SECTION VIII RIPARIAN HABITAT/LINKAGE ZONES

The importance of riparian areas cannot be overstated. The maintenance of connectivity throughout aquatic systems is vital. The Governor's Riparian Habitat Task Force (1990) defines riparian areas as including "vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage" (*Figure 8-1*). They are further characterized by having rich and diverse assemblages of plant and animal species in comparison to adjacent upland areas. The types of riparian and aquatic ecosystems within Arizona range widely from high-elevation montane meadows to low desert tinajas (rock pools). However, a common thread throughout all riparian communities is that they are recognized as one of the most important habitats for fish and wildlife in Arizona and the arid-southwest.

PERENNIAL: water flows year round

INTERMITTENT: water flows seasonally

EPHEMERAL: water flows in direct response to precipitation

Figure 8-1. Classification of Rivers and Streams

The riparian habitat/linkage zones (*Figure 8-2*) are unique because they function as both habitats and linear linkage zones. They provide essential (core) habitat for aquatic organisms such as fish, aquatic plants, some amphibians, and aquatic invertebrates. In addition, the riparian vegetated areas are important for a variety of wildlife and plant species because they provide the only habitat for some species (cottonwoods, willows, some flycatchers and warblers), prime habitat for many other species, water for an even larger number of species, travel paths for mammals, reptiles, and amphibians, and migratory paths for over half of the bird species that live in or visit Arizona. Thus, each river is critical both as habitat *and* as the spine of a potential movement corridor.

Given the enormous significance of the habitat these zones provide, conservation of the remaining riparian areas containing flowing waters is imperative in Arizona and vital to the wildlife that rely upon it. Thus, perennial waters are considered to be of the highest importance and priority status. Although intermittent and ephemeral waters are also important (*Figure 8-3*), particularly in urbanized areas where they may present the only opportunity for maintaining connectivity, all were not identified in this phase of the exercise.

Arizona Riparian Areas

Since the European settlement of North America, over half of the state's spring-fed marshlands (cienegas) and wet marshes have been destroyed (Defenders 1995). Less than 10 percent of the riparian ecosystems still exist in their natural state in Arizona (Arizona Riparian Council). Most flowing waters have been impounded or have had much of their flow diverted for human use. Even the few undammed Arizona Rivers (San Pedro River, Hassayampa River, Sonoita Creek and Aravaipa Creek) have been impacted by wood cutting, water diversions, groundwater alteration and pumping, invasion by exotic plants and fishes, urbanization, pollution, agriculture, and other factors.

Riparian areas in Arizona are small relative to other vegetative community types. Perennial streams constitute less than 0.4 percent of the total land area of the state (Valencia et al. 1993). However, they possess a disproportionate importance and biological value compared to their area. It has been estimated that 75 percent or more of Arizona's wildlife species depend on riparian communities during some portion of their life cycle. In addition, riparian areas are critical to the persistence of approximately 60 percent of the fish and wildlife species currently in jeopardy of extirpation from the state (Minckley and Brown 1994).

In a broader context, riverine systems serve as major pathways for the exchange of materials, energy, and organisms along longitudinal, lateral, and vertical dimensions (*Figure 8-4*). For example, biological longitudinal linkages include fish or terrestrial movement between upstream and downstream habitats for individuals, connectivity between metapopulations, or migratory bird stopover points between South/Central and North America. Lateral movement through riparian areas may occur at fine scales (e.g., amphibian movement from in-channel to bank, native fish that move from pools to riffles to feed) or at coarse scales (e.g., ungulate migration between mountain ranges).

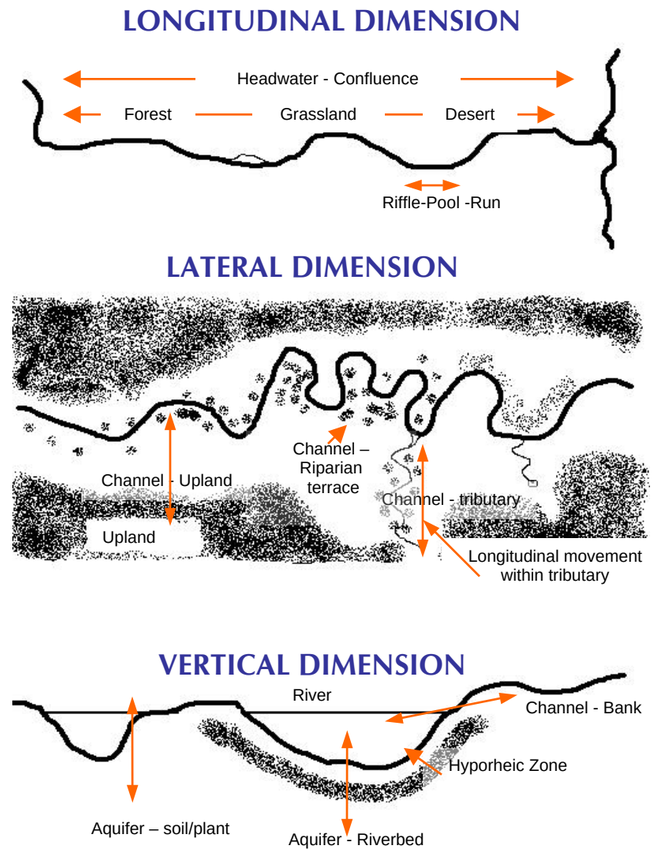
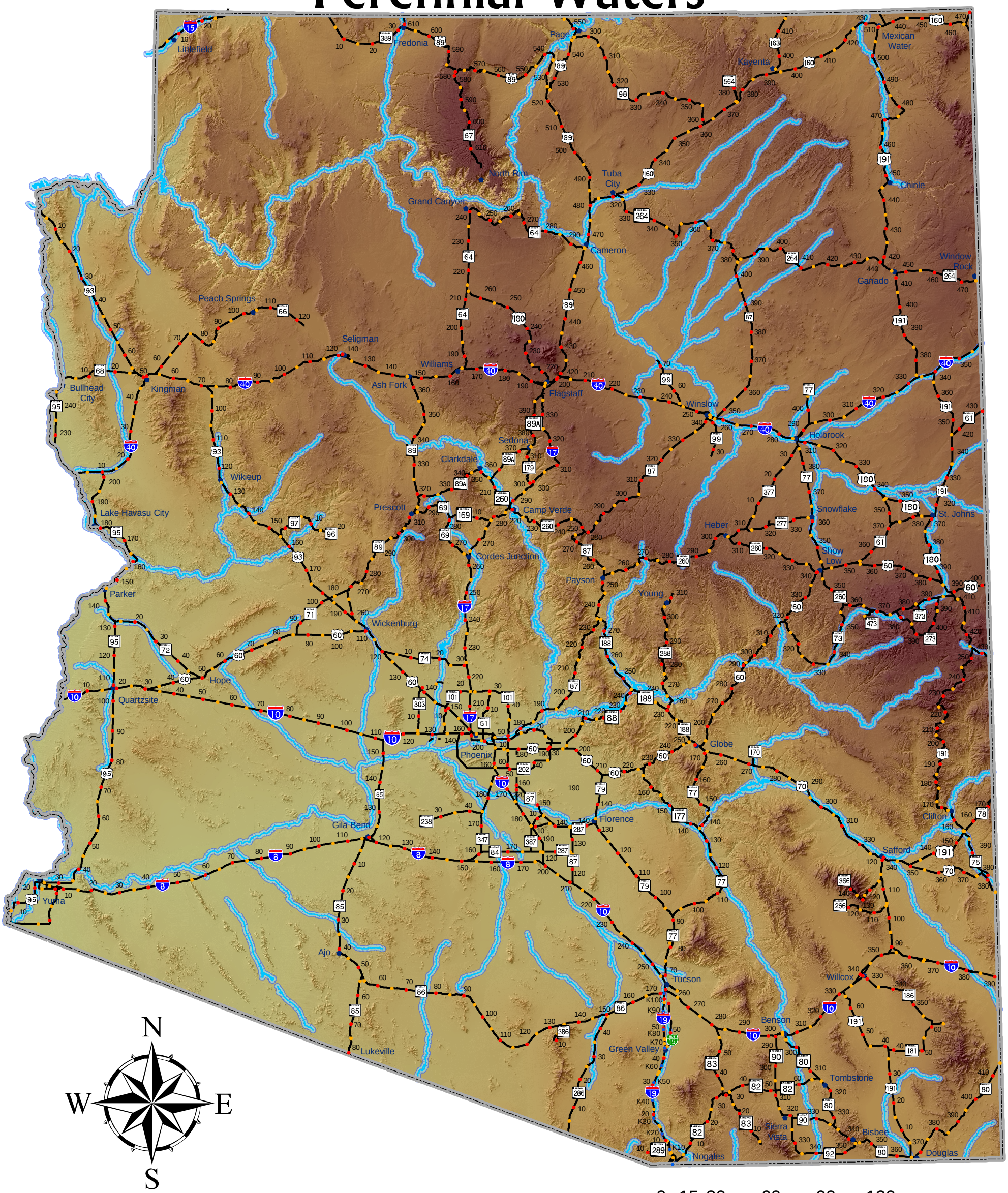


Figure 8-4. Major pathways of exchanges of materials, energy, and organisms in the longitudinal, lateral, and vertical dimensions of a riverine system (From Ward and Wiens 2001, Wiens 2002)

RIPARIAN HABITAT/LINKAGE ZONES

Perennial Waters



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Riparian Habitat/Linkage Zone

