Buck Mountain Wash	30	1503010303
CAP Canal	41	1503010401, 1503010505, 1503010504, 1503010502
Calcite Wash	10	1503010504
Castle Dome Wash	17	1507020115
Cave Creek	8	1503010602
Cementosa Wash	8	1507020104
Central Canal	12	1503010800
Cerbat Wash	17	1503010302
Chalk Wash	2	1503010602
Cherioni Wash	15	1507020301
Chico Shunie Arroyo	7	1507020303
Clanton Wash	10	1507020103
Clip Wash	8	1503010410
Colorado River	468	1503010101, 1503010102, 1503010103, 1503010104, 1503010305, 1503010106, 1503010401, 1503010403, 1503010404, 1503010406, 1503010407, 1503010409, 1503010410, 1503010411, 1503010701, 1503010702, 1503010800
Columbus Wash	23	1507020101
Cooper Lateral	6	1503010701, 1503010702
Copper Creek	2	1503010304
Copper Wash	26	1507020101
Cow Creek	26	1503010303
Coyote Wash	36	1507020113, 1507020114
Crazy Woman Wash	14	1503010409
Cuerda de Lena	20	1507020302

Stream Name	LENGTH (miles)	Subwatershed
Cummings Lateral	5	1503010800, 1503010702
Cunningham Wash	39	1503010503
Daniels Arroyo	38	1507020303
Darby Arroyo	8	1507020202
Daytona Wash	4	1503010106
Deadman Wash	25	1507020103
Dome Canal	13	1507020116
Dome Protective Channel	12	1507020116, 1507020115
E Main Canal	25	1503010800
Eagle Wash	4	1503010401
East Drain	8	1503010800
Ehrenberg Wash	17	1503010406
El Dorado Wash	5	1503010106
Falls Springs Wash	11	1503010106
Farmers Canal	7	1507020103, 1507020109
Fivemile Wash	11	1503010104
Flattop Wash	8	1503010304
Fortuna Wash	15	1507020116
Fourth of July Wash	22	1507020102
Franconia Wash	17	1503010305
French Creek	23	1503010601, 1503010602
Gibson Arroyo	10	1507020202
Giers Wash	4	1503010401
Gila Gravity Main Canal	8	1507020116
Gila River	129	1507020116, 1507020114, 1507020109, 1507020105, 1507020102
Goodman Slough	5	1503010406
Goodman Wash	7	1503010406
Gould Wash	26	1503010409
Granite Wash	13	1503010102
Gravel Wash	33	1507020108
Griffith Wash	10	1503010302
Growler Wash	179	1507020304
Gunsight Wash	18	1507020302
Happy Jack Wash	13	1503010304
Hart Mine Wash	7	1503010409
Havasupai Wash	6	1503010106
Hoodoo Wash	59	1507020106, 1507020104
Illavar Wash	9	1503010304

Stream Name	LENGTH (miles)	Subwatershed
Indian Wash	25	1503010411
Industrial Drain	2	1503010106
Iroquois Wash	3	1503010106
Italian Wash	18	1503010602
Jumbo Wash	14	1503010101
Kaiser Wash	6	1503010603
Katherine Wash	5	1503010102
Kiowa Drain	3	1503010106
Kofa Dam Wash	2	1507020107
Kuakatch Wash	22	1507020302
La Cholla Wash	1	1503010602
La Paz Wash	5	1503010406
Lake Wash	11	1503010406
Limekiln Wash	8	1503010406
Long Mountain Wash	5	1507020116
Lopez Wash	10	1503010410
Los Angeles Wash	17	1503010411
Lost Cabin Wash	13	1503010102
Loudermilk Wash	18	1507020101
Mackenzie Creek	6	1503010304
Mackenzie Wash	14	1503010304
Main Canal	23	1503010403
Main Drain	42	1503010800
Main Outlet Drain	9	1507020116
McAllister Wash	21	1503010411
McPherson Wash	24	1507020108
Meadow Creek	9	1503010302
Midway Wash	30	1507020201, 1507020203
Mohave Wash	25	1503010407
Mohawk Canal	49	1507020114, 1507020111
Mohawk Wash	26	1507020110
Montana Wash	7	1507020111
Morgan Wash	5	1507020114
Muggins Wash	3	1507020116
Mule Wash	12	1503010407
Neptune Wash	4	1503010106
North Drain	3	1503010800
North Gila East Main Canal	1	1507020116
North Gila Main Canal	6	1503010701

Stream Name	LENGTH (miles)	Subwatershed
Nottbusch Wash	23	1507020105
Nugget Wash	2	1507020116
Osborne Wash	25	1503010401
Owl Wash	6	1507020111, 1507020114
Palmtree Wash	2	1503010401
Palo Verde Wash	2	1503010401
Pesch Canal	2	1503010800
Petes Wash	11	1503010407
Plomosa Wash	9	1503010602
Plomosita Wash	5	1503010602
Poormans Wash	11	1503010602
Portland Wash	7	1503010102
Quail Spring Wash	11	1507020102
Red Cloud Wash	8	1503010410
Red Raven Wash	45	1507020104
Rio Cornez	13	1507020202
Rock Creek	14	1503010304
Sacramento Wash	81	1503010305, 1503010304, 1503010302, 1503010301
San Cristobal Wash	56	1507020305, 1507020307
Scadden Wash	7	1503010602
Secret Pass Wash	13	1503010302
Sentinel Wash	5	1507020105
Seventy Wash	8	1503010406
Shingle Canyon	18	1503010302
Sikort Chuapo Wash	31	1507020202
Silver Creek	6	1503010103
Silver Creek Wash	9	1503010103
Smith Wash	2	1503010602
Smoketree Wash	3	1503010106
Somerton Canal	7	1503010800
South Drain	5	1503010800
South Gila Valley Main Canal	8	1507020116
Standard Wash	15	1503010106
Tenmile Wash	69	1507020202, 1507020204
Tennessee Wash	18	1503010301
Texas Hill Canal	11	1507020109
Thacker Lateral	5	1503010800
The Lagoon	4	1507020109
Thirteenmile Wash	17	1503010302

Stream Name	LENGTH (miles)	Subwatershed
Topock Marsh	32	1503010104
Trigo Wash	18	1503010406
Twelvemile Slough	1	1503010403
Twin Tanks Wash	4	1507020116
Tyro Wash	10	1503010102
Tyson Wash	58	1503010603, 1503010302, 1503010601
Upper Bouse Wash	20	1503010502
Vinegarroon Wash	15	1507020115
W Main Canal	23	1503010800
Walnut Creek	24	1503010304
Warm Springs Wash	21	1503010104
Weaver Wash	14	1503010406
Wellton Canal	17	1507020114
Wellton Mohawk Canal	18	1507020116
Wellton Mohawk Main Channel	32	1507020116, 1507020114
West Drain	2	1503010800
West Fork Yuma Wash	8	1503010410
West Wash	1	1507020116
Willow Creek	20	1503010302
Willow Wash	1	1503010106
Woolsey Wash	12	1507020102
Yaqui Wash	42	1507020107
Yellow Flower Creek	7	1503010302
Yellow Medicine Wash	16	1507020102
Yuma Wash	19	1503010410

Table 1-3: Colorado-Lower Gila Watershed Major Lakes and Streams (part 2 of 2)

Lake Name	Area (acres)	Subwatershed
Adobe Lake	205	1503010410
Beal Lake	301	1503010104
Cibola Lake	170	1503010410
Cimarron Lake	9	1503010103
Cowbell Lake	26	1503010410
East Dam Tailings Pond	372	1507020202
Laguna Reservoir	41	1503010701
Lake Havasu	9,313	1503010106
Lake Mohave	13,349	1503010101, 1503010102
Lost Lake	567	1503010104

Mary Lake	417	1503010701
North Dam Tailings Pond	276	1503010104
Nortons Lake	48	1503010410
South Dam Tailings Pond	304	1503010410
Threemile Lake	22	1503010104
Topock Marsh	5,187	1503010104

Data Sources: GIS data layers "major streams" and "major lakes" originated by Arizona Land Information System. www.land.state.az.us/alris

Lakes and Reservoirs

The three largest lakes in the Colorado-Lower Gila Watershed are reservoirs or wetlands created by dams on the Colorado River:

- Lake Mohave was created by the Davis Dam, near Bullhead City, which was completed in 1951. The dam is operated by the U.S. Bureau of Reclamations to regulate water releases from Hoover Dam. It is also used to generate hydroelectric power. Lake Mohave is part of the Lake Mead National Recreation Area operated by the U.S. National Park Service;
- Lake Havasu was created by the Parker Dam near the confluence of the Colorado and the Bill Williams River. The dam was completed in 1938 and is operated by the U.S. Bureau of Reclamations. The Lake Havasu reservoir provides water to the Colorado aqueduct, serving the Los Angeles area, and the Central Arizona Project aqueduct, which provides Colorado River water to central and southern Arizona. The lake is an important recreational area.
- Topock Marsh was created in 1966 by the South Dike outlet structure. It is operated by the U.S. Fish and Wildlife Service as a wildlife habitat and recreation area. It is a nesting area for the endangered southwestern willow flycatcher (http://www.fws.gov/southwest/refuges/arizona/havasu/topockmarsh.html).

Streams

The Colorado-Lower Gila Watershed contains a total of 3,391 miles of major streams that are of three types: perennial, intermittent and ephemeral.

- Perennial stream means surface water that flows continuously throughout the year.
- Intermittent stream means 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.

Most of the streams in desert regions are intermittent or ephemeral. Some channels are dry for years at a time, but are subject to flash flooding during high-intensity storms (Gordon et al., 1992).

Groundwater

The Arizona Department of Water Resources has divided the State into seven planning areas (www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/). The Colorado-Lower Gila Watershed occupies portions of both the Upper Colorado River Planning Area and the Lower Colorado River Planning Area. There are eight groundwater basins within the area of the Colorado-Lower Gila Watershed, the Lake Mohave Basin, the Lake Havasu Basin, the Sacramento Basin, the Butler Valley Basin, the Parker Basin, the Ranegras Plain Basin, the Lower Gila Basin, and the Yuma Basin. Within both planning areas, the largest water use is for agriculture, followed by municipal demand and industrial demand. Annual municipal and industrial water supply is about 3 million acre-ft, one-third of which comes from groundwater pumping, and two-thirds from surface water diverted from the Colorado and Gila Rivers. A very small proportion comes from effluent re-use.

Soils

Information on soils in the Colorado-Lower Gila Watershed 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 texture is shown in Figure 1-7. 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;
- 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.

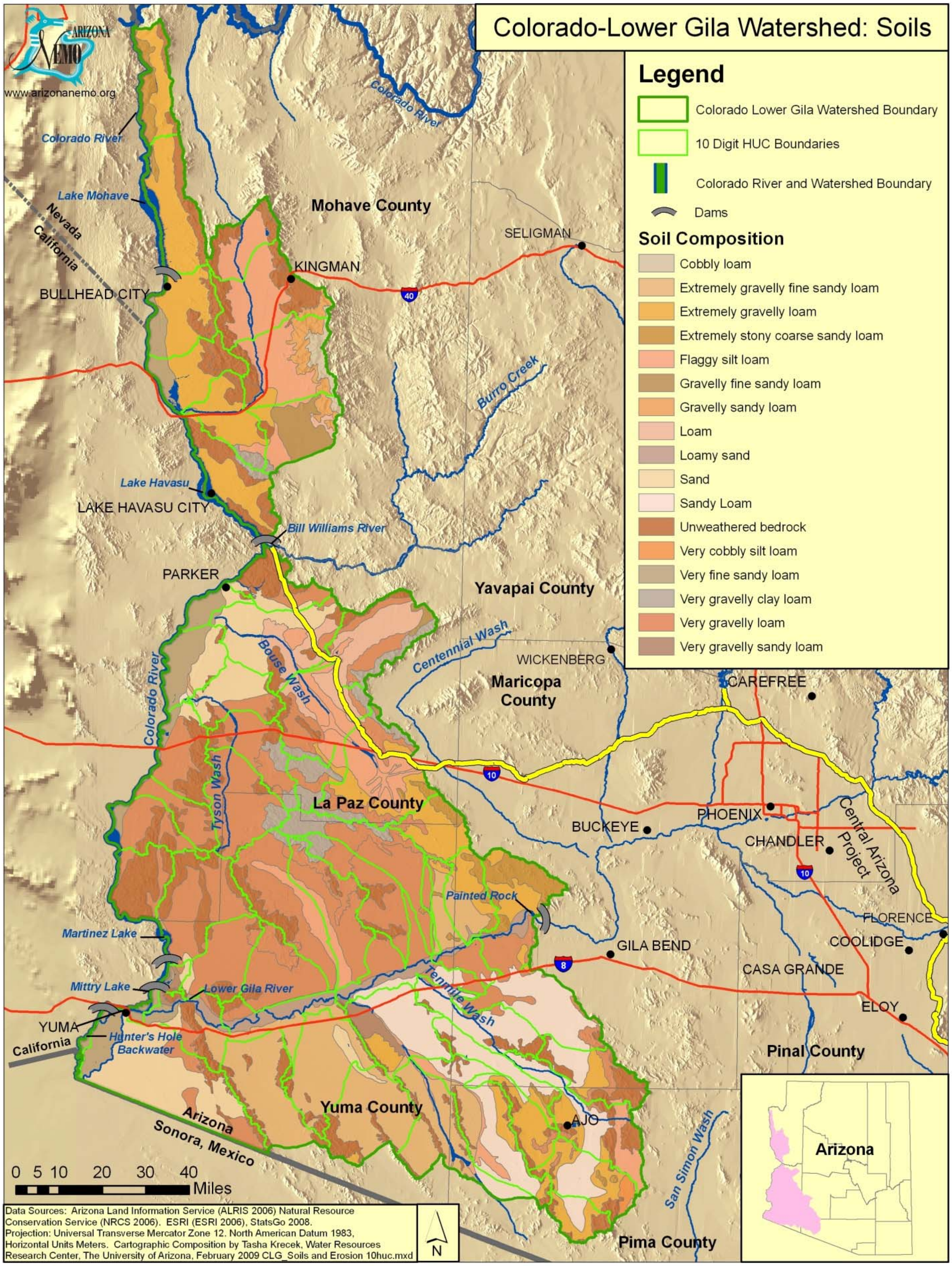
Metals from natural and anthropogenic sources can be transported to receiving waters via soil erosion and overland flows resulting from precipitation or through the release of irrigation waters into the environment (Antonius 2008). Because of their chemical reactivity, metals are especially mobile, and 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.



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), StatsGo 2008.
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Tasha Krecek, Water Resources Research Center, The University of Arizona, February 2009 CLG_Soils and Erosion 10huc.mxd

Figure 1-7: Soils

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 from flood irrigation evaporates and 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

Between Hoover Dam and Bullhead City, the Colorado-Lower Gila Watershed is within the Mohave Desert. The rest of the Watershed lies within the Lower Colorado River Valley subdivision of the Sonoran Desert (Dimmitt, 2000). Woodward (2003) describes the vegetation of this subdivision:

> Creosotebush [*Larrea trideantata*], white bursage [*Ambrosia dumosa*], and brittlebush (*Encelia farinosa*) dominate large areas of level land. Small trees, such as blue paloverde [*Parkinsonia floridum*], honey mesquite (*Prosopis glandulosa*), smoketree (*Dalea spinosa*), and ironwood (*Olneya tesota*), and a variety of shrubs, such as burroweed (*Hymenoclea salsola*), desert lavender (*Hyptis emoryi*), wolfberry (*Lycium andersonii*), and saltbushes (*Atriplex* spp.), grow in and near washes. Where the water table is high along exotic rivers, cottonwood (*Populus* spp.) and willows (*Salix* spp.) can be found, along with dense thickets of phreatophytes [deep rooted species that tap groundwater] such screwbean mesquite (*Prosopis pubescens*) and introduced salt cedar (*Tamarix* spp.). A fringe of arrowweed (*Pulchea sericea*) lies between them and the dry desert.

Saguaro cactus (*Carnegiea gigantea*), catclaw acacia (*Acacia greggii*), and ocotillo (*Fouquieria splendens*) dominate the bajadas (alluvial slopes), along with shrubs such as bladder sage (*Salazaria mexicana*), desert senna (*Cassia armata*), and indigobush (*Dalea schottii*), and various cacti, including hedgehog cactus (*Echinocereus englemannii*) and barrel cactus (*Ferocactus acanthodes*).

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 Colorado-Lower Gila 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 Colorado-Lower Gila Watershed are shown in Figure 1-8.

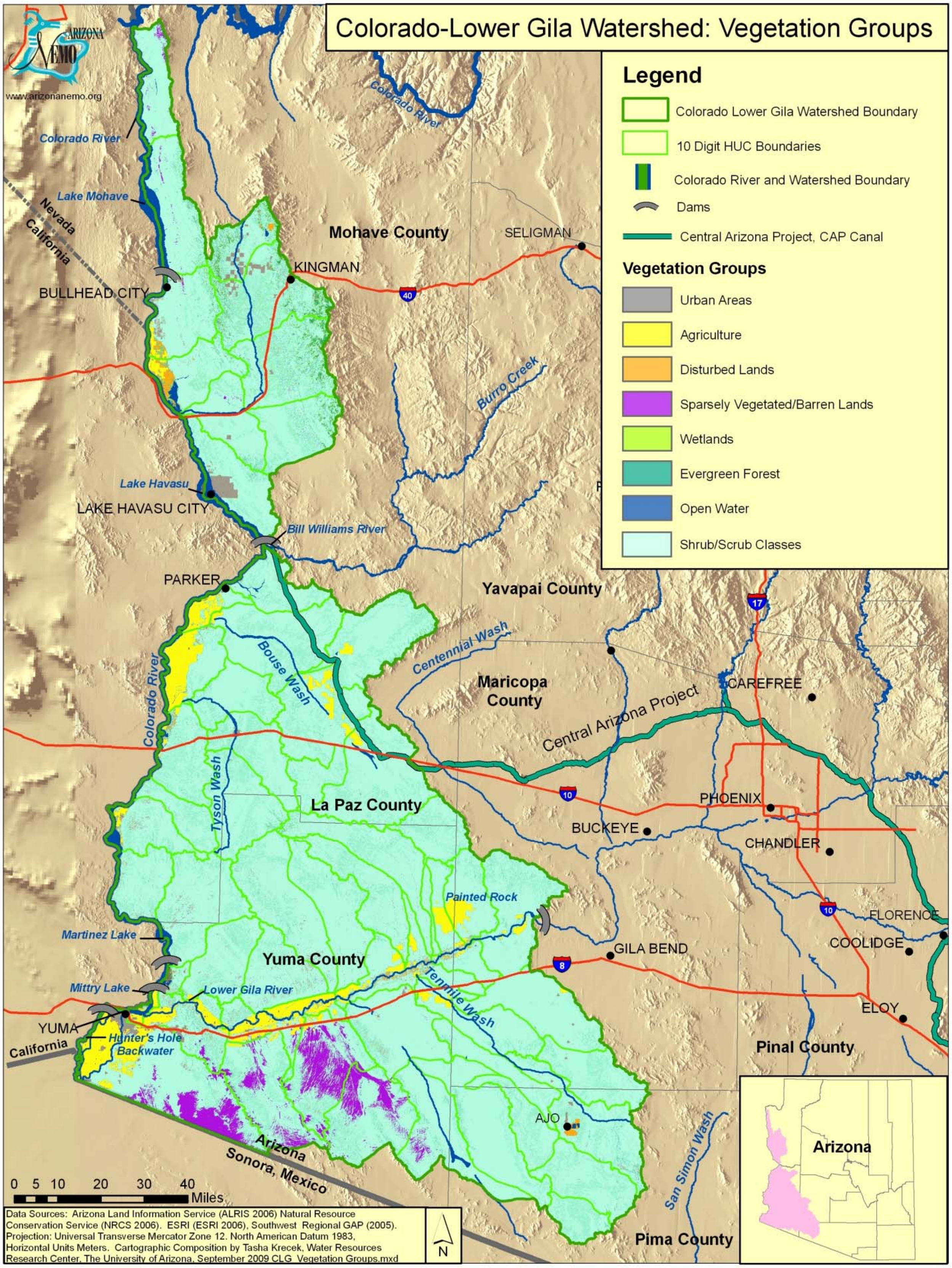
The predominant vegetation class in the Colorado-Lower Gila Watershed is shrubland/scrubland, with agricultural lands occurring along the rivers and canals. Some sparsely vegetated and barren lands occur in the southwest part of the watershed.

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. 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.



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP (2005). Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Tasha Krecek, Water Resources Research Center, The University of Arizona, September 2009 CLG Vegetation Groups.mxd

Figure 1-8 Vegetation Groups

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.

Appendix A of the present document is a summary of the ADEQ water quality monitoring and classification data for the Colorado-Lower Gila Watershed. These water quality data were used in Section 2 of this plan to classify each monitored waterbody based on its relative risk of impairment for the constituent groups. Figure 1-9 shows the results of the most recent ADEQ assessments of streams and lakes in the Colorado-Lower Gila Watershed.

The Colorado-Lower Gila Watershed has several reaches assessed as Impaired on Arizona's 303d List of Impaired Waters for 2004:

- Colorado River from Hoover Dam to Lake Mohave (105030101-015), impaired or not attaining due to water quality exceedances for selenium;
- Colorado River from Main Canal to Mexican Border (15030107-001), impaired or not attaining due to

water quality exceedances for dissolved oxygen and selenium;
- Painted Rock Borrow Pit Lake (15070201-1010), impaired or not attaining due to water quality exceedances for dissolved oxygen. Additionally, U.S. EPA assessment categorizes this water body as impaired or not attaining due to exceedances in DDT metabolites, toxaphene, and chlordane; Gila River from Coyote Wash to Fortuna Wash (15070301-003), impaired or not attaining due to exceedances for boron and selenium.

All other reaches were assessed as attaining all or some uses (Figure 1-9).

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

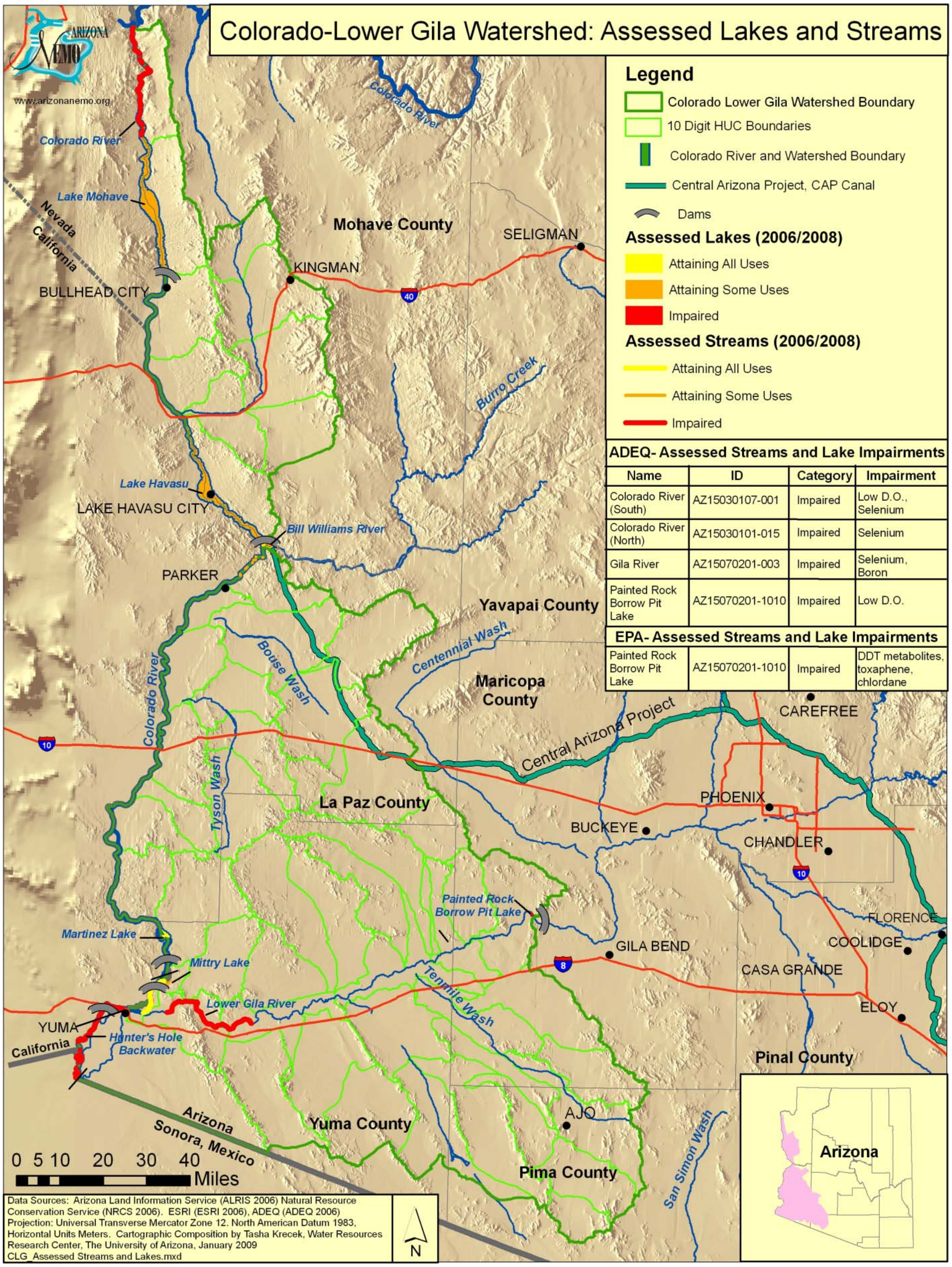
Natural Resource Areas

The Colorado-Lower Gila 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 Colorado-Lower Gila Watershed. These areas are shown in Figures 1-10 and 1-11.

At the northern end of the Colorado-Lower Gila Watershed, The Jumbo Wash-Lower Colorado River subwatershed and the Lower Colorado River-Lake Mohave subwatershed both include portions of the Lake Mead National Recreation Area and both contain critical habitat for the endangered razorback sucker; critical habitat for the bonytail chub also occurs in the Lower Colorado River-Lake Mohave subwatershed.

Further south, near the confluence of the Bill Williams River, the Havasu National Wildlife Refuge occurs within the Topock Marsh-Lower Colorado River subwatershed and the Lower Colorado River-Lake Havasu subwatershed; the latter subwatershed also provides critical habitat for the bonytail chub.

Several subwatersheds contain parts of the Imperial National Wildlife Refuge (Gould Wash-Lower Colorado River and Yuma Wash-Lower Colorado River); the Kofa National Wildlife Refuge (Alamo Wash, Upper Bouse Wash, Upper Tyson Wash, Middle Tyson Wash, Baragan Wash, Hoodoo Wash, Yaqui Wash, Gravel Wash, Big Eye Wash Area, and Castle Dome



ADEQ- Assessed Streams and Lake Impairments

Name	ID	Category	Impairment
Colorado River (South)	AZ15030107-001	Impaired	Low D.O., Selenium
Colorado River (North)	AZ15030101-015	Impaired	Selenium
Gila River	AZ15070201-003	Impaired	Selenium, Boron
Painted Rock Borrow Pit Lake	AZ15070201-1010	Impaired	Low D.O.

EPA- Assessed Streams and Lake Impairments

Name	ID	Category	Impairment
Painted Rock Borrow Pit Lake	AZ15070201-1010	Impaired	DDT metabolites, toxaphene, chlordane

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), ADEQ (ADEQ 2006)
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Tasha Krecek, Water Resources Research Center, The University of Arizona, January 2009
CLG_Assessed Streams and Lakes.mxd

Figure 1-9 Assessed Lakes and Streams

Wash); or both (Martinez Lake-Lower Colorado River).

Several subwatersheds within the Lower Gila River watershed contain portions of the Cabeza Prieta National Wildlife Refuge (Upper Mohawk Wash, Lower Mohawk Wash, Coyote Wash Area, Upper Tenmile Wash, Daniels Arroyo, Upper San Cristobal Wash, and Childs Valley); Organpipe National Monument (Cherioni Wash); or both (Cuerda de Lena and Growler Wash).

Outstanding Waters, Wilderness Areas, and Preserves

There are nine designated Wilderness Areas (and one Wilderness Study Area) within the Colorado-Lower Gila Watershed:

1) Mount Tipton Wilderness Area – This 30,760-acre wilderness area is managed by BLM (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/tipton.html). It is an extremely rugged area located in the Cerbat Mountains north of Kingman.

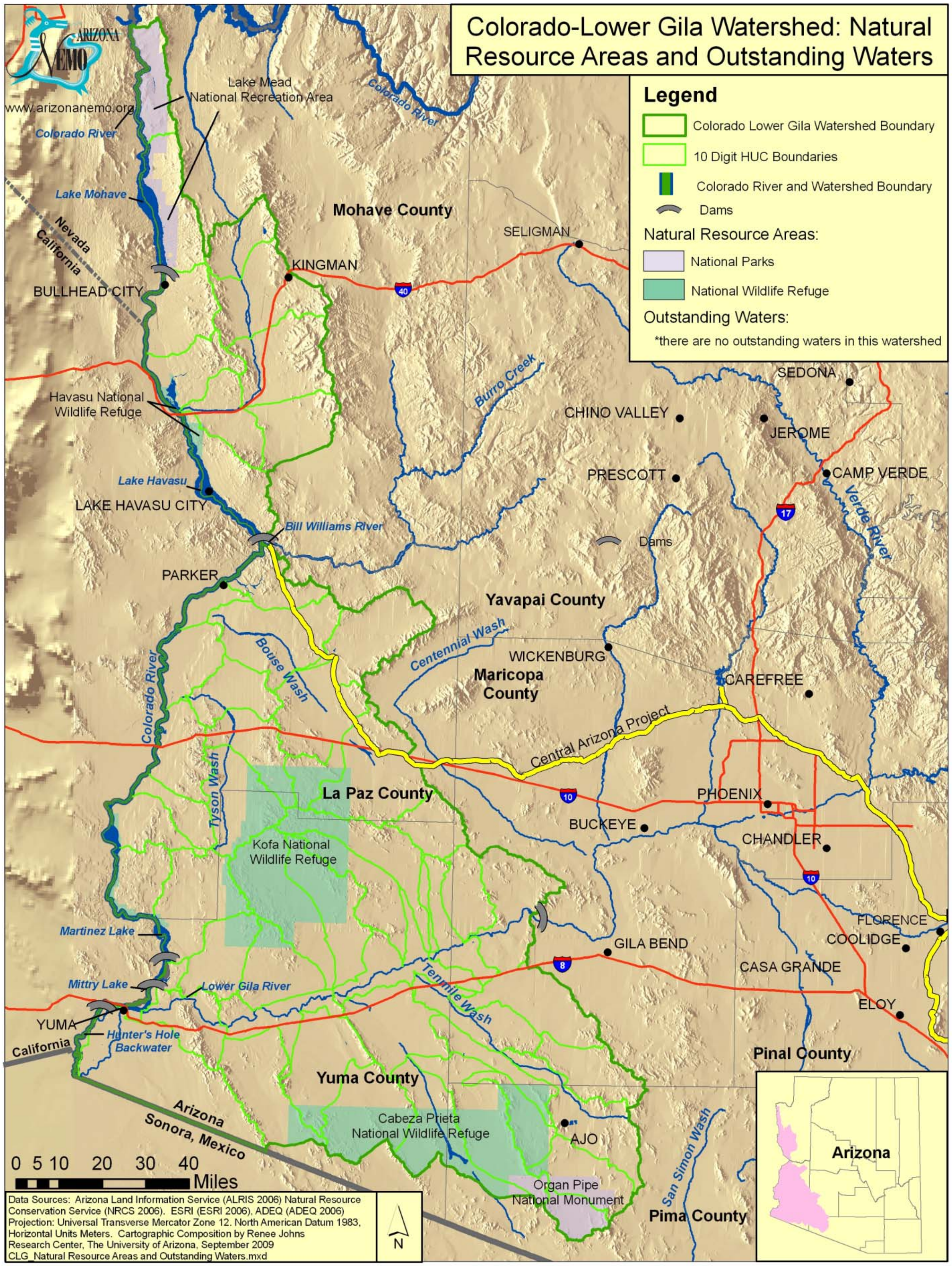
2) Mount Nutt Wilderness Area west of Kingman is also administered by BLM (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/nutt.html). This 27,660-acre wilderness area in the Black Mountains provides habitat for desert bighorn sheep. Scattered springs sustain cottonwoods, willows, and oaks.

3) Southwest of Kingman is the 112,400-acre Warm Springs Wilderness Area, administered by BLM (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/warmsprings.html). Bighorn sheep and wild burros are found here.

4) Wabayuma Peak Wilderness area occupies 40,000 acres in the Hualapai Mountains south of Kingman (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/wabayuma.html). A variety of ecosystem are represented across the elevation gradient of this wilderness area: Sonoran and Mohave desert vegetation in the lower zones, and chaparral and ponderosa pine in the uplands.

5) The 18,790-acre Gibraltar Mountain Wilderness Area is located about 10 miles east of Parker. This area of rugged topography is administered by BLM (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/gibraltar.html).

6) The East Cactus Plain Wilderness Area east of Parker, is a 14,630-acre wilderness dominated by crescent dunes and a unique and diverse community of dunescrub vegetation (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/ecactus.html).



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), ADEQ (ADEQ 2006)
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns Research Center, The University of Arizona, September 2009
CLG_Natural Resource Areas and Outstanding Waters.mxd

Figure 1-10: Natural Resource Areas and Outstanding Waters

7) The 59,100-acre Cactus Plain Wilderness Study area to the west is similarly dominated by sand dunes and dune vegetation communities (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/cactusplain.html).

8) The New Water Mountains Wilderness Area is a 24,600-acre area approximately 30 miles east of Ehrenberg. The Wilderness area contains lambing areas for desert bighorn sheep and Sonoran Desert scrub vegetation (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/nuwater.html).

9) Trigo Mountain Wilderness Area is located along the Colorado River between Ehrenberg and Yuma (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/trigo.html). This rugged 30,300-acre wilderness is administered by BLM.

10) The 7,640-acre Muggins Mountain Wilderness Area is 25 miles east of Yuma to the north of the Gila River (http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/muggins.html).

The U.S. Fish and Wildlife Service manages nine National Wildlife Refuges in Arizona (www.fws.gov/refuges/refugeLocatorMaps/Arizona.html), of which five are located in the Colorado-Lower Gila Watershed:

1) The Havasu National Wildlife Refuge extends for some 30 miles along the Colorado River from Needles, CA, to Lake Havasu City (http://www.fws.gov/southwest/refuges/arizona/havasu/index.html). It was established in 1941 to protect migratory birds make use of wetlands found in the area. A diverse assemblage of plants can be found in the Havasu NWR, and the refuge is implementing programs to remove invasive species, such as salt cedar, and to restore native vegetation to the area.

2) Cibola National Wildlife Refuge is located along the Colorado River about 25 miles downstream from Ehrenberg. It was established in 1964 to protect and restore wetland habitat for migratory birds (http://www.fws.gov/southwest/refuges/CibolaNWR/). More than 288 bird species have been recorded at Cibola NWR, including Canada geese that overwinter in the refuge.

3) Imperial National Wildlife Refuge extends another 30 miles along the Colorado River from the southern end of Cibola NWR. It covers some 27,768 acres and was established in 1941 as a refuge and breeding area for migratory birds and other wildlife (http://www.fws.gov/southwest/refuges/arizona/imperial.html). Efforts to restore native riparian vegetation are also being carried out at Imperial NWR.

4) Kofa National Wildlife Refuge, established in 1939, includes 665,400 acres of Sonoran desert habitat. It is located in southwest Arizona and includes the Kofa Mountains and the Castle Dome Mountains, habitat for one of the largest populations of desert bighorn sheep in the southwestern U.S. (http://www.fws.gov/southwest/refuges/Arizona/kofa/index.html).

5) Cabeza Prieta National Wildlife Refuge is an 860,010-acre refuge in southwest Arizona along the border with Mexico. The western portion of this refuge extends into the Colorado-Lower Gila Watershed. Cabeza Prieta NWR protects a diverse Sonoran desert ecosystem that contains endangered Sonoran pronghorn, bighorn sheep, elf owls, and many other species (http://www.fws.gov/southwest/refuges/arizona/cabeza.html).

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 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.

No designated Outstanding Arizona Waters occur in the Colorado-Lower Gila Watershed.

The Arizona Game and Fish Department (AZGFD) manages three wildlife areas within the Colorado-Lower Gila Watershed:

1) Colorado River Nature Center, at the southwest end of Bullhead City, provides opportunities for viewing a variety of native species of mammals, birds, reptiles, and amphibians (http://www.azgfd.gov/outdoor_recreation/wildlife_area_co_river_nature.shtml);

2) Mittry Lake Wildlife Area is along the Colorado River northeast of Yuma, downstream from Imperial Dam. This area contains a variety of aquatic, wetland, and riparian habitat and is home to many species of resident and migratory birds, including the federally endangered southwestern willow flycatcher. It is a popular area for nature study, bird watching, and small game hunting

(http://www.azgfd.gov/outdoor_recreation/ wildlife_area_mittry_lake.shtml);

3) Quigley Wildlife Area is a 612-acre area in the Gila River floodplain about 40 miles east of Yuma. Riparian habitats and wildlife are being restored and maintained in this area "to provide public opportunities for wildlife viewing, education, research, hunting and fishing" (http://www.azgfd.gov/ outdoor_recreation/ wildlife_area_quigley.shtml.

Riparian Areas

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 Colorado-Lower Gila Watershed can be found on the Arizona NEMO website (arizonanemo.org). Among the ecosystem 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.

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**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases and is also found on the NEMO IMS website (ArizonaNEMO.org). Metadata includes the original source of the data, when it was created, it's geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the*

Section 2: Pollution Risk Ranking

Purpose of this Section

This section of the Colorado-Lower Gila Watershed plan describes the methods used to assess the water quality status of each of the subwatersheds with respect to nonpoint pollution sources, and presents a classification and ranking of subwatersheds based on these water quality assessments. The classifications can be used to identify those subwatersheds for which pollution levels exceed applicable water quality standards as well as those most in danger of exceeding pollutant standards in the future. The prioritization of subwatersheds by need for corrective action can provide a basis for pursuing water quality improvement grants.

Methods

Classification of the subwatersheds was carried out using hydrological modeling and GIS spatial analyses. The general approach used is shown in Figure 2-1.

Input water quality data were provided by Arizona Department of Environmental Quality (see below) and are summarized in Appendix A. Spatial data were derived from the sources listed in Section 1.4 above.

GIS and Hydrological Modeling

Spatial and water quality data are inputs to watershed models which were used to estimate runoff and erosion values for each subwatershed. The models employed were AGWA (Automated Geospatial Watershed Assessment Tool) and SWAT (Soil and Water Assessment Tool).

AGWA is a GIS-based hydrologic modeling tool designed to perform a variety of watershed modeling and assessment functions. One of the modeling options within AGWA is SWAT, which can predict the impacts of land management practices on water, sediment and chemical yields in watersheds with varying soils, land use and management conditions (Arnold et al., 1994). AGWA provides the data management for SWAT and displays the output from SWAT as GIS products. For more information on AGWA and SWAT, see Appendix C.