Figure 8-2. Riparian Habitat/Linkage Zones

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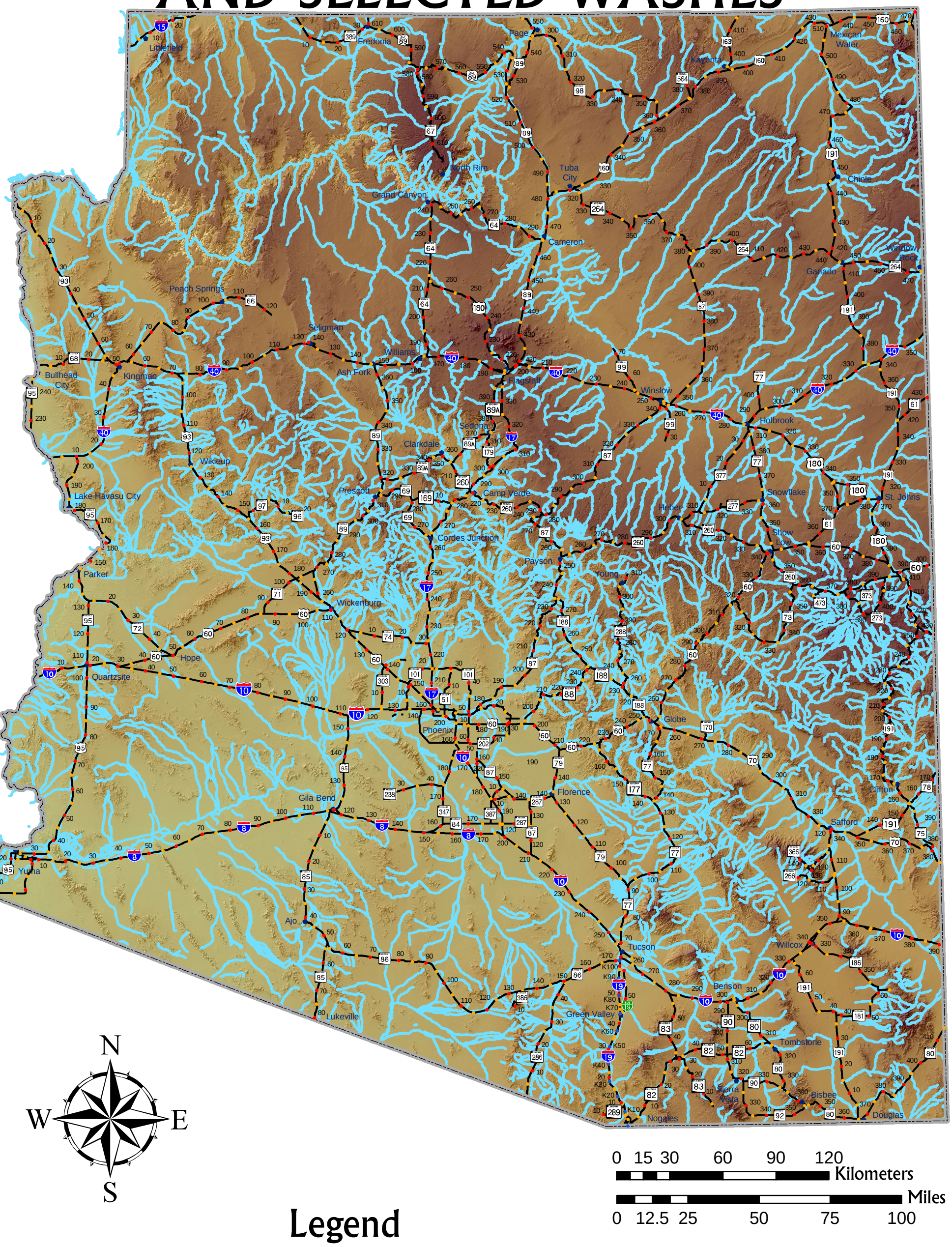
PERENNIAL WATERS, STREAMS AND SELECTED WASHES



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Perennial Rivers, Streams and Selected Washes

Figure 8-3. Perennial Waters, Streams and Selected Washes

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Scale is a critical concept to consider when analyzing impacts to ecological pathways. Habitat quality, habitat boundaries, patch context, connectivity, and species responses change with changes in scale (Wiens 2002). Although intuitive, species with different body sizes or mobility will have unique responses among differing scales, thus species may have variable responses to disturbances or impacts. In riparian systems, as in other communities, landscapes (and corresponding species responses) can be hierarchically classified into watersheds, segments, reaches, pool/riffle/run (aquatic) or patch (terrestrial), and microhabitat (*Figure 8-5*). Physical, chemical, and biological patterns and processes will vary across scales.

Juvenile heron killed by automobile near riparian area.

Figure 8-5. Hierarchical Classification of Stream Habitats (Wiens 2002)

Arizona Hydrological Classifications

There are 15 major surface water basins (*Figure 8-6*) identified by the Arizona Department of Water Resources (ADWR) in the state of Arizona. There are 90,375 miles (145,444 kilometers) of rivers and streams with an additional 37,130 (59,755 kilometers) stream miles on Tribal Lands. Only four percent, 4,980 miles (8,015 kilometers), of these are perennial while the rest are classified as ephemeral or intermittent. Manmade reservoirs, lakes, and ponds constitute 289,632 acres on non-tribal lands and 29,718 acres on tribal lands.

The Environmental Protection Agency (EPA) 404(b)(1) guidelines emphasize impacts on travel corridors of aquatic species. At present, there is no practical strategy for mitigating the impacts of roads and highways on wildlife movements that can easily be incorporated into highway design and permitting decisions (Jackson, S.D. and C.R. Griffin 2000). Road and highway projects that are subject to federal and state wetland protection laws are routinely evaluated for wildlife impacts. Urbanization, transportation corridors, and other infrastructure can result in the alteration of water movements, sedimentation and the transport of pollutants. Water quality and riparian areas are addressed during the planning process of proposed projects through permit requirements and compliance with existing laws and regulations. As an important component in the environmental review process and essential for maintaining riparian habitat health, this scrutiny on water quality affords an opportunity to take a closer look at wildlife habitat connectivity concerns in these same areas.

SURFACE WATER BASINS

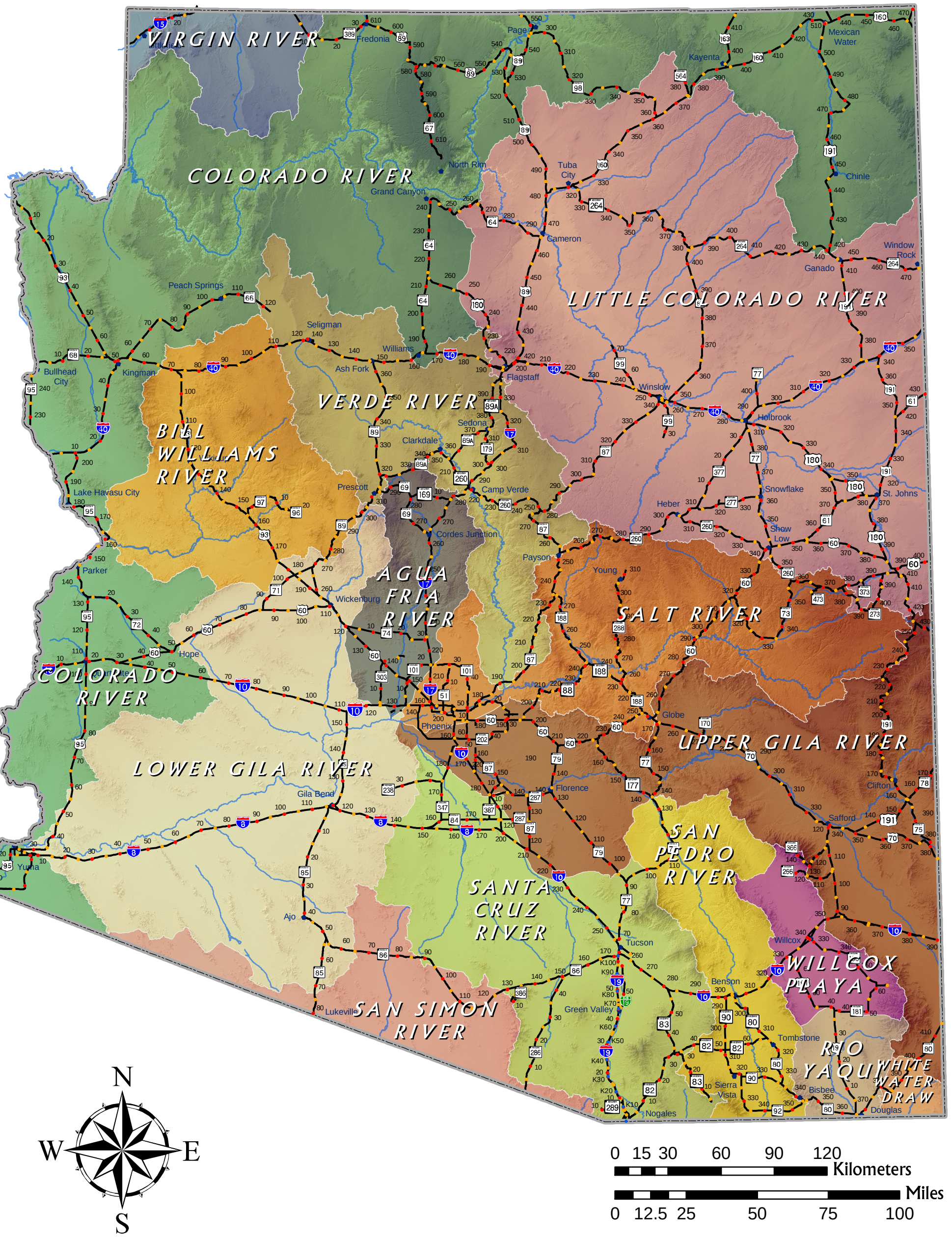

Figure 8-6. Arizona Department of Water Resources Surface Water Basins

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Unique Waters

Arizona has 18 watercourses that have been classified as "Unique Waters" (*Table 8-1, Figure 8-7*). These Outstanding Natural Resource Waters are designated only by the administrative rulemaking initiated by ADEQ. The public may also nominate surface waters for classification. A waterway is deemed a "unique water" and is legislatively defined as "outstanding state resource water" by the director of ADEQ. The determination and finding is based upon the decision criteria for designation including whether the waterway is perennial, free-flowing, unimpaired, and either has "exceptional recreational or ecological significance" or is found to be essential for the continued existence of threatened and endangered species as well as possibly providing critical habitat (Arizona Administrative Code [AAC] R18-11-112).

Unique waters are granted supplemental water quality protection through an anti-degradation requirement (AAC R18-11-107 [D]). Any new or additional discharge to a "unique water", including its tributaries, is prohibited if that discharge would degrade existing water quality. Site-specific water quality standards can also be applied to unique waters for an added level of protection (AAC R18-11-112).

Oak Creek Canyon is designated a Unique Water.

ARIZONA'S DESIGNATED UNIQUE WATERS

NAME	EXTENT PROTECTED
West Fork of the Little Colorado River	Above Government Springs
Oak Creek	Entire, including the West Fork of Oak Creek
Peoples Canyon Creek	Tributary to the Santa Maria River
Burro Creek	Above its confluence with Boulder Creek
Francis Creek	In Mohave and Yavapai counties
Bonita Creek	Tributary to the upper Gila River
Cienega Creek	From confluence with Gardner Canyon and Spring Water Canyon, in Pima County (I-10 to the Del Lago Dam)
Aravaipa Creek	From its confluence with Stowe Gulch to the downstream boundary of Aravaipa Canyon Wilderness Area
Cave Creek/South Fork of Cave Creek (Chiracahua Mountains)	From the headwaters to the Coronado National Forest boundary
Buehman Canyon Creek	From its headwaters to approximately 9.8 miles downstream
Lee Valley Creek	From its headwaters to Lee Valley Reservoir
Bear Wallow Creek	From its headwaters to the boundary of the San Carlos Indian Reservation
North Fork of Bear Wallow Creek	From its headwaters to Bear Wallow Creek
South Fork of Bear Wallow Creek	From its headwaters to Bear Wallow Creek
Snake Creek	From its headwaters to its confluence with the Black River
Hay Creek	From its headwaters to its confluence with the West Fork of the Black River
Stinky Creek	From the Fort Apache Indian Reservation boundary to its confluence with the West Fork of the Black River
KP Creek	From its headwaters to its confluence with the Blue River
Source: AAC R18-11-112(E)	

Table 8-1. Arizona's Designated Unique Waters

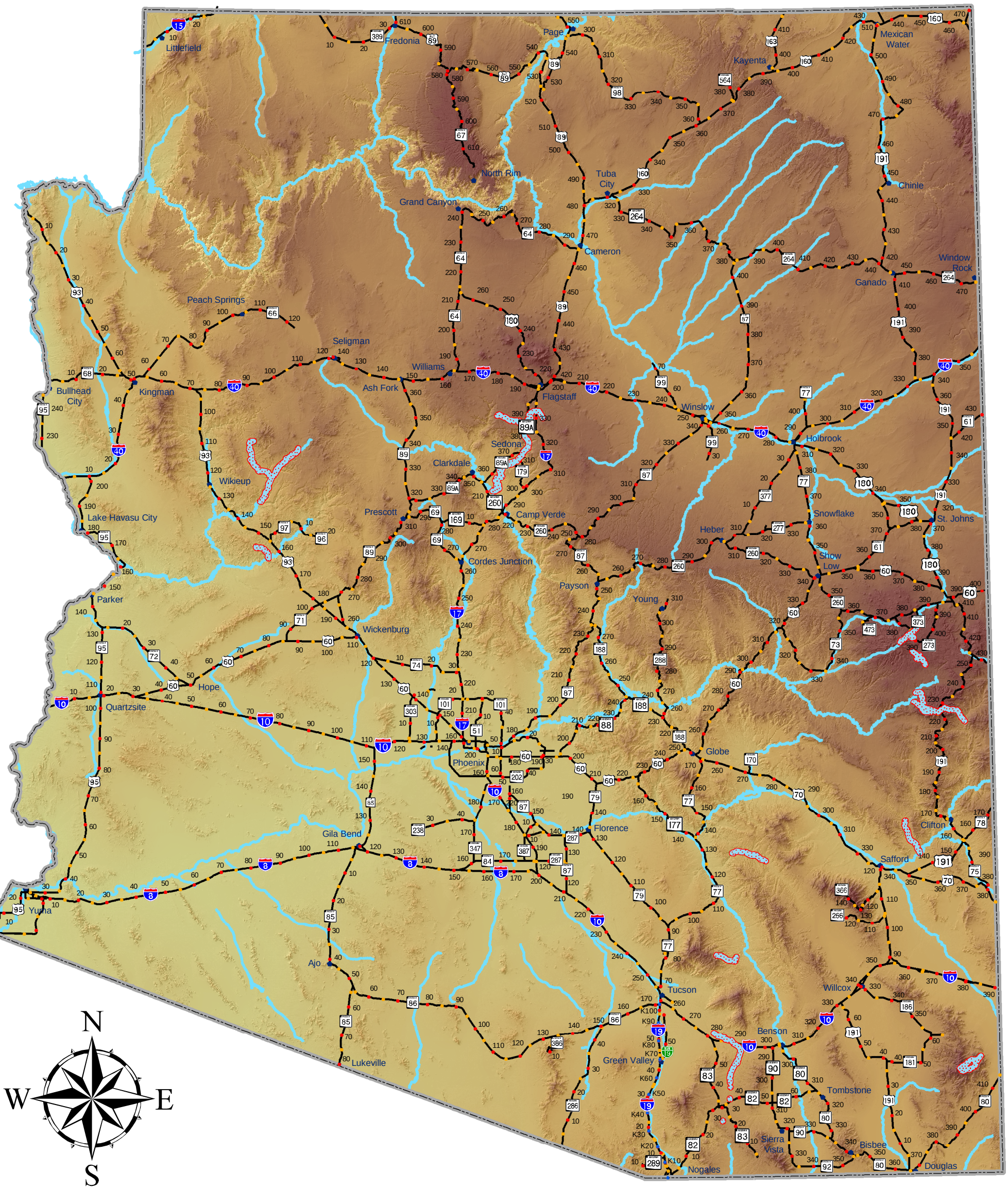
Wild and Scenic Rivers

The 1968 Wild and Scenic Rivers Act establishes a national policy for certain rivers and their immediate environments as designated by an Act of Congress or by the Secretary of the Interior upon application of the governor of a state that "possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, cultural, or similar values in a free-flowing condition" (16 United States Code (USC) §§ 1271) to be protected. Several Federal and State land management agencies (Bureau of Land Management, USDA Forest Service, and National Park Service) oversee Wild and Scenic Rivers. Once established, the Scenic River Area must be managed in a manner that protects and enhances the values determined to exist. "To protect free-flowing character the Federal Energy Regulatory Commission (which licenses non federal hydroelectric projects) is not allowed to license construction for dams, water conduits, reservoirs, powerhouses and transmission lines, or other project works on, or directly affecting, wild and scenic rivers. Other federal agencies may not assist by loan, grant, license or otherwise any water resource project which would have a direct and adverse effect on the values for which a river was designated" (Wild and Scenic Rivers Reference Guide 2004). There are similar restrictions for Section 5(a) congressionally authorized study rivers.

Arizona's only designated Wild and Scenic River corridor is 40.5 miles of the Verde River in Yavapai County and is managed by the USDA Forest Service (*Figure 8-8*). The classification is divided into the Wild River Area and the Scenic River Area. The Wild River Area traverses 22.2 miles (35.7 kilometers) covering 6,824 acres (2,730 hectares) almost entirely in the Mazatzal Wilderness Area. It is located primarily within the Tonto National Forest with a small percentage flowing within the Coconino National Forest. The Scenic River Area covers 5,692 acres (2,277 hectares) and crosses 18.3 miles (29.5 kilometers) through three National Forests. Half of the Scenic River Area is located in the Coconino National Forest, 38 percent in the Prescott National Forest and the remainder in the Tonto National Forest.

Twenty-two miles of the Salt River and 29 miles of the San Francisco River were initially considered as study rivers but designation was not recommended. Other reaches of rivers in Arizona are being considered as potential additions to the National Wild and Scenic Rivers System (*Table 8-2)*.