Fuzzy Logic

In order to develop risk evaluations (REs) for the various pollutants, we have employed a method known as "fuzzy logic" (Zadeh, 1991). Many classification methods place variables into discrete categories, and an entity is either in the category or it is not -- it is either black or white. Fuzzy logic is a method for classifying entities which allows for intermediate cases through the use of a scoring system to calculate the extent to which the entity, for example, is a shade of gray between the range of black and white. Fuzzy logic allows for degrees of a characteristic: a fuzzy logic classification produces output that is not only black and white, but also contains categories between the two "end members." Full membership in a class is given a score of 1.0; nonmembership is given a score of 0.0; and scores ranging between 0.0 and 1.0 are given for intermediate cases of

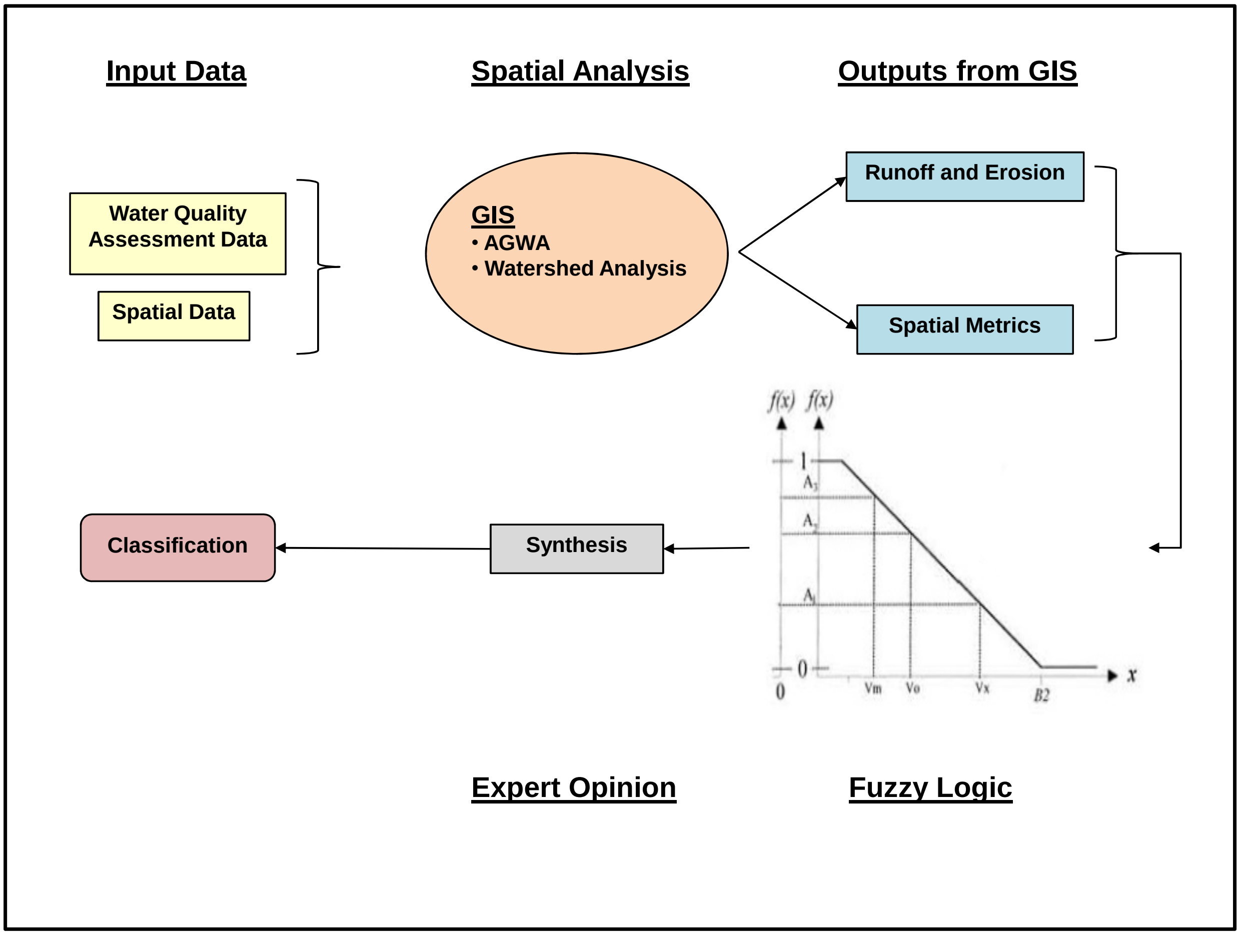


Figure 2-1: Methods Diagram

partial membership (Guertin et al., 2000; Miller et al., 2002; Reynolds et al., 2001).

In this watershed-based plan, fuzzy membership functions are used to assign risk evaluation (RE) scores to each subwatershed with respect to various geospatial and hydrological parameters . These fuzzy membership functions can be discrete or continuous depending on the characteristics of the input. The development of a fuzzy membership function can be based on published data, expert opinions, stakeholder values or institutional policy, and can be created in a data-poor environment. A benefit of this approach is that it provides for the use of different methods for combining individual factors to create the final classification and the goal set. Fuzzy membership functions and weighting schemes can also be changed based on watershed concerns and conditions.

Subwatershed Classification and Pollutant Risk Groups

Each of the subwatersheds within the Arizona portion of the Colorado-Lower Gila Watershed (Figure 1-1, Table 1-1) was classified with respect to the following risk groups of pollutants:

- Metals (ADEQ monitors some 16 metals, including arsenic, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc)
- Sediments
- Organics and nutrients (including *E. coli*, nutrients, excessively high or low pH, and low dissolved oxygen as a result of organic material being introduced into the aquatic system); and,
- Selenium

Water Quality Assessment Data

Arizona Department of Environmental Quality water quality assessment criteria and assessment definitions are found in Arizona's Integrated 305(b) Assessment and 303(d) Listing Report at http://www.azdeq.gov/environ/water/assessment/download/2008/binder1.pdf Monitoring and assessment data are available at the ADEQ website (www.azdeq.gov/environ/water/assessment/). The ADEQ water quality monitoring and classification data used in this plan are summarized in Appendix B.

This plan assigns four levels of risk classification which are based on the ADEQ assessment and the adequacy of the data available for making an assessment:

- Extreme risk - a surface water within the subwatershed is currently assessed by ADEQ or EPA as being "impaired or not attaining" (that is, does not meet the water quality standards appropriate for its intended uses) for one of the pollutant risk groups.
- High risk - a surface water within the subwatershed is currently assessed by ADEQ as being "inconclusive" (that is, available data indicate that water quality standards are not being met, but the data are too limited to allow a conclusive determination).
- Moderate risk - a surface water within the subwatershed is assessed by ADEQ as being "inconclusive" or "attaining" (that is, water quality meets the standards for the designated usage for the water body), but a small number of monitoring samples (fewer than 10%) fail to meet the standards for a pollutant risk group; or there were no water quality measurements available for a pollutant risk group at any site within the subwatershed.
- Low risk – a surface water within the subwatershed is assessed by ADEQ as meeting water quality standards for the pollutant risk group with sufficient data to make the assessment.

The risk evaluation of individual 10-digit HUC watersheds is based on the risk levels of the assessed surface waters within the specific HUC combined with a consideration of the risk levels of downstream waters as follows: An individual HUC is assigned to the risk level (extreme, high, moderate, and low) of the surface water with the highest assessed risk within its boundaries, and this risk level is considered in combination with the risk level of downstream waters according to the scheme in Table 2-1. On this basis, each 10-digit HUC watershed is assigned a numerical "risk evaluation score" ranging from 0 (least risk) to 1.0 (highest risk). Basing the risk level of the 10-digit HUC watershed on that of its most impaired or not attaining water body is a cautious approach which draws attention to waters most in need of corrective action. Factoring in the condition of downstream reaches puts greater emphasis on surface waters whose impairments are contributing to downstream water quality problems. Note, however, that some 10-digit HUC watersheds may not have been assessed for one or more (or any) of the risk groups.

Table 2-1: Risk Evaluation (RE) Scoring Method

Reach Condition	Downstream Condition	RE
Extreme	Any	1.0
High	Extreme	1.0
High	High	0.8
High	Moderate/Low	0.7
Moderate	Extreme	0.7
Moderate	High	0.6
Moderate	Moderate	0.5
Moderate	Low	0.3
Low	Any	0.0

Pollutant Risk Analyses

Each of the major pollutant risk groups is evaluated in the following sections for each 10-digit HUC subwatershed within the Colorado-Lower Gila Watershed.

Metals

The metal considered in this section is the only one that failed to meet ADEQ water quality standards in the Colorado-Lower Gila Watershed: boron.

The role of boron in plant physiology was reviewed by Blevins and Lukaszewski (1998). They state that "boron is essential for plant growth and development, and adequate boron nutrition of cultivated plants can be of great economic importance." However, Mahler (n.d.) notes, "Boron toxicity can result when plants have taken up too much boron; excessive levels of boron are toxic to plant growth." High concentration of boron in water can be toxic to some species of fish. Boron can have negative effects on humans as well, including nausea, vomiting, diarrhea, and blood clotting. There may be a relationship between concentrations of boron in soils and drinking water and early onset arthritis (http://www.lenntech.com/periodic/water/boron/boron-and-water.htm.

High levels of boron –containing compounds occur naturally in the Colorado River region. These compounds become dissolved in irrigation water, and when that water evaporates, boron becomes concentrated on the soil surface, where wind and water erosion can carry it into waterways.

The factors that are considered in calculating the risk classification for metals in the various 10-digit HUC subwatersheds in the Colorado-Lower Gila Watershed are (1) the risk level based on ADEQ water quality assessments, (2) the number of mines in the subwatershed, (3) the number of mines within riparian areas, (4) the rate of soil erosion, and (5) the proportion of the subwatershed occupied by urban areas.

Water Quality Assessment for Metals

Based on the ADEQ water quality assessments and the conditions of downstream reaches, and using the scoring methods described in Table 2-1 (above), the metals risk classifications for each 10-digit HUC subwatershed was calculated (Table 2-2).

The Morgan Wash-Lower Gila River subwatershed and the Fortuna Wash-Lower Gila River subwatershed had extreme risk evaluations (REs) of 1.0 for metals due to exceedances in boron. Six subwatersheds that drain to the Morgan Wash-Lower Gila subwatershed (Yaqui Wash, Gravel Wash, Park Valley-Lower Gila River, Lower Mohawk Wash, Big Eye Wash, and Coyote Wash) and one that drains to the Fortuna Wash-Lower Gila (Castle Dome Wash) received REs of 0.7 for metals.

Four subwatersheds, Jumbo Wash-Lower Colorado River, Lower Colorado River-Lake Mohave, Martinez Lake-Lower Colorado River, and Fourth of July Wash-Lower Gila River, received low risk evaluations for metals of 0.0

Table 2-2: Colorado-Lower Gila Watershed *Risk Evaluation (RE) for Metals, Assigned to each 10-digit HUC Subwatershed, Based on Water Quality Assessment (WQA) Result.*

Subwatershed Name	**Metals WQA RE**	**Justification**
Jumbo Wash-Lower Colorado River 1503010101	0.0	Classified as low risk, drains to Lower Colorado-Lake Mohave, which is classified as low risk.
Lower Colorado River-Lake Mohave 1503010102	0.0	Classified as low risk, drains to Silver Creek Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Silver Creek Wash-Lower Colorado River 1503010103	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Topock Marsh-Lower Colorado River 1503010104	0.5	Classified as moderate risk due to insufficient data, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Lower Colorado River-Lake Havasu 1503010106	0.5	Classified as moderate risk, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Tennessee Wash-Sacramento Wash 1503010301	0.5	Classified as moderate risk due to insufficient data, drains to Thirteenmile Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	Classified as moderate risk due to insufficient data, drains to Walnut Creek-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Buck Mountain Wash 1503010303	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Walnut Creek-Sacramento Wash 1503010304	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Metals WQA RE	Justification
Franconia Wash-Sacramento Wash 1503010305	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Osborne Wash-Lower Colorado River 1503010401	0.5	Classified as moderate risk, drains to Upper Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Parker Valley-Lower Colorado River 1503010403	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Lower Parker Valley-Lower Colorado River 1503010404	0.5	Classified as moderate risk due to insufficient data, drains to Ehrenberg Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	Classified as moderate risk due to insufficient data, drains to Mohave Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	Classified as moderate risk due to insufficient data, drains to Gould Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Gould Wash-Lower Colorado River 1503010409	0.5	Classified as moderate risk due to insufficient data, drains to Yuma Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Yuma Wash-Lower Colorado River 1503010410	0.3	Classified as moderate risk due to insufficient data, drains to Martinez Lake – Lower Colorado River, which is classified as low risk.
Martinez Lake-Lower Colorado River 1503010411	0.0	Classified as low risk, drains to Picacho Wash-Lower Colorado River, which is classified as moderate risk.
Alamo Wash 1503010501	0.5	Classified as moderate risk due to insufficient data, drains to Upper Bouse Wash, which is classified as moderate risk due to insufficient data.
Upper Bouse Wash 1503010502	0.5	Classified as moderate risk due to insufficient data, drains to Middle Bouse Wash, which is classified as moderate risk due to insufficient data.
Cunningham Wash 1503010503	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Middle Bouse Wash 1503010504	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Lower Bouse Wash 1503010505	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Tyson Wash 1503010601	0.5	Classified as moderate risk due to insufficient data, drains to Middle Tyson Wash, which is classified as moderate risk due to insufficient data.
Middle Tyson Wash 1503010602	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tyson Wash, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Metals WQA RE	Justification
Lower Tyson Wash 1503010603	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Picacho Wash-Lower Colorado River 1503010701	0.5	Classified as moderate risk, drains to Lower Colorado River below Morelos Dam, which is classified as moderate risk.
Lower Colorado River below Morelos Dam 1503010702	0.5	Classified as moderate risk, drains into Mexico, which is classified as moderate risk due to insufficient data.
Yuma Desert Area 1503010800	0.5	Classified as moderate risk due to insufficient data, drains to Lower Colorado River below Morelos Dam, which is classified as moderate risk.
Columbus Wash 1507020101	0.5	Classified as moderate risk due to insufficient data, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Fourth of July Wash-Lower Gila River 1507020102	0.0	Classified as low risk, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Clanton Wash 1507020103	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Baragan Wash 1507020104	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Nottbusch Wash-Lower Gila River 1507020105	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Hoodoo Wash 1507020106	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Yaqui Wash 1507020107	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.
Gravel Wash 1507020108	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.
Park Valley-Lower Gila River 1507020109	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.
Upper Mohawk Wash 1507020110	0.5	Classified as moderate risk due to insufficient data, drains to Lower Mohawk Wash, which is classified as moderate risk due to insufficient data.
Lower Mohawk Wash 1507020111	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.
Big Eye Wash Area 1507020112	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.
Coyote Wash Area 1507020113	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.

Subwatershed Name	Metals WQA RE	Justification
Morgan Wash-Lower Gila River 1507020114	1.0	Classified as extreme risk, drains to Fortuna Wash-Lower Gila River, which is classified as extreme risk.
Castle Dome Wash 1507020115	0.7	Classified as moderate risk due to insufficient data, drains to Fortuna Wash-Lower Gila River, which is classified as extreme risk.
Fortuna Wash-Lower Gila River 1507020116	1.0	Classified as extreme risk, drains to Picacho Wash-Lower Colorado River, which is classified as moderate risk.
Upper Midway Wash 1507020201	0.5	Classified as moderate risk due to insufficient data, drains to Lower Midway Wash Area, which is classified as moderate risk due to insufficient data.
Upper Tenmile Wash 1507020202	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Midway Wash Area 1507020203	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Tenmile Wash 1507020204	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Cherioni Wash 1507020301	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Cuerda de Lena 1507020302	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Daniels Arroyo 1507020303	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Growler Wash 1507020304	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Upper San Cristobal Wash 1507020305	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Childs Valley 1507020306	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Lower San Cristobal Wash 1507020307	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Location of Mining Activities

The number, type, and location of mines is an indicator of potential metals pollution for several reasons: (1) mines for metals are generally located in areas where metal ores occur and so are likely to be found in the soil; (2) the tailings of the mines themselves are sources of metals that can enter the environment; and (3) mines disturb the soil and can enhance erosion rates. Mines located in riparian zones (within 250 m of a waterway) are more likely to release metals into rivers and streams and so were weighted more heavily in the final analysis.

Mines producing a great variety of ores are found throughout the Colorado-Lower Gila Watershed (Figure 2-2), and of these, a significant number are located within 250 m of a riparian area (Figure 2-3).

Gold mines are common, as are mines for silver, copper, iron, and tungsten.

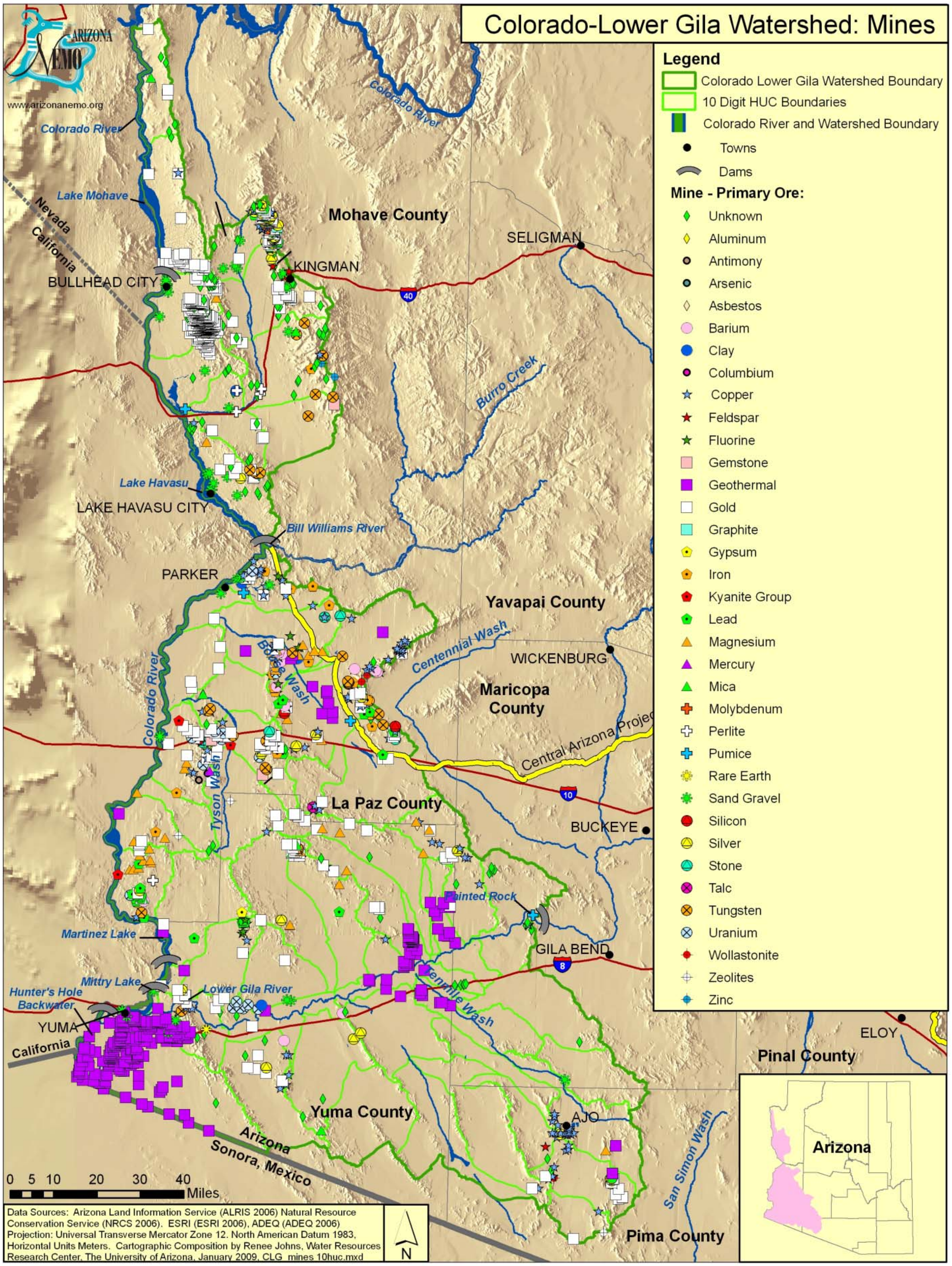
Numerous geothermal wells occur in the southwest corner of the watershed and along the Gila River. A geothermal database for Arizona indicates 1,251 discrete geothermal wells or springs in the state of Arizona (Fleishman, 2006). Geothermal wells are categorized within the Arizona State Mine Inspector's database and are considered a type of mine. The thermal fluids produced are put to traditional water resource uses, e.g., irrigation of field crops, municipal water supply, and industrial uses, with little advantage taken of the heat carried by the waters (Gelt, 2000). At present, geothermal aquaculture is the only major direct-use application in the state. In fact, Arizona leads the nation in the aquacultural use of geothermal fluids.

There are a wide range of possible uses of geothermal energy within various sectors, including domestic, industrial and especially agriculture (Gelt, 2000). Low-to-moderate-temperature geothermal fluids found in the state can be used to heat homes and businesses. Agriculture uses include controlled-environment agriculture, such as greenhouses and nurseries, aquaculture, grain and vegetable drying, and soil warming for mushroom growing and earthworm farms.

Currently active mines operate under ADEQ permits to ensure that their discharges into the environment do not exceed healthful standards established by law (http://www.azdeq.gov/function/permits/index.html). The primary nonpoint sources of anthropogenic metals are abandoned mines. In most cases the original owner or responsible party for an abandoned mine is unknown, and the responsibility for the orphaned mine falls to the current landowner. Abandoned mines are found on all classes of land ownership, including federal, state, and private lands. Surface runoff and erosion and subsurface drainage from mine waste are the principal sources of contamination.

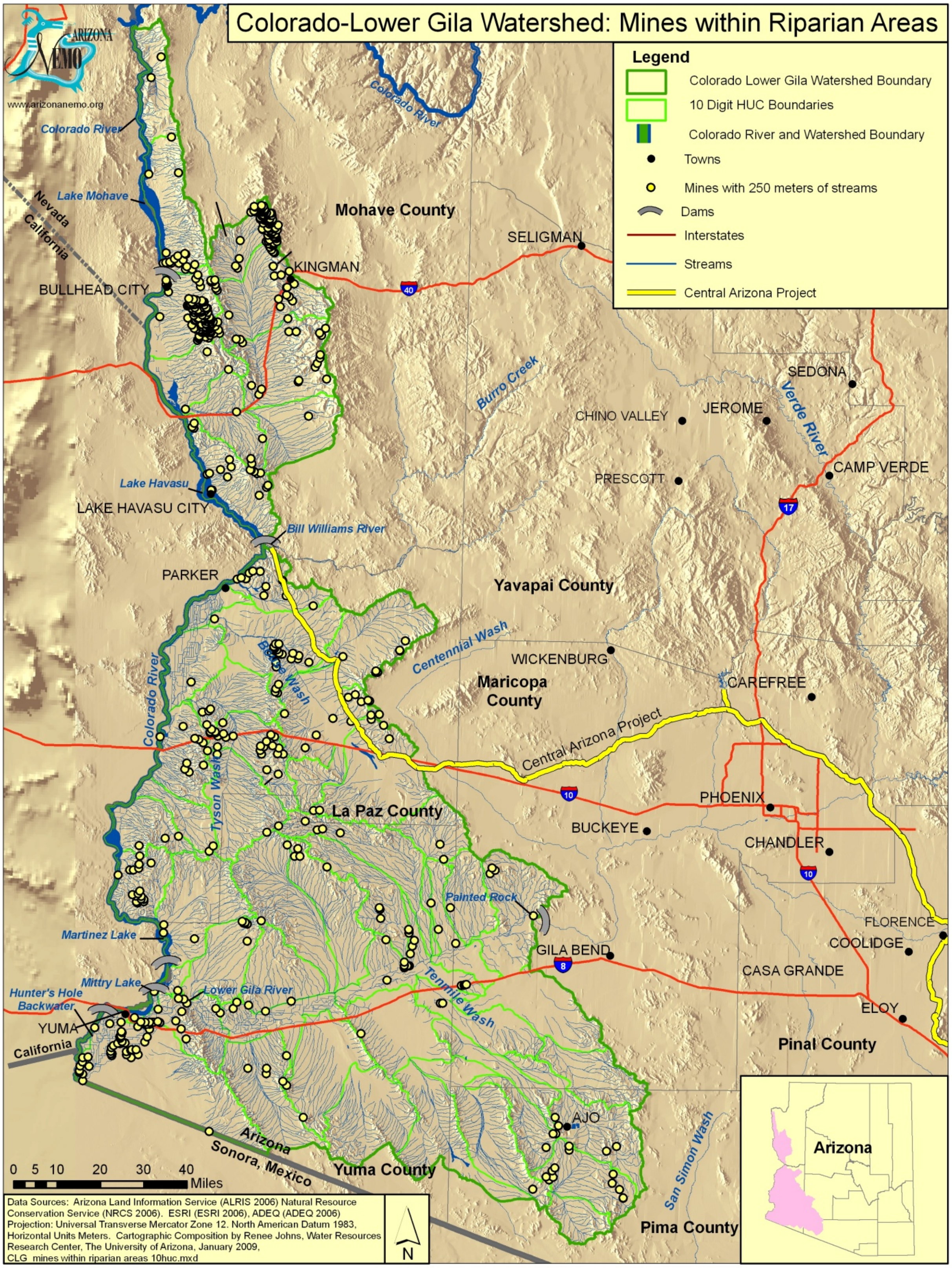
Relatively high concentrations of geothermal wells are located in Yuma County and in Santa Cruz County (Fleishman, 2006; Lienau, 1991). Geothermal wells (mines) are not likely to contribute to water quality concerns unless the geothermal waters contain elevated concentrations of chemical constituents. In the absence of geothermal water quality data, these wells (mines) were categorized within our risk evaluation on the basis of being a "mine."

On the basis of the number of mines per subwatershed, the following risk evaluation scoring method was used:



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), ADEQ (ADEQ 2006) Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, January 2009, CLG mines 10huc.mxd

Figure 2-2: Mines



Colorado-Lower Gila Watershed: Mines within Riparian Areas

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), ADEQ (ADEQ 2006)
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, January 2009,
CLG mines within riparian areas 10huc.mxd

Figure 2-3: Mines within Riparian Areas

If the number of mines is 2 or fewer, the RE (Risk Evaluation) = 0;
If the number of mines is between 2 and 10,
the RE = (the number of mines – 2) / 8;
If the number of mines is 10 or greater, the RE = 1

On the basis of the number of mines within riparian zones per subwatershed, the following risk evaluation scoring method was used:

If there are no mines within riparian zones, the RE = 0;
If the number of mines in riparian zones is greater than 0 and less than 5, the RE = the number of mines / 5;
If the number of mines is 5 or greater, the RE = 1.

The results of these calculations are shown in Table 2-3.

Table 2-3: Colorado-Lower Gila Watershed Risk Evaluation (RE) for each Subwatershed Based on the Number and Location of Mines

Subwatershed	RE #mines/HUC	RE #mines/ riparian
Jumbo Wash-Lower Colorado River 1503010101	0.75	0.4
Lower Colorado River-Lake Mohave 1503010102	1	1
Silver Creek Wash-Lower Colorado River 1503010103	1	1
Topock Marsh-Lower Colorado River 1503010104	1	1
Lower Colorado River-Lake Havasu 1503010106	1	1
Tennessee Wash-Sacramento Wash 1503010301	1	1
Thirteenmile Wash-Sacramento Wash 1503010302	1	1
Buck Mountain Wash 1503010303	0.13	0.2
Walnut Creek-Sacramento Wash 1503010304	1	1
Franconia Wash-Sacramento Wash 1503010305	1	1
Osborne Wash-Lower Colorado River 1503010401	1	1
Upper Parker Valley-Lower Colorado River 1503010403	0	0
Lower Parker Valley-Lower Colorado River 1503010404	0.25	0.2
Ehrenberg Wash-Lower Colorado River 1503010406	1	1
Mohave Wash-Lower Colorado River 1503010407	0.13	0.6
Gould Wash-Lower Colorado River 1503010409	1	0.8
Yuma Wash-Lower Colorado River 1503010410	1	1
Martinez Lake-Lower Colorado River 1503010411	0.375	0.6
Alamo Wash 1503010501	0	0
Upper Bouse Wash 1503010502	1	1
Cunningham Wash 1503010503	1	1
Middle Bouse Wash 1503010504	1	1

Subwatershed	RE #mines/HUC	RE #mines/ riparian
Lower Bouse Wash 1503010505	1	1
Upper Tyson Wash 1503010601	1	0.6
Middle Tyson Wash 1503010602	1	1
Lower Tyson Wash 1503010603	0.875	1
Picacho Wash-Lower Colorado River 1503010701	1	0.8
Lower Colorado River below Morelos Dam 1503010702	0.75	0.8
Yuma Desert Area 1503010800	1	1
Columbus Wash 1507020101	1	0.2
Fourth of July Wash-Lower Gila River 1507020102	1	0.8
Clanton Wash 1507020103	1	0.4
Baragan Wash 1507020104	1	0.8
Nottbusch Wash-Lower Gila River 1507020105	0.75	0.6
Hoodoo Wash 1507020106	1	1
Yaqui Wash 1507020107	1	1
Gravel Wash 1507020108	0.5	0.6
Park Valley-Lower Gila River 1507020109	1	1
Upper Mohawk Wash 1507020110	0	0
Lower Mohawk Wash 1507020111	0.375	0.4
Big Eye Wash Area 1507020112	0.5	0.4
Coyote Wash Area 1507020113	1	1
Morgan Wash-Lower Gila River 1507020114	1	0.8
Castle Dome Wash 1507020115	1	1
Fortuna Wash-Lower Gila River 1507020116	1	1
Upper Midway Wash 1507020201	0	0
Upper Tenmile Wash 1507020202	1	0.8
Lower Midway Wash Area 1507020203	0	0
Lower Tenmile Wash 1507020204	0.5	0.4
Cherioni Wash 1507020301	0	0
Cuerda de Lena 1507020302	1	1
Daniels Arroyo 1507020303	0.375	0.6
Growler Wash 1507020304	0.375	0.8
Upper San Cristobal Wash 1507020305	0	0
Childs Valley 1507020306	0	0
Lower San Cristobal Wash 1507020307	0.125	0.2

Data Sources: GIS data Layers “mines” and “mines within riparian areas” originated by the Arizona Land Information Service (ALRIS, 2006). www.land.state.az.us/alris/

Sediment Yield

Erosion of contaminated soils is the primary process by which metal contaminants are carried to waterways.

The magnitude of the soil loss through erosion, referred to as “sediment yield” is modeled using the Soils and Water Assessment Tool (SWAT), a modeling tool incorporated within the more comprehensive Automated Geospatial Watershed Assessment Tool (AGWA) developed by the USDA-ARS Southwest Watershed Research Center in cooperation with the US EPA Office of Research and Development, Landscape Ecology Branch (www.tucson.ars.ag.gov/agwa/). Sediment yield is mapped in Figure 2-4.

On the basis of the number of erosion categories, the following risk evaluation (RE) scoring method was used for each watershed:

RE = (erosion category – 1) / 5

The results of these calculations are shown in Table 2-4.

Contributions from Urban Areas

Because metals are or have been used in a variety of industrial processes and consumer goods (e.g., leaded gasoline, nickel-cadmium batteries), urban areas are potential non-point sources for metals pollution. Additionally, paved streets, parking lots, and other impervious surfaces contribute to increased erosion, enhancing the delivery of metals to waterways. The greater the proportion of urban area within a subwatershed, the greater is the importance of these factors. The following rubric has been used to assign a risk evaluation to urban area:

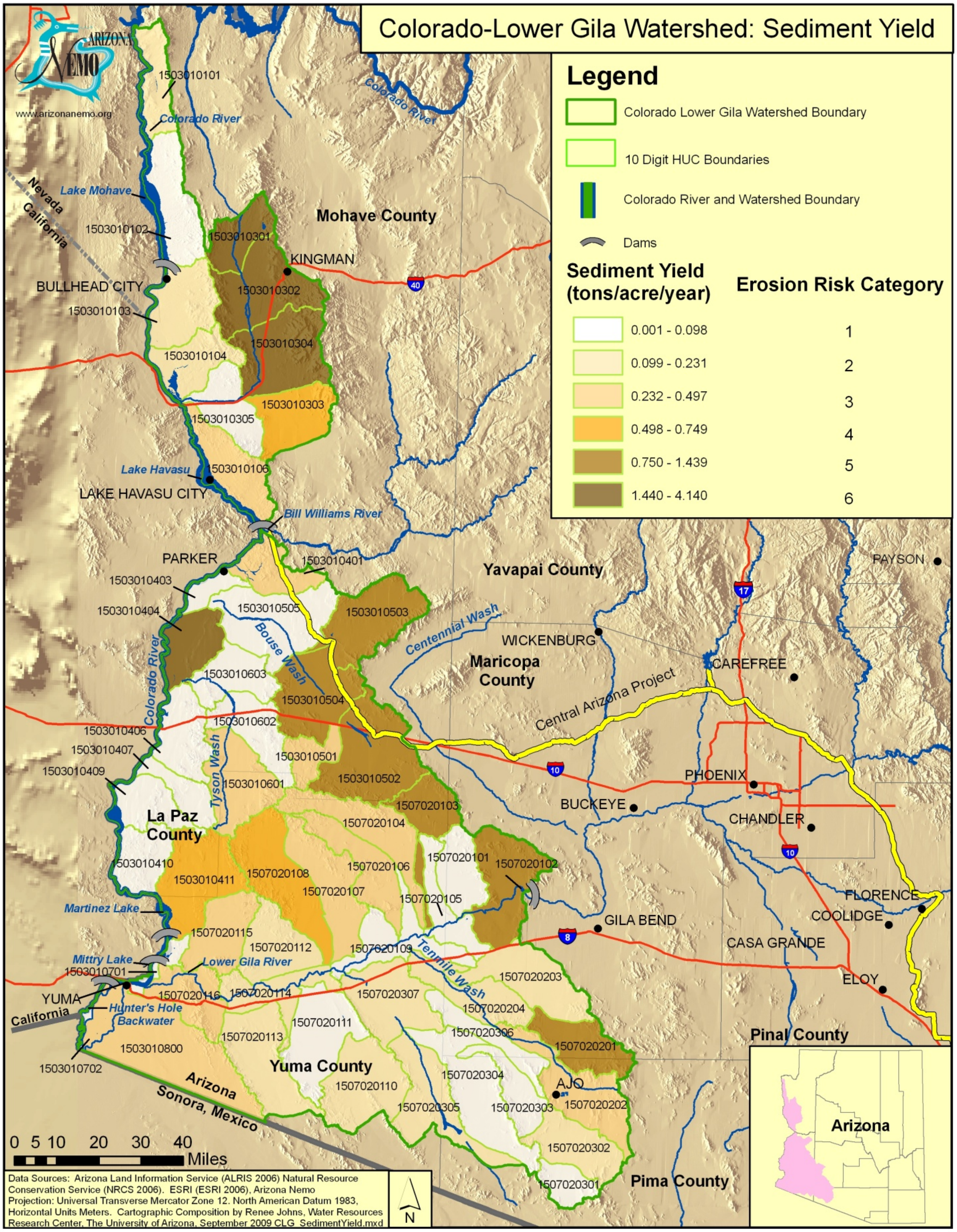
If urban area makes up less than 5% of the subwatershed area, the RE = 0;
If urban area makes up between 5% and 12% of the subwatershed area, the
RE = the percent urban / 12;
If urban area makes up 12% or more of the subwatershed area, the RE = 1.

The results of these calculations are shown in Table 2-5.

A final combined metals risk classification for each 10-digit HUC subwatershed was determined by a weighted combination of the risk evaluation (RE) for the metals water quality classification, the number of mines in the subwatershed and in riparian areas in the subwatershed, the erosion classification, and the classification by urban area (Table 2-6).

Weights were developed in consultation with ADEQ and attempt to approximate the relative importance of the five factors in contributing to the risk of watershed pollution by metals. Factors that received the highest weights were water quality assessment (0.30) and number of mines in riparian areas (0.30), followed by erosion (0.25), urban area (0.10), and total mines in the subwatershed (0.05).

The final weighted RE was used to categorize each 10-digit HUC subwatershed as low risk (RE ≤ 0.40) or high risk (RE > 0.40) for metals pollution (Table 2-6; Figure 2-5).



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona Nemo
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, September 2009 CLG_SedimentYield.mxd

Figure 2-4: Sediment Yield

Table 2-4: Colorado-Lower Gila Watershed Risk Evaluation (RE) and Erosion Categories

Subwatershed	**Erosion Category**	**RE**
Jumbo Wash-Lower Colorado River 1503010101	2	0.2
Lower Colorado River-Lake Mohave 1503010102	1	0.0
Silver Creek Wash-Lower Colorado River 1503010103	1	0.0
Topock Marsh-Lower Colorado River 1503010104	2	0.2
Lower Colorado River-Lake Havasu 1503010106	5	0.8
Tennessee Wash-Sacramento Wash 1503010301	5	0.8
Thirteenmile Wash-Sacramento Wash 1503010302	6	1.0
Buck Mountain Wash 1503010303	3	0.4
Walnut Creek-Sacramento Wash 1503010304	6	1.0
Franconia Wash-Sacramento Wash 1503010305	1	0.0
Osborne Wash-Lower Colorado River 1503010401	5	0.8
Upper Parker Valley-Lower Colorado River 1503010403	1	0.0
Lower Parker Valley-Lower Colorado River 1503010404	1	0.0
Ehrenberg Wash-Lower Colorado River 1503010406	3	0.4
Mohave Wash-Lower Colorado River 1503010407	3	0.4
Gould Wash-Lower Colorado River 1503010409	3	0.4
Yuma Wash-Lower Colorado River 1503010410	3	0.4
Martinez Lake-Lower Colorado River 1503010411	3	0.4
Alamo Wash 1503010501	5	0.8
Upper Bouse Wash 1503010502	3	0.4
Cunningham Wash 1503010503	4	0.6
Middle Bouse Wash 1503010504	5	0.8
Lower Bouse Wash 1503010505	1	0.0
Upper Tyson Wash 1503010601	3	0.4
Middle Tyson Wash 1503010602	2	0.2
Lower Tyson Wash 1503010603	2	0.2
Picacho Wash-Lower Colorado River 1503010701	1	0.0
Lower Colorado River below Morelos Dam 1503010702	2	0.2
Yuma Desert Area 1503010800	2	0.2
Columbus Wash 1507020101	2	0.2
Fourth of July Wash-Lower Gila River 1507020102	4	0.6
Clanton Wash 1507020103	4	0.6
Baragan Wash 1507020104	3	0.4
Nottbusch Wash-Lower Gila River 1507020105	1	0.0
Hoodoo Wash 1507020106	3	0.4
Yaqui Wash 1507020107	1	0.0
Gravel Wash 1507020108	2	0.2
Park Valley-Lower Gila River 1507020109	1	0.0
Upper Mohawk Wash 1507020110	1	0.0
Lower Mohawk Wash 1507020111	1	0.0

Subwatershed	Erosion Category	RE
Big Eye Wash Area 1507020112	2	0.2
Coyote Wash Area 1507020113	1	0.0
Morgan Wash-Lower Gila River 1507020114	2	0.2
Castle Dome Wash 1507020115	2	0.2
Fortuna Wash-Lower Gila River 1507020116	2	0.2
Upper Midway Wash 1507020201	4	0.6
Upper Tenmile Wash 1507020202	2	0.2
Lower Midway Wash Area 1507020203	1	0.0
Lower Tenmile Wash 1507020204	2	0.2
Cherioni Wash 1507020301	1	0.0
Cuerda de Lena 1507020302	1	0.0
Daniels Arroyo 1507020303	1	0.0
Growler Wash 1507020304	1	0.0
Upper San Cristobal Wash 1507020305	1	0.0
Childs Valley 1507020306	1	0.0
Lower San Cristobal Wash 1507020307	2	0.0

Data Sources: GIS data layer "sediment yield," originated by Arizona NEMO, 2009. www.arizonanemo.com*.*
GIS data layer "sediment yield" calculated using AGWA tool, 2009. http://www.tucson.ars.ag.gov/agwa/

Table: 2-5: Colorado-Lower Gila Watershed Risk Evaluations (RE) for-Urban Areas

Subwatershed	Percent Urban	RE
Jumbo Wash-Lower Colorado River 1503010101	0.53%	0
Lower Colorado River-Lake Mohave 1503010102	0.48%	0
Silver Creek Wash-Lower Colorado River 1503010103	5.37%	0.03
Topock Marsh-Lower Colorado River 1503010104	0.75%	0
Lower Colorado River-Lake Havasu 1503010106	6.76%	0.15
Tennessee Wash-Sacramento Wash 1503010301	1.83%	0
Thirteenmile Wash-Sacramento Wash 1503010302	5.82%	0.07
Buck Mountain Wash 1503010303	0.67%	0
Walnut Creek-Sacramento Wash 1503010304	2.37%	0
Franconia Wash-Sacramento Wash 1503010305	1%	0
Osborne Wash-Lower Colorado River 1503010401	1.7%	0
Upper Parker Valley-Lower Colorado River 1503010403	3.41%	0
Lower Parker Valley-Lower Colorado River 1503010404	0.87%	0
Ehrenberg Wash-Lower Colorado River 1503010406	0.68%	0
Mohave Wash-Lower Colorado River 1503010407	0.26%	0
Gould Wash-Lower Colorado River 1503010409	1.06%	0
Yuma Wash-Lower Colorado River 1503010410	0.13%	0
Martinez Lake-Lower Colorado River 1503010411	0.8%	0
Alamo Wash 1503010501	0.11%	0

Subwatershed	Percent Urban	RE
Upper Bouse Wash 1503010502	1.02%	0
Cunningham Wash 1503010503	1.32%	0
Middle Bouse Wash 1503010504	0.94%	0
Lower Bouse Wash 1503010505	1.98%	0
Upper Tyson Wash 1503010601	0.93%	0
Middle Tyson Wash 1503010602	2.25%	0
Lower Tyson Wash 1503010603	0.47%	0
Picacho Wash-Lower Colorado River 1503010701	0.53%	0
Lower Colorado River below Morelos Dam 1503010702	0.28%	0
Yuma Desert Area 1503010800	3.99%	0
Columbus Wash 1507020101	0.7%	0
Fourth of July Wash-Lower Gila River 1507020102	0.79%	0
Clanton Wash 1507020103	0.16%	0
Baragan Wash 1507020104	0.44%	0
Nottbusch Wash-Lower Gila River 1507020105	0.53%	0
Hoodoo Wash 1507020106	0.4%	0
Yaqui Wash 1507020107	0.36%	0
Gravel Wash 1507020108	0.57%	0
Park Valley-Lower Gila River 1507020109	3.28%	0
Upper Mohawk Wash 1507020110	0.1%	0
Lower Mohawk Wash 1507020111	0.4%	0
Big Eye Wash Area 1507020112	0.29%	0
Coyote Wash Area 1507020113	0.67%	0
Morgan Wash-Lower Gila River 1507020114	2.78%	0
Castle Dome Wash 1507020115	0.27%	0
Fortuna Wash-Lower Gila River 1507020116	1.69%	0
Upper Midway Wash 1507020201	6.36%	0.11
Upper Tenmile Wash 1507020202	1.45%	0
Lower Midway Wash Area 1507020203	0.19%	0
Lower Tenmile Wash 1507020204	0.15%	0
Cherioni Wash 1507020301	0.2%	0
Cuerda de Lena 1507020302	0.22%	0
Daniels Arroyo 1507020303	0%	0
Growler Wash 1507020304	0.06%	0
Upper San Cristobal Wash 1507020305	0.23%	0
Childs Valley 1507020306	0.13%	0
Lower San Cristobal Wash 1507020307	0.4%	0

Data Sources: GIS data Layer "impervious surfaces" originated by Multi-Resolution Land Characteristics consortium, National Land Cover Data Set, 2001. www.mrlc.gov

Table 2-6: Colorado-Lower Gila Watershed Summary Results for Metals Based on Risk Evaluations (RE)-Weighted Combination Approach

Subwatershed Name	**WQA RE**	**RE #mines /HUC**	**RE #mines/ riparian**	**RE Erosion**	**RE Urban**	**RE (Weighted)**
Jumbo Wash-Lower Colorado River 1503010101	0.0	0.75	0.4	0.2	0.0	0.21
Lower Colorado River-Lake Mohave 1503010102	0.0	1.0	1.0	0.0	0.0	0.35
Silver Creek Wash-Lower Colorado River 1503010103	0.5	1.0	1.0	0.0	0.03	0.50
Topock Marsh-Lower Colorado River 1503010104	0.5	1.0	1.0	0.2	0.0	0.55
Lower Colorado River-Lake Havasu 1503010106	0.5	1.0	1.0	0.8	0.15	0.72
Tennessee Wash-Sacramento Wash 1503010301	0.5	1.0	1.0	0.8	0.0	0.70
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	1.0	1.0	1.0	0.07	0.76
Buck Mountain Wash 1503010303	0.5	0.13	0.2	0.4	0.0	0.32
Walnut Creek-Sacramento Wash 1503010304	0.5	1.0	1.0	1.0	0.0	0.75
Franconia Wash-Sacramento Wash 1503010305	0.5	1.0	1.0	0.0	0.0	0.50
Osborne Wash-Lower Colorado River 1503010401	0.5	1.0	1.0	0.8	0.0	0.70
Upper Parker Valley-Lower Colorado River 1503010403	0.5	0.0	0.0	0.0	0.0	0.15
Lower Parker Valley-Lower Colorado River 1503010404	0.5	0.25	0.2	0.0	0.0	0.22
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	1.0	1.0	0.4	0.0	0.6
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	0.13	0.4	0.4	0.0	0.38
Gould Wash-Lower Colorado River 1503010409	0.5	1.0	0.8	0.4	0.0	0.54
Yuma Wash-Lower Colorado River 1503010410	0.3	1.0	1.0	0.4	0.0	0.54
Martinez Lake-Lower Colorado River 1503010411	0.0	0.38	0.6	0.4	0.0	0.30
Alamo Wash 1503010501	0.5	0.0	0.0	0.8	0.0	0.35
Upper Bouse Wash 1503010502	0.5	1.0	1.0	0.4	0.0	0.60
Cunningham Wash 1503010503	0.5	1.0	1.0	0.6	0.0	0.65
Middle Bouse Wash 1503010504	0.5	1.0	1.0	0.8	0.0	0.70
Lower Bouse Wash 1503010505	0.5	1.0	1.0	0.0	0.0	0.50
Upper Tyson Wash 1503010601	0.5	1.0	0.6	0.4	0.0	0.48
Middle Tyson Wash 1503010602	0.5	1.0	1.0	0.2	0.0	0.55
Lower Tyson Wash 1503010603	0.5	0.88	1.0	0.2	0.0	0.54

Subwatershed Name	WQA RE	RE #mines /HUC	RE #mines/ riparian	RE Erosion	RE Urban	RE (Weighted)
Picacho Wash-Lower Colorado River 1503010701	0.5	1.0	0.8	0.0	0.0	0.44
Lower Colorado River below Morelos Dam 1503010702	0.5	0.75	0.8	0.2	0.0	0.48
Yuma Desert Area 1503010800	0.5	1.0	1.0	0.2	0.0	0.55
Columbus Wash 1507020101	0.5	1.0	0.2	0.2	0.0	0.31
Fourth of July Wash-Lower Gila River 1507020102	0.0	1.0	0.8	0.6	0.0	0.44
Clanton Wash 1507020103	0.5	1.0	0.4	0.6	0.0	0.47
Baragan Wash 1507020104	0.5	1.0	0.8	0.4	0.0	0.54
Nottbusch Wash-Lower Gila River 1507020105	0.5	0.75	0.6	0.0	0.0	0.37
Hoodoo Wash 1507020106	0.5	1.0	1.0	0.4	0.0	0.60
Yaqui Wash 1507020107	0.7	1.0	1.0	0.0	0.0	.56
Gravel Wash 1507020108	0.7	0.5	0.6	0.2	0.0	0.47
Park Valley-Lower Gila River 1507020109	0.7	1.0	1.0	0.0	0.0	0.56
Upper Mohawk Wash 1507020110	0.5	0.0	0.0	0.0	0.0	0.15
Lower Mohawk Wash 1507020111	0.7	0.38	0.4	0.0	0.0	0.35
Big Eye Wash Area 1507020112	0.7	0.5	0.4	0.2	0.0	0.41
Coyote Wash Area 1507020113	0.7	1.0	1.0	0.0	0.0	0.56
Morgan Wash-Lower Gila River 1507020114	1.0	1.0	0.8	0.2	0.0	0.64
Castle Dome Wash 1507020115	0.7	1.0	1.0	0.2	0.0	0.61
Fortuna Wash-Lower Gila River 1507020116	1.0	1.0	1.0	0.2	0.0	0.7
Upper Midway Wash 1507020201	0.5	0.0	0	0.6	0.11	0.31
Upper Tenmile Wash 1507020202	0.5	1.0	0.8	0.2	0.0	0.49
Lower Midway Wash Area 1507020203	0.5	0.0	0.0	0.0	0.0	0.15
Lower Tenmile Wash 1507020204	0.5	0.5	0.4	0.2	0.0	0.35
Cherioni Wash 1507020301	0.5	0.0	0.0	0.0	0.0	0.15
Cuerda de Lena 1507020302	0.5	1.0	1.0	0.0	0.0	0.5
Daniels Arroyo 1507020303	0.5	0.38	0.6	0.0	0.0	0.35
Growler Wash 1507020304	0.5	0.38	0.8	0.0	0.0	0.41
Upper San Cristobal Wash 1507020305	0.5	0.0	0.0	0.0	0.0	0.15
Childs Valley 1507020306	0.5	0.0	0.0	0.0	0.0	0.15
Lower San Cristobal Wash 1507020307	0.5	0.13	0.2	0.0	0.0	0.22
Weights	0.3	0.05	0.3	0.25	0.1	

Data Sources: Water Quality Assessment data originated by ADEQ, 2008. GIS data Layer "mines" and "mines within riparian" originated by Arizona Land Information Service (ALRIS 2006). GIS data layer "sediment yield" originated by Arizona NEMO, 2009. GIS data layer "impervious surfaces," originated by Multi-Resolution Land Characteristics Consortium, National Land Cover Data Set, 2001. www.mrlc.gov

Sediment

The principal agency in the shaping of landscapes in arid environments is flowing waters (Huckleberry et al., 2009). In watersheds such as those of the Colorado and Lower Gila Rivers, streams acquire suspended sediments from adjacent uplands by surface flow and from upstream by channel erosion. Deposition of this sediment produces the floodplain through which the rivers run. The river and its floodplain comprise a dynamic landscape system that "..constantly adjust[s] channel size, shape, and gradient in response to changes in runoff and sediment" (Huckleberry et al., 2009:266).

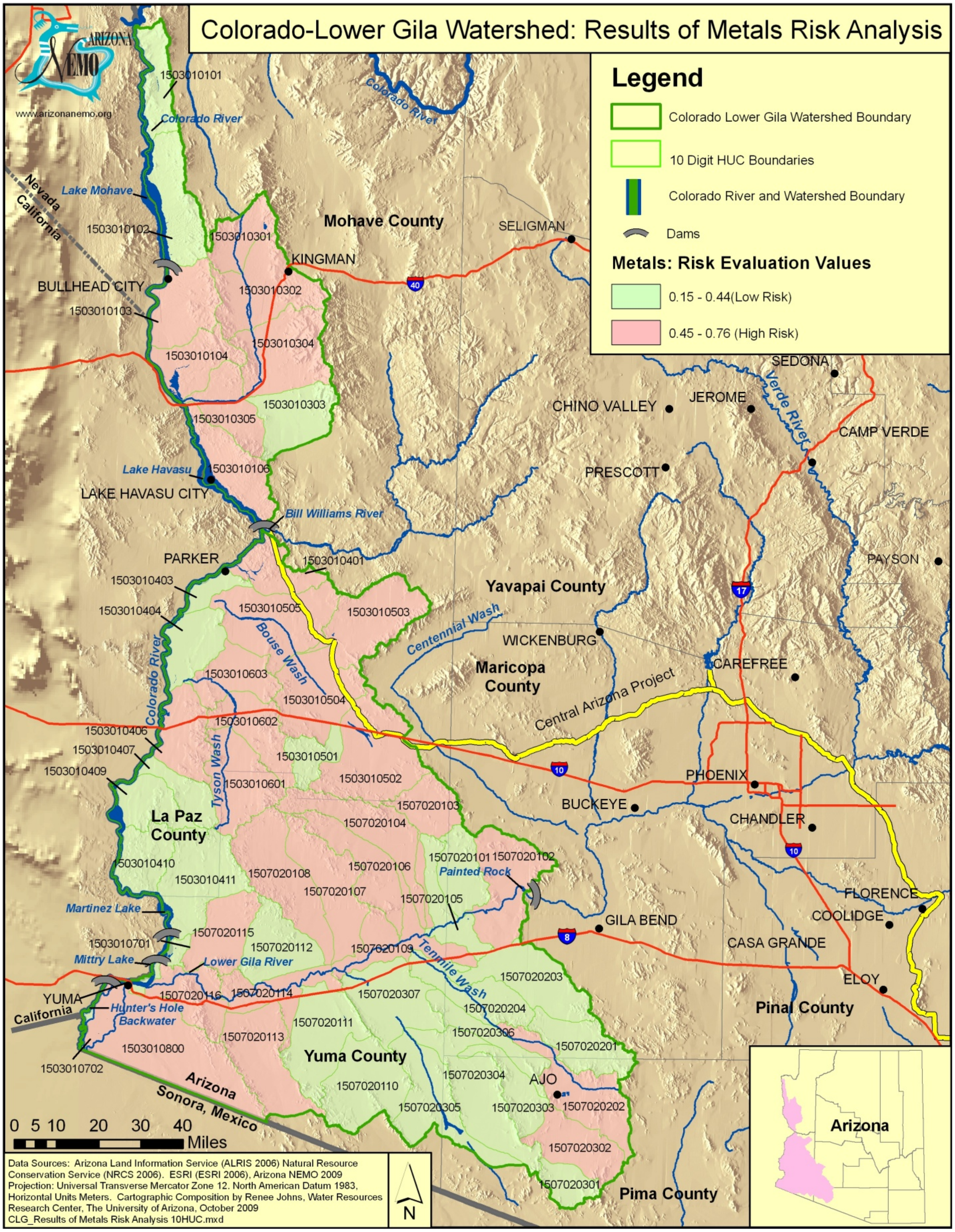
While erosion and sedimentation occur naturally, human activities in recent times may be contributing to significant changes in these natural processes. Huckleberry et al. (2009) discuss four agents of geomorphic change that are influenced to a greater or lesser degree by human activities. Although originally described for the San Pedro River, these same factors apply in the Gila and Colorado River watersheds and other river systems in the Southwest. One, rivers are experiencing changes in streamflow as a result of unprecedented human demands for water and the pumping of groundwater. Second, changing global climate is predicted to have the consequence in the US Southwest of greater variability in frequency and magnitude of precipitation events and flooding. Third, changes in fire regimes associated with invasive species, such as buffelgrass, human activities, and climate change can have important consequences for channel stabilizing riparian vegetation. Finally, livestock grazing can have important effects on upland and riparian vegetation that may contribute to erosion.

Erosion and sedimentation affect watershed ecosystems in several ways. Erosion removes soil from upland areas, impacting native vegetation and agricultural activities. Erosion also affects the stability of stream banks and can lead to the loss of valuable agricultural and residential lands. Suspended sediments reduce water quality for aquatic species. Sediment deposition can change river flow patterns, modify benthic habitats, and impact bridges, reservoirs, and other infrastructure.

The factors that are considered in calculating the risk classification for sediment in the various 10-digit HUC subwatersheds in the Colorado-Lower Gila Watershed are (1) the risk level based on ADEQ water quality assessments, (2) land ownership, (3) human use within subwatersheds and riparian areas, (4) the rate of soil erosion, and (5) the proportion of the subwatershed occupied by urban areas.

Water Quality Assessment for Sediment

Based on the ADEQ water quality assessments and the conditions of downstream reaches, and using the scoring methods described in Table 2-1 (above), the sediment risk classifications for each 10-digit HUC subwatershed was calculated (Table 2-7). No subwatersheds were classified as extreme risk for sediment, and ten were classified as low risk with REs of 0.0.


Colorado-Lower Gila Watershed: Results of Metals Risk Analysis

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona NEMO 2009
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, October 2009
CLG_Results of Metals Risk Analysis 10HUC.mxd

Figure 2-5: Results of Metals Risk Analysis

Table 2-7: Colorado-Lower Gila Watershed Risk Evaluations (RE) for Sediment, Assigned to each 10-digit HUC Subwatershed, Based on Water Quality Assessment Result.

Subwatershed Name	Sediment WQA RE	Justification
Jumbo Wash-Lower Colorado River 1503010101	0.0	Classified as low risk, drains to Lower Colorado-Lake Mohave, which is classified as low risk.
Lower Colorado River-Lake Mohave 1503010102	0.0	Classified as low risk, drains to Silver Creek Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Silver Creek Wash-Lower Colorado River 1503010103	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Topock Marsh-Lower Colorado River 1503010104	0.3	Classified as moderate risk due to insufficient data, drains to Lower Colorado River-Lake Havasu, which is classified as low risk.
Lower Colorado River-Lake Havasu 1503010106	0.0	Classified as low risk, drains to Lower Colorado River-Lake Havasu, which is classified as low risk.
Tennessee Wash-Sacramento Wash 1503010301	0.5	Classified as moderate risk due to insufficient data, drains to Thirteenmile Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	Classified as moderate risk due to insufficient data, drains to Walnut Creek-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Buck Mountain Wash 1503010303	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Walnut Creek-Sacramento Wash 1503010304	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Franconia Wash-Sacramento Wash 1503010305	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Osborne Wash-Lower Colorado River 1503010401	0.0	Classified as low risk, drains to Upper Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Parker Valley-Lower Colorado River 1503010403	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Lower Parker Valley-Lower Colorado River 1503010404	0.5	Classified as moderate risk due to insufficient data, drains to Ehrenberg Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	Classified as moderate risk due to insufficient data, drains to Mohave Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	Classified as moderate risk due to insufficient data, drains to Gould Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Gould Wash-Lower Colorado River 1503010409	0.5	Classified as moderate risk due to insufficient data, drains to Yuma Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Sediment WQA RE	Justification
Yuma Wash-Lower Colorado River 1503010410	0.3	Classified as moderate risk due to insufficient data, drains to Martinez Lake – Lower Colorado River, which is classified as low risk.
Martinez Lake-Lower Colorado River 1503010411	0.0	Classified as low risk, drains to Picacho Wash-Lower Colorado River, which is classified as low risk.
Alamo Wash 1503010501	0.5	Classified as moderate risk due to insufficient data, drains to Upper Bouse Wash, which is classified as moderate risk due to insufficient data.
Upper Bouse Wash 1503010502	0.5	Classified as moderate risk due to insufficient data, drains to Middle Bouse Wash, which is classified as moderate risk due to insufficient data.
Cunningham Wash 1503010503	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Middle Bouse Wash 1503010504	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Lower Bouse Wash 1503010505	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Tyson Wash 1503010601	0.5	Classified as moderate risk due to insufficient data, drains to Middle Tyson Wash, which is classified as moderate risk due to insufficient data.
Middle Tyson Wash 1503010602	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tyson Wash, which is classified as moderate risk due to insufficient data.
Lower Tyson Wash 1503010603	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Picacho Wash-Lower Colorado River 1503010701	0.0	Classified as low risk, drains to Lower Colorado River below Morelos Dam, which is classified as low risk.
Lower Colorado River below Morelos Dam 1503010702	0.0	Classified as low risk, drains into Mexico, which is classified as moderate risk due to insufficient data.
Yuma Desert Area 1503010800	0.3	Classified as moderate risk due to insufficient data, drains to Lower Colorado River below Morelos Dam, which is classified as low risk.
Columbus Wash 1507020101	0.5	Classified as moderate risk due to insufficient data, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Fourth of July Wash-Lower Gila River 1507020102	0.0	Classified as low risk, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Clanton Wash 1507020103	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Baragan Wash 1507020104	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Sediment WQA RE	Justification
Nottbusch Wash-Lower Gila River 1507020105	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Hoodoo Wash 1507020106	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Yaqui Wash 1507020107	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as low risk.
Gravel Wash 1507020108	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as low risk.
Park Valley-Lower Gila River 1507020109	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as low risk.
Upper Mohawk Wash 1507020110	0.5	Classified as moderate risk due to insufficient data, drains to Lower Mohawk Wash, which is classified as moderate risk due to insufficient data.
Lower Mohawk Wash 1507020111	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as low risk.
Big Eye Wash Area 1507020112	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as low risk.
Coyote Wash Area 1507020113	0.3	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as low risk.
Morgan Wash-Lower Gila River 1507020114	0.0	Classified as low risk, drains to Fortuna Wash-Lower Gila River, which is classified as low risk.
Castle Dome Wash 1507020115	0.3	Classified as moderate risk due to insufficient data, drains to Fortuna Wash-Lower Gila River, which is classified as low risk.
Fortuna Wash-Lower Gila River 1507020116	0.0	Classified as low risk, drains to Picacho Wash-Lower Colorado River, which is classified as low risk.
Upper Midway Wash 1507020201	0.5	Classified as moderate risk due to insufficient data, drains to Lower Midway Wash Area, which is classified as moderate risk due to insufficient data.
Upper Tenmile Wash 1507020202	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Midway Wash Area 1507020203	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Tenmile Wash 1507020204	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Cherioni Wash 1507020301	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Cuerda de Lena 1507020302	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Daniels Arroyo 1507020303	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Sediment WQA RE	Justification
Growler Wash 1507020304	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Upper San Cristobal Wash 1507020305	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Childs Valley 1507020306	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Lower San Cristobal Wash 1507020307	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Data Sources: Water Quality Assessment Data Originated by ADEQ, 2008. www.azdeq.gov

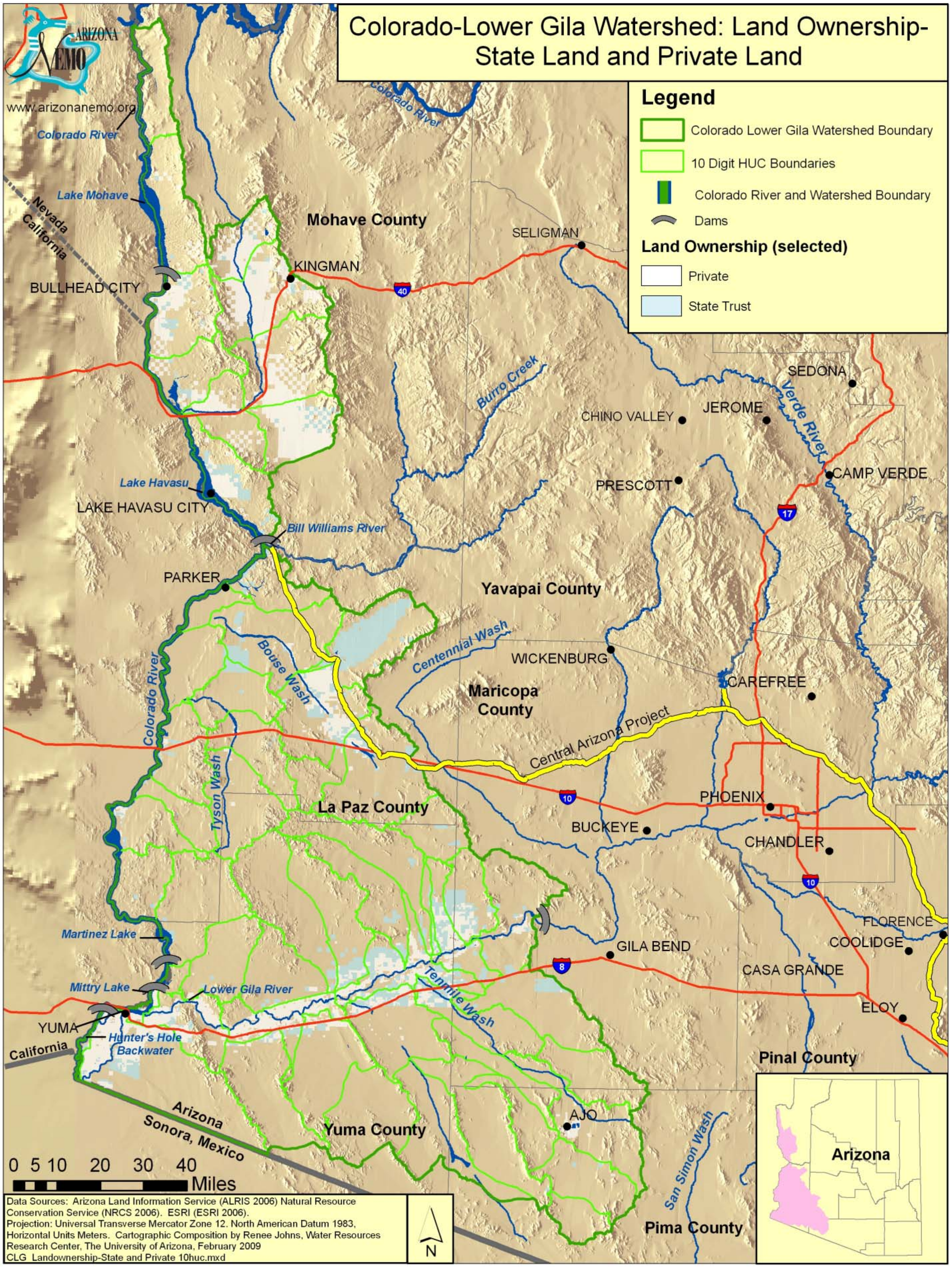
Land Ownership - Sediment

Lands managed by Federal agencies such as the US Forest Service, the US National Parks Service, and the US Bureau of Land Management are required to have management plans that include water quality management and erosion control, while private and Arizona State lands do not have such requirements. State and private land ownership are shown in Figure 2-6.

Therefore, in calculating the risk evaluation (RE) score associated with land ownership, the following rubric has been employed:

If the percentage of State and private lands comprises 10% or less of the subwatershed area, the RE = 0;
If the percentage of State and private lands comprise between 10% and 25% of the subwatershed area,
the RE = the percent State + private land -10 / 15;
If the percentage of State and private land comprises 25% or more of the subwatershed area, the RE = 1.

The results of these calculations are shown in Table 2-8.


Colorado-Lower Gila Watershed: Land Ownership-State Land and Private Land

Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006).
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009
CLG Landownership-State and Private 10huc.mxd

Figure 2-6: Land Ownership - State Land and Private Land

Table 2-8: Colorado-Lower Gila Watershed Risk Evaluations (RE) for Sediment Based on Land Ownership

Subwatershed	% State + Private	Risk Evaluation
Jumbo Wash-Lower Colorado River 1503010101	0%	0
Lower Colorado River-Lake Mohave 1503010102	8%	0
Silver Creek Wash-Lower Colorado River 1503010103	36%	1
Topock Marsh-Lower Colorado River 1503010104	18%	0.53
Lower Colorado River-Lake Havasu 1503010106	29%	1
Tennessee Wash-Sacramento Wash 1503010301	49%	1
Thirteenmile Wash-Sacramento Wash 1503010302	53%	1
Buck Mountain Wash 1503010303	66%	1
Walnut Creek-Sacramento Wash 1503010304	26.3%	1
Franconia Wash-Sacramento Wash 1503010305	27%	1
Osborne Wash-Lower Colorado River 1503010401	7%	0
Upper Parker Valley-Lower Colorado River 1503010403	2%	0
Lower Parker Valley-Lower Colorado River 1503010404	2%	0
Ehrenberg Wash-Lower Colorado River 1503010406	6%	0
Mohave Wash-Lower Colorado River 1503010407	3%	0
Gould Wash-Lower Colorado River 1503010409	8%	0
Yuma Wash-Lower Colorado River 1503010410	2%	0
Martinez Lake-Lower Colorado River 1503010411	1.9%	0
Alamo Wash 1503010501	2%	0
Upper Bouse Wash 1503010502	10%	0
Cunningham Wash 1503010503	41.7%	1
Middle Bouse Wash 1503010504	36%	1
Lower Bouse Wash 1503010505	10%	0
Upper Tyson Wash 1503010601	1%	0
Middle Tyson Wash 1503010602	2.8%	0
Lower Tyson Wash 1503010603	7.1%	0
Picacho Wash-Lower Colorado River 1503010701	40%	1
Lower Colorado River below Morelos Dam 1503010702	24%	0.93
Yuma Desert Area 1503010800	30%	1
Columbus Wash 1507020101	37%	1
Fourth of July Wash-Lower Gila River 1507020102	7%	0
Clanton Wash 1507020103	10%	0
Baragan Wash 1507020104	3.6%	0
Nottbusch Wash-Lower Gila River 1507020105	48%	1
Hoodoo Wash 1507020106	5.6%	0
Yaqui Wash 1507020107	12%	0.13
Gravel Wash 1507020108	2.5%	0
Park Valley-Lower Gila River 1507020109	62%	1
Upper Mohawk Wash 1507020110	0%	0

Subwatershed	% State + Private	Risk Evaluation
Lower Mohawk Wash 1507020111	9%	0
Big Eye Wash Area 1507020112	4%	0
Coyote Wash Area 1507020113	4%	0
Morgan Wash-Lower Gila River 1507020114	56%	1
Castle Dome Wash 1507020115	2.9%	0
Fortuna Wash-Lower Gila River 1507020116	39%	1
Upper Midway Wash 1507020201	0%	0
Upper Tenmile Wash 1507020202	5%	0
Lower Midway Wash Area 1507020203	7.2%	0
Lower Tenmile Wash 1507020204	19%	0.60
Cherioni Wash 1507020301	0%	0
Cuerda de Lena 1507020302	1.3%	0
Daniels Arroyo 1507020303	0%	0
Growler Wash 1507020304	0%	0
Upper San Cristobal Wash 1507020305	0%	0
Childs Valley 1507020306	0%	0
Lower San Cristobal Wash 1507020307	19.0%	0.60

Data Sources: GIS data layer "landownership" originated by Arizona Land Information System, 2006. www.land.state.az.us/alris

Human Use Index - Sediment

Human activities tend to increase erosion and sedimentation. Urban impervious surfaces prevent precipitation from penetrating the soil causing increased overland flow and erosion. Farming exposes agricultural soils and contributes to their erosion. Grazing can result in removal of vegetation and exposes soils to erosion. Mining activities also contribute to erosion. A Human Use Index (HUI) was calculated that expresses the percentage of the area within a subwatershed that is attributable to these human uses. The risk evaluation (RE) score associated with human use employed the following rubric for each subwatershed:

If HUI for a subwatershed is 5% or less, RE = 0;
If HUI for a subwatershed is between 5 and 20%, RE = (HUI-5) / 15;
If HUI for a subwatershed is 20% or greater, RE = 1.

Because human activities within riparian zones contribute disproportionately to sediment release, a risk evaluation (RE) score was also calculated for human use within 250 m of a stream for each subwatershed, using the scoring method below. The results of the RE calculations for human use are shown in Table 2-9. The distribution of human use in by subwatershed and within riparian areas is shown in Figures 2-7 and 2-8

If HUI within 250 m of a riparian zone is 1% or less, RE = 0;
If HUI within 250 m of a riparian zone is between 1 and 4%, RE = (HUI-1)/4;
If HUI within 250 m of a riparian zone is 5% or greater, RE = 1.

Table 2-9: Colorado-Lower Gila Watershed Risk Evaluation (RE) for Sediment Based on the Human Use Index (HUI)

Subwatershed	**Risk Eval. Based on Human Use Index/ Watershed**	**Risk Eval. Based on Human Use Index/ Riparian**
Jumbo Wash-Lower Colorado River 1503010101	0	0
Lower Colorado River-Lake Mohave 1503010102	0	0
Silver Creek Wash-Lower Colorado River 1503010103	0.44	0.76
Topock Marsh-Lower Colorado River 1503010104	0	0.51
Lower Colorado River-Lake Havasu 1503010106	0.12	1
Tennessee Wash-Sacramento Wash 1503010301	0	0.99
Thirteenmile Wash-Sacramento Wash 1503010302	0.05	0.79
Buck Mountain Wash 1503010303	0	0
Walnut Creek-Sacramento Wash 1503010304	0	0.23
Franconia Wash-Sacramento Wash 1503010305	0	0.2
Osborne Wash-Lower Colorado River 1503010401	0	0.51
Upper Parker Valley-Lower Colorado River 1503010403	1	1
Lower Parker Valley-Lower Colorado River 1503010404	1	1
Ehrenberg Wash-Lower Colorado River 1503010406	0	0.48
Mohave Wash-Lower Colorado River 1503010407	0	0
Gould Wash-Lower Colorado River 1503010409	0.05	0.6

Subwatershed	Risk Eval. Based on Human Use Index/ Watershed	Risk Eval. Based on Human Use Index/ Riparian
Yuma Wash-Lower Colorado River 1503010410	0	0
Martinez Lake-Lower Colorado River 1503010411	0	0
Alamo Wash 1503010501	0	0
Upper Bouse Wash 1503010502	0	0.05
Cunningham Wash 1503010503	0.08	0.07
Middle Bouse Wash 1503010504	0.31	0.44
Lower Bouse Wash 1503010505	0	0.06
Upper Tyson Wash 1503010601	0	0
Middle Tyson Wash 1503010602	0	0.44
Lower Tyson Wash 1503010603	0	0
Picacho Wash-Lower Colorado River 1503010701	0	1
Lower Colorado River below Morelos Dam 1503010702	0	1
Yuma Desert Area 1503010800	1	1
Columbus Wash 1507020101	0.77	1
Fourth of July Wash-Lower Gila River 1507020102	0	0
Clanton Wash 1507020103	0	0
Baragan Wash 1507020104	0	0
Nottbusch Wash-Lower Gila River 1507020105	0.59	0.89
Hoodoo Wash 1507020106	0	0
Yaqui Wash 1507020107	0	0
Gravel Wash 1507020108	0	0
Park Valley-Lower Gila River 1507020109	1	0.8
Upper Mohawk Wash 1507020110	0	0
Lower Mohawk Wash 1507020111	0	0.02
Big Eye Wash Area 1507020112	0	0
Coyote Wash Area 1507020113	0	0
Morgan Wash-Lower Gila River 1507020114	1	1
Castle Dome Wash 1507020115	0	0.08
Fortuna Wash-Lower Gila River 1507020116	0.56	1
Upper Midway Wash 1507020201	0.09	0
Upper Tenmile Wash 1507020202	0	0
Lower Midway Wash Area 1507020203	0	0

Subwatershed	Risk Eval. Based on Human Use Index/ Watershed	Risk Eval. Based on Human Use Index/ Riparian
Lower Tenmile Wash 1507020204	0.05	0.06
Cherioni Wash 1507020301	0	0
Cuerda de Lena 1507020302	0	0
Daniels Arroyo 1507020303	0	0
Growler Wash 1507020304	0	0
Upper San Cristobal Wash 1507020305	0	0
Childs Valley 1507020306	0	0
Lower San Cristobal Wash 1507020307	0	0

Data Sources: GIS data layers "impervious surfaces," and "impervious surfaces within riparian areas" originated by Multi-Resolution Land Characteristics Consortium, National Land Cover Data set, 2001. www.mrlc.gov. GIS data layers "agriculture," and "agriculture within riparian areas" originated by Southwest Regional GAP 2005. http://fws-nmcfwru.nmsu.edu/swregap/

Soil Loss Modeling

SWAT modeling (see Appendix C) was used to estimate the potential water yield and sediment yield for each subwatershed (Figure 2-9). The modeling results were reclassified into 5 categories, with the first category given a Risk Evaluation (RE) score of 0.0. RE scores were increased by 0.2 for each higher water yield and sediment yield category. Runoff categories are tabulated in Table 2-10 and erosion categories appear in Table 2-11.