UNIQUE WATERS



Legend

0 15 30 60 90 120 Kilometers

0 12.5 25 50 75 100 Miles

Unique Waters

Figure 8-7. Unique Waters

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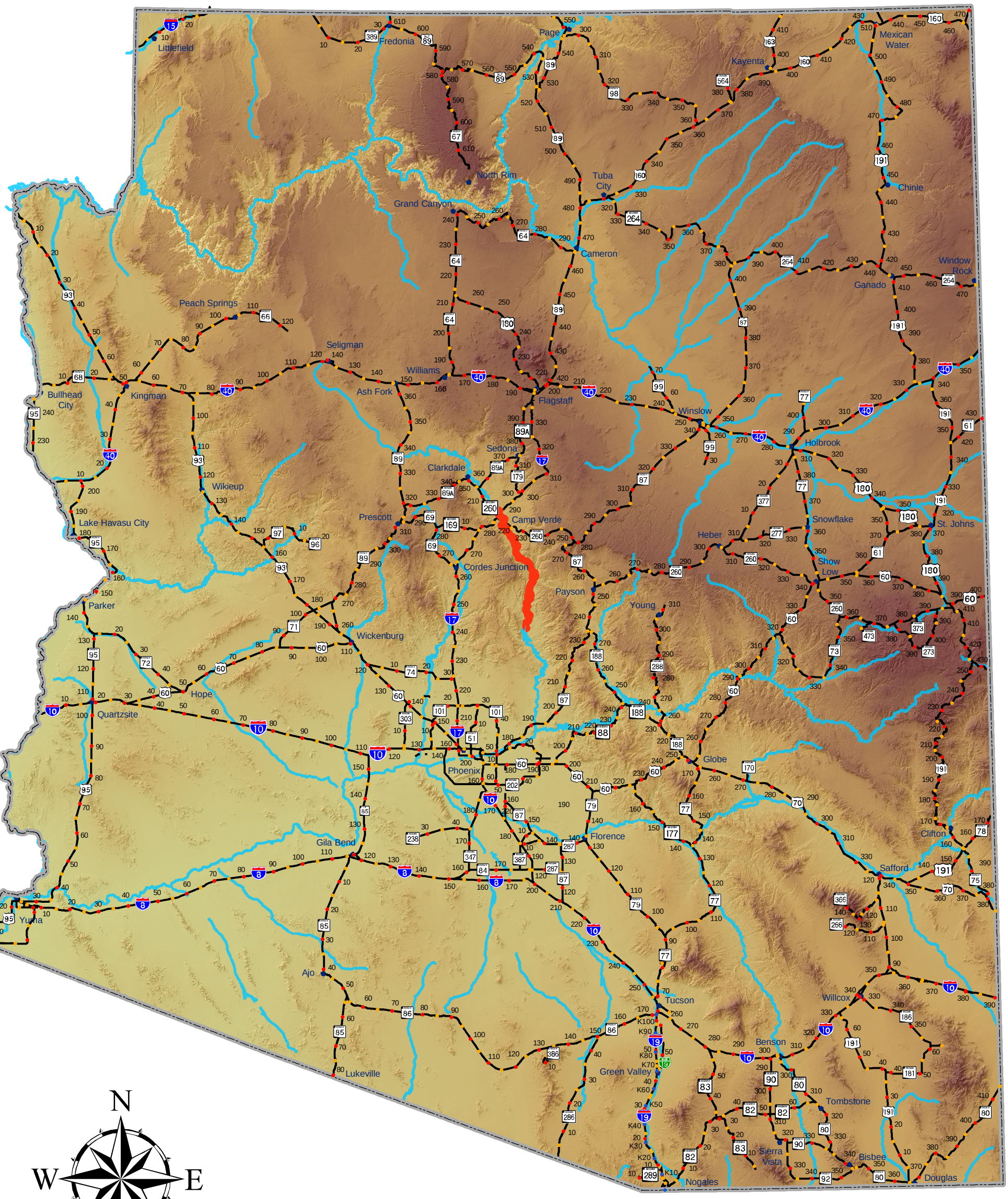
WILD AND SCENIC WATERS



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Wild and Scenic River

Figure 8-8. Arizona Wild and Scenic River

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Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Agua Fria River	Horseshoe Ranch to Larry Creek Area (15 miles) Sycamore Creek to Horseshoe Ranch (8 miles)	Perennial with some intermittent reach. Cottonwood/willow riparian area.	Yavapai
Aravaipa Creek	Confluence of Turkey Creek to Hell's Half Acre Canyon (10 miles)	Deep, colorful and incised gorge. Mixed broadleaf riparian area with mesquite bosques.	Yavapai
Arnett/ Telegraph Creeks	Arnett – Forest Road 4 to Mid – Section 7 (2 miles) Telegraph – Forest Road 4 to Arnett Creek (1 mile)	Unique cottonwood/willow riparian community in Sonoran Desert.	Pinal
Ash Creek	Headwater to diversion for Cluff Ranch (6 miles)	Perennial, with intermittent reaches. Mixed broadleaf riparian vegetation. Variable rugged steep slopes, deep canyons and falls.	Graham
Barbershop Canyon	Center of Section 16, Township 21 North, Range 11 East to confluence of East Clear Creek (10 miles)	Areas of riparian vegetation. Narrow canyon environment.	Coconino
Bear Wallow Creek	Confluence of North and South Forks to Forest boundary (4 miles)	Perennial. Riparian vegetation. Narrow canyon.	Greenlee
Big Sandy River	Highway 93 downstream to Signal Townsite (19 miles) Signal Townsite to Alamo Lake (9 miles)	Surrounding mountains and cliff features. Extensive riparian habitat important for bald eagle and peregrine falcon.	Mohave
Bill Williams River	West boundary of Rawhide Mountain Wilderness eastern boundary of Swansea Wilderness (5 miles) East Boundary of Swansea Wilderness to Planet Ranch (6 miles) Alamo Dam to West boundary of Rawhide Wilderness boundary (10 miles)	One of the most important desert riparian ecosystems in AZ. Diversity of vegetation and crucial habitat for bird, fish and other wildlife.	Mohave/La Paz Boundary
Black River	Salt River confluence to confluence of East and West Forks Black River (113 miles) Confluence of East and West Forks to ¼ mile upstream of Forest Road 25 Bridge (12 miles) ¼ mile upstream to ¼ mile downstream of Forest Road 25 Bridge (0.5 miles) ¼ mile downstream of Forest Road 25 Bridge to Forest Service boundary (8 miles)	Perennial. Riparian vegetation. Varied canyon widths. Sinuous river channel winds through open, low mountains with exposed rock formations and stand of juniper-pinion forests; excellent scenic values with numerous vistas and minimum cultural impact; excellent area to explore, backpack and hike; high quality trout fishery; provides solitude within a wilderness setting.	Apache, Gila, Graham, Greenlee, Navajo
Black River, East Fork	Black River confluence to source of North Fork of East Fork Black River (includes the North Fork of the East Fork Black River) (26 miles) Diamond Rock Campground to confluence with West Fork Black River (8 miles) Crosby Crossing to Diamond Rock Campground (10 miles)	Perennial. Riparian vegetation. Canyon width varies. Narrow river channel traverses alpine meadows and adjoining forest lands; portions provide outstanding scenery with very little man-made interference; lower half of the river is heavily used for recreation with considerable use by fishermen.	Apache, Greenlee
Black River, West Fork	Forest boundary to Forest Road 116 (3 miles) Forest Road 116 to West Fork Campground (7 miles) West Fork Campground to East Fork Black River (4 miles)	Perennial. Mixed Conifer and Alder/Willow riparian area. Alpine meadows and narrow canyons.	Apache
Blue River	Campbell Blue River from Highway 666/191 to Luce Ranch (4 miles) Smith Place to confluence with San Francisco River (30 miles) Above Luce Ranch through Smith Place (19 miles)	Perennial. Partially within Blue Range Primitive Area.	Greenlee
Bonita Creek	San Carlos Apache Indian Reservation to confluence with Gila River (15 miles)	Variable canyon width with incised reaches. Mixed broadleaf riparian area with short stretches of mesquite bosques.	Graham
Boucher Creek	Entire segment within Grand Canyon National Park (2 miles)	Free-flowing stream though Vishnu Schist and other older Precambrian rocks, creating a series of waterfall, pools and habitat for a variety of aquatic wildlife.	Coconino
Burro Creek	Scratch Canyon to Upper Burro Creek Wilderness Area (14 miles) Wilderness boundary near Boulder Creek to Six Mile Crossing (7 miles)	Broad river valley and narrow canyons. Mesquite and cottonwood/willow riparian area. Perennial with intermittent stretches.	Mohave

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Burro Creek	Six Mile Crossing to Highway 93 (9 miles) Highway 93 to Big Sandy River (14 miles) Portion with Upper Burro Creek Wilderness (8 miles)	Broad river valley and narrow canyons. Mesquite and cottonwood/willow riparian area. Perennial with intermittent stretches.	Mohave
Canada del Oro	(Upper) Headwaters to ¼ mile south of Forest Road 736 (6 miles) (Lower) ¼ mile south of Forest Road 736 to Forest boundary (3 miles	Riparian vegetation scattered along entire length. Rugged, rough, variable canyon.	Pima, Pinal
Canyon Creek	Canyon Creek Spring to Fort Apache Reservation boundary (5 miles)	Pleasant perennial stream in timber country.	Gila
Cave Creek, South Fork	(Upper) Headwaters to Wilderness boundary (6 miles) (Lower) Wilderness boundary to Cave Creek confluence (1 mile)	Highly diver flora/fauna, spectacular spires, caves, cliffs and arches. Narrow deep canyon. Internationally recognized birding location	Cochise
Cherry Creek	Forest Road 329 to Billy Lawrence Creek (18 miles) Billy Lawrence Creek to Ellison Ranch (7 miles)	Narrow canyon just north and east of Sierra Ancha Wilderness	Gila
Chevelon Canyon	Little Colorado River confluence to Chevelon Canyon Dam (62 miles) Chevelon Lake Dam to Forest boundary (16 miles)	Largely perennial; will pool during very dry summers. Riparian vegetation. Deep, narrow canyon. The stream cuts a scenic, steep twisting canyon through coniferous forests, evergreen woodland and plains grassland formations giving rise to a varied mosaic of vegetation communities and unusual habitats. With its variety of plant and animal species, Chevelon Canyon has been identified as a potential natural landmark.	Coconino, Navajo
Chitty Creek	Headwaters to East Eagle Creek (7 miles)	Maple covered canyons	Greenlee
Chuar Creek	Entire segment with Grand Canyon National Park (4 miles)	Crosses younger Precambrian rocks, exposed by Butte Fault.	Coconino
Cienega Creek	Headwaters to the Narrows (10 miles)		Pima, Santa Cruz
Cima (Winn Falls) Creek and Lower Cave Creek	(Cima Creek) Headwaters to Wilderness boundary (2 miles) (Lower) Wilderness boundary to Forest boundary, near Portal (7 miles)	Waterfalls, variable deep canyon and large escarpments. Mixed broadleaf riparian vegetation from conifer down to mesquite.	Cochise
Clear Creek	Entire segment with Grand Canyon National Park (4 miles)	Free-flowing stream through Vishnu Schist and other older Precambrian rocks, creating a series of waterfalls, pools and habitat for variety of aquatic wildlife.	Coconino
Clear Creek, East	Crossing of Forest Road 96 north to Forest boundary (25 miles)	Areas of riparian vegetation.	Coconino
Clear Creek, West	Clear Creek Campground in Section 18, Township 13 North, Range 6 East to Clover Creek confluence (32 miles) Headwaters, Section 14, Township 13 North, Range 6 East to Wilderness boundary (29 miles) Wilderness boundary to dispersed camping area Clear Creek Campground (7 miles)	One of Arizona's most rugged and pristine streams; steep-walled, red sandstone canyons are geologically distinct; unique multi-layered riparian vegetation; access is extremely limited; good quality rainbow and brown trout fishery. Narrow canyon. Broad river valley	Coconino, Yavapai
Colorado River	Paria Riffle (RM 1) to 237-Mile Rapid in Grand Canyon National Park (236 miles)	Offers a beautifully layered record covering nearly 2 billion years of geologic times. Passes through three of North America's four deserts. One of the world's premier white-water rafting rivers.	Coconino, Mohave
Colorado River	Lake Mead to Glen Canyon Dam (228 miles)	Flows through Grand Canyon National Park; magnificent multi-colored gorges and vistas spanning miles are world famous; heavy recreation use by river rafters and sports fishermen; unique geology of river is world famous; three fish species on rare and endangered lists; riparian habitat supports great variety of birdlife and large reptilian populations; at least 14 archaeological sites present; area is under extensive scientific research and is constantly used as an educational resource.	Coconino, Mohave
Colorado River	Upper end Lake Havasu (Blankenship Bend) to Interstate 40 bridge crossing Topock (11 miles)	Pristine stretch flows through scenic Topock Gorge and Havasu National Wildlife Refuge; outstanding scenery with premium quality riparian habitat; excellent opportunities for bird observation in fall/winter; may provide habitat for endangered Colorado squawfish, Bonytail and razorback sucker; very popular for a variety of boating activities	Mohave (AZ), San Bernadino (CA)

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Colorado River	Gauging station below Cibola Lake to Martinez Lake (Fishers Landing)	Traverses Cibola and Imperial National Wildlife refuges and Picacho State Recreation Area; high quality riparian habitat with excellent wildlife values; Picacho area is especially scenic; canoeing is excellent on this segment; one of the few remaining unchanneled stretches of the lower Colorado River.	Yuma (AZ), Imperial (CA)
Crystal Creek	Entire segment within the Grand Canyon National Park (4 miles)	Free-flowing stream through Vishnu Schist and other older Precambrian rocks; creating a series of waterfalls, pools and habitat for a variety of aquatic wildlife.	Coconino
Deer Creek	Entire segment within the Grand Canyon National Park (1 mile)	Highly visible waterfall at its confluence with the Colorado River. Very popular pools	Coconino
Eagle Creek	Gila River confluence to confluence with Dry Prong and East Eagle Creek (58 miles) Headwaters to Sheep Wash (26 miles)	Perennial. Sinuous gravel channel flows through rugged canyons with vertical walls and high rock formations; highly scenic canyon supports excellent riparian habitat; unusual species and diversity of raptors, high densities of black hawks and golden eagles; know nesting habitat for the peregrine falcon.	Graham, Greenlee
Fish Creek	Forest Road 24 to Black River (10 miles)	Perennial. Riparian vegetation. Deep canyon.	Greenlee
Fossil Creek	Below APS dam to Mazatzal Wilderness boundary (7 miles)	Intermittent in upper reach. Large narrow canyon. Special areas of geologic and historic interest.	Gila
Francis Creek	Mazatzal Wilderness boundary to Verde Wild River Area boundary (11 miles)	Perennial; cottonwood/willow riparian area; narrow canyon.	Mohave
Gila River	Hayden-Winkelman Tailings Pond to Coolidge Dam (32 miles)	River flows through a narrow canyon; spectacular gorge in upper portion with steep cliffs and distinctive geologic strata; dense riparian vegetation along river bottom with a minimum of cultural development.	Gila, Pinal
Gila River	From San Carlos Reservoir in AZ confluence with East and West Forks of the Gila River (255 miles)	River flows through Gila Wilderness and Gila National Forest; Red Rock Cliff area has been identified as significant by New Mexico Natural Areas inventory; area possesses tremendous wildlife diversity including State endangered species and the richest avifauna of any riparian system in New Mexico; river provides habitat for Gila trout, a federally endangered species.	Grant (AZ), Hildalgo (NM)
Gila River	Northeast corner, Section 31, Township 6 South, Range 28 East to Northeast corner, Section 3, Township 6 South Range 30 East (26 miles)	River flows through a steep-walled canyon with the Gila Box are; this region possesses spectacular geology with diverse, variegated strata; Gila Box offers unexcelled habitat for birds of prey including the endangered bald eagle; the undeveloped canyon exhibits outstanding scenic qualities.	Graham. Greenlee
Gila River (Gila Box)	Section 3 (Guthrie), Township 6 South, Range 30 East to Section 26, Township 5 South, Range 29 East (7 miles) Section 26, Township 5 South, Range 29 East to Section 22, Township 6 South, Range 28 East (15 miles) Section 22, Township 6 South, Range 28 East to Section 29, Township 6 South, Range 28 East (Brown's Canal) (4 miles)	Steep cliffs, colorful bluffs and deep canyons. Riparian vegetation which is uncommon in the southwest enhances wildlife. Popular rafting and canoeing area.	Graham, Greenlee
Gila River (Middle)	Coolidge Dam to Hook and Line Ranch (Section 24, Township 3 South, Range 17 East) (6 miles) Hook and Line Ranch to Little Ash Creek (12 miles) Little Ash Creek to east edge of Hayden-Winkelman Tailing Ponds (14 miles)	Cuts through Mescal Mountains forming deep and narrow gorge then passes through open terrain. Wintering bald eagle habitat.	Gila, Pinal
Grant Creek	Headwater to diversion 0.75 miles from Forest boundary (5 miles)	Broadleaf riparian vegetation up to mix conifer series. Rugged, variable steep slopes and falls.	Graham
Hassayampa River	Headwaters to railroad trestle northwest of Morristown Nature Conservancy Preserve (60 miles)	Broad river valley. Cottonwood/willow riparian area. Perennial with some intermittent reaches.	Maricopa, Yavapai
Havasu Creek	Entire segment within Grand Canyon National Park (3 miles)	Renowned for its blue-green waters cascading over numerous travertine falls through quiet pools. Velvet Ash and Arizona Ash, uncommon in other areas, thrive in this riparian zone.	Coconino
Hermit Creek	Entire segment within Grand Canyon National Park (2 miles)	Free-flowing stream in Vishnu Schist and other older Precambrian rocks, creating a series of waterfalls, pools and habitat for a variety of aquatic wildlife.	Coconino