Table 2-10: Colorado-Lower Gila Watershed Risk Evaluation (RE) and Runoff Categories

Subwatershed	Runoff Category	Risk Evaluation
Jumbo Wash-Lower Colorado River 1503010101	2	0.2
Lower Colorado River-Lake Mohave 1503010102	3	0.4
Silver Creek Wash-Lower Colorado River 1503010103	3	0.4
Topock Marsh-Lower Colorado River 1503010104	4	0.6
Lower Colorado River-Lake Havasu 1503010106	4	0.6
Tennessee Wash-Sacramento Wash 1503010301	2	0.2
Thirteenmile Wash-Sacramento Wash 1503010302	3	0.4
Buck Mountain Wash 1503010303	1	0.0
Walnut Creek-Sacramento Wash 1503010304	3	0.4
Franconia Wash-Sacramento Wash 1503010305	4	0.6
Osborne Wash-Lower Colorado River 1503010401	3	0.4
Upper Parker Valley-Lower Colorado River 1503010403	2	0.2
Lower Parker Valley-Lower Colorado River 1503010404	1	0.0
Ehrenberg Wash-Lower Colorado River 1503010406	5	0.8
Mohave Wash-Lower Colorado River 1503010407	5	0.8
Gould Wash-Lower Colorado River 1503010409	5	0.8

Subwatershed	Runoff Category	Risk Evaluation
Yuma Wash-Lower Colorado River 1503010410	5	0.8
Martinez Lake-Lower Colorado River 1503010411	5	0.8
Alamo Wash 1503010501	2	0.2
Upper Bouse Wash 1503010502	3	0.4
Cunningham Wash 1503010503	5	0.8
Middle Bouse Wash 1503010504	2	0.2
Lower Bouse Wash 1503010505	2	0.2
Upper Tyson Wash 1503010601	5	0.8
Middle Tyson Wash 1503010602	4	0.6
Lower Tyson Wash 1503010603	4	0.6
Picacho Wash-Lower Colorado River 1503010701	4	0.6
Lower Colorado River below Morelos Dam 1503010702	1	0.0
Yuma Desert Area 1503010800	1	0.0
Columbus Wash 1507020101	5	0.8
Fourth of July Wash-Lower Gila River 1507020102	3	0.4
Clanton Wash 1507020103	6	1.0
Baragan Wash 1507020104	6	1.0
Nottbusch Wash-Lower Gila River 1507020105	5	0.8
Hoodoo Wash 1507020106	6	1.0
Yaqui Wash 1507020107	4	0.6
Gravel Wash 1507020108	5	0.8
Park Valley-Lower Gila River 1507020109	3	0.4
Upper Mohawk Wash 1507020110	3	0.4
Lower Mohawk Wash 1507020111	6	1.0
Big Eye Wash Area 1507020112	5	0.8
Coyote Wash Area 1507020113	5	0.8
Morgan Wash-Lower Gila River 1507020114	6	1.0
Castle Dome Wash 1507020115	5	0.8
Fortuna Wash-Lower Gila River 1507020116	3	0.4
Upper Midway Wash 1507020201	4	0.6
Upper Tenmile Wash 1507020202	5	0.8
Lower Midway Wash Area 1507020203	1	0.0
Lower Tenmile Wash 1507020204	2	0.2
Cherioni Wash 1507020301	1	0.0
Cuerda de Lena 1507020302	2	0.2
Daniels Arroyo 1507020303	1	0.0
Growler Wash 1507020304	1	0.0
Upper San Cristobal Wash 1507020305	2	0.2
Childs Valley 1507020306	1	0.0
Lower San Cristobal Wash 1507020307	2	0.2

Data Sources: GIS data layer "water yield," originated by Arizona NEMO, 2009. www.arizonanemo.com. GIS data layer "sediment yield" calculated using AGWA tool, 2009. http://www.tucson.ars.ag.gov/agwa/

Table 2-11: Colorado-Lower Gila Watershed Risk Evaluation (RE) and Erosion Categories

Subwatershed	Erosion Category	Risk Evalution
Jumbo Wash-Lower Colorado River 1503010101	2	0.2
Lower Colorado River-Lake Mohave 1503010102	1	0.0
Silver Creek Wash-Lower Colorado River 1503010103	1	0.0
Topock Marsh-Lower Colorado River 1503010104	2	0.2
Lower Colorado River-Lake Havasu 1503010106	5	0.8
Tennessee Wash-Sacramento Wash 1503010301	5	0.8
Thirteenmile Wash-Sacramento Wash 1503010302	6	1.0
Buck Mountain Wash 1503010303	3	0.4
Walnut Creek-Sacramento Wash 1503010304	6	1.0
Franconia Wash-Sacramento Wash 1503010305	1	0.0
Osborne Wash-Lower Colorado River 1503010401	5	0.8
Upper Parker Valley-Lower Colorado River 1503010403	1	0.0
Lower Parker Valley-Lower Colorado River 1503010404	1	0.0
Ehrenberg Wash-Lower Colorado River 1503010406	3	0.4
Mohave Wash-Lower Colorado River 1503010407	3	0.4
Gould Wash-Lower Colorado River 1503010409	3	0.4
Yuma Wash-Lower Colorado River 1503010410	3	0.4
Martinez Lake-Lower Colorado River 1503010411	3	0.4
Alamo Wash 1503010501	5	0.8
Upper Bouse Wash 1503010502	3	0.4
Cunningham Wash 1503010503	4	0.6
Middle Bouse Wash 1503010504	5	0.8
Lower Bouse Wash 1503010505	1	0.0
Upper Tyson Wash 1503010601	3	0.4
Middle Tyson Wash 1503010602	2	0.2
Lower Tyson Wash 1503010603	2	0.2
Picacho Wash-Lower Colorado River 1503010701	1	0.0
Lower Colorado River below Morelos Dam 1503010702	2	0.2
Yuma Desert Area 1503010800	2	0.2
Columbus Wash 1507020101	2	0.2
Fourth of July Wash-Lower Gila River 1507020102	4	0.6
Clanton Wash 1507020103	4	0.6
Baragan Wash 1507020104	3	0.4
Nottbusch Wash-Lower Gila River 1507020105	1	0.0
Hoodoo Wash 1507020106	3	0.4
Yaqui Wash 1507020107	1	0.0
Gravel Wash 1507020108	2	0.2
Park Valley-Lower Gila River 1507020109	1	0.0
Upper Mohawk Wash 1507020110	1	0.0

Subwatershed	Erosion Category	Risk Evalution
Lower Mohawk Wash 1507020111	1	0.0
Big Eye Wash Area 1507020112	2	0.2
Coyote Wash Area 1507020113	1	0.0
Morgan Wash-Lower Gila River 1507020114	2	0.2
Castle Dome Wash 1507020115	2	0.2
Fortuna Wash-Lower Gila River 1507020116	2	0.2
Upper Midway Wash 1507020201	4	0.6
Upper Tenmile Wash 1507020202	2	0.2
Lower Midway Wash Area 1507020203	1	0.0
Lower Tenmile Wash 1507020204	2	0.2
Cherioni Wash 1507020301	1	0.0
Cuerda de Lena 1507020302	1	0.0
Daniels Arroyo 1507020303	1	0.0
Growler Wash 1507020304	1	0.0
Upper San Cristobal Wash 1507020305	1	0.0
Childs Valley 1507020306	1	0.0
Lower San Cristobal Wash 1507020307	1	0.0

Data Sources: GIS data layer "sediment yield," originated by Arizona NEMO, 2009. www.arizonanemo.com. GIS data layer "sediment yield" calculated using AGWA tool, 2009. http://www.tucson.ars.ag.gov/agwa/

A final combined sediment risk classification for each 10-digit HUC subwatershed was determined by a weighted combination of the risk evaluation (RE) for the sediment water quality classification, land ownership, the human use index for the subwatershed and for riparian areas in the subwatershed, and the classification by water yield (Figure 2-10; Table 2-12). Weights were developed in consultation with ADEQ and attempt to approximate the relative importance of the five factors in contributing to the risk of watershed pollution by metals.

Table 2-12: Colorado-Lower Gila Watershed Summary Results for Sediment Based on the Risk Evaluations (RE)-Weighted Combination Approach

Subwatershed	WQA	RE Land Ownership	RE HUI/ Watershed	RE HUI/ Riparian	RE Runoff	RE Erosion	RE Urban	RE (Weighted)
Jumbo Wash-Lower Colorado River 1503010101	0.0	0	0	0	0.2	0.2	0.0	0.12
Lower Colorado River-Lake Mohave 1503010102	0.0	0	0	0	0.4	0.0	0.0	0.12
Silver Creek Wash-Lower Colorado River 1503010103	0.5	1	0.44	0.76	0.4	0.0	0.03	0.33

Subwatershed	WQA	RE Land Ownership	RE HUI/ Watershed	RE HUI/ Riparian	RE Runoff	RE Erosion	RE Urban	RE (Weighted)
Topock Marsh-Lower Colorado River 1503010104	0.3	0.53	0	0.51	0.6	0.2	0.0	0.36
Lower Colorado River-Lake Havasu 1503010106	0.0	1	0.12	1	0.6	0.8	0.15	0.64
Tennessee Wash-Sacramento Wash 1503010301	0.5	1	0	0.99	0.2	0.8	0.0	0.52
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	1	0.05	0.79	0.4	1.0	0.07	0.62
Buck Mountain Wash 1503010303	0.5	1	0	0	0.0	0.4	0.0	0.20
Walnut Creek-Sacramento Wash 1503010304	0.5	1	0	0.23	0.4	1.0	0.0	0.53
Franconia Wash-Sacramento Wash 1503010305	0.5	1	0	0.2	0.6	0.0	0.0	0.29
Osborne Wash-Lower Colorado River 1503010401	0.0	0	0	0.51	0.4	0.8	0.0	0.44
Upper Parker Valley-Lower Colorado River 1503010403	0.5	0	1	1	0.2	0.0	0.0	0.29
Lower Parker Valley-Lower Colorado River 1503010404	0.5	0	1	1	0.0	0.0	0.0	0.23
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	0	0	0.48	0.8	0.4	0.0	0.46
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	0	0	0	0.8	0.4	0.0	0.39
Gould Wash-Lower Colorado River 1503010409	0.5	0	0.05	0.6	0.8	0.4	0.0	0.48
Yuma Wash-Lower Colorado River 1503010410	0.3	0	0	0	0.8	0.4	0.0	0.38
Martinez Lake-Lower Colorado River 1503010411	0.0	0	0	0	0.8	0.4	0.0	0.36
Alamo Wash 1503010501	0.5	0	0	0	0.2	0.8	0.0	0.33

Subwatershed	WQA	RE Land Ownership	RE HUI/ Watershed	RE HUI/ Riparian	RE Runoff	RE Erosion	RE Urban	RE (Weighted)
Upper Bouse Wash 1503010502	0.5	0	0	0.05	0.4	0.4	0.0	0.27
Cunningham Wash 1503010503	0.5	1	0.08	0.07	0.8	0.6	0.0	0.51
Middle Bouse Wash 1503010504	0.5	1	0.31	0.44	0.2	0.8	0.0	0.46
Lower Bouse Wash 1503010505	0.5	0	0	0.06	0.2	0.0	0.0	0.09
Upper Tyson Wash 1503010601	0.5	0	0	0	0.8	0.4	0.0	0.39
Middle Tyson Wash 1503010602	0.5	0	0	0.44	0.6	0.2	0.0	0.33
Lower Tyson Wash 1503010603	0.5	0	0	0	0.6	0.2	0.0	0.27
Picacho Wash-Lower Colorado River 1503010701	0.0	1	0	1	0.6	0.0	0.0	0.38
Lower Colorado River below Morelos Dam 1503010702	0.0	0.93	0	1	0.0	0.2	0.0	0.26
Yuma Desert Area 1503010800	0.3	1	1	1	0.0	0.2	0.0	0.33
Columbus Wash 1507020101	0.5	1	0.77	1	0.8	0.2	0.0	0.56
Fourth of July Wash-Lower Gila River 1507020102	0.0	0	0	0	0.4	0.6	0.0	0.30
Clanton Wash 1507020103	0.5	0	0	0	1.0	0.6	0.0	0.51
Baragan Wash 1507020104	0.5	0	0	0	1.0	0.4	0.0	0.45
Nottbusch Wash-Lower Gila River 1507020105	0.5	1	0.59	0.89	0.8	0.0	0.0	0.48
Hoodoo Wash 1507020106	0.5	0	0	0	1.0	0.4	0.0	0.45
Yaqui Wash 1507020107	0.3	0.13	0	0	0.6	0.0	0.0	0.20
Gravel Wash 1507020108	0.3	0	0	0	0.8	0.2	0.0	0.32
Park Valley-Lower Gila River 1507020109	0.3	1	1	0.8	0.4	0.0	0.0	0.36
Upper Mohawk Wash 1507020110	0.5	0	0	0	0.4	0.0	0.0	0.15
Lower Mohawk Wash 1507020111	0.3	0	0	0.02	1.0	0.0	0.0	0.32

Subwatershed	WQA	RE Land Ownership	RE HUI/ Watershed	RE HUI/ Riparian	RE Runoff	RE Erosion	RE Urban	RE (Weighted)
Big Eye Wash Area 1507020112	0.3	0	0	0	0.8	0.2	0.0	0.32
Coyote Wash Area 1507020113	0.3	0	0	0	0.8	0.0	0.0	0.26
Morgan Wash-Lower Gila River 1507020114	0.0	1	1	1	1.0	0.2	0.0	0.61
Castle Dome Wash 1507020115	0.3	0	0	0.08	0.8	0.2	0.0	0.33
Fortuna Wash-Lower Gila River 1507020116	0.0	1	0.56	1	0.4	0.2	0.0	0.41
Upper Midway Wash 1507020201	0.5	0	0.09	0	0.6	0.6	0.11	0.40
Upper Tenmile Wash 1507020202	0.5	0	0	0	0.8	0.2	0.0	0.33
Lower Midway Wash Area 1507020203	0.5	0	0	0	0.0	0.0	0.0	0.03
Lower Tenmile Wash 1507020204	0.5	0.60	0.05	0.06	0.2	0.2	0.0	0.19
Cherioni Wash 1507020301	0.5	0	0	0	0.0	0.0	0.0	0.03
Cuerda de Lena 1507020302	0.5	0	0	0	0.2	0.0	0.0	0.09
Daniels Arroyo 1507020303	0.5	0	0	0	0.0	0.0	0.0	0.03
Growler Wash 1507020304	0.5	0	0	0	0.0	0.0	0.0	0.03
Upper San Cristobal Wash 1507020305	0.5	0	0	0	0.2	0.0	0.0	0.09
Childs Valley 1507020306	0.5	0	0	0	0.0	0.0	0.0	0.03
Lower San Cristobal Wash 1507020307	0.5	0.60	0	0	0.2	0.0	0.0	0.12
Weights	0.05	0.05	0.05	0.15	0.3	0.3	0.1	

Data Sources: Water Quality Assessment data originated by ADEQ, 2008. GIS data layer "landownership" originated by Arizona Land Information Service, 2006. http://www.land.state.az.us/alris/. GIS data layer "impervious surfaces," originated by Multi-Resolution Land Characteristics Consortium, National Land Cover Data Set, 2001. www.mrlc.gov. GIS data layers "Human Use," "Human Use within riparian," "sediment yield," and "water yield" originated by Arizona NEMO, 2009. www.arizonanemo.org.

Organics and Nutrients

The category "organics and nutrients" includes a variety of water quality parameters including nitrogen (in the form of nitrates and nitrites), ammonia, phosphorus, sulfides, chlorine, fluorine, dissolved oxygen, pH, DDE (a metabolite of the insecticide DDT), and *E. coli* bacteria.

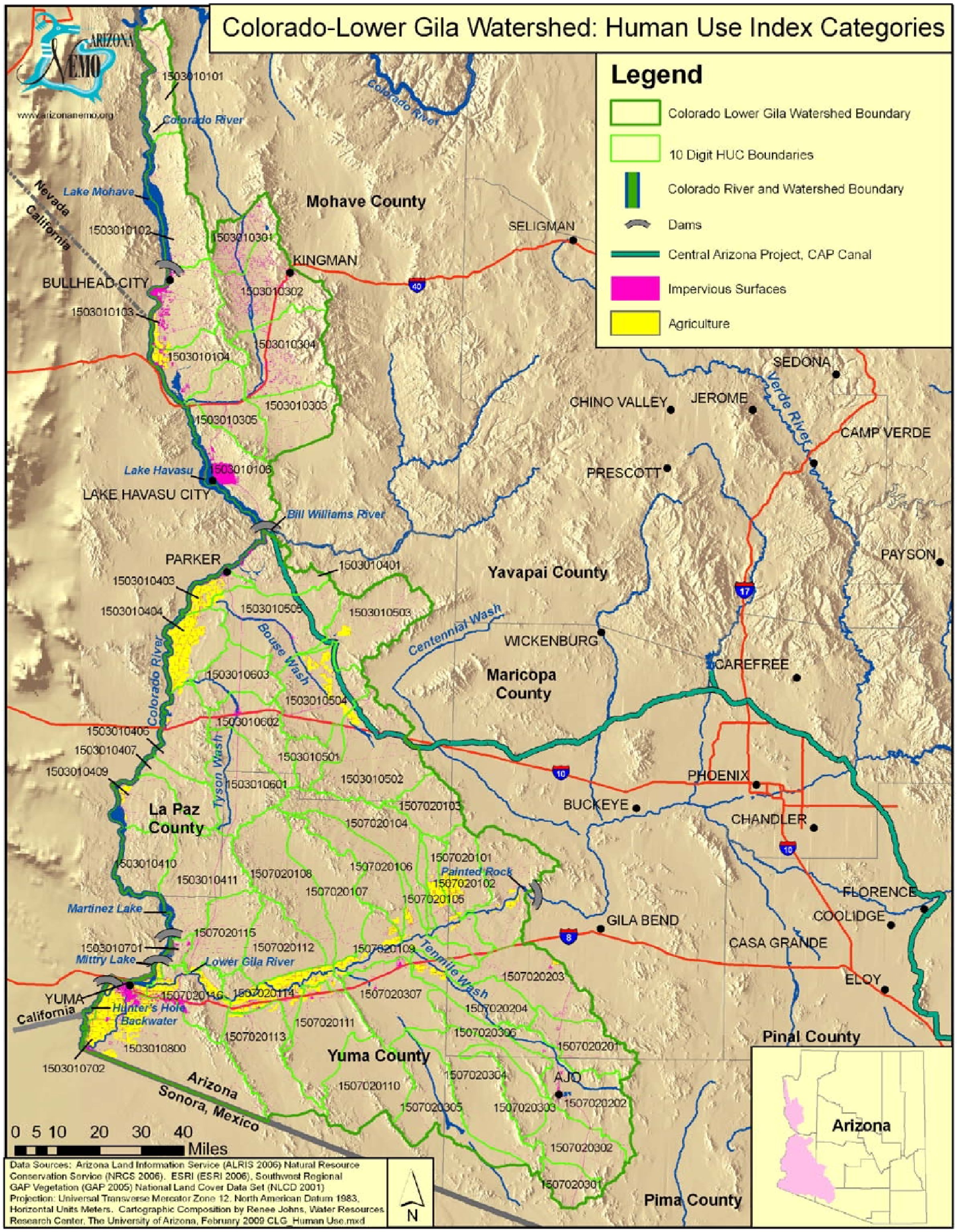
The organics and nutrients factor discussed in this section is the only one that failed to meet ADEQ water quality standards in the Colorado-Lower Gila Watershed: low dissolved oxygen.

Dissolved oxygen is essential for aquatic animal life. Oxygen is provided to streams and lakes by plant photosynthetic and through diffusion from the atmosphere. Decomposers also require dissolved oxygen, and when algae blooms die or organic-rich effluents are discharged into waterways, the subsequent decomposition process can lower dissolved oxygen levels. In rivers with fluctuating flows, such as the Colorado, dissolved oxygen concentration will decline during times of low flow. Groundwater is usually quite low in dissolved oxygen because it is isolated from atmospheric sources of oxygen and photosynthesis (which generates oxygen) does not occur in the absence of light. If groundwater upwelling is supplying a significant part of the stream flow, stream dissolved oxygen will be low.

The factors that are considered in calculating the risk classification for organics and nutrients in the various 10-digit HUC subwatersheds in the Colorado-Lower Gila Watershed are (1) the risk level based on ADEQ water quality assessments, (2) human use index in the subwatershed, (3) human use index in riparian areas, (4) land use, and (5) urban area.

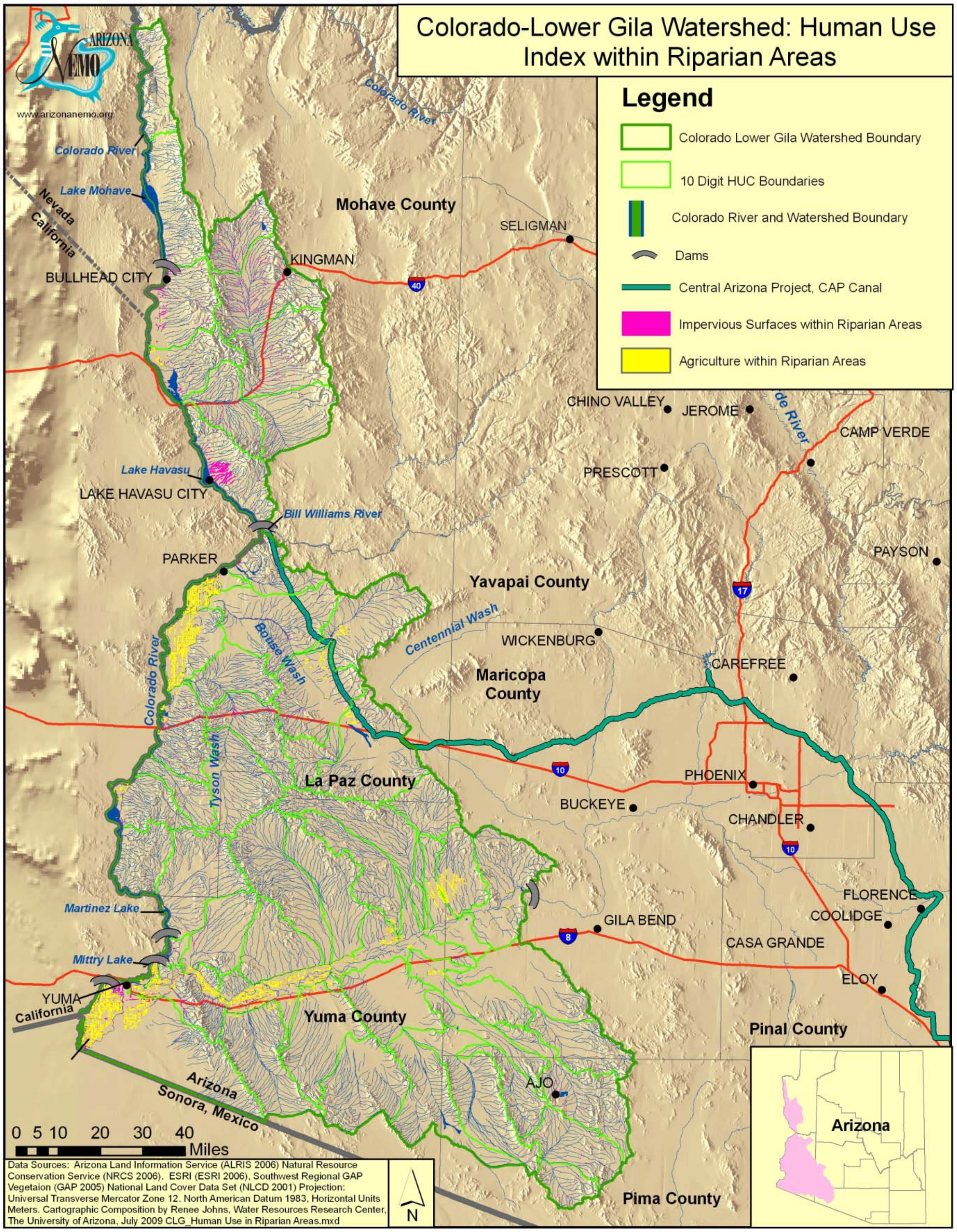
Water Quality Assessment for Organics and Nutrients

Based on the ADEQ water quality assessments and the conditions of downstream reaches, and using the scoring methods described in Table 2-1 (above), the organics/nutrients risk classifications for each 10-digit HUC subwatershed was calculated (Table 2-13).



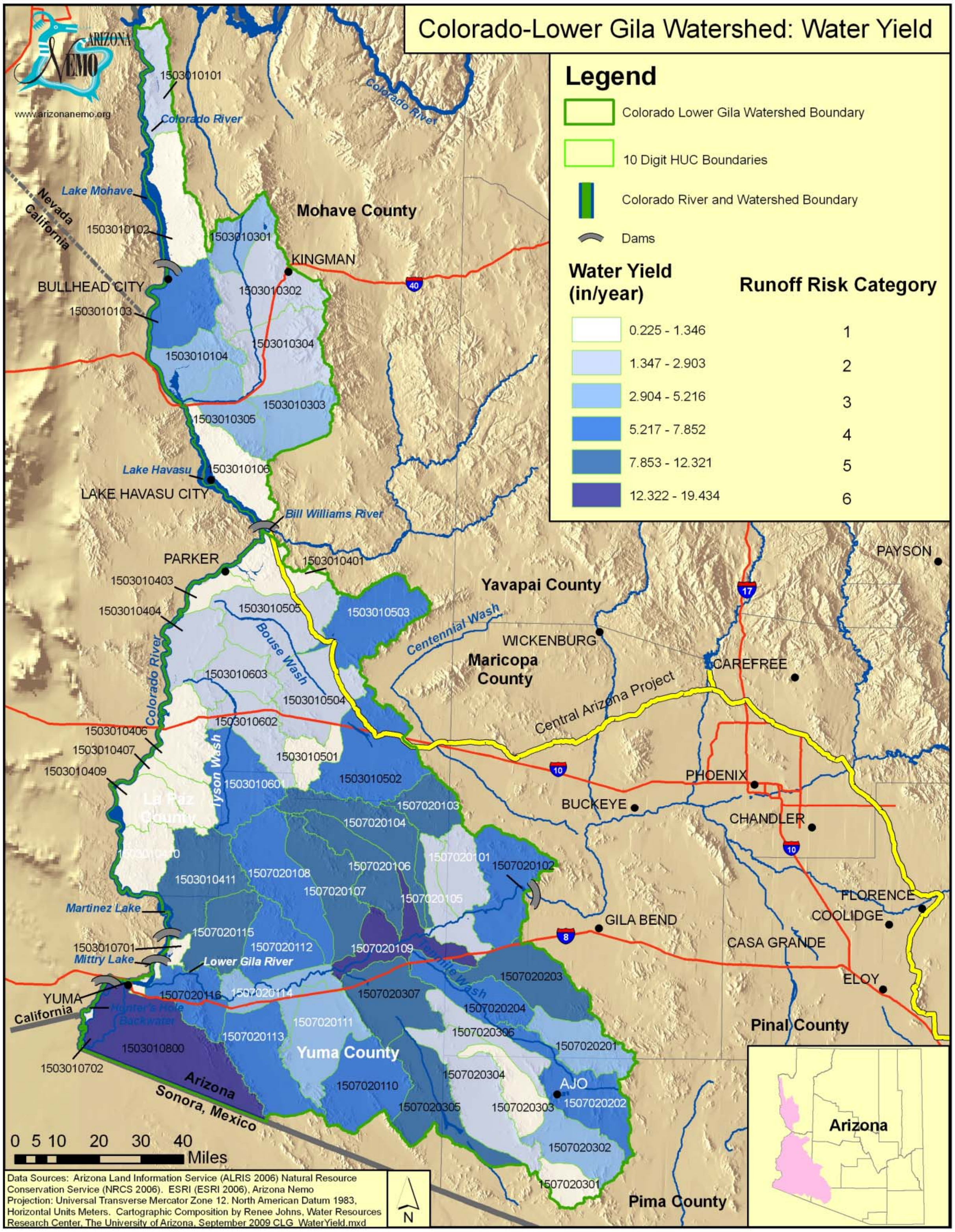
Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP Vegetation (GAP 2005) National Land Cover Data Set (NLCD 2001) Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG_Human Use.mxd

Figure 2-7: Human Use Index Categories



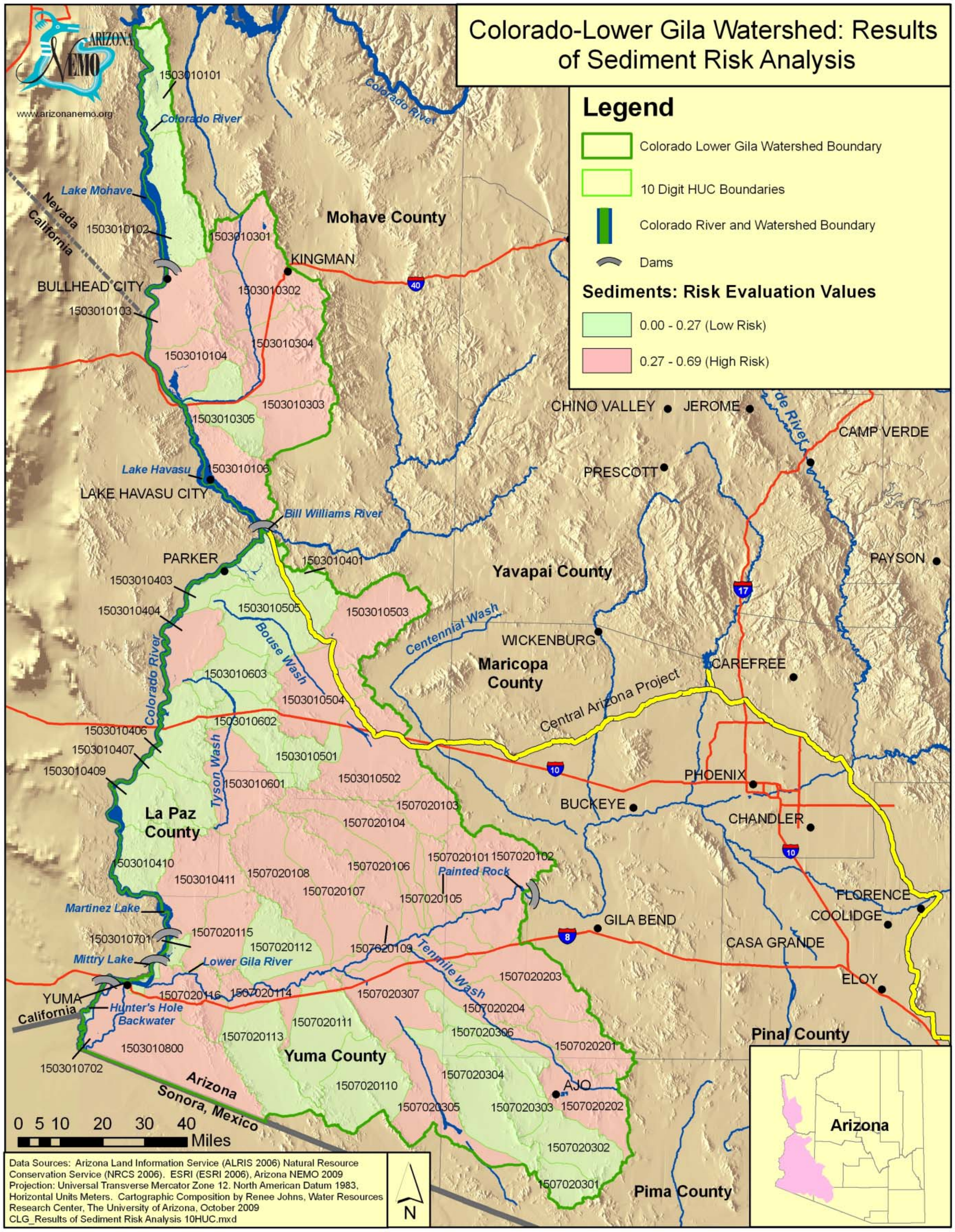
Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP Vegetaion (GAP 2005) National Land Cover Data Set (NLCD 2001) Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, July 2009 CLG_Human Use in Riparian Areas.mxd

Figure 2-8: Human Use Index within Riparian Areas



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona Nemo
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, September 2009 CLG_WaterYield.mxd

Figure 2-9: Water Yield



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona NEMO 2009
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, October 2009
CLG_Results of Sediment Risk Analysis 10HUC.mxd

Figure 2-10: Results of Sediment Risk Analysis

Table 2-13 Colorado-Lower Gila Watershed Risk Evaluation (RE) for Organics Assigned to Each 10-Digit HUC Subwatershed, Based on Water Quality Assessment (WQA) Results

Subwatershed Name	WQA RE	Justification
Jumbo Wash-Lower Colorado River 1503010101	0.3	Classified as moderate risk, drains to Lower Colorado-Lake Mohave, which is classified as low risk.
Lower Colorado River-Lake Mohave 1503010102	0.0	Classified as low risk, drains to Silver Creek Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Silver Creek Wash-Lower Colorado River 1503010103	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Topock Marsh-Lower Colorado River 1503010104	0.5	Classified as moderate risk due to insufficient data, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Lower Colorado River-Lake Havasu 1503010106	0.5	Classified as moderate risk, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Tennessee Wash-Sacramento Wash 1503010301	0.5	Classified as moderate risk due to insufficient data, drains to Thirteenmile Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	Classified as moderate risk due to insufficient data, drains to Walnut Creek-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Buck Mountain Wash 1503010303	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Walnut Creek-Sacramento Wash 1503010304	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Franconia Wash-Sacramento Wash 1503010305	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Osborne Wash-Lower Colorado River 1503010401	0.5	Classified as moderate risk, drains to Upper Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Parker Valley-Lower Colorado River 1503010403	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Lower Parker Valley-Lower Colorado River 1503010404	0.5	Classified as moderate risk due to insufficient data, drains to Ehrenberg Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	Classified as moderate risk due to insufficient data, drains to Mohave Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	Classified as moderate risk due to insufficient data, drains to Gould Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	WQA RE	Justification
Gould Wash-Lower Colorado River 1503010409	0.5	Classified as moderate risk due to insufficient data, drains to Yuma Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Yuma Wash-Lower Colorado River 1503010410	0.3	Classified as moderate risk due to insufficient data, drains to Martinez Lake – Lower Colorado River, which is classified as low risk.
Martinez Lake-Lower Colorado River 1503010411	0.0	Classified as low risk, drains to Picacho Wash-Lower Colorado River, which is classified as extreme risk.
Alamo Wash 1503010501	0.5	Classified as moderate risk due to insufficient data, drains to Upper Bouse Wash, which is classified as moderate risk due to insufficient data.
Upper Bouse Wash 1503010502	0.5	Classified as moderate risk due to insufficient data, drains to Middle Bouse Wash, which is classified as moderate risk due to insufficient data.
Cunningham Wash 1503010503	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Middle Bouse Wash 1503010504	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Lower Bouse Wash 1503010505	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Tyson Wash 1503010601	0.5	Classified as moderate risk due to insufficient data, drains to Middle Tyson Wash, which is classified as moderate risk due to insufficient data.
Middle Tyson Wash 1503010602	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tyson Wash, which is classified as moderate risk due to insufficient data.
Lower Tyson Wash 1503010603	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Picacho Wash-Lower Colorado River 1503010701	1.0	Classified as extreme risk, drains to Lower Colorado River below Morelos Dam, which is classified as extreme risk.
Lower Colorado River below Morelos Dam 1503010702	1.0	Classified as extreme risk, drains into Mexico, which is classified as moderate risk due to insufficient data.
Yuma Desert Area 1503010800	0.7	Classified as moderate risk due to insufficient data, drains to Lower Colorado River below Morelos Dam, which is classified as extreme risk.
Columbus Wash 1507020101	0.5	Classified as moderate risk due to insufficient data, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Fourth of July Wash-Lower Gila River 1507020102	1.0	Classified as extreme risk, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Clanton Wash 1507020103	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	WQA RE	Justification
Baragan Wash 1507020104	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Nottbusch Wash-Lower Gila River 1507020105	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Hoodoo Wash 1507020106	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Yaqui Wash 1507020107	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as moderate risk.
Gravel Wash 1507020108	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as moderate risk.
Park Valley-Lower Gila River 1507020109	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as moderate risk.
Upper Mohawk Wash 1507020110	0.5	Classified as moderate risk due to insufficient data, drains to Lower Mohawk Wash, which is classified as moderate risk due to insufficient data.
Lower Mohawk Wash 1507020111	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as moderate risk.
Big Eye Wash Area 1507020112	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as moderate risk.
Coyote Wash Area 1507020113	0.5	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as moderate risk.
Morgan Wash-Lower Gila River 1507020114	0.5	Classified as moderate risk, drains to Fortuna Wash-Lower Gila River, which is classified as moderate risk.
Castle Dome Wash 1507020115	0.5	Classified as moderate risk due to insufficient data, drains to Fortuna Wash-Lower Gila River, which is classified as moderate risk.
Fortuna Wash-Lower Gila River 1507020116	0.7	Classified as moderate risk, drains to Picacho Wash-Lower Colorado River, which is classified as extreme risk.
Upper Midway Wash 1507020201	0.5	Classified as moderate risk due to insufficient data, drains to Lower Midway Wash Area, which is classified as moderate risk due to insufficient data.
Upper Tenmile Wash 1507020202	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Midway Wash Area 1507020203	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Tenmile Wash 1507020204	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	WQA RE	Justification
Cherioni Wash 1507020301	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Cuerda de Lena 1507020302	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Daniels Arroyo 1507020303	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Growler Wash 1507020304	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Upper San Cristobal Wash 1507020305	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Childs Valley 1507020306	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Lower San Cristobal Wash 1507020307	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Data Sources: Water Quality Assessment Data originated by ADEQ, 2008. www.azdeq.gov

The Picacho Wash–Lower Colorado River subwatershed and the Lower Colorado River below Morelos Dam had extreme risk evaluations (REs) for organics and nutrients, specifically for low dissolved oxygen. The Painted Rock Borrow Pit Lake in the Fourth of July Wash-Lower Gila River subwatershed also received an extreme risk evaluation for low dissolved oxygen.

Two subwatersheds, Lower Colorado River-Lake Mohave and Martinez Lake-Lower Colorado River, received low risk evaluations (0.0) for organics and nutrients.

Human Use Index – Organics and Nutrients

Human activities increase the likelihood of water pollution by organics and nutrients. Nitrate and ammonia fertilizers used in farming can be transported to streams through water runoff and erosion. Sewage entering streams from improperly functioning sewer systems or unsewered residences can cause reductions in dissolved oxygen and contamination by *E. coli*. Livestock grazing can also contribute to *E.* coli contamination. The likelihood of these pollutants reaching surface waters is greater when human sources are within riparian areas. Patterns of human use in each subwatershed and in riparian areas are shown in Figures 2-11 and 2-12, and state and private land ownership is shown in Figure 2-13.

A Human Use Index (HUI) was calculated that expresses the percentage of the area within a subwatershed that is attributable to these human uses. The risk evaluation (RE) score associated with human use employed the following rubric for each subwatershed:

If HUI for a subwatershed is 1% or less, RE = 0;
If HUI for a subwatershed is between 1 and 4%, RE = (HUI-1) / 3;
If HUI for a subwatershed is 4% or greater, RE = 1.

Because human activities within riparian zones contribute disproportionately to sediment release, a risk evaluation (RE) score was also calculated for human use within 250 m of a stream for each subwatershed, using the following scoring method:

If HUI within 250 m of a riparian zone is 0%, RE = 0;
If HUI within 250 m of a riparian zone is between 0 and 4%, RE = HUI/4;
If HUI within 250 m of a riparian zone is 4% or greater, RE = 1.

The results of the RE calculations for human use are shown in Table 2-14. Risk associated with urban areas is shown in Table 2-15.