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Home Creek	Headwaters to West Fork Black River (10 miles)	Perennial. Riparian vegetation. Narrow canyon.	Apache
Hot Springs Canyon	Confluence of Bass Canyon to Section 5, Township 13 South, Range 20 East (6 miles)	Broad canyon with narrow sections. Cottonwood/willow with some sycamore and mesquite bosques. Perennial with short intermittent reaches.	Cochise
Kanab Creek	Entire segment within Grand Canyon National Park (12 miles)	Second larges tributary drainage entering Grand Canyon National Park. Native fish species used for spawning.	Mohave
Kanab Creek	Forest Service/Bureau of Land Management boundary line to the National Park Service/Forest Service boundary (20 miles)	Intermittent, isolated reaches of perennial flow. Riparian vegetation. Broad canyon.	Coconino, Mohave
KP Creek	KP Trailhead/Cienega to Private Land (11 miles)	Perennial. Waterfalls and narrow canyon. Riparian vegetation.	Greenlee
Kwagunt Creek	Entire segment within Grand Canyon National Park (3 miles)	Crosses younger Precambrian rocks, exposed by Butte Fault.	Coconino
Leonard Canyon	Knoll Lake Dam to confluence of East Clear Creek	Areas of riparian vegetation. Canyon environment.	Coconino
Little Colorado River	Colorado River confluence to Sunrise (115 miles)	River channel varies from steep, multi-colored canyon walls in Lower Colorado River Gorge to tablelands of moderate relief in the scenic Painted Desert region; extreme lower portion flow through Grand Canyon National Park, important habitat for the endangered humpback chub.	Coconino
Little Colorado River	Entire segment within Grand Canyon National Park (2 miles)	Travertine terraces and dams, cliffs and milky-blue water create spectacular geologic and scenic arena. Contains religiously significant routes and sites by Hopi people.	Coconino
Little Colorado River, East Fork	Headwaters to confluence with West Fork Little Colorado River (12 miles)	Perennial. Mixed conifer and alder/willow riparian area.	Apache
Little Colorado River, South Fork	Forest Road to Little Colorado River (10 miles)	Mixed conifer, Ponderosa pine, pinon/juniper and alder. Willow/cottonwood riparian areas.	Apache
Little Colorado River, West Fork	Headwaters to Wilderness boundary (5 miles) Wilderness boundary to Powerline Crossing (2 miles) Powerline Crossing to Greer (4 miles)	Perennial. Spruce/fir, mixed conifer and alder/willow riparian area. Alpine meadows and narrow canyons.	Apache
Marijilda Creek	Headwaters to Forest boundary (7 miles)	Riparian vegetation. Variable, rugged canyon.	Graham
Nankoweap Creek	Entire segment within Grand Canyon National Park (39 miles)	Crosses younger Precambrian rocks, exposed by Butte Fault	Coconino
Oak Creek	Sterling Springs Fish Hatchery to private land Section 5, Township 17 North, Range 6 North (14 miles)	Adjacent to major state highway full length. Numerous developed residence, campgrounds and lodges.	Coconino
Oak Creek, West Fork	Headwaters, Section 14, Township 19 North, Range 5 East to confluence of Oak Creek (8 miles)	Canyon environment. Boundary between two Geologic Zones.	Coconino
Paria River	Colorado River to source (92 miles) Utah/Arizona state line to confluence with Colorado River (28 miles)	Deep, narrow, sheer-walled canyon. Riparian vegetation. Hiking, backpacking and some horseback riding.	Coconino
Paria River	Entire segment within Glen Canyon National Recreation Area (3 miles)	Scenic, recreational, geological, cultural and wildlife values.	Kane (Utah)
Parker Creek	Rock Spring to confluence with Cottonwood Creek (8 miles)	Perennial stream dropping from mixed conifer down into Sonoran Desert.	Gila
Pigeon Creek	Headwaters to Turkey Creek (12 miles) Turkey Creek to confluence with Blue River (4 miles)	Perennial. Steep canyon and waterfalls.	Greenlee
Pinto Creek	North of private land (Layton Ranch) to lower end of Pinto Box (9 miles)	Scenic perennial stream in low country with good riparian habitat.	Gila
Post Creek	Headwater confluence with Grant Creek (2 miles)	Riparian vegetation within mixed conifer series. Variable, rugged, steep canyon.	Graham
Redfield Canyon	Headwaters to Forest boundary (9 miles)	Broadleaf riparian vegetation mostly within the woodland series. Rugged canyon.	Graham
Romero Canyon	(Lower) Wilderness boundary to Canada del Oro confluence (2 miles) (Upper) Headwaters to Wilderness boundary (6 miles)	Scattered riparian vegetation along entire length. Variable, rugged canyon.	Pima

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Rucker Canyon	(Upper) Headwaters to Wilderness boundary (6 miles)	Riparian vegetation. Spectacular scenery/beauty, deep and rugged canyon.	Cochise
Sabino Creek	(Upper) Marshall Gulch recreation site to Sabino Canyon recreation area (8 miles) (Lower) Wilderness boundary to Forest boundary (3 miles)	Mixed broadleaf riparian vegetation. Variable, rugged canyon.	Pima
Salome Creek	Confluence of Salome/Turkey creek to Forest Road 60 (19 miles)	Major canyon with perennial stream dropping into Sonoran Desert. Deep canyon.	Gila
Salt River	East boundary of Salt Wilderness to west boundary of Fort Apache Indian Reservation (9 miles) Fort Apache Indian Reservation to confluence of White and Black River (61 miles)	Pristine, river channel; upper port of Salt River canyon contains extremely varied geologic formations and is often called a mini-Grand Canyon; three federally listed endangered species are present – bald eagle, Mexican duck, Colorado River squawfish; riparian vegetation supports both high populations and diverse species of wildlife; on of the best whitewater streams in the Southwest.	Gila
Salt River	San Carlos Indian Reservation boundary to east boundary of Salt Wilderness (15 miles)	Nationally known whitewater river through spectacular canyons.	Gila
San Francisco River	Southern Arizona/New Mexico boundary to Luna Lake, Arizona (104 miles)	Located entirely within Gila National Forest; white sand and gravel floodplain traverses pinon/juniper forests and grassy meadow; scenic limestone gorges and rock outcropping; San Francisco River Box Canyon, Hot Spring and Natural Bridge are identified as significant natural areas; hot springs in lower reaches are popular recreation spots; hiking and fishing are dominant recreation activities; evidence of prehistoric remains and rock art on cliffs, canyon walls and in caves; Arizona trout habitat.	Apache (AZ), Catron (NM)
San Francisco River, Lower	Section 7, Township 5 South, Range 30 East to Section 14, Township 5 South, Range 29 East (5 miles) Section 14, Township 5 South, Range 29 East to confluence with Gila River (3 miles)	Perennial. Incised river canyon.	Greenlee
San Pedro River	US/Mexico border to Section 21, Township 18 South, Range 21 East (46 miles)	Perennial with intermittent reaches. Cottonwood/willow riparian with mesquite bosques. Broad river valley.	Cochise
Santa Maria River	Highway 93 to Alamo Lake (21 miles) Public land boundary to Highway 93 (18 miles)	Extensive riparian complex – habitat for bald eagles and breeding peregrine falcon. Surrounding Mountains and cliff features.	Mohave/La Paz boundary, Yavapai
Sardine Creek	Headwaters to San Francisco River (9 miles)	Waterfalls and pools up during the summer.	Greenlee
Shinumo Creek	Entire segment within Grand Canyon National Park (8 miles)	Retains its native fishery without the influence of trout and other aquatic non-natives entering from mainstream due to waterfall at mouth.	Coconino
Spring Creek	Forest Road 416 to Wilderness boundary (12 miles) Wilderness boundary to confluence with Tonto Creek (6 miles)	Little known perennial stream with good riparian habitat.	Gila
Stone Creek	Entire segment within Grand Canyon National Park (2 miles)	Consists of series of waterfalls, including one of the most spectacular in Grand Canyon.	Coconino
Swamp Springs Creek	Section 34, Township 11 South, Range 20 East to confluence with Redfield Canyon (2 miles)	Perennial with standing pools during drier periods. Mixed broadleaf riparian area. Narrow, variable canyon.	Graham
Sycamore Canyon	Ruby Road Forest Road 39 to US/Mexico border (5 miles)	Riparian vegetation scattered along entire segment. Rugged, rough, deep and incised in places.	Santa Cruz
Sycamore Creek	Parson Springs to confluence of Verde River (4 miles)	Mouth of large, well developed canyon.	Yavapai
Tapeats Creek and Thunder River	Entire segment within Grand Canyon National Park (3 miles)	Tapeats Creek is dependent on groundwater from the Kaibab Plateau. Thunder Falls is one of the better known wilderness waterfalls within the Grand Canyon.	Coconino
Tonto Creek	Theodore Roosevelt Lake to source (60 miles)	Originates on extreme slopes below Mogollon Rim; descending rapidly, water cascades through boulder strewn canyons characterized by steep ridges, interesting rock formation, deep pools and numerous side canyons; wide ranges in elevation contribute to large floral diversity varying from ponderosa pine, mixed evergreen forests in upper reaches to chaparral woodlands further downstream; Hells Gate area displays outstanding scenic qualities.	Coconino, Gila

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Tonto Creek	Hells Gate Wilderness boundary (north) to Hells Gate Wilderness boundary (south) (21 miles) Mouth of Cocomunga Creek to mouth of Gun Creek (9 miles)	Significant perennial stream in deep canyon. Many bluffs and good riparian habitat.	Gila
Turkey Creek	Section 32, Township 6 South, Range 19 East to Aravaipa Creek confluence (3 miles)	Perennial with intermittent reaches. Mixed broadleaf riparian area. Incised canyon.	Graham
Verde River	End of Horseshoe Reservoir to vicinity of Table Mountain (14 miles)	Wide floodplain dotted with saguaro cacti and riparian vegetation; some rocky bluffs and talus slopes present; identified as essential habitat for both nest and wintering bald eagles; outstanding historic and cultural values with many sites significant to the development of the southwest. The segment from the boundary between National Forest and private land in Section 26 and 27, Township 13 North, Range 5 East downstream to confluence with Red Creek was added as a component of the National Wild and Scenic Rivers System on 8/28/84.	Gila
Verde River, East	Verde River to confluence to source (56 miles)	Headwater at Mogollon Rim; narrow rock strewn stream channel winds through Mazatzal Wilderness and Tonto National Forest. This highly scenic river canyon possesses notable recreational, fish and wildlife and historic and cultural values.	Gila
Verde River, East	West boundary of "East Verde Park" to west boundary of L. F. Ranch (20 miles) West boundary of L. F. Ranch to Verde Wild River Area boundary (13 miles)	Major stream with large areas of riparian habitat.	Gila
Verde River, Lower	Mouth of Red Creek to south boundary of Mazatzal Wilderness (9 miles) South boundary of Mazatzal Wilderness to Sheep Bridge (1 mile)	Major desert river with significant riparian habitat and excellent (but brief) river-running opportunities.	Yavapai
Verde River, Upper	Prescott National Forest boundary near Paulden to Clarkdale (33 miles)	Perennial. Riparian vegetation. Narrow canyon.	Yavapai
Virgin River	Utah/Arizona state line to first I 15 bridge (3 miles) Virgin River Recreation Area to mouth of Virgin River Gorge (7 miles) Lake mead to Highway 17 near Hurricane, Utah (76 miles) Mouth of Virgin River Gorge to Arizona/Nevada state line (17 miles)	Cuts through area of extreme geologic faulting and folding, exposing numerous layers of earth's crust and providing spectacular scenery. Unique riparian corridor.	Mohave
Wet Beaver Creek	Headwaters, Section 16, Township 15 North, Range 8 East to Wilderness boundary (13 miles) Wilderness boundary to private land Section 32, Township 15 North, Range 6 East (5 miles)	Narrow canyon. Broad river valley.	Coconino, Yavapai
Willow Creek	From ¼ mile north of Wiggins Crossing to confluence with Clear Creek (14 miles)	Ephemeral – will pool during wet years. Deep, narrow canyon. Riparian vegetation.	Coconino
Willow Springs Canyon	Willow Springs Dam to Woods Canyon Creek (3 miles)	Perennial.	Coconino
Woods Canyon	Woods Canyon 1 mile below Woods Canyon Lake Dam to confluence with Chevelon Canyon (4 miles)	Largely perennial; will pool during very dry summer. Riparian vegetation. Deep, narrow canyon.	Coconino
Workman Creek	Workman Falls to Salome Wilderness boundary (6 miles) Salome Wilderness boundary to confluence with Salome Creek (3 miles)	Begins in mixed conifer forest, dropping rapidly into lower country. Special plan species present.	Gila
Wright Creek	East Fork of Wright Canyon downstream to Section 36, Township 24 North, Range 13 West (13 miles)	Narrow Canyon. Cottonwood/willow riparian area. 1000 year old Indian trail became first wagon road across Arizona.	Mohave

Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations (continued)

ARIZONA WATERS POTENTIAL CANDIDATES FOR WILD AND SCENIC DESIGNATIONS			
RIVER	**REACH/LENGTH**	**DESCRIPTION**	**COUNTY**
Wet Beaver Creek	Headwaters, Section 16, Township 15 North, Range 8 East to Wilderness boundary (13 miles) Wilderness boundary to private land Section 32, Township 15 North, Range 6 East (5 miles)	Narrow canyon. Broad river valley.	Coconino, Yavapai
Willow Creek	From ¼ mile north of Wiggins Crossing to confluence with Clear Creek (14 miles)	Ephemeral – will pool during wet years. Deep, narrow canyon. Riparian vegetation.	Coconino
Willow Springs Canyon	Willow Springs Dam to Woods Canyon Creek (3 miles)	Perennial.	Coconino
Woods Canyon	Woods Canyon 1 mile below Woods Canyon Lake Dam to confluence with Chevelon Canyon (4 miles)	Largely perennial; will pool during very dry summer. Riparian vegetation. Deep, narrow canyon.	Coconino
Workman Creek	Workman Falls to Salome Wilderness boundary (6 miles) Salome Wilderness boundary to confluence with Salome Creek (3 miles)	Begins in mixed conifer forest, dropping rapidly into lower country. Special plan species present.	Gila
Wright Creek	East Fork of Wright Canyon downstream to Section 36, Township 24 North, Range 13 West (13 miles)	Narrow Canyon. Cottonwood/willow riparian area. 1000 year old Indian trail became first wagon road across Arizona.	Mohave

Impaired Waters

The identification of impaired waters can be used as a tool to depict general watershed health indicating which watershed, and watercourses in particular, may be more vulnerable to consequences of existing or proposed transportation corridors, urbanization, and other infrastructure. Impaired water is defined as a watercourse that does not meet established water quality standards even after point source limitations have been implemented. Under section 303(d) of the Clean Water Act, each state must submit a list of waters to the EPA considered to be impaired. The EPA then can partially approve or partially disapprove of the listing. In addition, the EPA may identify and include additional waters and pollutants. Each impaired water requires a total maximum daily load analysis (TMDL). This outlines monitoring efforts and the necessary corrective measures that must be conducted to meet water quality standards.

On November 16, 2004, the EPA partially approved and partially disapproved Arizona's 303(d) list that contained 53 waters listed by the state. The EPA added 19 water bodies as well as additional pollutants to 8 water bodies already listed. There are 54 impaired waters currently recognized by the EPA in Arizona (*Figure 8-9*). The top three general causes of impairment are metals, pesticides and fish consumption advisories. The category of metals includes arsenic, cadmium, copper, copper manganese, silver and zinc. The principal pesticides are DDT metabolites and toxaphene. The fish consumption advisories are based on chlordane in fish tissue and mercury levels. Other causes include turbidity, pathogens, pH and dissolved oxygen levels. After meeting the requirements set forth in Arizona's Impaired Water Identification Rule, these waters will be delisted.

Adult Blue Heron at edge of riparian area.

Potential Impacts

Disruption of physical (e.g., stream flow, channel or terrace substrates), chemical (e.g., nutrient cycling), or biological (e.g., food webs, bank/terrace vegetation) components will affect system integrity and function due to changes in ecological processes or mechanisms. Alterations to these processes will influence distribution and abundance patterns of flora and fauna across multiple scales within the riparian zone and may limit the riparian areas suitability as a corridor for movement of animals. For example, changes to flow regimes (i.e., magnitude, frequency, duration, timing, rate of change) has been identified as one of the primary mechanisms that has caused shifts from native to exotic dominated forests in riparian plant communities along desert rivers (Poff et al. 1997). Such shifts in riparian flora, at the patch scale, have been linked to changes in breeding and migratory avian communities (Haig et al. 1998). Conserving sensitive riparian fauna and the utility of riparian areas as movement corridors must begin with minimizing and mitigating potential impacts to those physical, chemical, and biological parameters and processes that sustain the integrity of the riparian ecosystem.

In this report, key riparian habitat/linkage zones are not separately identified or prioritized for animals and fish as done for the terrestrial potential linkage zones. This process will be conducted in the future (*Section IX Future Directions*). However, a high level of protection for all perennial flowing waters is recommended. Furthermore, it is advocated that project proponents consider all water courses (perennial, intermittent, and ephemeral) as key habitats and potential linkages, and assess the potential impact of roads on organisms across multiple spatial and temporal scales.

Overview of Spatial and Temporal Impacts of Roads and Other Construction Projects

Riparian systems in Arizona are highly dynamic and are maintained by varying levels of disturbance (e.g., flooding). Often, a goal of construction is to limit impacts to infrastructure through control or constraint of the channel within the floodplain. These control structures can directly impact habitat availability, and over the long term may alter the physical, chemical, or biological processes identified above. Angermeier et al. (2004) identified that impacts occur at three phases of road development (i.e., construction, road presence, and urbanization/cumulative effects), and these phase impacts affect ecological processes and organisms across multiple spatial scales (<1 sq km – 1000 sq km) (*Figure 8-10*).

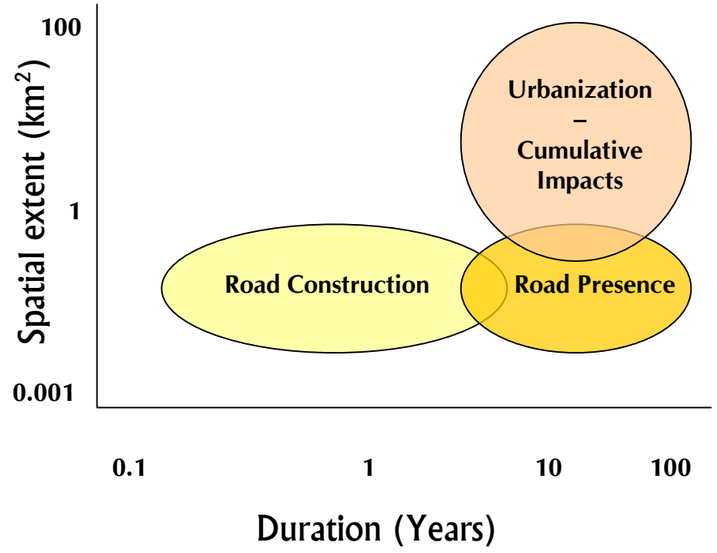

Figure 8-10. Temporal and Spatial Extent of Ecological Impacts on Riparian Areas Due to Three Phases of Road Development (Angermeier et al. 2004)