Table 2-14: Colorado-Lower Gila Watershed Risk Evaluation (RE) For Organics Based on the Human Use (HU) Index

Subwatershed	RE HU Index Watershed	RE HU Index Riparian
Jumbo Wash-Lower Colorado River 1503010101	0.0	0.13
Lower Colorado River-Lake Mohave 1503010102	0.0	0.19
Silver Creek Wash-Lower Colorado River 1503010103	1.0	1.0
Topock Marsh-Lower Colorado River 1503010104	1.0	0.76
Lower Colorado River-Lake Havasu 1503010106	1.0	1.0
Tennessee Wash-Sacramento Wash 1503010301	0.28	1.0
Thirteenmile Wash-Sacramento Wash 1503010302	1.0	1.0
Buck Mountain Wash 1503010303	0.0	0.20
Walnut Creek-Sacramento Wash 1503010304	0.46	0.12
Franconia Wash-Sacramento Wash 1503010305	0.0	0.60
Osborne Wash-Lower Colorado River 1503010401	0.23	0.76
Upper Parker Valley-Lower Colorado River 1503010403	1.0	1.0

Subwatershed	RE HU Index Watershed	RE HU Index Riparian
Lower Parker Valley-Lower Colorado River 1503010404	1.0	1.0
Ehrenberg Wash-Lower Colorado River 1503010406	0.30	0.73
Mohave Wash-Lower Colorado River 1503010407	0.0	0.16
Gould Wash-Lower Colorado River 1503010409	1.0	0.85
Yuma Wash-Lower Colorado River 1503010410	0.0	0.10
Martinez Lake-Lower Colorado River 1503010411	0.0	0.21
Alamo Wash 1503010501	0.0	0.13
Upper Bouse Wash 1503010502	0.97	0.30
Cunningham Wash 1503010503	1.0	0.32
Middle Bouse Wash 1503010504	1.0	0.69
Lower Bouse Wash 1503010505	1.0	0.31
Upper Tyson Wash 1503010601	0.0	0.18
Middle Tyson Wash 1503010602	0.41	0.69
Lower Tyson Wash 1503010603	0.0	0.21
Picacho Wash-Lower Colorado River 1503010701	1.0	1.0
Lower Colorado River below Morelos Dam 1503010702	0.60	1.0
Yuma Desert Area 1503010800	1.0	1.0
Columbus Wash 1507020101	1.0	1.0
Fourth of July Wash-Lower Gila River 1507020102	1.0	0.24
Clanton Wash 1507020103	1.0	0.08
Baragan Wash 1507020104	1.0	0.15
Nottbusch Wash-Lower Gila River 1507020105	1.0	1.0
Hoodoo Wash 1507020106	0.08	0.24
Yaqui Wash 1507020107	0.0	0.08
Gravel Wash 1507020108	0.0	0.12
Park Valley-Lower Gila River 1507020109	1.0	1.0
Upper Mohawk Wash 1507020110	0.0	0.04
Lower Mohawk Wash 1507020111	0.67	0.27
Big Eye Wash Area 1507020112	0.0	0.12
Coyote Wash Area 1507020113	0.52	0.25
Morgan Wash-Lower Gila River 1507020114	1.0	1.0
Castle Dome Wash 1507020115	0.0	0.33

Subwatershed	RE HU Index Watershed	RE HU Index Riparian
Fortuna Wash-Lower Gila River 1507020116	1.0	1.0
Upper Midway Wash 1507020201	1.0	0.12
Upper Tenmile Wash 1507020202	0.15	0.19
Lower Midway Wash Area 1507020203	0.0	0.10
Lower Tenmile Wash 1507020204	1.0	0.31
Cherioni Wash 1507020301	0.0	0.17
Cuerda de Lena 1507020302	0.0	0.11
Daniels Arroyo 1507020303	0.0	0.0
Growler Wash 1507020304	0.0	0.02
Upper San Cristobal Wash 1507020305	0.0	0.04
Childs Valley 1507020306	0.0	0.05
Lower San Cristobal Wash 1507020307	0.09	0.04

Data Sources: GIS data layers "impervious surfaces," and "impervious surfaces within riparian areas" originated by Multi-Resolution Land Characteristics Consortium, National Land Cover Data set, 2001. www.mrlc.gov. GIS data layers "agriculture," and "agriculture within riparian areas" originated by Southwest Regional GAP 2005. http://fws-nmcfwru.nmsu.edu/swregap/

Table: 2-15: Colorado-Lower Gila Watershed Risk Evaluation (RE) for Urbanized Areas for Organics

Subwatershed	Percent Urban	RE
Jumbo Wash-Lower Colorado River 1503010101	0.53%	0
Lower Colorado River-Lake Mohave 1503010102	0.48%	0
Silver Creek Wash-Lower Colorado River 1503010103	5.37%	0.03
Topock Marsh-Lower Colorado River 1503010104	0.75%	0
Lower Colorado River-Lake Havasu 1503010106	6.76%	0.15
Tennessee Wash-Sacramento Wash 1503010301	1.83%	0
Thirteenmile Wash-Sacramento Wash 1503010302	5.82%	0.07
Buck Mountain Wash 1503010303	0.67%	0
Walnut Creek-Sacramento Wash 1503010304	2.37%	0
Franconia Wash-Sacramento Wash 1503010305	1%	0
Osborne Wash-Lower Colorado River 1503010401	1.7%	0
Upper Parker Valley-Lower Colorado River 1503010403	3.41%	0
Lower Parker Valley-Lower Colorado River 1503010404	0.87%	0
Ehrenberg Wash-Lower Colorado River 1503010406	0.68%	0

Subwatershed	Percent Urban	RE
Mohave Wash-Lower Colorado River 1503010407	0.26%	0
Gould Wash-Lower Colorado River 1503010409	1.06%	0
Yuma Wash-Lower Colorado River 1503010410	0.13%	0
Martinez Lake-Lower Colorado River 1503010411	0.8%	0
Alamo Wash 1503010501	0.11%	0
Upper Bouse Wash 1503010502	1.02%	0
Cunningham Wash 1503010503	1.32%	0
Middle Bouse Wash 1503010504	0.94%	0
Lower Bouse Wash 1503010505	1.98%	0
Upper Tyson Wash 1503010601	0.93%	0
Middle Tyson Wash 1503010602	2.25%	0
Lower Tyson Wash 1503010603	0.47%	0
Picacho Wash-Lower Colorado River 1503010701	0.53%	0
Lower Colorado River below Morelos Dam 1503010702	0.28%	0
Yuma Desert Area 1503010800	3.99%	0
Columbus Wash 1507020101	0.7%	0
Fourth of July Wash-Lower Gila River 1507020102	0.79%	0
Clanton Wash 1507020103	0.16%	0
Baragan Wash 1507020104	0.44%	0
Nottbusch Wash-Lower Gila River 1507020105	0.53%	0
Hoodoo Wash 1507020106	0.4%	0
Yaqui Wash 1507020107	0.36%	0
Gravel Wash 1507020108	0.57%	0
Park Valley-Lower Gila River 1507020109	3.28%	0
Upper Mohawk Wash 1507020110	0.1%	0
Lower Mohawk Wash 1507020111	0.4%	0
Big Eye Wash Area 1507020112	0.29%	0
Coyote Wash Area 1507020113	0.67%	0
Morgan Wash-Lower Gila River 1507020114	2.78%	0
Castle Dome Wash 1507020115	0.27%	0
Fortuna Wash-Lower Gila River 1507020116	1.69%	0
Upper Midway Wash 1507020201	6.36%	0.11
Upper Tenmile Wash 1507020202	1.45%	0
Lower Midway Wash Area 1507020203	0.19%	0
Lower Tenmile Wash 1507020204	0.15%	0
Cherioni Wash 1507020301	0.2%	0
Cuerda de Lena 1507020302	0.22%	0

Subwatershed	Percent Urban	RE
Daniels Arroyo 1507020303	0%	0
Growler Wash 1507020304	0.06%	0
Upper San Cristobal Wash 1507020305	0.23%	0
Childs Valley 1507020306	0.13%	0
Lower San Cristobal Wash 1507020307	0.4%	0

Data Sources: GIS data Layer "impervious surfaces" originated by Multi-Resolution Land Characteristics consortium, National Land Cover Data Set, 2001. www.mrlc.gov

A final combined organics and nutrients risk classification for each 10-digit HUC subwatershed was determined by a weighted combination of the risk evaluation (RE) for the organic/nutrients water quality classification, the human use index for the subwatershed and for riparian areas in the subwatershed, land use, and urban area (Figure 2-14; Table 2-16). Weights were developed in consultation with ADEQ and attempt to approximate the relative importance of each factor in contributing to the risk of watershed pollution by metals

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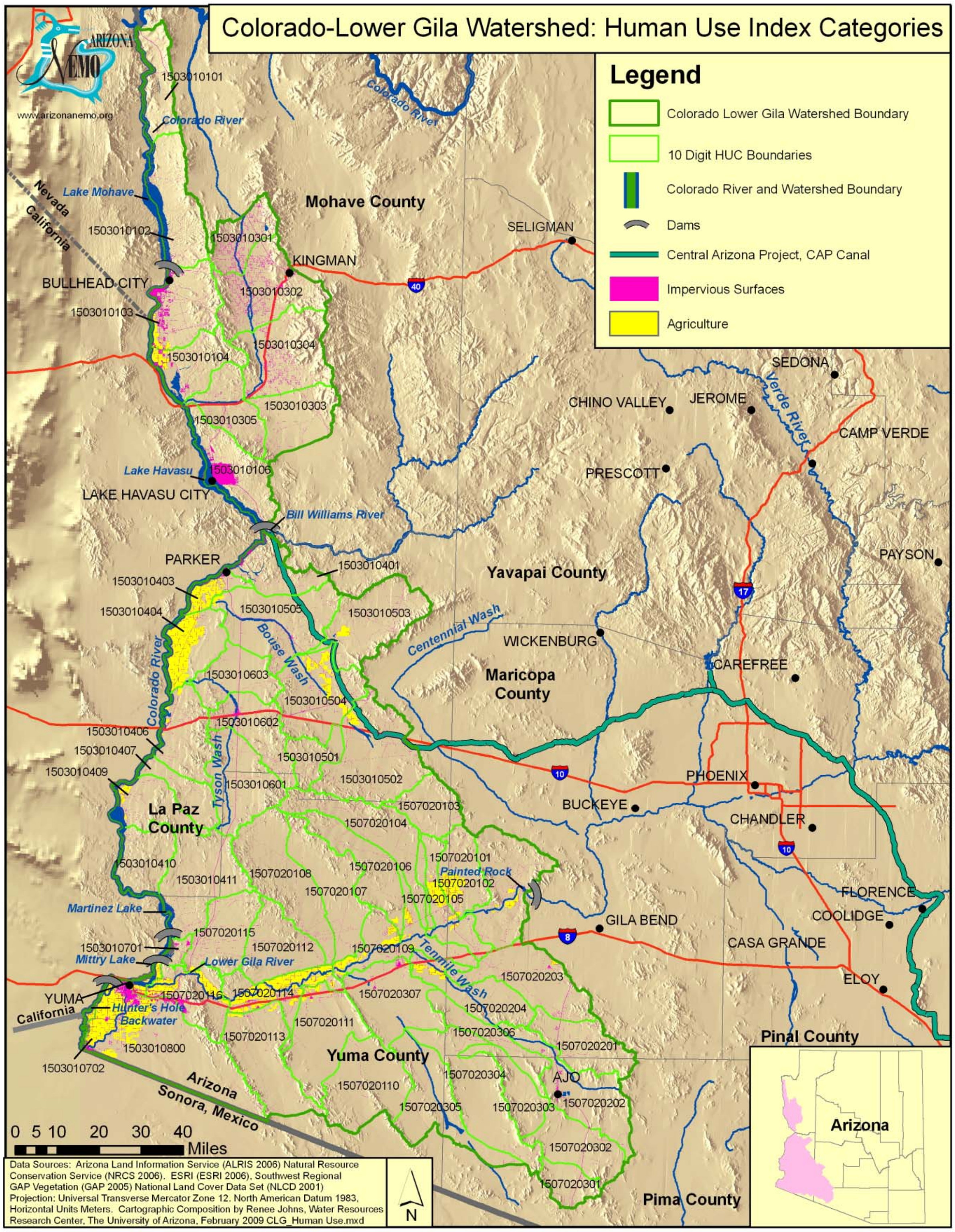
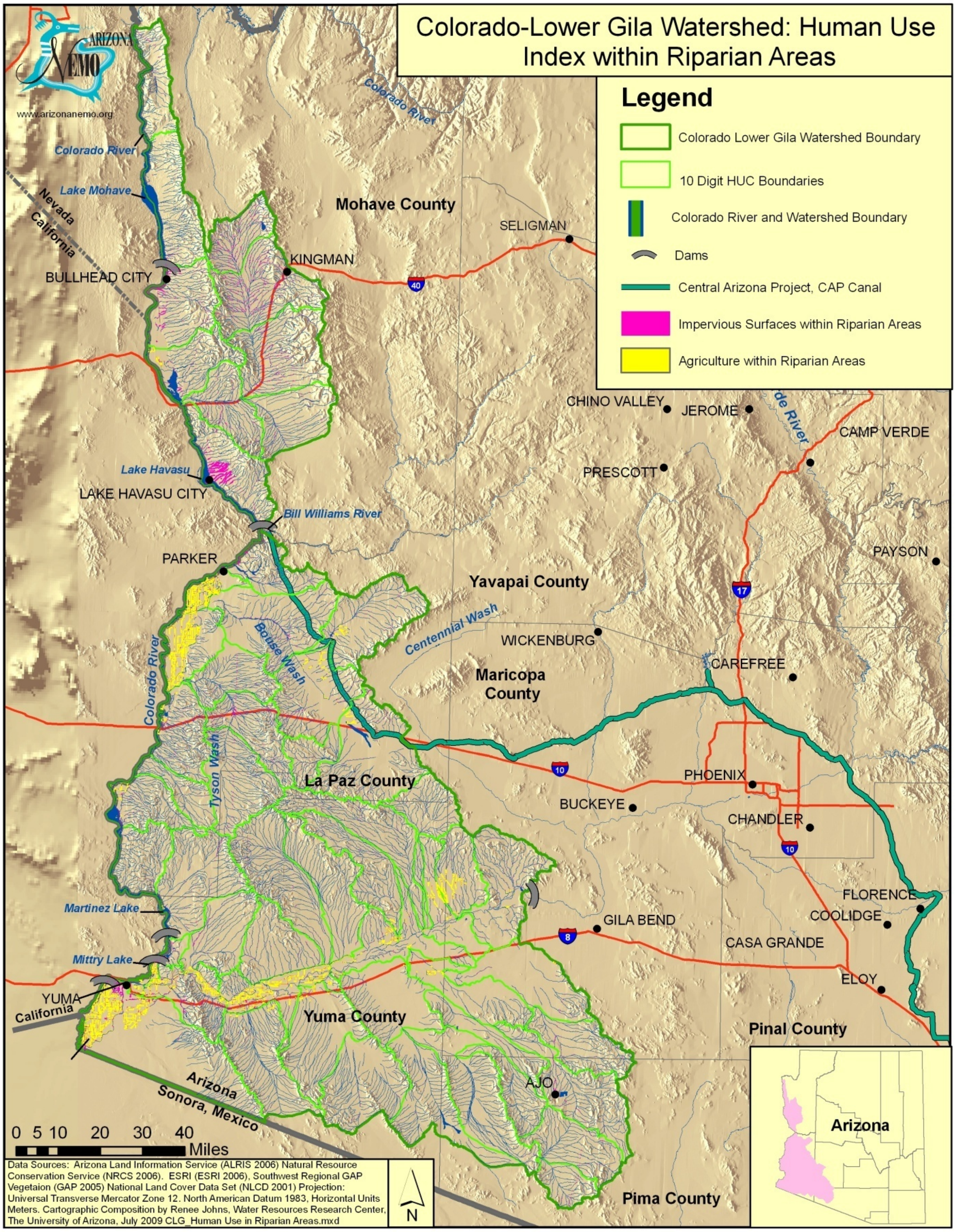


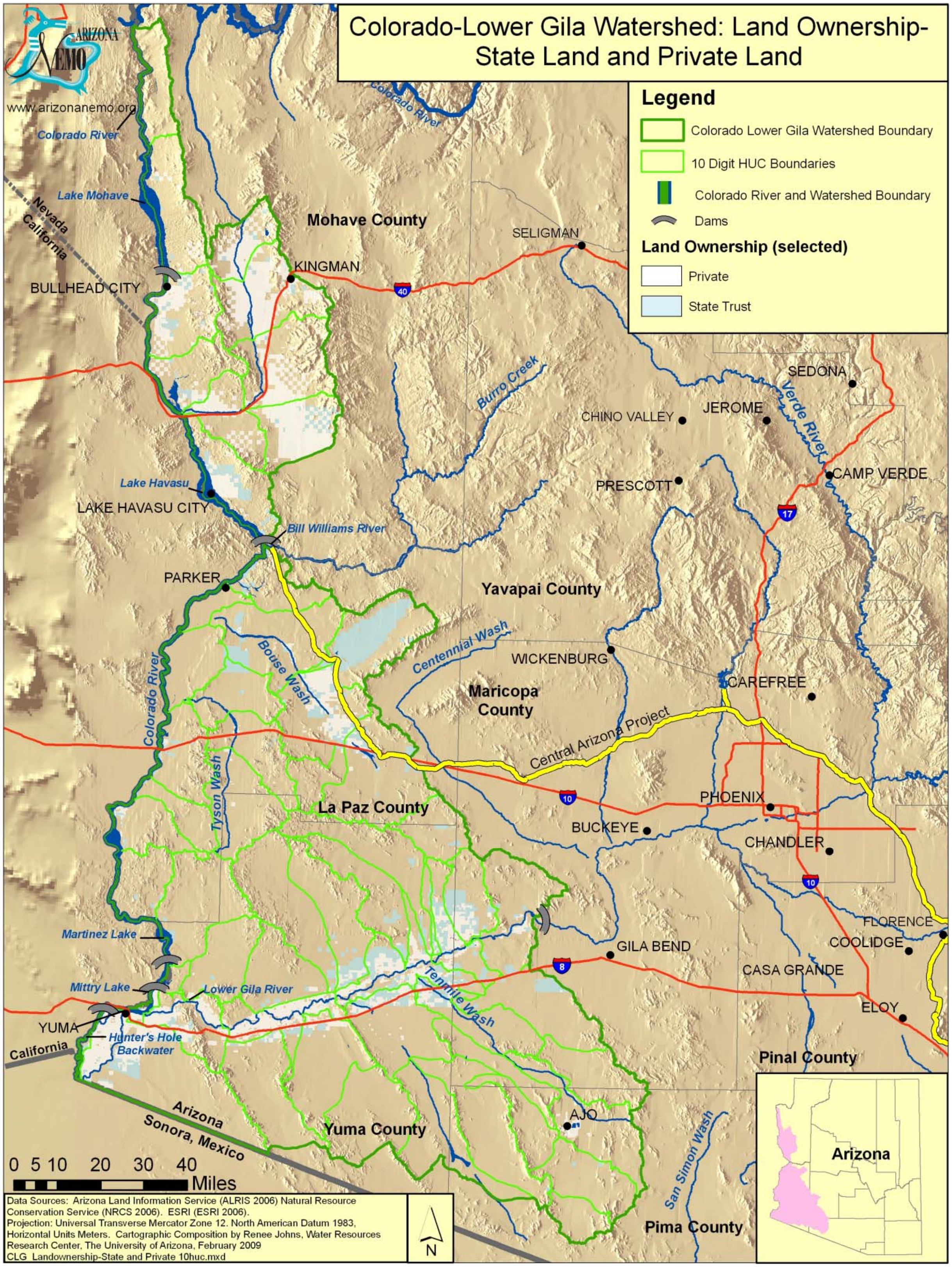
Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP Vegetation (GAP 2005) National Land Cover Data Set (NLCD 2001)
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009 CLG_Human Use.mxd

Figure 2-11: Human Use Index Categories



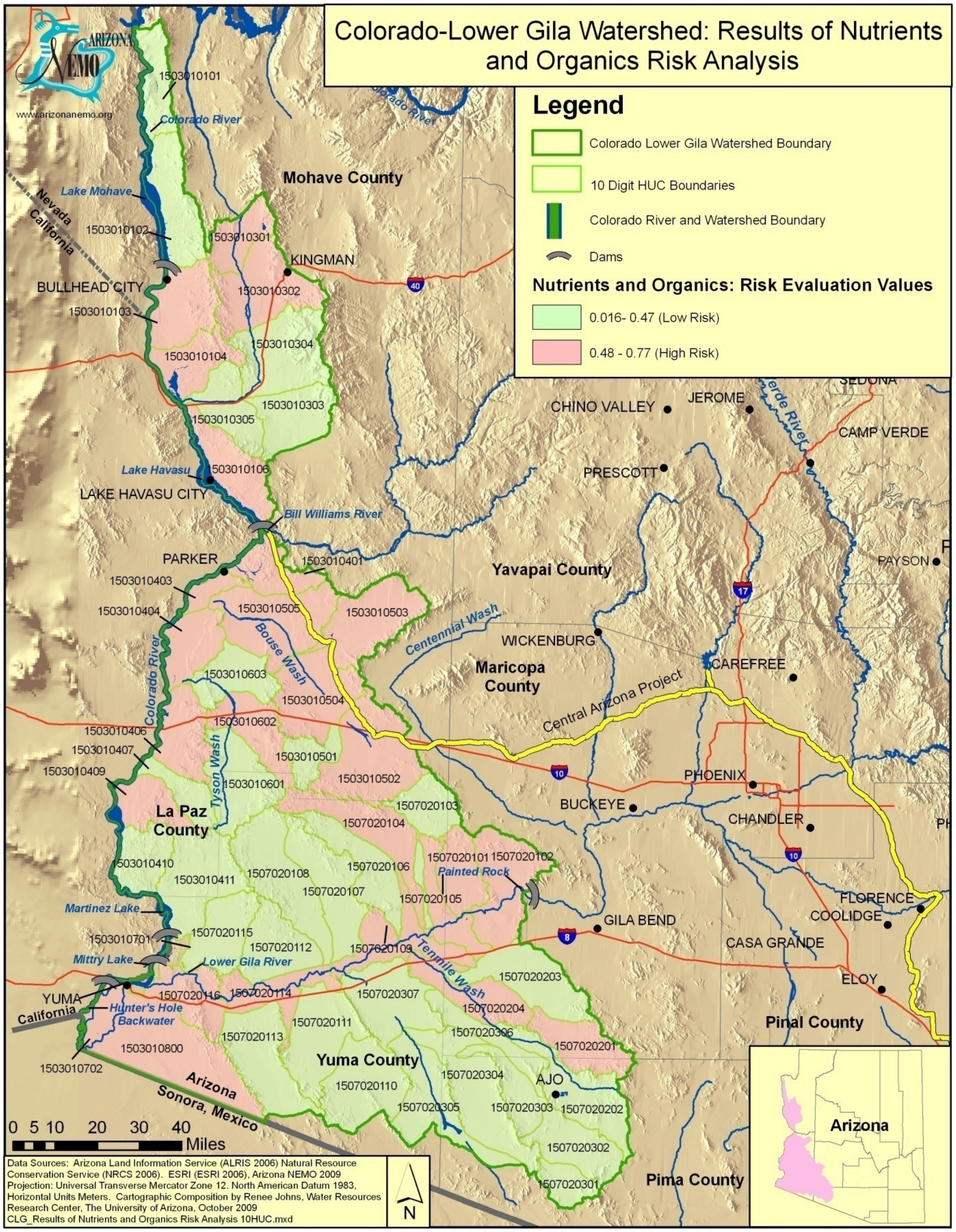
Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP Vegetaion (GAP 2005) National Land Cover Data Set (NLCD 2001) Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, July 2009 CLG_Human Use in Riparian Areas.mxd

Figure 2-12: Human Use Index within Riparian Areas



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006).
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, February 2009
CLG Landownership-State and Private 10huc.mxd

Figure 2-13: Land ownership – State Land and Private Land



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona NEMO 2009
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, October 2009
CLG_Results of Nutrients and Organics Risk Analysis 10HUC.mxd

Figure 2-14: Results of Nutrients and Organics Risk Analysis

Table 2-16: Colorado-Lower Gila Watershed Summary Results for Organics Based on the Risk Evaluation (RE)-Weighted Combination Approach

Subwatershed Name	RE WQA	RE HU Index Watershed	RE HU Index Riparian	RE Land Use	RE Urban Areas	RE (Weighted)
Jumbo Wash-Lower Colorado River 1503010101	0.3	0.0	0.13	1	0	0.23
Lower Colorado River-Lake Mohave 1503010102	0.0	0.0	0.19	1	0	0.16
Silver Creek Wash-Lower Colorado River 1503010103	0.5	1.0	1.0	1	0.03	0.75
Topock Marsh-Lower Colorado River 1503010104	0.5	1.0	0.76	1	0	0.68
Lower Colorado River-Lake Havasu 1503010106	0.5	1.0	1.0	1	0.15	0.77
Tennessee Wash-Sacramento Wash 1503010301	0.5	0.28	1.0	1	0	0.61
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	1.0	1.0	1	0.07	0.76
Buck Mountain Wash 1503010303	0.5	0.0	0.20	1	0	0.31
Walnut Creek-Sacramento Wash 1503010304	0.5	0.46	0.115	1	0	0.38
Franconia Wash-Sacramento Wash 1503010305	0.5	0.0	0.60	1	0	0.43
Osborne Wash-Lower Colorado River 1503010401	0.5	0.23	0.76	1	0	0.52
Upper Parker Valley-Lower Colorado River 1503010403	0.5	1.0	1.0	0.25	0	0.68
Lower Parker Valley-Lower Colorado River 1503010404	0.5	1.0	1.0	0.50	0	0.70
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	0.30	0.73	1	0	0.53
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	0.0	0.16	1	0	0.30

Subwatershed Name	RE WQA	RE HU Index Watershed	RE HU Index Riparian	RE Land Use	RE Urban Areas	RE (Weighted)
Gould Wash-Lower Colorado River 1503010409	0.5	1.0	0.85	1	0	0.71
Yuma Wash-Lower Colorado River 1503010410	0.3	0.0	0.10	1	0	0.22
Martinez Lake-Lower Colorado River 1503010411	0.0	0.0	0.21	1	0	0.16
Alamo Wash 1503010501	0.5	0.0	0.13	1	0	0.29
Upper Bouse Wash 1503010502	0.5	0.97	0.30	1	0	0.53
Cunningham Wash 1503010503	0.5	1.0	0.32	1	0	0.55
Middle Bouse Wash 1503010504	0.5	1.0	0.69	1	0	0.66
Lower Bouse Wash 1503010505	0.5	1.0	0.31	1	0	0.54
Upper Tyson Wash 1503010601	0.5	0.0	0.18	1	0	0.30
Middle Tyson Wash 1503010602	0.5	0.41	0.69	1	0	0.54
Lower Tyson Wash 1503010603	0.5	0.0	0.21	1	0	0.31
Picacho Wash-Lower Colorado River 1503010701	1.0	1.0	1.0	0.50	0	0.85
Lower Colorado River below Morelos Dam 1503010702	1.0	0.60	1.0	0.25	0	0.75
Yuma Desert Area 1503010800	0.7	1.0	1.0	0.50	0	0.76
Columbus Wash 1507020101	0.5	1.0	1.0	1	0	0.75
Fourth of July Wash-Lower Gila River 1507020102	1.0	1.0	0.24	1	0	0.67
Clanton Wash 1507020103	0.5	1.0	0.08	1	0	0.47
Baragan Wash 1507020104	0.5	1.0	0.15	1	0	0.50
Nottbusch Wash-Lower Gila River 1507020105	0.5	1.0	1.0	1	0	0.75
Hoodoo Wash 1507020106	0.5	0.08	0.24	1	0	0.34
Yaqui Wash 1507020107	0.5	0.0	0.08	1	0	0.27

Subwatershed Name	RE WQA	RE HU Index Watershed	RE HU Index Riparian	RE Land Use	RE Urban Areas	RE (Weighted)
Gravel Wash 1507020108	0.5	0.0	0.12	1	0	0.29
Park Valley-Lower Gila River 1507020109	0.5	1.0	1.0	1	0	0.75
Upper Mohawk Wash 1507020110	0.5	0.0	0.04	1	0	0.26
Lower Mohawk Wash 1507020111	0.5	0.67	0.27	1	0	0.47
Big Eye Wash Area 1507020112	0.5	0.0	0.12	1	0	0.29
Coyote Wash Area 1507020113	0.5	0.52	0.25	1	0	0.43
Morgan Wash-Lower Gila River 1507020114	0.5	1.0	1.0	0.50	0	0.70
Castle Dome Wash 1507020115	0.5	0.0	0.33	1	0	0.35
Fortuna Wash-Lower Gila River 1507020116	0.7	1.0	1.0	0.50	0	0.76
Upper Midway Wash 1507020201	0.5	1.0	0.12	1	0.11	0.50
Upper Tenmile Wash 1507020202	0.5	0.15	0.19	1	0	0.34
Lower Midway Wash Area 1507020203	0.5	0.0	0.10	1	0	0.28
Lower Tenmile Wash 1507020204	0.5	1.0	0.31	1	0	0.54
Cherioni Wash 1507020301	0.5	0.0	0.17	1	0	0.30
Cuerda de Lena 1507020302	0.5	0.0	0.11	1	0	0.28
Daniels Arroyo 1507020303	0.5	0.0	0.0	1	0	0.25
Growler Wash 1507020304	0.5	0.0	0.02	1	0	0.26
Upper San Cristobal Wash 1507020305	0.5	0.0	0.04	1	0	0.26
Childs Valley 1507020306	0.5	0.0	0.05	1	0	0.27
Lower San Cristobal Wash 1507020307	0.5	0.09	0.04	1	0	0.28
Weights	0.3	0.2	0.3	0.1	0.1	

Data Sources: Water Quality Assessment data originated by ADEQ, 2008. GIS data layer "land use" originated by Southwest GAP, 2005. http://fws-nmcfwru.nmsu.edu/swregap/. GIS data layer "impervious surfaces," originated by Multi-Resolution Land Characteristics Consortium, National Land Cover Data Set, 2001. www.mrlc.gov. GIS data layers "Human Use" and "Human Use within riparian" originated by Arizona NEMO, 2009. www.arizonanemo.org.

Selenium

At low concentrations, selenium can be beneficial to humans, acting to ameliorate the effects of mercury and cadmium toxicity, but it can be harmful at higher concentrations (Wright and Welbourne, 2002). Some plants, including locoweed (*Astragalus*), growing on selenium-rich soils can accumulate selenium in their tissues which can be potentially toxic to grazing animals. The sudden death of 21 polo ponies in Florida in April 2009 has been attributed to selenium toxicity (Ballantyne, 2009). Fish in water contaminated by selenium accumulate selenium which can be passed on to fish-eating predators (Wright and Welbourne, 2002).

Selenium occurs in sedimentary rocks, often in association with silver and copper (Wright and Welbourne, 2002). Some salts of selenium are highly water-soluble and thus available to aquatic organisms. A common source of elevated selenium in the western United States is drainage water from selenium-rich irrigated soils (Hem, 1970) where evaporation has increased the concentration of selenium and salts in the tail water. A variety of industrial processes, including the burning of coal and the manufacture of glass and paint, can release selenium into the environment.

The factors considered for developing the final risk classification for selenium were the ADEQ water quality assessments for selenium, the number of mines per 10-digit HUC subwatershed, and the percentage of agricultural land in the subwatershed.

Water Quality Assessment - Selenium

The ADEQ Water Quality Assessment results were used to define the current water quality based on water monitoring results. In assigning risk evaluation (RE) values, the location of a subwatershed relative to an impaired or not attaining water was considered (see Table 2-1). Table 2-17 contains the risk evaluation (RE) scores for selenium for each subwatershed based on the water quality assessment results.

Table 2-17: Colorado-Lower Gila Watershed Risk Evaluations (RE) for Selenium, Assigned to each 10-digit HUC Subwatershed, Based on Water Quality Assessment Result.

Subwatershed Name	**Selenium WQA RE**	**Justification**
Jumbo Wash-Lower Colorado River 1503010101	1.0	Classified as extreme risk, drains to Lower Colorado-Lake Mohave, which is classified as moderate risk.
Lower Colorado River-Lake Mohave 1503010102	0.5	Classified as moderate risk, drains to Silver Creek Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Silver Creek Wash-Lower Colorado River 1503010103	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Selenium WQA RE	Justification
Topock Marsh-Lower Colorado River 1503010104	0.5	Classified as moderate risk due to insufficient data, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Lower Colorado River-Lake Havasu 1503010106	0.5	Classified as moderate risk, drains to Lower Colorado River-Lake Havasu, which is classified as moderate risk.
Tennessee Wash-Sacramento Wash 1503010301	0.5	Classified as moderate risk due to insufficient data, drains to Thirteenmile Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	Classified as moderate risk due to insufficient data, drains to Walnut Creek-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Buck Mountain Wash 1503010303	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Walnut Creek-Sacramento Wash 1503010304	0.5	Classified as moderate risk due to insufficient data, drains to Franconia Wash-Sacramento Wash, which is classified as moderate risk due to insufficient data.
Franconia Wash-Sacramento Wash 1503010305	0.5	Classified as moderate risk due to insufficient data, drains to Topock Marsh-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Osborne Wash-Lower Colorado River 1503010401	0.5	Classified as moderate risk, drains to Upper Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Parker Valley-Lower Colorado River 1503010403	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Lower Parker Valley-Lower Colorado River 1503010404	0.5	Classified as moderate risk due to insufficient data, drains to Ehrenberg Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	Classified as moderate risk due to insufficient data, drains to Mohave Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	Classified as moderate risk due to insufficient data, drains to Gould Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Gould Wash-Lower Colorado River 1503010409	0.5	Classified as moderate risk due to insufficient data, drains to Yuma Wash-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Yuma Wash-Lower Colorado River 1503010410	0.3	Classified as moderate risk due to insufficient data, drains to Martinez Lake – Lower Colorado River, which is classified as low risk.
Martinez Lake-Lower Colorado River 1503010411	0.0	Classified as low risk, drains to Picacho Wash-Lower Colorado River, which is classified as extreme risk.
Alamo Wash 1503010501	0.5	Classified as moderate risk due to insufficient data, drains to Upper Bouse Wash, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Selenium WQA RE	Justification
Upper Bouse Wash 1503010502	0.5	Classified as moderate risk due to insufficient data, drains to Middle Bouse Wash, which is classified as moderate risk due to insufficient data.
Cunningham Wash 1503010503	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Middle Bouse Wash 1503010504	0.5	Classified as moderate risk due to insufficient data, drains to Lower Bouse Wash, which is classified as moderate risk due to insufficient data.
Lower Bouse Wash 1503010505	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Upper Tyson Wash 1503010601	0.5	Classified as moderate risk due to insufficient data, drains to Middle Tyson Wash, which is classified as moderate risk due to insufficient data.
Middle Tyson Wash 1503010602	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tyson Wash, which is classified as moderate risk due to insufficient data.
Lower Tyson Wash 1503010603	0.5	Classified as moderate risk due to insufficient data, drains to Lower Parker Valley-Lower Colorado River, which is classified as moderate risk due to insufficient data.
Picacho Wash-Lower Colorado River 1503010701	1.0	Classified as extreme risk, drains to Lower Colorado River below Morelos Dam, which is classified as extreme risk.
Lower Colorado River below Morelos Dam 1503010702	1.0	Classified as extreme risk, drains into Mexico, which is classified as moderate risk due to insufficient data.
Yuma Desert Area 1503010800	0.7	Classified as moderate risk due to insufficient data, drains to Lower Colorado River below Morelos Dam, which is classified as extreme risk.
Columbus Wash 1507020101	0.5	Classified as moderate risk due to insufficient data, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Fourth of July Wash-Lower Gila River 1507020102	0.5	Classified as moderate risk, drains to Nottbusch Wash-Lower Gila River, which is classified as moderate risk due to insufficient data.
Clanton Wash 1507020103	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Baragan Wash 1507020104	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Nottbusch Wash-Lower Gila River 1507020105	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Hoodoo Wash 1507020106	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Yaqui Wash 1507020107	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.

Subwatershed Name	Selenium WQA RE	Justification
Gravel Wash 1507020108	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.
Park Valley-Lower Gila River 1507020109	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash-Lower Gila River, which is classified as extreme risk.
Upper Mohawk Wash 1507020110	0.5	Classified as moderate risk due to insufficient data, drains to Lower Mohawk Wash, which is classified as moderate risk due to insufficient data.
Lower Mohawk Wash 1507020111	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.
Big Eye Wash Area 1507020112	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.
Coyote Wash Area 1507020113	0.7	Classified as moderate risk due to insufficient data, drains to Morgan Wash- Lower Gila River, which is classified as extreme risk.
Morgan Wash-Lower Gila River 1507020114	1.0	Classified as extreme risk, drains to Fortuna Wash-Lower Gila River, which is classified as extreme risk.
Castle Dome Wash 1507020115	0.7	Classified as moderate risk due to insufficient data, drains to Fortuna Wash-Lower Gila River, which is classified as extreme risk.
Fortuna Wash-Lower Gila River 1507020116	1.0	Classified as extreme risk, drains to Picacho Wash-Lower Colorado River, which is classified as extreme risk.
Upper Midway Wash 1507020201	0.5	Classified as moderate risk due to insufficient data, drains to Lower Midway Wash Area, which is classified as moderate risk due to insufficient data.
Upper Tenmile Wash 1507020202	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Midway Wash Area 1507020203	0.5	Classified as moderate risk due to insufficient data, drains to Lower Tenmile Wash, which is classified as moderate risk due to insufficient data.
Lower Tenmile Wash 1507020204	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.
Cherioni Wash 1507020301	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Cuerda de Lena 1507020302	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.
Daniels Arroyo 1507020303	0.5	Classified as moderate risk due to insufficient data, drains to Growler Wash, which is classified as moderate risk due to insufficient data.

Subwatershed Name	Selenium WQA RE	Justification
Growler Wash 1507020304	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Upper San Cristobal Wash 1507020305	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Childs Valley 1507020306	0.5	Classified as moderate risk due to insufficient data, drains to Lower San Cristobal Wash, which is classified as moderate risk due to insufficient data.
Lower San Cristobal Wash 1507020307	0.5	Classified as moderate risk due to insufficient data, drains to Park Valley-Lower Gila River, which is classified as moderate risk due to insufficient data.

Subwatersheds with extreme risk evaluations (RE=1.0) for selenium are Jumbo Wash-Lower Colorado River, Picacho Wash Lower Colorado River, Lower Colorado River below Morelos Dam, Morgan Wash-Lower Gila River, and Fortuna Wash-Lower Gila River.

Martinez Wash-Lower Colorado River received a low risk evaluation (RE=0.0) for selenium.

Agricultural Lands

Runoff irrigation water from agricultural land is a potential source of selenium pollution and so the percentage of agricultural land was considered in the risk classification for each 10-digit HUC watershed (Figure 2-15).

The risk evaluation (RE) values based on percentage of agricultural land were calculated as follows:

If the percentage of agricultural land in a subwatershed = 0, the RE = 0;
If the percentage of agricultural land is greater than 0 and less than 10%, the
    RE = % agricultural land / 10;
If the percentage of agricultural land is 10% or more, the RE = 1.

The results appear in Table 2-18.

Table 2-18: Colorado-Lower Gila Watershed Risk Evaluations (RE) for Percentage of Agricultural Lands in each Subwatershed

Subwatershed	**% Agricultural Land**	**RE Agricultural Land**
Jumbo Wash-Lower Colorado River 1503010101	0%	0.00
Lower Colorado River-Lake Mohave 1503010102	0%	0.00
Silver Creek Wash-Lower Colorado River 1503010103	4%	0.40
Topock Marsh-Lower Colorado River 1503010104	6%	0.59
Lower Colorado River-Lake Havasu 1503010106	0%	0.00
Tennessee Wash-Sacramento Wash 1503010301	0%	0.00
Thirteenmile Wash-Sacramento Wash 1503010302	0%	0.00
Buck Mountain Wash 1503010303	0%	0.00
Walnut Creek-Sacramento Wash 1503010304	0%	0.00
Franconia Wash-Sacramento Wash 1503010305	0%	0.00
Osborne Wash-Lower Colorado River 1503010401	0%	0.00
Upper Parker Valley-Lower Colorado River 1503010403	51%	1.00
Lower Parker Valley-Lower Colorado River 1503010404	44%	1.00
Ehrenberg Wash-Lower Colorado River 1503010406	2%	0.21
Mohave Wash-Lower Colorado River 1503010407	0%	0.00
Gould Wash-Lower Colorado River 1503010409	5%	0.52
Yuma Wash-Lower Colorado River 1503010410	0%	0.00
Martinez Lake-Lower Colorado River 1503010411	0.1%	0.01
Alamo Wash 1503010501	0%	0.00
Upper Bouse Wash 1503010502	1%	0.15
Cunningham Wash 1503010503	2%	0.17
Middle Bouse Wash 1503010504	8%	0.79
Lower Bouse Wash 1503010505	0.95%	0.09
Upper Tyson Wash 1503010601	0%	0.00
Middle Tyson Wash 1503010602	0%	0.00
Lower Tyson Wash 1503010603	0%	0.00
Picacho Wash-Lower Colorado River 1503010701	27%	1.00
Lower Colorado River below Morelos Dam 1503010702	49%	1.00
Yuma Desert Area 1503010800	20%	1.00
Columbus Wash 1507020101	17%	1.00
Fourth of July Wash-Lower Gila River 1507020102	2%	0.21
Clanton Wash 1507020103	0.04%	0.00
Baragan Wash 1507020104	0%	0.00
Nottbusch Wash-Lower Gila River 1507020105	13%	1.00
Hoodoo Wash 1507020106	0.9%	0.09
Yaqui Wash 1507020107	0%	0.00
Gravel Wash 1507020108	0%	0.00
Park Valley-Lower Gila River 1507020109	12%	1.00
Upper Mohawk Wash 1507020110	0%	0.00

Subwatershed	% Agricultural Land	RE Agricultural Land
Lower Mohawk Wash 1507020111	2%	0.19
Big Eye Wash Area 1507020112	0%	0.00
Coyote Wash Area 1507020113	1%	0.12
Morgan Wash-Lower Gila River 1507020114	41%	1.00
Castle Dome Wash 1507020115	0.64%	0.06
Fortuna Wash-Lower Gila River 1507020116	18%	1.00
Upper Midway Wash 1507020201	0%	0.00
Upper Tenmile Wash 1507020202	0%	0.00
Lower Midway Wash Area 1507020203	0.7%	0.07
Lower Tenmile Wash 1507020204	5%	0.54
Cherioni Wash 1507020301	0%	0.00
Cuerda de Lena 1507020302	0%	0.00
Daniels Arroyo 1507020303	0%	0.00
Growler Wash 1507020304	0%	0.00
Upper San Cristobal Wash 1507020305	0%	0.00
Childs Valley 1507020306	0%	0.00
Lower San Cristobal Wash 1507020307	0.3%	0.03

Data Sources: GIS data layer "agricultural lands" originated by Southwest Regional GAP, 2005. http://fws-nmcfwru.nmsu.edu/swregap/

Number of Mines per Watershed

Because of the association of selenium with metal ores, the number of mines per 10-digit HUC subwatershed (Figure 2-2) was used in the determination of the selenium risk classification. The risk evaluation (RE) values were calculated as follows:

If the number of mines is 10 or fewer, the RE = 0;
If the number of mines is 11 to 25, the RE = 0.33;
If the number of mines is 26 to 50, the RE = 0.66;
If the number of mines is greater than 50, the RE = 1.

The results appear in Table 2-19.

Table 2-19: Colorado-Lower Gila Watershed Risk Evaluations (RE) for Selenium, for each 10-digit HUC Subwatershed Based on Number of Mines

Subwatershed	Number of Mines	RE for Mines
Jumbo Wash-Lower Colorado River 1503010101	8	0.0
Lower Colorado River-Lake Mohave 1503010102	34	0.66
Silver Creek Wash-Lower Colorado River 1503010103	264	1.0
Topock Marsh-Lower Colorado River 1503010104	23	0.33
Lower Colorado River-Lake Havasu 1503010106	35	0.66
Tennessee Wash-Sacramento Wash 1503010301	195	1.0

Subwatershed	**Number of Mines**	**RE for Mines**
Thirteenmile Wash-Sacramento Wash 1503010302	84	1.0
Buck Mountain Wash 1503010303	3	0.0
Walnut Creek-Sacramento Wash 1503010304	33	0.66
Franconia Wash-Sacramento Wash 1503010305	18	0.33
Osborne Wash-Lower Colorado River 1503010401	59	1.0
Upper Parker Valley-Lower Colorado River 1503010403	1	0.0
Lower Parker Valley-Lower Colorado River 1503010404	4	0.0
Ehrenberg Wash-Lower Colorado River 1503010406	28	0.66
Mohave Wash-Lower Colorado River 1503010407	3	0.0
Gould Wash-Lower Colorado River 1503010409	10	0.0
Yuma Wash-Lower Colorado River 1503010410	36	0.66
Martinez Lake-Lower Colorado River 1503010411	5	0.00
Alamo Wash 1503010501	0	0.00
Upper Bouse Wash 1503010502	42	.66
Cunningham Wash 1503010503	52	1.0
Middle Bouse Wash 1503010504	153	1.0
Lower Bouse Wash 1503010505	62	1.0
Upper Tyson Wash 1503010601	10	0.0
Middle Tyson Wash 1503010602	44	0.66
Lower Tyson Wash 1503010603	9	0.0
Picacho Wash-Lower Colorado River 1503010701	15	0.33
Lower Colorado River below Morelos Dam 1503010702	8	0.0
Yuma Desert Area 1503010800	129	1.0
Columbus Wash 1507020101	12	0.33
Fourth of July Wash-Lower Gila River 1507020102	11	0.33
Clanton Wash 1507020103	15	0.33
Baragan Wash 1507020104	10	0.0
Nottbusch Wash-Lower Gila River 1507020105	8	0.0
Hoodoo Wash 1507020106	11	0.33
Yaqui Wash 1507020107	31	0.66
Gravel Wash 1507020108	6	0.0
Park Valley-Lower Gila River 1507020109	37	0.66
Upper Mohawk Wash 1507020110	0	0.0
Lower Mohawk Wash 1507020111	5	0.0
Big Eye Wash Area 1507020112	6	0.0
Coyote Wash Area 1507020113	12	0.33
Morgan Wash-Lower Gila River 1507020114	13	0.33
Castle Dome Wash 1507020115	69	1.0
Fortuna Wash-Lower Gila River 1507020116	46	0.66
Upper Midway Wash 1507020201	0	0.0
Upper Tenmile Wash 1507020202	16	0.33
Lower Midway Wash Area 1507020203	1	0.0

Subwatershed	Number of Mines	RE for Mines
Lower Tenmile Wash 1507020204	6	0.0
Cherioni Wash 1507020301	2	0.0
Cuerda de Lena 1507020302	25	0.33
Daniels Arroyo 1507020303	5	0.0
Growler Wash 1507020304	5	0.0
Upper San Cristobal Wash 1507020305	0	0.0
Childs Valley 1507020306	1	0.0
Lower San Cristobal Wash 1507020307	3	0.0

Data Sources: GIS data layer "mines" originated by Arizona Land Information System (ALRIS 2006). www.landstate.az.us/alris/

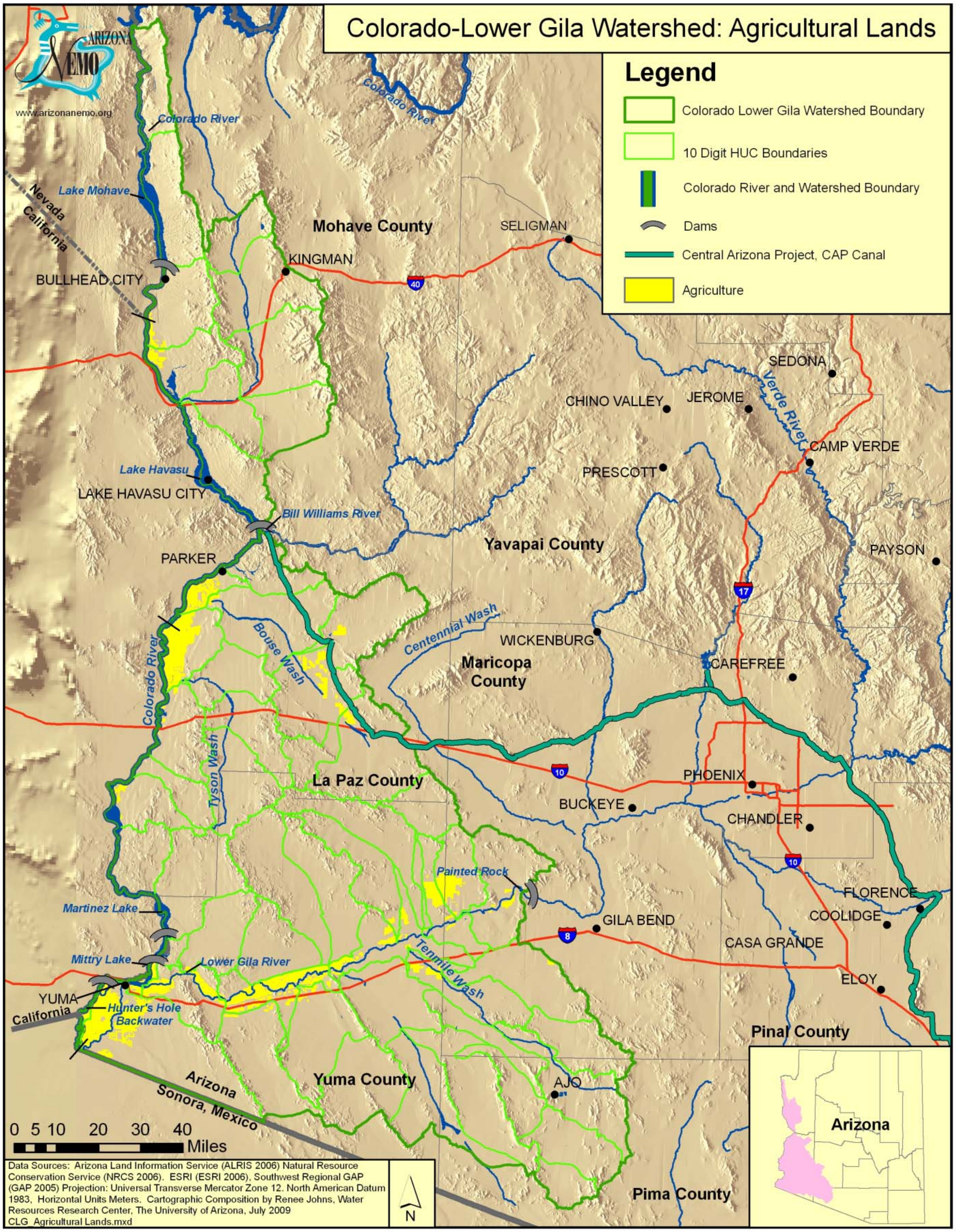
The factors described above were used to compute a final risk classification for selenium (Table 2-20; Figure 2-16).

Table 2-20: Colorado-Lower Gila Watershed Summary Results for Selenium Based on the Risk Evaluations (RE)- Weighted Combination Approach

Subwatershed Name	WQA RE	RE Agriculture/HUC	RE mines/HUC	RE Weighted
Jumbo Wash-Lower Colorado River 1503010101	1.0	0.00	0.0	0.5
Lower Colorado River-Lake Mohave 1503010102	0.5	0.00	0.66	0.42
Silver Creek Wash-Lower Colorado River 1503010103	0.5	0.40	1.0	0.60
Topock Marsh-Lower Colorado River 1503010104	0.5	0.59	0.33	0.48
Lower Colorado River-Lake Havasu 1503010106	0.5	0.00	0.66	0.42
Tennessee Wash-Sacramento Wash 1503010301	0.5	0.00	1.0	0.50
Thirteenmile Wash-Sacramento Wash 1503010302	0.5	0.00	1.0	0.50
Buck Mountain Wash 1503010303	0.5	0.00	0.0	0.25
Walnut Creek-Sacramento Wash 1503010304	0.5	0.00	0.66	.42
Franconia Wash-Sacramento Wash 1503010305	0.5	0.00	0.33	0.33
Osborne Wash-Lower Colorado River 1503010401	0.5	0.00	1.0	0.50
Upper Parker Valley-Lower Colorado River 1503010403	0.5	1.00	0.0	0.50
Lower Parker Valley-Lower Colorado River 1503010404	0.5	1.00	0.0	0.50
Ehrenberg Wash-Lower Colorado River 1503010406	0.5	0.21	0.66	0.47
Drains to Mohave Wash-Lower Colorado River 1503010407	0.5	0.00	0.0	0.25
Gould Wash-Lower Colorado River 1503010409	0.5	0.52	0.0	0.38
Yuma Wash-Lower Colorado River 1503010410	0.3	0.00	0.66	0.32
Martinez Lake-Lower Colorado River 1503010411	0.0	0.01	0.00	>0.00
Alamo Wash 1503010501	0.5	0.00	0.00	0.25

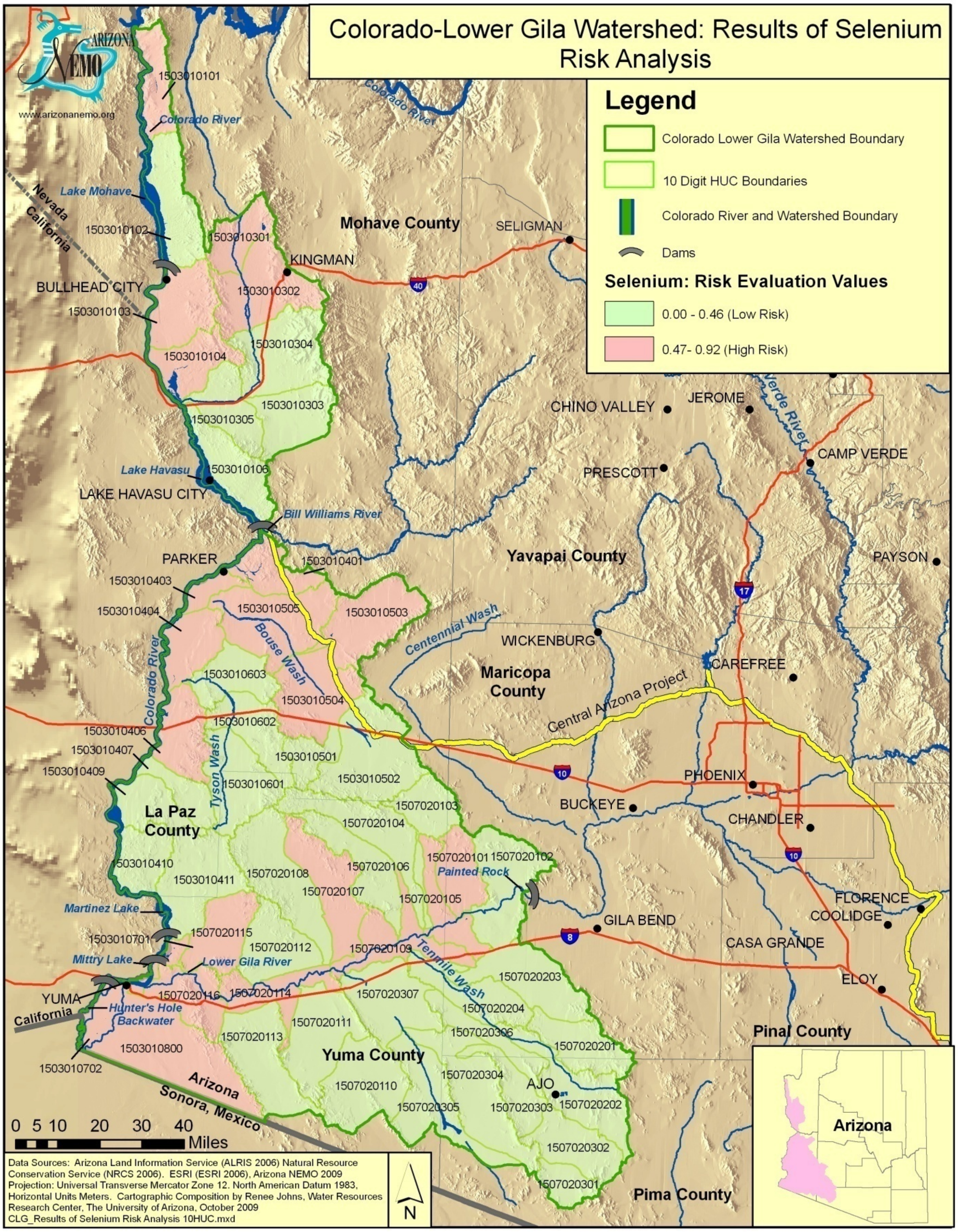
Subwatershed Name	WQA RE	RE Agriculture/HUC	RE mines/HUC	RE Weighted
Upper Bouse Wash 1503010502	0.5	0.15	0.66	.45
Cunningham Wash 1503010503	0.5	0.17	1.0	0.54
Middle Bouse Wash 1503010504	0.5	0.79	1.0	0.70
Lower Bouse Wash 1503010505	0.5	0.09	1.0	0.52
Upper Tyson Wash 1503010601	0.5	0.00	0.0	0.25
Middle Tyson Wash 1503010602	0.5	0.00	0.66	0.42
Lower Tyson Wash 1503010603	0.5	0.00	0.0	0.25
Picacho Wash-Lower Colorado River 1503010701	1.0	1.00	0.33	0.83
Lower Colorado River below Morelos Dam 1503010702	1.0	1.00	0.0	0.75
Yuma Desert Area 1503010800	0.7	1.00	1.0	0.85
Columbus Wash 1507020101	0.5	1.00	0.33	0.58
Fourth of July Wash-Lower Gila River 1507020102	0.5	0.21	0.33	0.39
Clanton Wash 1507020103	0.5	0.00	0.33	0.33
Baragan Wash 1507020104	0.5	0.00	0.0	0.25
Nottbusch Wash-Lower Gila River 1507020105	0.5	1.00	0.0	0.50
Hoodoo Wash 1507020106	0.5	0.09	0.33	0.36
Yaqui Wash 1507020107	0.7	0.00	0.66	0.52
Gravel Wash 1507020108	0.7	0.00	0.0	0.35
Park Valley-Lower Gila River 1507020109	0.7	1.00	0.66	0.77
Upper Mohawk Wash 1507020110	0.5	0.00	0.0	0.25
Lower Mohawk Wash 1507020111	0.7	0.19	0.0	0.40
Big Eye Wash Area 1507020112	0.7	0.00	0.0	0.35
Coyote Wash Area 1507020113	0.7	0.12	0.33	0.46
Morgan Wash-Lower Gila River 1507020114	1.0	1.00	0.33	0.83
Castle Dome Wash 1507020115	0.7	0.06	1.0	0.62
Fortuna Wash-Lower Gila River 1507020116	1.0	1.00	0.66	0.92
Upper Midway Wash 1507020201	0.5	0.00	0.0	0.25
Upper Tenmile Wash 1507020202	0.5	0.00	0.33	0.33
Lower Midway Wash Area 1507020203	0.5	0.07	0.0	0.27
Lower Tenmile Wash 1507020204	0.5	0.54	0.0	0.39
Cherioni Wash 1507020301	0.5	0.00	0.0	0.25
Cuerda de Lena 1507020302	0.5	0.00	0.33	0.33
Daniels Arroyo 1507020303	0.5	0.00	0.0	0.25
Growler Wash 1507020304	0.5	0.00	0.0	0.25
Upper San Cristobal Wash 1507020305	0.5	0.00	0.0	0.25
Childs Valley 1507020306	0.5	0.00	0.0	0.25
Lower San Cristobal Wash 1507020307	0.5	0.30	0.0	0.33
Weights	0.5	0.25	0.25	

Data Sources: Water Quality Assessment data originated by ADEQ, 2008, www.azdeq.gov. GIS data Layer "agriculture" originated by Southwest GAP, 2005. http://fws-nmcfwru.nmsu.edu/swregap. GIS data layer "mines" originated by Arizona Land Information System (ALRIS 2006) www.land.state.az.us/alris/.



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Southwest Regional GAP (GAP 2005) Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, July 2009
CLG_Agricultural Lands.mxd

Figure 2-15: Agricultural Lands



Data Sources: Arizona Land Information Service (ALRIS 2006) Natural Resource Conservation Service (NRCS 2006). ESRI (ESRI 2006), Arizona NEMO 2009
Projection: Universal Transverse Mercator Zone 12. North American Datum 1983, Horizontal Units Meters. Cartographic Composition by Renee Johns, Water Resources Research Center, The University of Arizona, October 2009
CLG_Results of Selenium Risk Analysis 10HUC.mxd

Figure 2-16: Results of Selenium Risk Analysis

Summary of Risk Analyses

The risk evaluations (REs) for each of the four risk categories, metals, sediment, organics/nutrients, and selenium, for each 10-digit HUC subwatershed in the Colorado-Lower Gila Watershed are compiled and summarized in Table 2-21. These rankings are used to identify locations for the implementation of water quality improvement projects to reduce nonpoint source pollution in the Colorado-Lower Gila Watershed.

Table 2-21: Colorado-Lower Gila Watershed Summary of Ranking and Risk

Subwatershed Name	**RE (Weighted) Metals**	**RE (Weighted) Sediments**	**RE (Weighted) Organics**	**RE (Weighted) Selenium**
Jumbo Wash-Lower Colorado River 1503010101	0.21	0.12	0.23	0.5
Lower Colorado River-Lake Mohave 1503010102	0.35	0.12	0.16	0.42
Silver Creek Wash-Lower Colorado River 1503010103	0.50	0.33	0.75	0.60
Topock Marsh-Lower Colorado River 1503010104	0.55	0.36	0.68	0.48
Lower Colorado River-Lake Havasu 1503010106	0.72	0.64	0.77	0.42
Tennessee Wash-Sacramento Wash 1503010301	0.70	0.52	0.61	0.50
Thirteenmile Wash-Sacramento Wash 1503010302	0.76	0.62	0.76	0.50
Buck Mountain Wash 1503010303	0.32	0.20	0.31	0.25
Walnut Creek-Sacramento Wash 1503010304	0.75	0.53	0.38	.42
Franconia Wash-Sacramento Wash 1503010305	0.50	0.29	0.43	0.33
Osborne Wash-Lower Colorado River 1503010401	0.70	0.44	0.52	0.50
Upper Parker Valley-Lower Colorado River 1503010403	0.15	0.29	0.68	0.50
Lower Parker Valley-Lower Colorado River 1503010404	0.22	0.23	0.70	0.50
Ehrenberg Wash-Lower Colorado River 1503010406	0.6	0.46	0.53	0.47
Drains to Mohave Wash-Lower Colorado River 1503010407	0.38	0.39	0.30	0.25
Gould Wash-Lower Colorado River 1503010409	0.54	0.48	0.71	0.38
Yuma Wash-Lower Colorado River 1503010410	0.54	0.38	0.22	0.32
Martinez Lake-Lower Colorado River 1503010411	0.30	0.36	0.16	>0.00

Subwatershed Name	RE (Weighted) Metals	RE (Weighted) Sediments	RE (Weighted) Organics	RE (Weighted) Selenium
Alamo Wash 1503010501	0.35	0.33	0.29	0.25
Upper Bouse Wash 1503010502	0.60	0.27	0.53	0.45
Cunningham Wash 1503010503	0.65	0.51	0.55	0.54
Middle Bouse Wash 1503010504	0.70	0.46	0.66	0.70
Lower Bouse Wash 1503010505	0.50	0.09	0.54	0.52
Upper Tyson Wash 1503010601	0.48	0.39	0.30	0.25
Middle Tyson Wash 1503010602	0.55	0.33	0.54	0.42
Lower Tyson Wash 1503010603	0.54	0.27	0.31	0.25
Picacho Wash-Lower Colorado River 1503010701	0.44	0.38	0.85	0.83
Lower Colorado River below Morelos Dam 1503010702	0.48	0.26	0.75	0.75
Yuma Desert Area 1503010800	0.55	0.33	0.76	0.85
Columbus Wash 1507020101	0.31	0.56	0.75	0.58
Fourth of July Wash-Lower Gila River 1507020102	0.44	0.30	0.67	0.39
Clanton Wash 1507020103	0.47	0.51	0.47	0.33
Baragan Wash 1507020104	0.54	0.45	0.50	0.25
Nottbusch Wash-Lower Gila River 1507020105	0.37	0.48	0.75	0.50
Hoodoo Wash 1507020106	0.60	0.45	0.34	0.36
Yaqui Wash 1507020107	0.56	0.20	0.27	0.52
Gravel Wash 1507020108	0.47	0.32	0.29	0.35
Park Valley-Lower Gila River 1507020109	0.56	0.36	0.75	0.77
Upper Mohawk Wash 1507020110	0.15	0.15	0.26	0.25
Lower Mohawk Wash 1507020111	0.35	0.32	0.47	0.40
Big Eye Wash Area 1507020112	0.41	0.32	0.29	0.35
Coyote Wash Area 1507020113	0.56	0.26	0.43	0.46
Morgan Wash-Lower Gila River 1507020114	0.64	0.61	0.70	0.83
Castle Dome Wash 1507020115	0.61	0.33	0.35	0.62
Fortuna Wash-Lower Gila River 1507020116	0.7	0.41	0.76	0.92
Upper Midway Wash 1507020201	0.31	0.40	0.50	0.25
Upper Tenmile Wash 1507020202	0.49	0.33	0.34	0.33
Lower Midway Wash Area 1507020203	0.15	0.03	0.28	0.27
Lower Tenmile Wash 1507020204	0.35	0.19	0.54	0.39
Cherioni Wash 1507020301	0.15	0.03	0.30	0.25
Cuerda de Lena 1507020302	0.5	0.09	0.28	0.33
Daniels Arroyo 1507020303	0.35	0.03	0.25	0.25
Growler Wash 1507020304	0.41	0.03	0.26	0.25
Upper San Cristobal Wash 1507020305	0.15	0.09	0.26	0.25
Childs Valley 1507020306	0.15	0.03	0.27	0.25
Lower San Cristobal Wash 1507020307	0.22	0.12	0.28	0.33

Data Sources: RE weighted values originated by Arizona NEMO. www.arizonanemo.org

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**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases and is also found on the NEMO website (ArizonaNEMO.org). Metadata includes the original source of the data, when it was created, it's geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Section 3: Watershed Management and Improvements

Watershed Management

The foregoing section of this plan identifies sub-watersheds at highest risk for four categories of pollutants: metals sediment, organics, and selenium. This section discusses management measures that can be used to address these problems. These recommendations are subject to revision by land use decision makers and stakeholders, and may need to be revised based on new data as they become available.

It is understood that the application of any management activities will require site-specific design and may require licensed engineering design. The recommendations in this section are general in nature and are presented to help land use decision makers and watershed stakeholders conceptualize how best to address watershed management.

Management in Impaired or Not Attaining Watersheds

When a surface water is assessed as impaired or not attaining (see discussion in Section 1), ADEQ implements a series of strategies that should eventually result in pollutant load reductions in the watershed. ADEQ recognizes that improvements in water quality do not just happen. They take hard work, cooperation, and frequently money to fund water quality improvement projects. To properly expend limited resources, concerned stakeholders must become knowledgeable about sources of the pollutants causing water quality impairments and the best methods for reducing pollutant loadings. Both regulatory and non-regulatory ways to lessen pollutant loading must be considered.

For each impaired or not attaining watershed, ADEQ tries to determine the best strategies for educating the target audiences about the pollutant of concern and implementing projects that would restore water quality. Identifying the best education and water quality improvement projects requires planning, coordination, and cooperation. Once an impairment is identified, one or more of the following occurs:

- Total Maximum Daily Load (TMDL) and a TMDL Improvement Plan (TIP)
- Watershed Improvement Plan
- Best Management Practices (BMP) at critical sites across a watershed
- Stakeholder teams and ADEQ program teams are created to identify regulatory and non-regulatory strategies that could reduce pollutant loading

TMDLs and TIPs

A Total Maximum Daily Load is the maximum amount (load) of a water quality parameter which can be carried by a surface water on a daily basis, without causing an exceedance of surface water quality standards. A TMDL must be prepared for each surface water listed as impaired or not attaining unless other actions are being taken that will result in the surface water meeting standards.

A TMDL is the sum of the load allocations (LAs) plus the sum of the wasteload allocations (WLAs) plus a margin of safety (MOS): **TMDL = ΣLA + ΣWLA + MOS**

Load allocations include nonpoint source pollutant contributions, like loads from runoff from fields, streets, rangeland, or forest land. Natural background is included in the load allocation for nonpoint sources. Wasteload allocations include point source contributions, like the loads from sewage treatment plant discharges and mine adit discharges. Load allocations and wasteload allocations are based on historic and recent water quality measurements and other environmental information. Once a TMDL is calculated, necessary load reductions are determined by comparing the TMDL to the total measured or modeled load on a source-by-source basis.

A wasteload allocation would be developed for each source category identified (e.g., septic systems, grazing, urban runoff). Sampling data is also used to identify critical conditions when exceedances tend to occur. Critical conditions may be climactic (summer, winter, monsoons), hydrologic (high flows, low flows), or event-based (discharges, spills). These conditions must be considered when identifying strategies to reduce loading and when doing effectiveness monitoring.

TMDLs are calculated by ADEQ technical staff or ADEQ contractors; however, decisions about how to implement TMDLs must be made by local watershed stakeholders (the affected parties). After the TMDL is developed, ADEQ works with watershed partners to develop TMDL Implementation Plans to identify priority projects that must be implemented so that surface water standards can be met.

A TMDL Improvement Plan (TIP) indicates the improvements and strategies that need to be implemented, along with schedules, milestones, funding commitments, education needs, and effectiveness monitoring needed. It is a guidebook for bringing the impaired or not attaining surface water back into compliance with water quality standards.

TMDL Improvement Plans are a required component of developing the TMDL and are often incorporated into the document. The TIP may be the best way to direct mitigation efforts, especially if the pollutant is toxic or private property concerns rule out citizen surveys and sampling (e.g., metals and acid mine waste). TIP development may all the planning needed if the TMDL identified distinct pollutant sources that can be remediated or when adjustments in permitted discharges can resolve the problem.

Watershed Improvement Plans

ADEQ has recently initiated a Nonpoint Source grant for locally-led development of Watershed Improvement Plans (WIPs). The WIP contains the same components as a TIP -- strategies, schedules, milestones, funding commitments, education needs, and effectiveness monitoring plans. The difference is in the level of citizen involvement in developing the plan. A Watershed Improvement Council, with broad representation of groups and individuals who might be affected by the plan (stakeholders), is developed to oversee the plan development. Volunteer citizens are recruited to survey and do further sampling in the watershed. The plan Watershed Improvement Council also identifies the priority water quality improvement projects and education needs for the watershed. The WIP developed by the community will direct the use of resources available to reduce pollutant loading.

Development of a WIP is preferable when pollutant loading from many types of sources spread out across the watershed, and when long-term voluntary efforts will be required to mitigate the loading. In such cases, the watershed community must be empowered to identify sources of the pollutants and actions that need to be taken, and then develop a Watershed Improvement Plan (WIP) to focus resources. Plan implementation is more likely when watershed stakeholders identify strategies, remediation, and education efforts for the watershed, rather than outside state government entities. Improvement projects are more likely to be maintained when the community has been involved in its development.

Such locally-led planning efforts must be closely integrated with efforts to develop and implement other types of plans and TMDLs. If successful, the WIP may shorten the time needed to develop the TMDL or eliminate the need for doing one.

BMP Implementation Across a Watershed

Sometimes additional formal planning efforts are not needed. ADEQ has recently developed another Nonpoint Source Grant to implement Best Management Practices across a watershed.

This approach is appropriate when:

- The impaired or not attaining watershed has uniform land uses
- Applicable BMPs have been identified and have been shown to be effective
- Land owners want to implement the BMPs
- Criteria can be established for determining where BMPs will be implemented and how they will be designed for maximum effectiveness

Due to the complexity associated with accurately identifying all of the relevant pollutant sources, and having all target land owners involved, these grants are usually implemented at 10-digit HUC scale or smaller.

Stakeholder Teams and ADEQ Program Teams

It will take time to address all stream reaches and lakes listed as impaired or not meeting designated uses in Arizona – more than 100 are currently listed. Therefore, ADEQ sometimes uses something as simple as a team to develop and implement regulatory and non-regulatory strategies to mitigate impairment. This can be effective in watersheds where land is primarily owned by a state or federal agency with a commitment to eliminate the water quality impairment. It could also be effective when permit compliance issues will need to be resolved to mitigate pollutant loading.

Site Management on New Development

Control the quantity and quality of water run-off from new development sites. The primary sources for future development in the Colorado-Lower Gila Watershed include new housing developments and increased urbanization, new road construction, and agriculture.

ADEQ requires Aquifer Protection Permitting and the issuance of Stormwater Management Plans for active mine sites, and it is assumed that ongoing nonpoint pollutants are originating from abandoned mine sites. It is important to promote the application of nonpoint source management measures on all new development sites through cooperation with local government, developers and private land owners.

Monitoring and Enforcement Activities

- Continue and expand water quality monitoring programs in the watershed to measure the effectiveness of management practices on protecting and restoring the waters of the Colorado-Lower Gila Watershed.
- Promote septic tank inspections and certification of septic systems by local government entities.
- Promote construction site inspection and enforcement action for new development.

Water Quality Improvement and Restoration Projects

- Promote efforts to protect and restore the natural functions and characteristics of impaired or not attaining water bodies. Potential projects are discussed below.
- Integrate adaptive management methods and activities across the watershed to address existing and future problems.

Education

- Develop programs to increase the awareness and participation of citizens, developers and local decision makers on land use activities that generate nonpoint pollutants and encourage watershed management efforts. Education programs are discussed below.

Strategy for Addressing Existing Impairments: Metals

A TMDL (Total Maximum Daily Load) is the maximum amount of a water quality parameter that can be carried by a surface water body, on a daily basis, without causing surface water quality standards to be exceeded (http://www.azdeq.gov/environ/water/assessment/tmdl.html). The Arizona Department of Environmental Quality (ADEQ) TMDL Program is designed to help an impaired or not attaining stream or lake meet its water quality standards and support its designated uses.

ADEQ currently has no TMDL projects for metals in the Colorado-Lower Gila Watershed.

Potential Sources

The primary nonpoint sources of anthropogenic metals in the Colorado-Lower Gila Watershed are abandoned or inactive mines, although naturally occurring metals originating from local highly mineralized soils may contribute to elevated background concentrations in streams and lakes. Industrial and urban sources of metals may also be important due to the amount of development in the Yuma and Las Vegas areas. Portions of the Colorado-Lower Gila Watershed have a long history of mining, with many abandoned and several active mines found across the watershed. In most cases the original owner or responsible party for an abandoned mine is unknown and the responsibility for the orphaned mine falls to the current landowner.

Abandoned mines are found on all classes of land ownership in the Colorado-Lower Gila Watershed, including Federal, State and private lands, with a majority of the mines located on land administered by the Federal government and the State of Arizona. Surface runoff and erosion from mine waste are the principal source of nonpoint contamination. Subsurface drainage from mine waste can also be a concern.

Potential BMPs or other management action

The recommended actions include the following

- Inventory of existing abandoned mines;
- Revegetation of disturbed mined lands;
- Erosion control;
- Runoff and sediment capture;
- Tailings and mine waste removal or containment; and
- Education.

Load reduction potential, maintenance, cost and estimated life of revegetation and erosion control treatments for addressing metals from abandoned mines are given in Table 3-1.

Inventory of Existing Abandoned Mines

All existing abandoned mines are not equal sources for elevated concentrations of metals. One of the difficulties in developing this assessment is the lack of thorough and centralized data on abandoned mine sites. Some of the mapped abandoned mine sites are prospector claims with limited land disturbance, while others are remote and disconnected from natural drainage features and represent a low risk pollutant source.

At sites where water and oxygen are in contact with waste rock containing sulfates, sulfuric acid is formed. As the water becomes more acidic, metals are leached from the soils and rock, generating toxic concentrations of heavy metals in the water. Acid rock drainage (also known as acid mine drainage) can be a significant water quality concern. Management of this important source of

Table 3-1. Proposed Treatments for Addressing Metals from Abandoned Mines.

Action	Load Reduction Potential	Estimated Time Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Revegetation	Medium	< 2 years	Low	Low-Medium	Long
Erosion Control Fabric	High	Immediate	Low	Low-Medium	Short
Plant Mulch	Low	Immediate	Low	Low	Short
Rock Mulch	High	Immediate	Medium	Low-High	Long
Toe Drains	High	Immediate	Medium	Medium	Medium
Detention Basin	High	Immediate	High	High	Medium-Long
Silt Fence	Medium	Immediate	Medium	Low	Short-Medium
Straw Roll/bale	Medium	Immediate	High	Low	Short
Removal	High	Immediate	Low	High	Long

NOTE: The actual cost, load reduction, or life expectancy of any treatment is dependent on site specific conditions. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

watershed impairment begins with compiling available information from the responsible agencies. This information can be used to conduct an onsite inventory to clarify the degree of risk the site exhibits towards discharging elevated concentrations of metals to a water body.

Risk factors to be assessed include: area and volume of mine waste; metal species present and toxicity; site drainage features and metal transport characteristics (air dispersion, sediment transport, acid mine drainage, etc.); distance to a water body; and evidence of active site erosion. Abandoned mine sites can then be ranked and prioritized for site management and restoration.

Revegetation

Revegetation of the mine site is the only long-term, low maintenance restoration alternative in the absence of funding to install engineered site containment and capping. In semi-arid environments, revegetation of a disturbed site is relatively difficult even under optimal conditions. The amount of effort required to revegetate an abandoned mine site depends on the chemical composition of the mine waste, which may be too toxic to sustain growth.

Figure 3-1: Reclaimed Mine Site
(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/awardwy.htm)

The addition of soil amendments, buffering agents, or capping with top soil to sustain vegetation often approaches the costs associated with engineered capping. If acid mine drainage is a significant concern, intercepting and managing the acidic water may necessitate extensive site drainage control systems and water treatment, a significant increase in cost and requiring on-going site operation and maintenance.

Erosion Control

If revegetation of the mine site is impractical, site drainage and erosion control treatments are alternatives. Erosion control actions can also be applied in combination with revegetation to control erosion as the vegetation cover is established. Erosion control fabric and plant mulch are two short-term treatments that are usually applied in combination with revegetation.

Rock mulch (rock riprap) is a long-term treatment, but can be costly and impractical on an isolated site.
Rock mulch can be an inexpensive acid buffering treatment if carbonate rocks (limestone) are locally available. As the acidic mine drainage comes in contact with the rock mulch, the water loses its acidity, and dissolved metals precipitate out of the water column. A disadvantage of erosion control treatments is that they do not assist in dewatering a site and may have little impact on subsurface acidic leaching.

Runoff and Sediment Capture

The capture and containment of site runoff and sediment, and the prevention of waste rock and tailings from coming into contact with a water body are other management approaches. Short-term treatments include installing straw roll/bale or silt fence barriers at the toe of the source area to capture sediment.

Long-term treatments include trenching the toe of the source area to capture the runoff and sediment. If the source area is large, the construction of a detention basin may be warranted.

Disadvantages of runoff and sediment capture and containment treatments are that they may concentrate the contaminated material, especially if dissolved metals are concentrated by evaporation in detention ponds. Structural failure can lead to downstream transport of pollutants. The detention of site runoff can also escalate subsurface drainage problems by ponding water.

Load reduction potential, maintenance, cost and estimated life of runoff and sediment control treatments such as toe drains, basins, and silt fences are found in Table 3-2.

Table 3-2. Proposed Treatments for Addressing Erosion and Sedimentation.