IMPAIRED WATERS

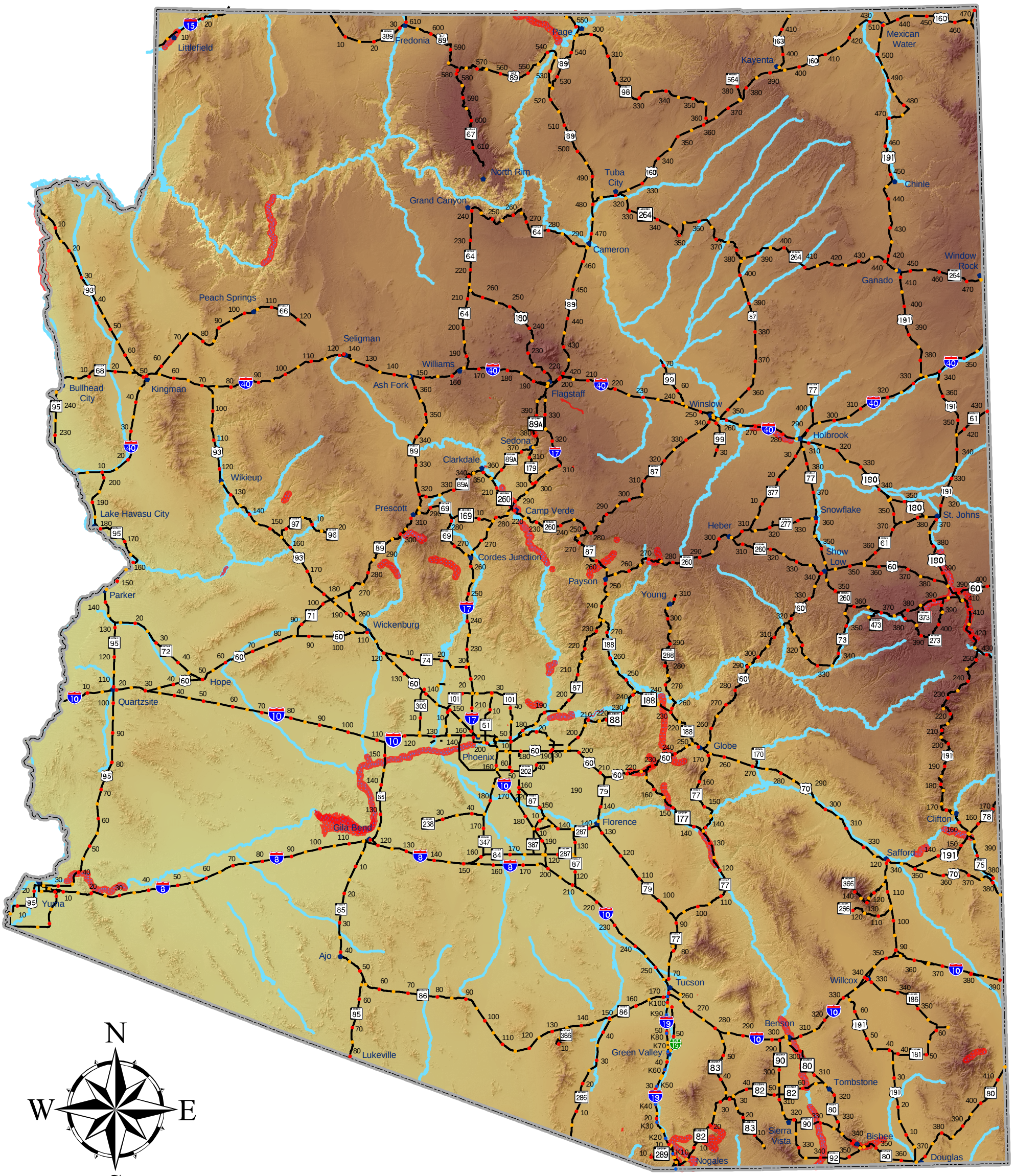

Figure 8-9. Impaired Waters

Siobhan Nordhaugen 2006
ADOT Statewide Natural Resources Management Group

Because each project involves unique construction requirements, channel and floodplain geomorphology, hydrology, and associated biotic communities, managers must consider the broad range of potential impacts during project planning, biological assessments, and environmental impact statements. The following segments summarize (with additions for terrestrial riparian species) the key considerations identified by Angermeier et al. (2004) and Adair et al. (2002) for assessing and mitigating the impact of roads on aquatic biota. It is recommended that resource managers work with an interdisciplinary team (biologists, geomorphologists, hydrologists, ecologists) to develop a list of the potential physical, chemical, and biological components for each phase of road construction, and describe how impacts to these components could influence biota and movement corridors over space and time. The phase descriptions provide a starting point for that discussion. The ecological components should be considered within each phase.

Wood duck, a species reliant on riparian areas.

Phase Descriptions

(From Angermeier et al. 2004):

Phase 1– Construction Impacts: Road construction generally takes place over short time frames and limited spatial scales. Impacts are largely direct and localized alterations to physical, chemical, and biological resources. Typical impacts could include fine sediment runoff, spillage of oil or other hazardous waste from machinery, channelization of rivers, changes to stream gradient and substrate that affect movement of aquatic organisms, and disruption of groundwater regimes.

Phase 2– Road Presence: Road presence includes impacts that are directly due to the existence of the road but that occur later in time than construction. Angermeier et al. (2004) considered roads within 0.6 miles (1 km) of a riparian area as potentially impacting riparian areas. Generally, the impacts are at similar spatial scales as construction but occur over longer time scales. These disturbances may include habitat alterations such as intermittent occurrence of road maintenance, long-term affects to hydrology, channel adjustment, and sediment regimes. There may also be effects on water quality due to precipitation runoff or deicing salt. Terrestrial animals may be impacted by noise or presence of vehicles. Compared to construction impacts, the impacts of road presence and urbanization on movement corridors are more severe and longer term. Roads may also increase the spread of nonnative organisms or pathogens. Human use of a riparian zone (e.g., fishing, hiking) may be increased by easing access to the area, which could cause deleterious impacts to species.

Phase 3 – Urbanization/Cumulative Effects: By providing access to areas that are previously undisturbed, roads often lead to increased urbanization, which should be analyzed for impacts to riparian flora and fauna. The cumulative impact of multiple single road projects should be considered at large spatial and temporal scales within the watershed. Future impacts to riparian systems due to long-term impacts (changes to physical, chemical, or biological characteristics) are often difficult to quantify or predict, but potential impacts should be discussed in impact analyses.

Ecological Components Consideration

Habitat Structure

- Water Depth
- Current Velocity
- Substrate Composition
- Floodplain Connectivity
- Upland Connectivity
- Tributary Connectivity
- Sediment Deposition/Erosion Balance

Water Chemistry

- pH
- Dissolved Oxygen
- Contaminant Concentrations

Flow Regime

- Temporal patterns of water availability of surface water (e.g., timing, magnitude, frequency, duration of flood events)
- Connectivity to floodplain
- Ground water availability (seasonal and annual variation)

Energy Source

- Size, abundance, and nutritional qualities of food particles (e.g., removal of trees or woody debris reduces coarse particulate matter in stream)

Biotic Interactions

- Barriers to longitudinal or lateral movement for various organisms (in channel and floodplain)
- Changes to plant species composition or structure due to changes to physical or hydrological conditions
- Influence of flora changes on organisms: terrestrial (e.g., avian community changes, changes to stream temperature due to shading which may affect aquatic species)
- Community shifts
- Invasive species
- Impacts to threatened, endangered, or sensitive riparian/aquatic species directly or indirectly through changes to habitat over time

General Recommendations

We offer the following guidelines regarding management of these resources:

- Even in the most urbanized perennial or intermittent stream reaches, maintain or re-establish water flows and rehabilitate natural or semi-natural vegetation in streams and on stream banks, so that every mile of every stream (with appropriate exceptions, such as airport approaches) can support aquatic organisms and facilitate gene flow for these species.

- Maintain or enhance the ability of riverine systems to provide for movement of mammals, reptiles, and other non-aquatic species by maintaining natural vegetation for at least 200 m on each side of each mapped riparian zone (where possible). Urban planners need to prevent housing from impinging on stream banks and flood plains.

- Prohibit vehicles, including off-road vehicles, from streambeds. Plan hiking trails and recreation areas to minimize impact on wildlife movement.

- Every paved road, railroad or other linear structure that intersects a riparian/habitat linkage zone should be designed with minimal downstream effects and ensure wildlife connectivity. Culverts are acceptable in ephemeral washes, but are never acceptable for perennial waters where only bridged crossings can conserve the essential ecological and hydrological processes (Johnson 2003). Use road upgrade projects as opportunities to replace culverts and narrow bridges with over-sized structures that can accommodate wildlife. Consider every crossing of a perennial water to be a key linkage that must be minimally disturbed.

- Apply aggressive measures to prevent mine tailings, pollutants, agricultural wastes and fertilizers from entering these zones.

- Use educational signage at trailheads and other access points, especially in urban areas, to encourage responsible behavior.

- In non-urban areas, each bridge over one of these waters should be wide enough when feasible to span at least the natural or original floodplain, plus a swath of upland vegetation to accommodate movement of mammals, reptiles, and other species that prefer to move along riparian corridors without entering the water.

- In general, build structures that do not impede movement of aquatic organisms along the stream, and seek opportunities to remove such structures, or to provide alternative paths around dams. However, maintain those barriers that prevent upstream movement of non-native fishes into reaches occupied by native fishes.

- None of the above guidelines should be construed as requiring the removal of existing occupied buildings or other human facilities.

Elk using riparian underpass.


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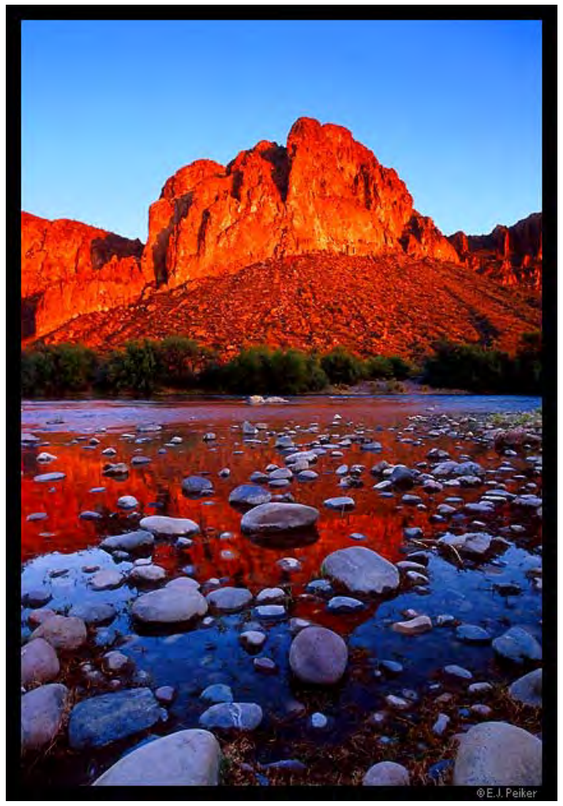
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