Action	Load Reduction Potential	Estimated Time to Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Grazing Mgt.	Medium	< 2 years	Low	Low	Long
Filter Strips	High	< 2 years	Low	Low	Long
Fencing	Low	Immediate	Low	Low	Medium
Watering Facility	Medium	Immediate	Low	Low-Medium	Medium
Rock Riprap	High	Immediate	Medium	Medium-High	Long
Erosion Control Fabric	High	Immediate	Low	Low-Medium	Short
Toe Rock	High	Immediate	Low	Medium	Long
Water Bars	Medium	Immediate	Medium	Medium	Medium
Road Surface	High	Immediate	Medium	High	Long

Note: The actual cost, load reduction, or life expectancy of any treatment is dependent on site specific conditions. Low costs could range from nominal to $10,000, medium costs could range between $5,000 and $50,000, and high costs could be anything greater than $25,000. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

Removal

The mine waste/tailing material can be excavated and removed for pollution control. This treatment is very expensive and infeasible for some sites due to lack of accessibility.

Figure 3-2: Rock Rip-Rap Sediment Control

(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/ocphoto.htm)

Education/Training Needs

Land use decision makers and stakeholders need to be educated on the problems associated with abandoned mines and the available treatments to mitigate the problems. In addition, abandoned mine sites are health and safety concerns and the public should be warned about entering open shafts or traversing unstable slopes. Due to the financial liability associated with site restoration, legal and regulatory constraints must also be addressed.

The target audiences for education programs are private land owners, watershed groups, local officials and land management agencies (U.S. Forest Service, Bureau of Land Management, and Tribal entities).

Figure 3-3: Rock Structure for Runoff Control

(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/ocphoto.htm)

Map 1.4 and Table 1.2 shows land ownership across the Colorado-Lower Gila subwatersheds. This table provides a basis from which to identify stakeholders pertinent to each subwatershed area. Subwatershed areas prioritized for educational outreach to address metals include Lower Colorado-Lake Havasu, Tennessee Wash-Sacramento Wash, Thirteenmile Wash-Sacramento Wash, Walnut Creek-Sacramento Wash, Osborne Wash-Lower Colorado River, Middle Bouse Wash, and Fortuna Wash-Lower Gila River.

Strategy for Addressing existing impairments: Sediment

ADEQ currently has no TMDL projects for sediment in the Colorado-Lower Gila Watershed.

Potential Sources

Erosion and sedimentation are major environment problems in the western United States, including the Colorado-Lower Gila Watershed. In semiarid regions, the primary source of sediment is from channel scour. Excessive channel scour and down-cutting can lead to deterioration of the condition and extent of riparian ecosystems. Increases in channel scour are caused by increased surface runoff produced by changing watershed conditions. Restoration of impaired channel riparian areas can also mitigate erosion damage.

The primary land uses in the Colorado-Lower Gila Watershed that can contribute to erosion are livestock grazing and mining. Development and road building which also contribute to erosion, are increasing in some portions of the watershed. Impervious land surfaces accelerate surface runoff, increase flow velocity, and exacerbates channel scour. Dirt roads can be an important source of sediment as well.

Potential BMPs or Other Management Action

The recommended sediment management actions are:

- Grazing Management
- Filter Strips
- Fencing
- Watering Facilities
- Rock Riprap
- Erosion Control Fabrics
- Toe Rock
- Water Bars
- Erosion Control on Dirt Roads
- Education

Grazing Management

Livestock grazing is currently a major land use in the Colorado-Lower Gila Watershed. Implementing grazing management practices to improve or maintain the health and vigor of plant communities will lead to reductions in surface runoff and erosion. Sustainable livestock grazing can be achieved in all plant communities by managing the duration, frequency and intensity of grazing.

Management may include exclusion of land such as riparian areas from grazing, seasonal rotation, rest or some combination of these options. Proper grazing land management provides for a healthy riparian plant community that stabilizes stream banks, creates habitat and slows flood velocities.

Filter Strips

A filter strip along a stream, lake or other waterbody will retard the movement of sediment, and may remove pollutants from runoff before the material enters the body of water. Filter strips will protect channel and riparian systems from livestock grazing and trampling. Fencing the filter strip is usually required when livestock are present. Filter strips and fencing can be used to protect other sensitive ecological resources.

Fencing

Restricting access to riparian corridors by fencing will allow for the reestablishment of riparian vegetation. Straw bale fencing slows runoff and traps sediment from sheet flow or channelized flow in areas of soil disturbance.

Figure 3-4: Filter strip near waterbody
(http://jasperswcd.org/practices.htm)

Watering Facilities

Alternative watering facilities, such as a tank, trough, or other watertight container at a location removed from the waterbody, can provide animal access to water, protect and enhance vegetative cover, provide erosion control through better management of grazing stock and wildlife, and protect streams, ponds and water supplies from biological contamination. Providing alternative water sources is usually required when creating filter strips and fencing.

Figure 3-5: Alternative cattle watering facilities (http://www.2gosolar.com/typical_installations.htm)

Rock Riprap

Large diameter rock riprap reduces erosion when installed along stream channels and in areas subject to head cutting. Regrading may be necessary before placing the rocks, boulders or coarse stones, and best management practices should be applied to reduce erosion during regrading.

Erosion Control Fabric

Geotextile filter fabrics reduce the potential for soil erosion as well as weed growth and are often installed beneath rock riprap.

Figure 3-6: Rock Riprap and Jute Matting Erosion Control along a stream.
(Photo: Lainie Levick)

Toe Rock

Placement of rock and riprap along the toe of soil slopes reduces erosion and increases slope stability.

Water Bars

A water bar is a shallow trench with mounding along the down-slope edge that intercepts and redirects runoff water in areas of soil disturbance. This erosion control method is most frequently used at tailings piles or on dirt roads.

Erosion Control on Dirt Roads

In collaboration with responsible parties, implement runoff and erosion control treatments on dirt roads and other disturbed areas. Dirt roads can contribute significant quantities of runoff and sediment if not properly constructed and managed. Water bars and surfacing are potential treatments. When a road is adjacent to a stream, it may be necessary to use engineered road stabilization treatments.

The stabilization of roads and embankments reduces sediment input from erosion and protects the related infrastructure. Traditional stabilization relied on expensive rock (riprap) treatments. Other options to stabilize banks include the use of erosion control fabric, toe rock and revegetation.

Figure 3-7: Bank Stabilization and Erosion Control along a highway
(Photo: Lainie Levick)

Channel and Riparian Restoration

Restoration or reconstruction of a stream reach is used when the stream reach has approached or crossed a threshold of stability from which natural recovery may take too long or be unachievable. This practice significantly reduces sediment input to a system and will promote the riparian recovery process. Channel and riparian restoration will be discussed in more detail below.

Education/Training Needs

The development of education programs will help address the impact of livestock grazing and promote the implementation of erosion control treatments. Education programs should address stormwater management from land development and target citizen groups, developers and watershed partnerships.

Based on the sediment and erosion classification completed in Section 6, subwatershed areas prioritized for educational outreach to address erosion control include Lower Colorado River-Lake Havasu, Thirteenmile Wash-Sacramento Wash, and Morgan Wash-Lower Gila River.

Strategy for Addressing Existing Impairments: Organics/Nutrients

Currently there is one TMDL projects for nutrients and organics in the Colorado-Lower Gila Watershed: the Colorado River from the Lower Colorado River-Yuma USGS Gage 0952110 to the International Border that is concentrating on exceedances in nitrogen and phosphorus. A final TMDL report has been completed, and is available on the ADEQ web site (http://www.azdeq.gov/environ/water/assessment/tmdl.html).

Potential Sources

At locations within the Colorado-Lower Gila Watershed, water quality problems associated with the introduction of animal waste occur. The two primary sources of animal waste in the watershed are livestock grazing in riparian areas and failing septic systems.

According to ADEQ, recent investigations have shown that nutrients and *E. coli* bacteria are primarily being contributed by inadequate septic systems, livestock, irrigated crop production, and human impacts in recreational areas due to inadequate toilets and trash, including animals attracted to the garbage left behind or feeding geese at urban lakes. ADEQ has learned that community-wide or watershed-wide plans and project implementation are needed to address such contributions. Replacing a dozen scattered septic systems will have only short term reductions in areas where 500 systems are inadequately sized and located adjacent to a stream. Trash clean-up campaigns have only short-term impacts if the reasons why the trash is being left have not been addressed (http://www.azdeq.gov/environ/water/watershed/download/nonpoint.pdf).

Potential BMPs or Other Management Action

The recommended actions for management of organics are:

- Filter Strips
- Fencing
- Watering Facilities
- Septic System Repair
- Education

Filter Strips

Creating a filter strip along a water body will reduce and may remove pollutants from runoff before the material enters a body of water. Filter strips have been found to be very effective in removing animal waste due to livestock grazing, allowing the organics to bio-attenuate (i.e. be used by the plants), and degrade. Fencing the filter strip and providing an alternative watering source are usually required when dealing with livestock.

Fencing

Restricting access to riparian corridors by fencing will allow for the reestablishment of riparian vegetation. Straw bale or silt fencing slows runoff and traps organics from sheet flow or channelized flow in areas of soil disturbance.

Watering Facilities

Alternative watering facilities, such as a tank, trough, or other watertight container at a location removed from the waterbody, can provide animal access to water and protect streams, ponds and water supplies from biological contamination by grazing cattle. Providing alternative water sources is usually required when creating filter strips.

Figure 3-8: Filter strip near waterbody

(http://jasperswcd.org/practices.htm)

Septic System Repair

One of the difficulties in assessing the impact of failing septic systems to streams is the lack of thorough and centralized data on septic systems. Although it can be assumed that residential development in areas not served by sanitary sewers will rely on private on-site septic systems, the condition of the systems are usually unknown until failure is obvious to the home owner.

Table 3-3. Proposed Treatments for Addressing Organics and Nutrients

Action	Load Reduction Potential	Estimated Time to Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Filter Strips	High	< 2 years	Low	Low	Long
Fencing	Low	Immediate	Low	Low	Medium
Watering Facility	Medium	Immediate	Low	Low-Medium	Medium
Septic System Repair	High	Medium	High	High	Medium

Note: The actual cost, load reduction, or life expectancy of any treatment is dependent on site specific conditions. Low costs could range from nominal to $10,000, medium costs could range between $5,000 and $20,000, and high costs could be anything greater than $15,000. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

Currently, the construction of new septic systems requires a permit from ADEQ in the State of Arizona (some exemptions apply). In addition, ADEQ requires that the septic system be inspected when a property is sold if it was originally approved for use on or after Jan. 1, 2001, by ADEQ or a delegated county agency. This is to help selling and buying property owners understand the physical and operational condition of the septic system serving the home or business. More information is available at the ADEQ website (http://www.azdeq.gov/environ/water/permits/wastewater.html). Although not required by ADEQ, older septic systems should be inspected when purchasing a home with an existing system.

At a minimum, conduct an inventory of locations where private septic systems occur to clarify the degree of risk a stream reach may exhibit due to failure of these systems. Risk factors can be assessed with GIS mapping tools, such as proximity to a waterbody, soil type, depth to the water table, and density of development. Septic system sites can then be ranked and prioritized for further evaluation.

Education/Training Needs

Develop educational programs that explain the sources of organics, address the impacts of livestock grazing, and promote the implementation of filter strips, fencing and alternative watering facilities. In addition, the programs should promote residential septic system maintenance, septic tank inspections and certification of septic systems by local municipalities or government entities.

Based on the results of the organics classification and ranking in Section 2, subwatershed areas that are prioritized for educational outreach to address organics include Silver Creek Wash-Lower Colorado River, Topock Marsh-Lower Colorado River, Lower Colorado-Lake Havasu, Thirteenmile Wash-Sacramento Wash, Upper Parker Valley-Lower Colorado River, Lower Parker Valley-Lower Colorado River, Picacho Wash-Lower Colorado River, Lower Colorado River below Morelos Dam, Yuma Desert

Area, Columbus Wash, Fourth of July Wash-Lower Gila River, Parker Valley-Lower Gila River, and others.

Strategy for Addressing Existing Impairments: Selenium

ADEQ currently has no TMDL projects for selenium in the Colorado-Lower Gila Watershed.

Potential Sources

Selenium occurs naturally in the environment; however, it can enter groundwater or surface water from hazardous waste-sites or irrigated farmland.

Potential BMPs or Other Management Action

The recommended action for the management of selenium is to avoid flood irrigation of croplands, and install a mechanized irrigation system to reduce evaporation. Mechanized irrigation systems include center pivot, linear move, gated pipe, wheel line or drip irrigation. Based on a 1998 study (Hoffman and Willett, 1998) costs range from a low of $340 per acre for the PVC gated pipe to a high of $1,095 per acre for the linear move. The center pivot cost per acre is $550, and wheel line is $805 per acre.

Education/Training Needs

Develop educational programs that explain the sources of selenium, and illustrate the various alternative irrigation systems.

Agriculture represents an important land use in the Colorado-Lower Gila Watershed. Based on the results of the selenium classification and ranking in Section 2, the subwatershed areas that are prioritized for educational outreach to address selenium are Silver Creek Wash-Lower Colorado River, Cunningham Wash, Middle Bouse Wash, Lower Bouse Wash, Picacho Wash-Lower Colorado River, Lower Colorado River below Morelos Dam, Yuma Desert Area, Columbus Wash, Taqui Wash, Park Valley-Lower Gila River, Morgan Wash-Lower Gila River, Castle Dome Wash, and Fortuna Wash-Lower Colorado River.

Strategy for Channel and Riparian Protection and Restoration

Riparian areas are one of the most critical resources in the Colorado-Lower Gila Watershed. Healthy riparian areas stabilize stream banks, decrease channel erosion and sedimentation, remove pollutants from surface runoff, create wildlife habitat, slow flood velocities, promote aquifer recharge, and provide recreational opportunities.

As ground water resources are tapped for water supply, many riparian areas across the watershed are in danger of being dewatered as the water table drops below the base of the stream channel. A large portion of the riparian systems in the watershed are managed by the State of Arizona, Bureau of Land Management, and private landowners. In cooperation with responsible management agencies, riparian protection and restoration efforts should be implemented across the watershed.

Education/Training Needs

The education effort can be supported by the Arizona Nonpoint Education of Municipal Officials (NEMO) program. Arizona NEMO works through the University of Arizona Cooperative Extension Service, in partnership with the Arizona Department of Environmental Quality (ADEQ) Water Quality Division, and the Water Resources Research Center. The goal of Arizona NEMO is to educate land use decision-makers to take voluntary actions that will mitigate nonpoint source pollution and protect our natural resources.

Education programs need to be developed for land use decision makers and stakeholders that will address the various sources of water quality degradation and present management options. The key sources of concern for educational programs are:

- *Abandoned Mines* (control of runoff and sediment)
- *Grazing Management* (erosion control treatments and riparian area protection)
- *Streamside Protection* (filter strips and alternative watering facilities)
- *Riparian Management* (bank stabilization, filter strips and livestock fencing)
- *Septic Systems* (residential septic system maintenance, licensing and inspection programs)
- *Stormwater Management* (control of stormwater runoff from urbanized and developing areas)
- *Water Conservation* (for private residents and to prevent dewatering of natural stream flow and riparian areas)

Local Watershed Planning

The first component of the watershed-based planning process is to summarize all readily available natural resource information and other data for a given watershed. As seen in Section 1 of this document, these data are at a broad-based, large watershed scale and include information on water quality, land use and cover, natural resources and wildlife habitat.

It is anticipated that stakeholder groups will develop their own planning documents. The stakeholder group watershed-based plans may cover a subwatershed within the Colorado-Lower Gila Watershed or include the entire watershed area.
In addition, stakeholder group local watershed-based plans should incorporate local knowledge and concerns gleaned from stakeholder involvement and could include:

- A description of the stakeholder / partnership process;
- A well-stated, overarching goal aimed at protecting, preserving, and restoring habitat and water quality, and encouragement of land stewardship;
- A plan to coordinate natural resource protection and planning efforts;
- A detailed and prioritized description of natural resource management objectives; and
- A detailed and prioritized discussion of best management practices,

strategies and projects to be implemented by the partnership.

The U.S. Environmental Protection Agency has developed a list of 9 key elements that must be included in watershed projects submitted for Section 319 funding. These elements are discussed in Section 3.3 of this Plan.

Potential Water Quality Improvement Projects

GIS, hydrologic modeling and fuzzy logic were used to rank and prioritize the 10-digit HUC subwatersheds for known water quality concerns (Section 2, Watershed Classification). These rankings are used to identify where water quality improvement projects should be implemented to reduce nonpoint source pollution in the Colorado-Lower Gila Watershed. This methodology ranked subwatersheds for four key nonpoint source water quality concerns:

1. Metals originating from abandoned mine sites;
2. Stream sedimentation due to land use activities;
3. Organic and nutrient pollution due to land use activities; and
4. Selenium due to agricultural practices.

Table 2-21 lists the subwatersheds in the Colorado-Lower Gila Watershed and their final weighted risk evaluation (RE) scores for each of these four constituents. The rankings range from a low risk of 0.0 to higher risk values approaching 1.0. See Section 2 for a full discussion on the derivation of these values.

Based on these values, subwatersheds that ranked among the highest for each of the types of nonpoint sources were selected for an example water quality improvement project.

The four example subwatershed projects that will be discussed here are:

- Thirteenmile Wash-Sacramento Wash for metals pollution;
- Lower Colorado River-Lake Havasu for sediment pollution;
- Fourth of July Wash-Lower Gila River; and,
- Fortuna Wash-Lower Gila River for selenium.

Example projects with best management practices to reduce metals, sediment, organic, nutrient and selenium pollution are discussed below. Management measures and their associated costs must be designed and calculated based on site-specific conditions.

Methods for calculating and documenting pollutant reductions for sediment, sediment-borne phosphorus and nitrogen, feedlot runoff, and commercial fertilizer, pesticides and manure utilization can be found on the NEMO web site in the Best Management Practices (BMP) Manual, under Links (www.ArizonaNEMO.org). It is expected that the local stakeholder partnership watershed-based plan will identify projects and locations important to their community, and may differ from the example project locations proposed here.

1. Thirteenmile Wash-Sacramento Wash Subwatershed Example Project

Pollutant Type and Source

Metal-laden sediment originating from an abandoned tailings or spoil pile at an assumed abandoned mine site within the riparian area.

The Thirteenmile Wash-Sacramento Wash Subwatershed was ranked as the most critical area in the Colorado-Lower Gila Watershed impacted by metals related to abandoned mine sites (i.e. highest risk evaluation (RE) value for metals), and a project to control the movement of metal-laden sediment is recommended. Approximately 56% of the land within this subwatershed is federally owned (Bureau of Land Management and the National Park Service), and most of the remainder (43%) is privately owned. Projects implemented on federal or state lands must obtain the permission of the owner and must comply with all local, state and federal permits. In addition, projects implemented on private lands must meet the same permit obligations and notification requirements.

Load Reductions

Calculate and document sediment delivery and pollutant reductions for sediment-borne metals using Michigan DEQ (1999) methodology (found in the NEMO BMP Manual under “Links”). Although this manual addresses sediment reduction with respect to nutrients, the methods can be applied when addressing metals. Particulate metals that generate dissolved metals in the water column and dissolved metals have a tendency to behave like nutrients in the water column.

Management Measures

Various options are available to restore a mine site, ranging from erosion control fabrics and revegetation to the removal and relocation of the tailings material. Table 3-1 presents these management measures along with associated load reduction potential, maintenance, and anticipated costs. It should be recognized that only after a site-specific evaluation can the best treatment option be identified and that the installation of engineered erosion control systems and/or the relocation of the tailings will necessitate project design by a licensed engineer.

2. Lower Colorado River-Lake Havasu Subwatershed Example Project

Pollutant Type and Source

Sediment pollution due to urbanization.

The Lower Colorado River-Lake Havasu subwatershed ranked as the most critical area for sediment pollution, largely due to high erosion and runoff due to high human use (impervious urban areas). For purposes of outlining an example project it will be assumed that urbanization within the riparian area has exacerbated erosion. More than 70% of the land within this subwatershed is federally owned (primarily by Bureau of Land Management); 14% is state owned and 15% is private land). Projects implemented on private, federal or state lands must obtain the permission of the owner and must comply with all local, state and federal permits.

Load Reductions

The goal of this example is to reduce sediment pollution to the subwatershed. Because increased sediment load is assumed to be the result of increased urban stormwater concerns, some background information on current stormwater regulations is necessary.

The Environmental Protection Agency (EPA) has estimated that about 30 percent of known pollution to our nation's waters is attributable to stormwater runoff. In 1987, Congress directed EPA to develop a regulatory program to address the stormwater problem. EPA issued regulations in 1990 authorizing the creation of a National Pollution Discharge Elimination System (NPDES) permitting system for stormwater discharges. In Arizona, this program is called AZPDES, which stands for Arizona Pollutant Discharge Elimination System. Because stormwater runoff can transport pollutants to either a municipal storm sewer system or to a water of the United States, permits are required for those discharges.

Stormwater discharges generated during construction activities can also cause an array of physical, chemical, and biological water quality impacts. Water quality impairment occurs, in part, because a number of pollutants are preferentially absorbed onto mineral or organic particles found in fine sediment. The interconnected process of erosion (detachment of soil particles) and sediment transport during storm events results in water quality degradation. Stormwater runoff from construction sites can include pollutants other than sediment, which may become mobilized when land surfaces are disturbed. These include phosphorous, nitrogen, pesticides, petroleum derivatives, construction chemical and solid wastes.

ADEQ stormwater regulations address both small and large construction sites. Large construction activity refers to the disturbance of 5 or more acres. It also refers to the disturbance of less than 5 acres of total land area that is a part of a larger common plan of development or sale if the large common plan will ultimately disturb five acres or more (see 40 CFR 122.26(b)(14)(x)) (http://www.gpoaccess.gov/cfr/index.html).

Small construction activity refers to the disturbance of 1 or more, but less than 5, acres of land. It also refers to the disturbance of less than 1 acre of total land area that is part of a larger common plan of development of sale if the larger common plan will ultimately disturb 1 or more, but less than 5 acres (see 40 CFR 122.26(b0(15)) (http://www.gpoaccess.gov/cfr/index.html).

To obtain authorization for discharges of stormwater associated with construction activity, the operator must comply with all the requirements of the general permit and submit a Notice of Intent (NOI) and a Stormwater Management Plan (SWMP). More information about Arizona Stormwater.

Regulations and permitting can be found at: http://azdeq.gov/environ.water/permits/stormwater.html.

Management Measures

Municipal ordinances addressing stormwater detention, construction site management, housing density, drainage buffers, impermeable surfaces, and grading are the most effective management measures to address sediment pollution due to stormwater runoff. New ordinance proposals can be initiated by citizen groups within the jurisdiction of the municipality, such as the stake-holder group local watershed partnership.

Generally, properly implemented and enforced construction site ordinances effectively reduce sediment pollution.

In many areas, however, the effectiveness of ordinances in reducing pollutants is limited due to inadequate information or incomplete compliance with local ordinances by construction site operators. Report of obvious construction site violations or local ordinances, for example, failure to manage site waste (messy housekeeping) and tracking of mud onto roadway can be performed by local citizens.

In addition to ordinances as a best management practices to address stormwater sediment, ADEQ Stormwater Regulations require an outreach education component of the Stormwater Management Plans. Stakeholder-group local watershed partnerships can play an important role in educating the public about individual property owner responsibilities in protecting stream water quality.

3. Fourth of July Wash-Lower Gila Subwatershed Example Project

Pollutant Type and Source

Organics and nutrients pollution due to low dissolved oxygen

The rural areas of the Fourth of July Wash-Lower Gila River Subwatershed generally do not have access to public waste water treatment and for this reason organic pollutants are assumed to originate from failing septic systems. However, livestock grazing and cattle watering in the stream channel may also contribute to the pollution concern. The principal land owner within the Fourth of July Wash-Lower Gila River Subwatershed is the U.S. Bureau of Land Management (Table 1-2). Projects implemented on private, state, or federal lands must obtain the permission of the owner and must comply with all local, state, and federal permits.

Load Reductions

Low levels of dissolved oxygen are assumed to result from the introduction into the watershed of animal wastes from feedlots, dairies, and open the grazing of cattle. Load reductions of organic wastes can be calculated and documented for grazing runoff using Michigan DEQ (1999) methodology (see the NEMO BMP Manual).

Management Measures

Implementing grazing management practices to improve or maintain riparian health will help reduce organic pollutants. Management may include exclusion of the land from grazing and/or restricting access to riparian corridors by fencing, which will also reduce the introduction of fecal matter to the stream.

Alternative watering facilities at a location removed from the water body may be necessary. Table 3-2 present load reduction potential, required maintenance and anticipated costs associated with each project option. It should be recognized that only after a site-specific evaluation can the best treatment option be identified.

Failing septic systems can also result in partially treated or untreated surface wastewater containing organics and nutrients, causing nonpoint source pollution in drainage ways, streams, and lakes. The only practical long-term Best Management Practice would be to either upgrade individual septic systems by redesigning and replacing part or all of them, or requiring hook-up to a public wastewater treatment facility. This work must be done by a registered contractor or a business licensed to design and install individual sewage treatment systems, but the greatest constraint to this practice is the significant cost to the homeowner. The Arizona Water Infrastructure Finance Authority (WIFA) could be a source of low interest financing to rural communities seeking to upgrade their wastewater disposal systems to protect water supply, however requiring hook-up still results in costs to the homeowner.

Some locations experiencing rapid development across the state are putting into place ordinances requiring new development to install wastewater treatment facilities, but this does little to address existing systems. Constructed wetland systems have been successfully applied in more humid regions of the country; in Arizona, shallow ground water would be necessary to sustain a constructed wetland treatment system. The constructed wetland system would consist of two shallow basins about 1 foot in depth and containing gravel, which supports emergent vegetation. The first of the two cells is lined to prevent seepage, while the second is unlined and acts as a disposal field. The water level is maintained below the gravel surface, thus preventing odors, public exposure, and vector problems. In an alternative design, a standard septic drain-tile field drain system could be used in place of the second cell.

4. Fortuna Wash-Lower Gila River Subwatershed Example Project

Pollutant Type and Source

Selenium pollution due to irrigation practices.

The Fortuna Wash-Lower Gila River subwatershed ranked as the most critical area impacted by agricultural land use practices that exacerbate the concentration of naturally occurring selenium (Table 2-21).

For this example project it will be assumed that irrigation tail water has introduced elevated concentrations of selenium into the stream. Federal agencies are the largest land owners (approximately 60%) within the Fortuna Wash-Lower Gila River subwatershed (Table 1-2); the State of Arizona owns 6% and the remaining 33% is privately owned. Projects implemented on private, federal, tribal, or state lands must obtain the permission of the owner and must comply with all local, state and federal permits.

Load Reductions

Naturally occurring selenium is concentrated in water by evaporation, and also when irrigation water leaches selenium from the soil. To calculate the load reduction resulting from implementation of a best management practice, an estimate of the reduction in volume of irrigation tail water that returns to the stream is required.

Support for calculating load reductions can be obtained from the local Agricultural Research Service or County Cooperative Extension office (http://cals.arizona.edu/extension/).

Management Measures:

Implementing agricultural irrigation practices to reduce tail water pollution will necessitate dramatic changes from the typical practice of flood irrigation. This may involve the installation of mechanized irrigation systems or on-site treatment.

As an example of a situation where drainage water must be managed, some watersheds in California have agricultural drainage water containing levels of selenium that approach the numeric criterion defining hazardous waste (above 1,000 parts per billion). This situation is being considered for permit regulation to manage drainage at the farm level (San Joaquin Valley Drainage Implementation Program, 1999).

Currently, Arizona is not considering such extreme measures, but selenium remains an important nonpoint source contaminant and a known risk to wildlife. The use of treatment technologies to reduce selenium concentrations include ion exchange, reverse osmosis, solar ponds, chemical reduction with iron, microalgal-bacterial treatment, biological precipitation, and constructed wetlands. Engineered water treatment systems, however, may be beyond the scope of a proposed best management practices project, and technologies are still in the research stage.

The load reduction potential, maintenance, and anticipated costs associated with the installation of mechanized irrigation systems are discussed above. These types of systems allow for improved water conservation and improved management of limited water resources. It should be recognized that only after a site-specific evaluation can the best treatment option be identified and that the installation of mechanized irrigation systems involve capital expense and may necessitate project design by a licensed engineer.

Technical and Financial Assistance

Stakeholder-group local watershed-based plans should identify specific projects important to their partnership, and during the planning process should estimate the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the plan. Technical support sources include NEMO, University of Arizona Cooperative Extension, government agencies, engineering contractors, volunteers, and other environmental professionals. Funding sources may include:

- Clean Water Act Section 319(h) funds;
- State revolving funds though the Arizona Department of Environmental Quality;
- Central Hazardous Materials Fund;
- USDA Environmental Quality Incentives Program and Conservation Security Program;
- Arizona Water Protection Fund through the Arizona Department of Water Resources;
- Water Infrastructure Finance Authority;
- Arizona Heritage Fund though Arizona State Parks and Arizona Game and Fish; and
- Private donations or non-profit organization donations.

In addition to the extensive listing of funding and grant sources on the NEMO web site (www.ArizonaNEMO.org), searchable grant funding databases can be found at the EPA grant opportunity web site www.grants.gov or www.epa.gov/owow/funding.html.

In Arizona, Clean Water Act Section 319(h) funds are managed by ADEQ and the funding cycle and grant application data can be found at: http://www.azdeq.gov/environ/water/watershed/fin.html

The Arizona legislature allocates funding to the Arizona Water Protection Fund. In addition, the fund is supplemented by income generated by water-banking agreements with the Central Arizona Project. Information can be found at http://www.awpf.state.az.us/

Most grants require matching funds in dollars or in-kind services. In-kind services may include volunteer labor, access to equipment and facilities, and a reduction on fee schedules / rates for subcontracted tasks. Grant matching and cost share strategies allow for creative management of limited financial resources to fund a project.

Education and Outreach

An information/education component is an important aspect of the Stakeholder-group local watershed-based plan that will be used to enhance public understanding of the project and encourage early and continued participation in selecting, designing and implementing management measures.

The NEMO program offers each watershed partnership the opportunity to post information, fact sheets and status reports on the NEMO web site, and to announce important events on the NEMO calendar. In addition, a partnership can obtain guidance and technical support in designing an outreach program through the University of Arizona Cooperative Extension.

Implementation Schedules & Milestones

Necessary to the watershed planning process is a schedule for project selection, design, funding, implementation, reporting, operation and maintenance, and project closure. In the Colorado-Lower Gila Watershed, 10-digit HUC subwatershed areas have been prioritized in this plan for potential water quality improvement projects, but other locations across the watershed may hold greater interest by the stakeholders for project implementation. Private land owners or partnerships of stakeholders may propose specific projects to respond to immediate water quality concerns, such as stream bank erosion exacerbated by a recent flooding event.

After project selection, implementation may be dependent on the availability of funds, and because of this most watershed partnerships find themselves planning around grant cycles. Table 3-4A depicts the planning process, and suggests that the stakeholder group may want to revisit the listing and ranking of proposed projects on a regular basis, giving the group the opportunity to address changing conditions.

As shown in the table, a ‘short’ one-year project actually may take as many as three years from conception, to implementation, and ultimate project closure. With the number of grants currently available in Arizona for water quality improvement projects, the watershed partnership may find themselves in a continual cycle of grant writing and project reporting, overlapping and managing several aspects of several projects simultaneously.

Table 3.4A: Example Watershed Project Planning Schedule.

Watershed Project Planning Steps	Year				
	1	**2**	**3**	**4**	**5**
Stakeholder-Group 319 Plan Development	X				
Identify and rank priority projects	X				
Grant Cycle Year 1: Select Project(s)	X				
Project(s) Design, Mobilization, and Implementation	X	X			
Project(s) Reporting and Outreach		X			
Project(s) Operation and Maintenance, Closure		X	X		
Grant Cycle Year 2: Select Project(s)		X			
Project(s) Design, Mobilization, and Implementation		X	X		
Project(s) Reporting and Outreach			X		
Project(s) Operation and Maintenance, Closure			X	X	
Revisit Plan, Identify and re-rank priority projects			X		
Grant Cycle Year 3: Select Project(s)			X		
Project(s) Design, Mobilization, and Implementation			X	X	
Project(s) Reporting and Outreach				X	
Project(s) Operation and Maintenance, Closure				X	X

Most funding agencies operate on a reimbursement basis and will require reporting of project progress and reimbursement on a percent completion basis. In addition, the individual project schedule should be tied to important measurable milestones which should include both project implementation milestones and pollutant load reduction milestones. Implementation milestones may include interim tasks, such as shown in Table 3-4A, and can be tied to grant funding-source reporting requirements.

Based on funding availability, the activities outlined in Table 3-4B could be broken down into three separate projects based on location (Stream Channel, Stream Bank or Flood Plain), or organized into activity-based projects (Wildcat Dump Cleanup, Engineered Culverts, etc).

Table 3.4B - Example Project Schedule.

Management Measures and Implementation Schedule Streambank Stabilization and Estimated Load Reduction					
			Water Quality Milestone Target Load Reduction: 100% Hazardous Materials / 75% Sediment Load		
Milestone	**Date**	**Implementation Milestone**	**Area 1 Stream Channel**	**Area 2 Stream Bank**	**Area 3 Flood Plain**
Task 1: Contract Administration	04/01/05 Thru 09/31/06	Contract signed Quarterly reports Final report			
Task 2: Wildcat Dump Clean-up	04/01/05 Thru 07/05/05	Select & Advertise Clean-up date Schedule Containers and removal	Remove hazardous materials from stream channel 100% hazardous material removal	Remove tires and vehicle bodies from streambank 100% hazardous material removal	
Task 3: Engineering Design	04/01/05 Thru 08/15/05	Conceptual design, select final design based on 75% load reduction		Gabions, culverts, calculate estimated load reduction	Re-contour, regrade, berms, water bars, gully plugs: calculate estimated load reduction.
Task 4: Permits	04/01/05 Thru 09/01/05	Confirm permit requirements and apply for necessary permits	US Army Corps of Engineers may require permits to conduct projects within the stream channel	Local government ordinances as well as the US Army Corps and State Historical Preservation permits may be needed.	In addition to local and State permits, the presence of listed or Endangered Species will require special permitting and reporting.
Task 5: Monitoring	07/05/05 thru 10/31/06	Establish photo points and water quality sample locations	Turbidity sampling, baseline and quarterly, compare to anticipated 75% Sediment load reduction	Photo points, baseline and quarterly, Calculate Sediment load reduction	Photo points, baseline and quarterly, Calculate Sediment load reduction
Task 6: Revegetation	08/15/05 thru 09/15/05	Survey and select appropriate vegetation			Willows, native grasses, cotton wood, mulch

Management Measures and Implementation Schedule Streambank Stabilization and Estimated Load Reduction					
			Water Quality Milestone Target Load Reduction: 100% Hazardous Materials / 75% Sediment Load		
Milestone	**Date**	**Implementation Milestone**	**Area 1 Stream Channel**	**Area 2 Stream Bank**	**Area 3 Flood Plain**
Task 7: Mobilization	09/01/05 thru 10/31/05	Purchase, delivery and installation of engineered structures and revegetation material		Install gabions, resized culverts / professional and volunteer labor	Regrade, plant vegetation with protective wire screens around trees / install gully plugs and water bars, volunteer labor
Task 8: Outreach	04/01/05 thru 10/31/06	Publication of news articles, posters, monthly reports during stakeholder-group local watershed meetings			
Task 9: Operation and Maintenance	09/01/05 thru 10/31/06	Documentation of routine operation and maintenance in project quarterly reports during contract period, continued internal record keeping after contract / project closure		Maintenance and routine repair of engineered structures	Maintenance / irrigation of new plantings until established, removal of weeds and invasive species

Evaluation Criteria

The evaluation section of a watershed plan will provide a set of criteria that can be used to determine whether progress towards individual project goals is being achieved and/or the effectiveness of implementation is meeting expectations. These criteria will help define the course of action as milestones and monitoring activities are being reviewed.

The estimate of the load reductions expected for each of the management measures or best management practices to be implemented is an excellent criterion against which progress can be measured. Prior to project implementation, baselines should be established to track water quality improvements, and standard measurement protocols should be established so as to assure measurement methodology does not change during the life of the project.

To evaluate the example project outlined in Table 3-4B, the following key evaluation attributes must be met:

- Schedule and timeliness: Grant applications, invoices and quarterly reports must be submitted to the funding source when due or risk cancellation of contracts. If permits are not obtained prior to project mobilization, the project crew may be subject to penalties or fines.
- Compliance with standards: Engineered designs must meet the standards of the Arizona State Board of Technical and Professional Registration, Engineering Board of Licensing; water quality analytical work must be in compliance with State of Arizona Laboratory Certification. Excellent evaluation criteria would include engineer-stamped 'as-built' construction diagrams and documentation of laboratory certification, for example. Methods for estimating load reduction must be consistent with established methodology, and the means by which load reductions are calculated throughout the life of the plan must be maintained.
- Consistency of measurement: The project Sampling and Analysis Plan should identify what is being measured, the units of measurement, and the standard protocol for obtaining measurements. For example, turbidity can be measured in 'Nephelometric Units' or more qualitatively with a Secchi disk. Water volume can be measured as acre/feet, gallons, or cubic feet. Failure to train project staff to perform field activities consistently and to use comparable units of measure can result in project failure.
- Documentation and reporting: Field note books, spread sheets, and data reporting methodology must remain consistent throughout the project. Photo point locations must be permanently marked so as to assure changes identified over the life of the project are comparable. If the frequency of data collection changes or the methodology of reporting changes in the midst of the project, the project and overall plan looses credibility.

The project is a near success if the reports are on time, the engineered structures do not fail, data are reported accurately, and an independent person reviewing your project a year after project closure understands what was accomplished. The project is a full success if water quality improvement and load reductions have been made.

The criteria for determining whether the overall watershed plan needs to be revised are an appropriate function of the evaluation section as well. For example, successful implementation of a culvert redesign may reduce the urgency of a stream bank stabilization project downstream from the culvert, allowing for reprioritization of projects.

It is necessary to evaluate the progress of the overall watershed plan to determine effectiveness, project suitability, or the need to revise goals, BMPs or management measures. The criteria used to determine whether there has been success, failure or progress will also determine if objectives, strategies or plan activities need to be revised, as well as the watershed-based plan itself.

Effectiveness Monitoring

Monitoring of watershed management activities is intrinsically linked to the evaluation performed within the watershed because both track effectiveness. While monitoring evaluates the effectiveness of implementation measures over time, the criteria used to judge success/failure/progress is part of the Evaluation process.

Following the example of the project outlined in Table 3-4B, other water quality and watershed health constituents to be monitored include:

- Turbidity. Measuring stream turbidity before, during and after project implementation will allow for quantification of load reduction.
- Stream flow and volume, presence or absence of flow in a wash following precipitation. Monitoring of these attributes is important especially after stream channel hydromodification.
- Presence / absence of waste material. This can be monitored with photo-points.
- Riparian health, based on diversity of vegetation and wildlife. Monitoring can include photo-points, wildlife surveys and plant mapping.

The monitoring section will determine if the partnership's watershed strategies/management plan is successful, and/or the need to revise implementation strategies, milestones or schedule. It is necessary to evaluate the progress of the plan to determine effectiveness, unsuitability, or need to revise goals or BMPs.

Water quality monitoring for chemical constituents that may expose the sampler to hazardous conditions will require appropriate health and safety training and the development of a Quality Assurance Project Plan (QAPP). Monitoring for metals derived from abandoned mine sites, pollutants due to organics, *E. coli*, nutrients derived from land use, and selenium will require specialized sample collection and preservation techniques, in addition to laboratory analysis. Monitoring for sediment load reduction may be implemented in the field without extensive protocol development.

Resources to design a project monitoring program can be found at the EPA water quality and assessment web site: www.epa.gov/owow/monitoring/ as well as through the Master Watershed Steward Program available through the local county office of University of Arizona Cooperative Extension. In addition, ADEQ will provide assistance in reviewing a QAPP and monitoring program.

Conclusions

This watershed-based plan ranked twelve 10-digit HUC subwatersheds within the Colorado-Lower Gila Watershed for risk of water quality degradation from nonpoint source pollutants (Section 2 and Table 2-18). This ranking was based on Arizona's Integrated 305(b) Water Quality Assessment and 303(d) Listing Report, for the Colorado-Lower Gila Watershed (ADEQ, 2005).

In addition to the subwatershed classifications, this plan contains information on the natural resources and socio-economic characteristics of the watershed (Section 1). Based on the results of the Classification in Section 2, example best management practices and water quality improvement projects to reduce nonpoint source pollutants are also provided (Section 3).

The subwatershed rankings were determined for the four major constituent groups (metals, sediment, organics and selenium) using fuzzy logic (see Section 2 for more information on this methodology and the classification procedure). The final results are summarized in this section and are shown in Table 2-18. In addition, technical and financial assistance to implement the stakeholder-group local watershed-based plans are outlined in this section.

Of the subwatersheds included in this assessment, the ones selected for example load reduction projects were:

- Thirteenmile Wash-Sacramento Wash for metals pollution;
- Lower Colorado River-Lake Havasu for sediment pollution;
- Fourth of July Wash-Lower Gila River for organics pollution; and,
- Fortuna Wash-Lower Gila River for selenium.

This NEMO Watershed-Based Plan is consistent with EPA guidelines for CWA Section 319 Nonpoint Source Grant funding. The nine planning elements required to be eligible for 319 grant funding are discussed, including education and outreach, project scheduling and implementation, project evaluation, and monitoring.

Some basic elements are common to almost all forms of planning: data gathering, data analysis, project identification, implementation and monitoring. It is expected that local stakeholder groups and communities will identify specific projects important to their partnership, and will rely on the NEMO Plan in developing their own plans.

Summary of EPA's 9 Key Elements

Introduction

All projects that apply for Section 319 funding under the Clean Water Act and administered through the Arizona Department of Environmental Quality must include nine key elements in their watershed-based plans. These elements are listed in Section 1 of this Watershed-Based Management Plan and are also discussed in the Nonpoint Source Guidance Document by the US EPA (http://www.epa.gov/owow/nps/319/index.html).

The nine key elements are described below and the corresponding sections of this NEMO Watershed-Based Management Plan are noted. Information and data to support this requirement can be found in these sections of this Plan.

Element 1: Causes and Sources

Found in NEMO Watershed-Based Plan – Section 2

The watershed-based plan must identify the sources that will need to be controlled to achieve load reductions established in the nonpoint source TMDL.

In addition, pollutants of concern must be identified, and the causes and sources (primary and secondary) of waterbody impairment (physical, chemical, and biological, both point and non-point sources) must be linked to each pollutant of concern.

Section 2 of the NEMO Watershed-based management plan prioritizes the subwatersheds for risk of impairment due to metals, sediment, organics and selenium nonpoint source pollution. In addition, the potential causes for each constituent are described so that the watershed group can begin identifying the source of the risk.

Element 2: Expected Load Reductions

Not included in NEMO Plan, must be calculated based on site-specific and project-specific attributes.

The plan must contain an overview of TMDL load reductions expected for each Best Management Practice, linked to an identifiable source (only required for sediment (tons/yr), nitrogen or phosphorus (lbs/yr)). See the NEMO web site in the Best Management Practices (BMP) Manual (http://nemo.srnr.arizona.edu/nemo/BMPdocs/deq-swq-nps-POLCNTRL.pdf) for calculation methods.

Element 3: Management Measures

Found in NEMO Watershed-Based Plan – Section 3

The plan must contain a description of the nonpoint source Best Management Practices or management measures and associated costs needed to achieve load reductions for the critical areas identified in which the measures will need to be implemented to achieve the nonpoint source TMDL.

Section 3 *Strategy for Addressing Existing Impairments* of the NEMO plan describes a variety of nonpoint source BMPs that may be applied for load reduction and management of metals, sediment, organics and selenium pollution.

Section 3 *Potential Water Quality Improvement Projects* includes an example water quality improvement project for each of the four constituents (metals, sediment, organics and selenium) with specific example management measures.

Element 4: Technical and Financial Assistance

Found in NEMO Watershed-Based Plan – Section 3 and NEMO website www.ArizonaNEMO.org

The plan must include an estimate of the technical and financial assistance needed, including associated costs, and funding strategy (funding sources), and permits required to implement the plan.

Section 3 includes several tables that include various management measures and their relative costs, life expectancy and load reduction potential.

Section 3 *Technical and Financial Assistance* includes a list of possible funding sources and links for water quality improvement projects. In addition, the NEMO website (www.ArizonaNEMO.org) has an extensive list of links to a wide variety of funding sources.

Element 5: Information / Education Component

Example found in NEMO Watershed-Based Plan - Section 3

This is the information/education component intended to enhance public understanding and participation in selecting, designing, and implementing the nonpoint source management measures, including the outreach strategy with long and short term goals, and funding strategy.

Section 3 *Education and Outreach* lists local resources that may be valuable in education and outreach to the local community or other targeted audiences. In addition, examples of local educational outreach projects are presented.

Element 6: Schedule

Example found in NEMO Watershed-Based Plan - Section 3

The plan must include a schedule for implementing, operating and maintaining the nonpoint source Best Management Practices identified in the plan.

Section 3 *Implementation Schedules & Milestones* describes the importance of schedules in a water quality improvement project and presents an example schedule.

Element 7: Measurable Milestones

Example found in NEMO Watershed-Based Plan - Section 3

The plan must include a schedule of interim, measurable milestones for determining whether nonpoint source Best Management Practices or other control actions are being implemented and water quality improvements are occurring.

Section 3 *Implementation Schedules & Milestones* describes some measurable milestones and presents an example schedule that includes milestones.

Element 8: Evaluation of Progress

Example found in NEMO Watershed-Based Plan - Section 3

The plan must contain a set of criteria used to determine whether load reductions are being achieved and substantial progress is being made towards attaining water quality standards, including criteria for determining whether the plan needs to be revised or if the Total Maximum Daily Load (TMDL) needs to be revised.

Section 3 *Evaluation Criteria* describes how to evaluate the progress and success of a water quality improvement project and describes the key attributes that must be met for a successful project.

Element 9: Effectiveness Monitoring

Example found in NEMO Watershed-Based Plan - Section 3

The plan must include a monitoring plan to evaluate the effectiveness of implementation efforts over time, measured against the set of criteria established in the Evaluation of Progress element (8).

Section 3 *Effectiveness Monitoring* discusses the importance of project monitoring, and presents several example water quality and health constituents that should be monitored.

Conclusions

The NEMO Watershed based plans are structured to be a watershed wide, broad evaluation of the nine key elements. The community watershed groups, as they apply for 319 Grant Funds to implement projects, will need to readdress each of these 9 key elements for their specific site and watershed project.

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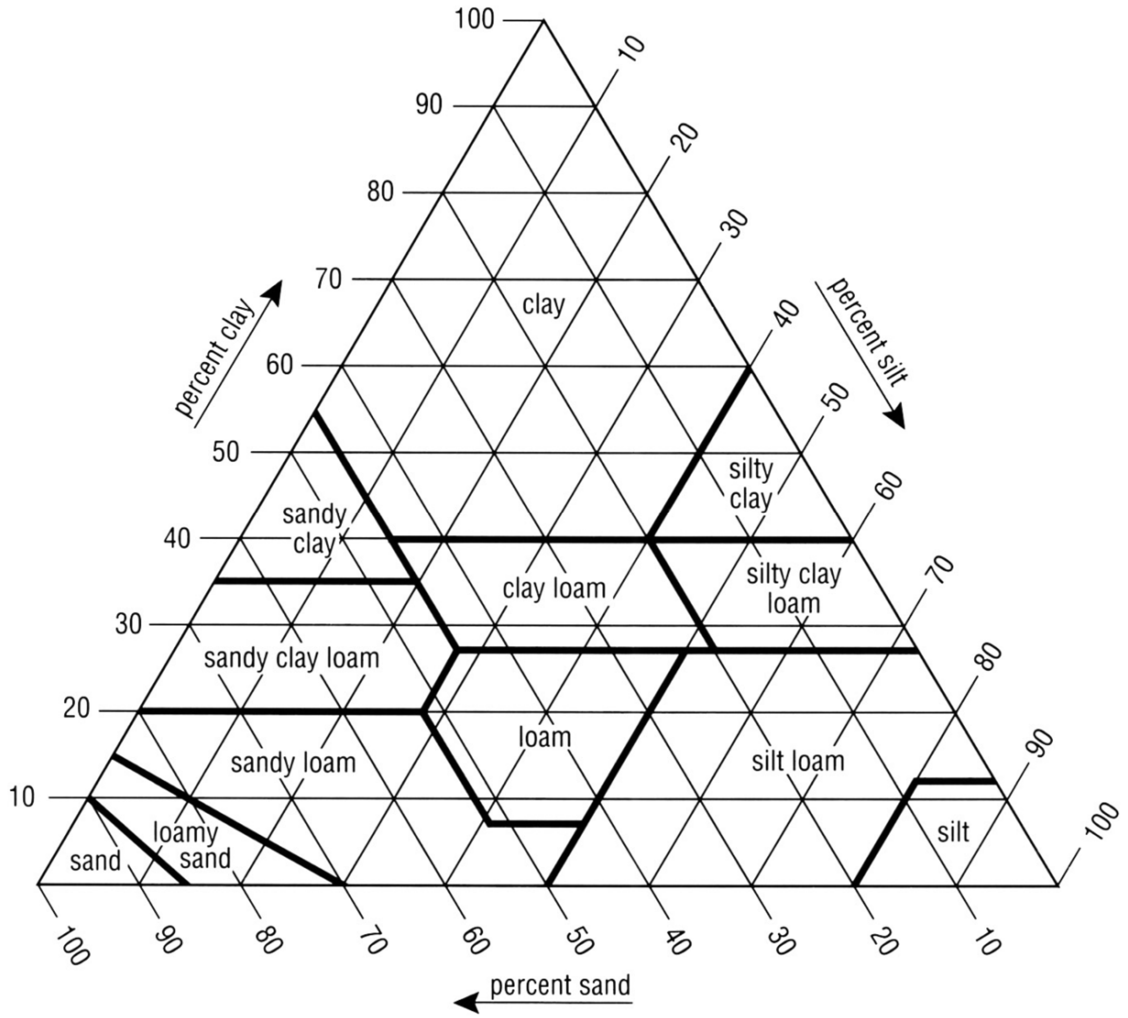
http://www.land.state.az.us/alris/index.html
Land ownership, February 7, 2002.

**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases and is also found on the NEMO website (www.ArizonaNEMO.org). Metadata includes the original source of the data, when it was created, it's geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Appendix A: Soil Classification

Soil is a complex material whose properties are of importance in many applications, and it can be characterized and classified in many ways. The primary importance of soil classification in modeling non-point source pollution risks is its tendency to be eroded, and the features of soil that are most related to erodibility are its texture and its content of rock fragments. These two characteristics are used to classify and name soils throughout the watershed.

Soil texture is determined by the proportion (by weight) of three basic types of soil particles, sand, silt, and clay. These three materials vary from place to place, but generally sand particles feel gritty and can be seen individually with the naked eye; silt particles feel smooth whether wet or dry and individual particles cannot be seen without magnification; and clay is made up of very fine particles and is usually sticky to the touch (soils.usda.gov/technical/manual/contents/ chapter3_index.html). The diagram below shows the classification and names for various proportions of these three soil components:



Rock fragments may be included within soils of various textures. Based on size and shape, the rock fragments in the Colorado-Lower Gila Watershed are categorized as gravels (spherical or cube like, 2-75 mm diameter), cobbles (spherical or cube like, 75-250 mm diameter), and flagstones (flat and 150-380 mm long). Depending on how much of the soil volume is made up of included rock fragments, the soil name is modified by “extremely” (more than 60%), “very” (between 35 to 60%), just the rock fragment designation itself (15 to 35%), or no rock fragment designation (0 to 15%).

The soil texture designations in Figure 1-7 are based on the two characteristics of texture and included rock fragments, so that, for instance, “very flaggy silt loam” has proportions of sand, silt, and clay that put it in the category of “silt loam” (see illustration above) and also include 35 to 60 percent flagstones; “clay loam” has the appropriate mix of sand, silt, and clay to fall in the “clay loam” category and contains less than 15% by weight of rock fragments.

Appendix B: Subwatershed Classification for Risk of Impairment, Colorado/ Lower Gila Watershed.

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2007) includes water quality data and assessments of water quality in several surface waterbodies across the Santa Cruz Watershed. This table summarizes the surface waterbody data used to assess the risk of impairment for each 10-digit HUC subwatershed; some HUCs may have more than one surface waterbody assessed within the watershed, some have none. Some surface water bodies are present in more than one 10-digit HUC. The table includes the ADEQ water quality data (sampling and assessment status) and the NEMO risk classification assigned to individual surface waterbodies within each subwatershed. It also includes the NEMO risk classification for each subwatershed, which is determined by the highest risk level of the surface waterbodies within that subwatershed.

The four levels of NEMO risk classification are defined in Section 2: extreme; high; moderate; and low. This table is organized to determine the relative risk of nonpoint source water quality degradation due to metals, sediment, organics and selenium for each 10-digit HUC subwatershed based on existing ADEQ water quality data. See the footnotes at the end of the table for more information and definitions of abbreviations, and Section 2 for the NEMO ranking values assigned to each risk classification.

Subwatershed

Jumbo Wash-Lower Colorado River
HUC 1503010101

Combined Classification for Risk of Impairment:

- **Metals:** Low.
- **Sediment:** Low.
- **Organics:** Moderate due to inconclusive data.
- **Selenium:** Extreme.

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status**[1,2,3]	
Lake Mohave ADEQ ID: 15030101-0960 One sample site at this surface waterbody.	Sampling	**Metals** (d&t 3): Cadmium, chromium, copper, lead, nickel, silver, and zinc; fluoride (3). (d 0-2& t 3): Antimony, arsenic, barium, beryllium, boron, manganese, mercury and thallium. **Sediment**: Total dissolved solids (3), turbidity (2). **Organics** (3): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen and pH; *E. coli* (1). **Selenium** (d 0-2& t 3): Selenium

	Status	Parameters exceeding standards: Selenium Currently assessed as Category 2, "Attaining some uses." Insufficient E. Coli bacteria samples to assess FBC. Lab detection limits for dissolved mercury and selenium were higher than the A&W chronic criteria. Subwatershed risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Moderate due to insufficient data and lab detection limit.
Colorado River From Hoover Dam to Lake Mohave (below Lake Mead) ADEQ ID: 15030101-015 One sampling sites at this surface waterbody.	Sampling	**Metals**: (d 18-23): Antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, manganese, nickel, silver, zinc, uranium. **Sediment**: Suspended sediment concentration (20), dissolved solids (23), turbidity (9). **Organics** (23): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (3), pesticides (7-23). **Selenium** (d18-23): Selenium

	Status	Parameters exceeding standards: dissolved oxygen and selenium. Currently assessed as Category 5, “Impaired or not attaining” due to selenium. Insufficient data for E. Coli bacteria and fluoride to asses FBC and DWS. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Moderate due to inconclusive data. **Selenium**: Extreme.
Subwatershed		
Lower Colorado River Lake Mohave **HUC 1503010102** **Combined Classification for Risk of Impairment:** • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to insufficient data		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status** [1,2,3]	

Lake Mohave ADEQ ID: 15030101-0960 One sample site at this surface waterbody.	Sampling	**Metals** (d&t 3): Cadmium, chromium, copper, lead, nickel, silver, and zinc; fluoride (3). (d 0-2& t 3): Antimony, arsenic, barium, beryllium, boron, manganese, mercury and thallium. **Sediment**: Total dissolved solids (3), turbidity (2). **Organics** (3): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen and pH; *E. coli* (1). **Selenium** (d 0-2& t 3): Selenium
	Status	Parameters exceeding standards: Selenium Currently assessed as Category 2, "Attaining some uses." Insufficient E. Coli bacteria samples to assess FBC. Lab detection limits for dissolved mercury and selenium were higher than the A&W chronic criteria. Subwatershed risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Moderate due to insufficient data.

Subwatershed

Lower Colorado River-Lake Havasu
HUC 1503010106

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to inconclusive data**.**
- **Sediment:** Low
- **Organics:** Moderate due to inconclusive data**.**
- **Selenium:** Moderate due to inconclusive data.

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status** [1,2,3]	
Lake Havasu ADEQ ID: 15030101-0590 43 samples site at this surface waterbody.	Sampling	**Metals**: (d&t 14-33): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc; fluoride (34). Total metals only (9): Thallium **Sediment**: total dissolved solids (31), turbidity (36). **Organics** (29-33): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (32) and pH (33); *E. coli* (1285). **Selenium** (d&t 14-33): Selenium

	Status	Parameters exceeding standards: E. Coli, mercury (dissolved) and selenium. Currently assessed as Category 2, "Attaining some uses." Lab detection limits for dissolved mercury and selenium were higher than the A&W chronic criteria. Subwatershed risk classification: **Metals**: Moderate due to inconclusive data. **Sediment**: Low **Organics**: Moderate due to inconclusive data. **Selenium**: Moderate due to inconclusive data.
Colorado River From Bill Williams to Osborne Wash ADEQ ID: 15030104-020 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 17-29): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; Fluoride (20). **Sediment** (19-20): Total dissolved solids, turbidity. **Organics** (19-20): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (17). **Selenium**: Selenium

	Status	Parameters exceeding standards: selenium. Currently assessed as Category 2, “Attaining some uses.” Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Moderate due to inconclusive testing.
Subwatershed		
Osborne Wash-Lower Colorado River **HUC 1503010401** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate due to inconclusive data. • **Sediment:** Low • **Organics:** Moderate due to inconclusive data. • **Selenium:** Moderate due to inconclusive data.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status** [1,2,3]	
Lake Havasu ADEQ ID: 15030101-0590 43 samples site at this surface waterbody.	Sampling	**Metals**: (d&t 14-33): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc; fluoride (34). Total metals only (9): Thallium **Sediment**: total dissolved solids (31), turbidity (36). **Organics** (29-33): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (32) and pH (33); *E. coli* (1285). **Selenium** (d&t 14-33): Selenium

	Status	Parameters exceeding standards: E. Coli, mercury (dissolved) and selenium. Currently assessed as Category 2, "Attaining some uses." Lab detection limits for dissolved mercury and selenium were higher than the A&W chronic criteria. Subwatershed risk classification: **Metals**: Moderate due to inconclusive data. **Sediment**: Low **Organics**: Moderate due to inconclusive data. **Selenium**: Moderate due to inconclusive data.
Colorado River From Bill Williams to Osborne Wash ADEQ ID: 15030104-020 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 17-29): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; Fluoride (20). **Sediment** (19-20): Total dissolved solids, turbidity. **Organics** (19-20): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (17). **Selenium**: Selenium

	Status	Parameters exceeding standards: selenium. Currently assessed as Category 2, “Attaining some uses.” Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Moderate due to inconclusive testing.
Subwatershed		
Martinez Lake-Lower Colorado River **HUC 1503010411** **Combined Classification for Risk of Impairment:** • **Metals:** Low • **Sediment:** Low • **Organics:** Low • **Selenium:** Low		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status** [1,2,3]	
Martinez Lake ADEQ ID: 15030104-0880 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 3): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; fluoride (3). **Sediment** (3): Total dissolved solids, turbidity. **Organics** (3): Ammonia, , pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (2); *E. coli* (3). **Selenium** (d&t 3): Selenium.

	Status	Parameters exceeding standards: none. Currently assessed as Category 1, “Attaining all uses”. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Low.
Subwatershed		
Mittry Lake **HUC 1503010701** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate due to insufficient data**.** • **Sediment:** Low. • **Organics:** Extreme. • **Selenium:** Extreme.		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status** [1,2,3]	
Mittry Lake ADEQ ID: 15030107-0950 One sampling site at this surface waterbody.	Sampling	**Metals**: (d 0-2&t 3): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; fluoride (2). **Sediment** (2-3): Total dissolved solids, turbidity. **Organics** (2): Ammonia, nitrate/nitrite, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (3); *E. coli (3)*. **Selenium** (d 0-2&t 3): Selenium

	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses". Missing core parameters need dissolved metals; (cadmium, copper, and zinc), mercury, fluoride, arsenic, chromium, lead, boron, manganese, and copper to assess A&Ww, FC, DWS, Agl, and AgL. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Low.
Colorado River From Main Canal to Mexico Border ADEQ ID: 15030107-001 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 19-30): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; Fluoride (30). **Sediment**: Pesticides (16), radiochemicals (3-4), suspended sediment concentration (30), total dissolved solids (30), and turbidity (21). **Organics** (19-30): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (19). **Selenium** (d&t 19-30): Selenium.

	Status	Parameters exceeding standards: DDE (dissolved), diphthalate (dissolved), dissolved oxygen, alpha hexachlorocyclohexane, Gamma hexachlorocyclohexane (lindane), mercury (dissolved), and selenium. Currently assessed as Category 5, "Impaired or not attaining" due to selenium and low dissolved oxygen. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Moderate due to insufficient data. **Sediment**: Low. **Organics**: Extreme. **Selenium**: Extreme.
Colorado River From Imperial Dam to Gila River ADEQ ID: 15030107-003 One sampling sites at this surface waterbody.	Sampling	**Metals**: (d&t 12-19): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; Fluoride (19). **Sediment**: Pesticides (5), suspended sediment concentration (19), total dissolved solids (19), and turbidity (18). **Organics** (12-19): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (11). **Selenium** (d&t 12-19): Selenium.

	Status	Parameters exceeding standards: dissolved oxygen. Currently assessed as Category 1, “Attaining all uses”. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Moderate. **Selenium**: Low.
Subwatershed		
Lower Colorado River below Morelos Dam **HUC 15030108-0660** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate due to insufficient data**.** • **Sediment:** Low. • **Organics:** Extreme. • **Selenium:** Extreme.		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status** [1,2,3]	
Hunter’s Hole (Colorado River backwater) ADEQ ID: 15030108-0660 One sampling sites at this surface waterbody.	Sampling	**Metals**: (t1): chromium, copper, lead, manganese, mercury; Fluoride (1). **Sediment**: Total dissolved solids (1) **Organics** (1): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen. **Selenium** (t1): Selenium

	Status	Parameters exceeding standards: Selenium. Currently assessed as Category 3, "Inconclusive". Insufficient core parameters. Lab detection limits for dissolved mercury were higher than the FC criterion. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Low. **Selenium**: Moderate.
Colorado River From main canal to Mexico border ADEQ ID: 15030107-001 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 19-30): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; Fluoride (30). **Sediment**: Pesticides (16), radiochemicals (3-4), suspended sediment concentration (30), total dissolved solids (30), and turbidity (21). **Organics** (19-30): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (19). **Selenium** (d&t 19-30): Selenium.

	Status	Parameters exceeding standards: DDE (dissolved), diphthalate (dissolved), dissolved oxygen, alpha hexachlorocyclohexane, Gamma hexachlorocyclohexane (lindane), mercury (dissolved), and selenium. Currently assessed as Category 5, “Impaired or not attaining” due to selenium and low dissolved oxygen. Lab detection limits for dissolved mercury were higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Moderate due to insufficient data. **Sediment**: Low. **Organics**: Extreme. **Selenium**: Extreme.
Subwatershed		
Fourth of July Wash-Lower Gila River **HUC 1507020102** **Combined Classification for Risk of Impairment:** • **Metals:** Low. • **Sediment:** Low. • **Organics:** Extreme due to dissolved oxygen. • **Selenium:** Moderate due to insufficient data.		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status** [1,2,3]	

Painted Rock Borrow Pit Lake ADEQ ID: 15070201-1010 One sampling sites at this surface waterbody.	Sampling	**Metals**: (Total metals only: 1): Arsenic, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, and zinc. **Sediment**: Total dissolved solids (1) **Organics** (2): Ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen (5), pH. **Selenium**: None
	Status	Parameters exceeding standards: Dissolved oxygen. Currently assessed as Category 5, "Impaired or not attaining," due to low dissolved oxygen. EPA assessment: "Impaired or not attaining" due to DDT metabolites, toxaphene, and chlordane. Insufficient core parameters. Lab detection limits for selenium was higher than the A&W chronic criteria. Surface Waterbody risk classification: **Metals**: Low. **Sediment**: Low. **Organics**: Extreme due to dissolved oxygen. **Selenium**: Moderate due to lab detection limits.

<table>
<tr><th colspan="3">Subwatershed</th></tr>
<tr><th colspan="3">Morgan Wash-Lower Gila River
HUC 1507020114
Combined Classification for Risk of Impairment:
• Metals: Extreme.
• Sediment: Low.
• Organics: Moderate due to inconclusive data.
• Selenium: Extreme.</th></tr>
<tr><th>Surface Waterbody</th><th colspan="2">Water Quality Data:
Sampling and Assessment Status [1,2,3]</th></tr>
<tr><td>Gila River
From Coyote Wash to Fortuna Wash

ADEQ ID: 15070301-003

One sampling site at this surface waterbody.</td><td>Sampling</td><td>Metals: (d&t 8-22): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, thallium and zinc; Fluoride (22).

22 total metals only: Boron and manganese.

Sediment: Suspended sediment concentration (11), total dissolved solids (18), and turbidity (22).

Organics (21-22): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; <i>E. coli</i> (17).

Selenium (d&t 8-22): Selenium</td></tr>
</table>

	Status	Parameters exceeding standards: Boron, dissolved oxygen, E. Coli, and selenium. Currently assessed as Category 5, "Impaired or not attaining," due to; boron and selenium. Lab detection limits for selenium and dissolved mercury was higher than the A&W chronic criteria in at least 17 samples. Surface Waterbody risk classification: **Metals**: Extreme. **Sediment**: Low. **Organics**: Moderate due to inconclusive data. **Selenium**: Extreme.

Subwatershed

Fortuna Wash-Lower Gila River
HUC 1507020116

Combined Classification for Risk of Impairment:

- **Metals: Extreme.**
- **Sediment: Low.**
- **Organics: Moderate due to inconclusive data.**
- **Selenium: Extreme.**

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status** [1,2,3]

Gila River From Coyote Wash to Fortuna Wash ADEQ ID: 15070301-003 One sampling site at this surface waterbody.	Sampling	**Metals**: (d&t 8-22): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, thallium and zinc; Fluoride (22). 22 total metals only: Boron and manganese. **Sediment**: Suspended sediment concentration (11), total dissolved solids (18), and turbidity (22). **Organics** (21-22): Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen; *E. coli* (17). **Selenium** (d&t 8-22): Selenium
	Status	Parameters exceeding standards: Boron, dissolved oxygen, E. Coli, and selenium. Currently assessed as Category 5, "Impaired or not attaining," due to; boron and selenium. Lab detection limits for selenium and dissolved mercury was higher than the A&W chronic criteria in at least 17 samples. Surface Waterbody risk classification: **Metals**: Extreme. **Sediment**: Low. **Organics**: Moderate due to inconclusive data. **Selenium**: Extreme.

1 All water quality constituents had a minimum of three samples unless otherwise indicated by numbers in parenthesis. For example, arsenic (2) indicates two samples have been taken for arsenic on this reach.

2 The number of samples that exceed a standard is described by a ratio. For example, the statement "Exceedances reported for E. coli (1/2)," indicates that one from two samples has exceeded standards for E. coli.
3 The acronyms used for the water quality parameters are defined below:

(d) = dissolved fraction of the metal or metalloid (after filtration), ug/L
(t) = total metal or metalloid (before filtration), ug/L
(d&t) = both dissolved and total metal samples
cadmium (d): Filtered water sample analyzed for dissolved cadmium.
cadmium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) cadmium content.
chromium (d): Filtered water sample analyzed for dissolved chromium.
chromium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) chromium content.
copper (d): Filtered water sample analyzed for dissolved copper.
copper (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) copper content.
dissolved oxygen: O2 (mg/L)
E. coli: Escherichia coli bacteria (CFU/100mL)
lead (d): Filtered water sample analyzed for dissolved lead.
lead (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) lead content.
manganese (d): Filtered water sample analyzed for dissolved manganese.
manganese (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) manganese content.
mercury (d): Filtered water sample analyzed for dissolved mercury.
mercury (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) mercury content.
nickel (d): Filtered water sample analyzed for dissolved nickel.
nickel (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) nickel content.
nitrite/nitrate: Water sample analyzed for Nitrite/Nitrate content.
n-kjeldahl: Water sample analyzed by the Kjeldahl nitrogen analytical method which determines the nitrogen content of organic and inorganic substances by a process of sample acid digestion, distillation, and titration.
pH: Water sample analyzed for levels of acidity or alkalinity.
selenium (d): Filtered water sample analyzed for dissolved selenium.
selenium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) selenium content.
silver (d): Filtered water sample analyzed for dissolved silver.
silver (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) silver content.
suspended sediment concentration: Suspended Sediment Concentration
temperature: Sample temperature
total dissolved solids: tds, (mg/L)
total solids: (t) Solids
total suspended solids: (t) Suspended Solids

turbidity: Measurement of suspended matter in water sample (NTU)
zinc (d): Filtered water sample analyzed for dissolved zinc.
zinc (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) zinc content.

Designated Uses:
AgI: Agricultural Irrigation. Surface water is used for the irrigation of crops.
AgL: Agricultural Livestock Watering. Surface water is used as a supply of water for consumption by livestock.
A&Ww: Aquatic and Wildlife Warm water Fishery. Surface water used by animals, plants, or other organisms (excluding salmonid fish) for habitation, growth, or propagation, generally occurring at elevations less than 5000 feet.
FC: Fish Consumption. Surface water is used by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, crayfish, and frogs.
FBC: Full Body Contact. Surface water use causes the human body to come into direct contact with the water to the point of complete submergence (e.g., swimming). The use is such that ingestion of the water is likely to occur and certain sensitive body organs (e.g., eyes, ears, or nose) may be exposed to direct contact with the water.

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Appendix C: Automated Geospatial Watershed Assessment Tool – AGWA

The Automated Geospatial Watershed Assessment (AGWA) tool is a multipurpose hydrologic analysis system for use by watershed, water resource, land use, and biological resource managers and scientists in performing watershed- and basin-scale studies (Burns et al., 2004). It was developed by the U.S.D.A. Agricultural Research Service's Southwest Watershed Research Center. AGWA is an extension for the Environmental Systems Research Institute's (ESRI) ArcView versions 3.x, a widely used and relatively inexpensive geographic information system (GIS) software package.

AGWA provides the functionality to conduct all phases of a watershed assessment for two widely used watershed hydrologic models: the Soil and Water Assessment Tool (SWAT); and the KINematic Runoff and EROSion model, KINEROS2.

The watershed assessment for the Upper Gila Watershed was performed with the Soil and Water Assessment Tool. SWAT (Arnold et al., 1994) was developed by the USDA Agricultural Research Service (ARS) to predict the effect of alternative land management decisions on water, sediment and chemical yields with reasonable accuracy for ungaged rural watersheds. It is a distributed, lumped-parameter model that will evaluate large, complex watersheds with varying soils, land use and management conditions over long periods of time (> 1 year). SWAT is a continuous-time model, i.e. a long-term yield model, using daily average input values, and is not designed to simulate detailed, single-event flood routing. Major components of the model include: hydrology, weather generator, sedimentation, soil temperature, crop growth, nutrients, pesticides, groundwater and lateral flow, and agricultural management. The Curve Number method is used to compute rainfall excess, and flow is routed through the channels using a variable storage coefficient method developed by Williams (1969). Additional information and the latest model updates for SWAT can be found at http://www.brc.tamus.edu/swat/.

Data used in AGWA include Digital Elevation Models (DEMs), land cover grids, soil data and precipitation data.

For this study data were obtained from the following sources:

- DEM: United States Geological Survey National Elevation Dataset, 30-Meter Digital Elevation Models (DEMs). April 8, 2003. http://gisdata.usgs.net/NED/default.asp

- Soils: USDA Natural Resource Conservation Service, STATSGO Soils. April 17, 2003. http://www.ncgc.nrcs.usda.gov/branch/ssb/products/statsgo/

- Land cover: Southwest GAP Analysis Project Regional Provisional Land Cover dataset. September, 2004.
  http://earth.gis.usu.edu/swgap/

- Precipitation Data: Cooperative Summary of the Day TD3200: Includes daily weather data from the Western United States and the Pacific Islands. Version 1.0. August 2002. National Oceanic and Atmospheric Administration/National Climatic Data Center, Asheville, North Carolina.

The AGWA Tools menu is designed to reflect the order of tasks necessary to conduct a watershed assessment, which is broken out into five major steps, as shown in Figure 1 and listed below:

1. Watershed delineation and discretization;
2. Land cover and soils parameterization;
3. Writing the precipitation file for model input;
4. Writing the input parameter file and running the chosen model; and
5. Viewing the results.

When following these steps, the user first creates a watershed outline, which is a grid based on the accumulated flow to the designated outlet (pour point) of the study area. The user then specifies the contributing area for the establishment of stream channels and subwatersheds (model elements) as required by the model of choice.

From this point, the tasks are specific to the model that will be used, which in this case is SWAT. If internal runoff gages for model validation or ponds/reservoirs are present in the discretization, they can be used to further subdivide the watershed.

The application of AGWA is dependent on the presence of both land cover and soil GIS coverages. The watershed is intersected with these data, and parameters necessary for the hydrologic model runs are determined through a series of look-up tables. The hydrologic parameters are added to the watershed polygon and stream channel tables.

For SWAT, the user must provide daily rainfall values for rainfall gages within and near the watershed. If multiple gages are present, AGWA will build a Thiessen polygon map and create an area-weighted rainfall file. Precipitation files for model input are written from uniform (single gage) rainfall or distributed (multiple gage) rainfall data.

In this modeling process, the precipitation file was created for a 10-year period (1990-2000) based on data from the National Climatic Data Center. In each study watershed multiple gages were selected based on the adequacy of the data for this time period. The precipitation data file for model input was created from distributed rainfall data.

After all necessary input data have been prepared, the watershed has been subdivided into model elements, hydrologic parameters have been determined for each element, and rainfall files have been prepared, the user can run the hydrologic model of choice. SWAT was used in this application.

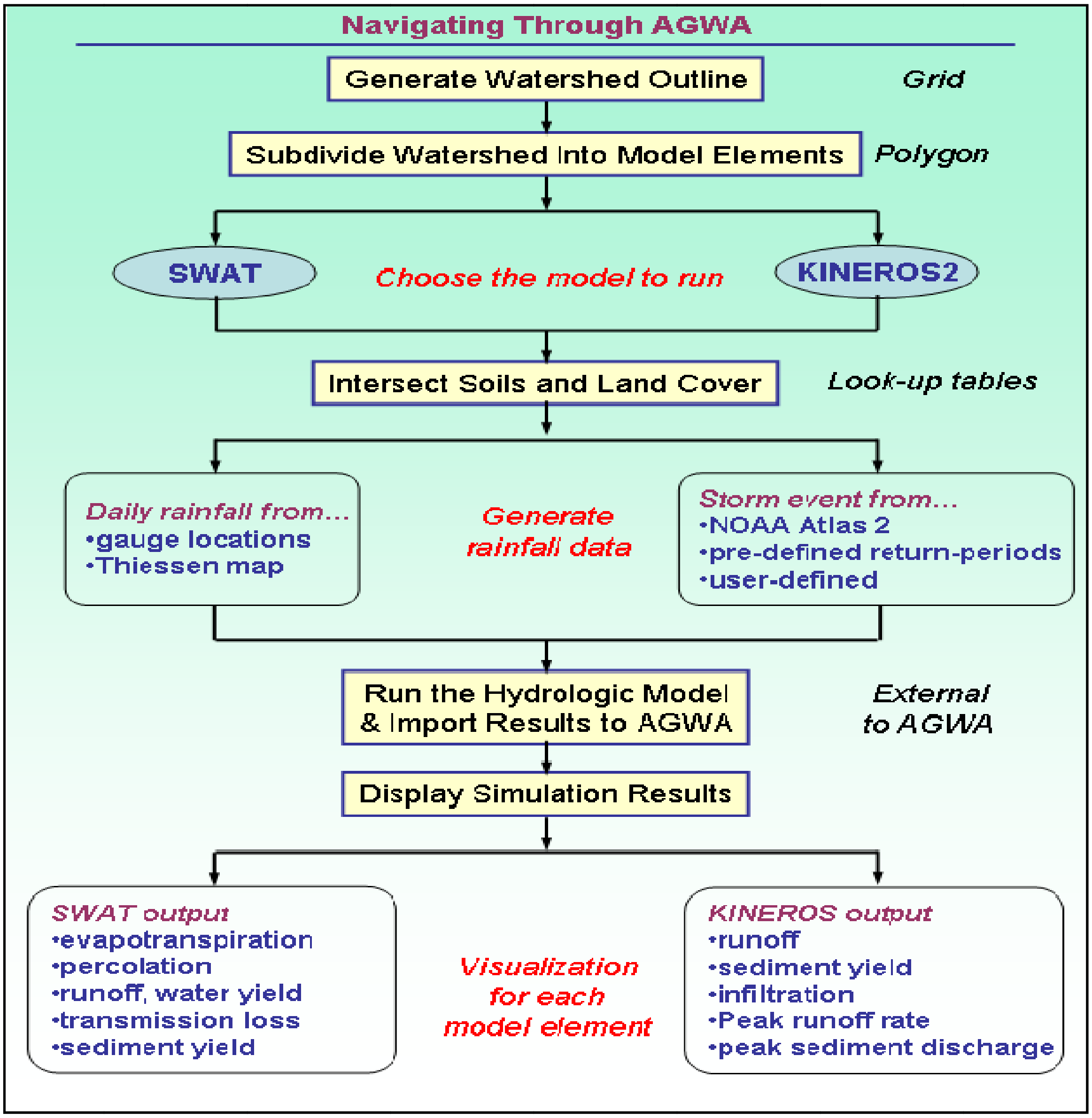

Figure D-1: Flow chart showing the general framework for using KINEROS2 and SWAT in AGWA.

After the model has run to completion, AGWA will automatically import the model results and add them to the polygon and stream map tables for display. A separate module within AGWA controls the visualization of model results. The user can toggle between viewing the total depth or accumulated volume of runoff, erosion, and infiltration output for both upland and channel elements. This enables problem areas to be identified visually so that limited resources can be focused for maximum effectiveness. Model results can also be overlaid with other digital data layers to further prioritize management activities.

Output variables available in AGWA/SWAT are:

- Channel Discharge (m^3/day);
- Evapotranspiration (ET) (mm);
- Percolation (mm);
- Surface Runoff (mm);
- Transmission loss (mm);
- Water yield (mm);
- Sediment yield (t/ha); and
- Precipitation (mm).

It is important to note that AGWA is designed to evaluate relative change and can only provide qualitative estimates of runoff and erosion. It cannot provide reliable quantitative estimates of runoff and erosion without careful calibration. It is also subject to the assumptions and limitations of its component models, and should always be applied with these in mind.

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Appendix D: Suggested Readings
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