DRAFT AMARGOSA WATER REPORT

Prepared by Bill Christian and Greg James for the Resources Legacy Fund Foundation
October 2007

EXECUTIVE SUMMARY


Grimshaw Lake Complex, Tecopa Hot Springs, California

The Amargosa River is a unique and life-giving resource of the Mojave Desert. Its waters support one of the largest arrays of endemic, sensitive, and listed plant and animal species of any area in the United States. The renowned and threatened Devil's Hole pupfish, for example, is only one of the biologically key Amargosa species. As shown on the Amargosa River map, the river flows free and undammed for 125 miles, along and across the boundary of Nevada and California, terminating at Badwater in Death Valley National Park. The river is principally fed by vital springs supplied by groundwater that is thought to originate over a vast region ranging across Nevada to Utah. Flowing mostly underground through the severe desert terrain, the Amargosa and its spring sources surface in a number of striking oases whose waters are absolutely essential to life in the desert.

Ash Meadows Spring Pool, Nevada

While the Amargosa River system is still largely intact, it is subject to significant and potentially devastating long term threats. Rapid population growth in the Las Vegas Valley and its northward-spreading satellite communities in Nevada have led to expanding and unsustainable demands for withdrawal of regional groundwater. Potential development on the California side of the border poses a similar threat to the regional groundwater system.

Groundwater pumping to supply agriculture in the Amargosa drainage adds to the pressure on the river's groundwater sources and agricultural runoff poses contamination threats. Additional contamination threats arise in the form of the risk of radiological pollution from the Nevada Test Site and Yucca Mountain, both of which are within the Amargosa drainage. Invasive non-native vegetation, such as tamarisk, presents another threat by displacing native vegetation and by consuming large quantities of groundwater.

Protecting the waters of the Amargosa River regional aquifer system through all available means is of cardinal importance. Without adequate water, all of the region's assets and life, including human enterprise, will wither and fail. And water-dependent habitats for the region's rich array of biodiversity are particularly at risk.

Groundwater withdrawal for alfalfa irrigation, Amargosa Valley, Nevada

In addition to its rich riparian areas, the Amargosa region contains an extensive array of recreational and cultural resources, hosting networks of hiking and equestrian trails and a great variety of historic, geological and palentological features.

Hiking above China Ranch, Tecopa, California

Because of the river's valuable and rare attributes, Congress is considering legislation to designate a 20-mile free flowing section of the river as the nation's first Wild and Scenic River in a desert. Congressional designation as a Wild and Scenic River would help protect the Amargosa, but, alone, would not be sufficient to avert damaging groundwater withdrawals in the region.


Amargosa River Canyon—Proposed wild segment

While the area is rich in ecological, historic and cultural resources, many areas within the Amargosa's watershed region are not economically robust, with no significant industry or commercial activity-- other than tourism--to support local residents. Thus, activities such as development, agriculture, mining, and even water exports, offer attractive sources of income. Under existing laws, rights to the groundwater resources of the Amargosa can be secured for such uses and can attain priority over other uses of the water. Protecting the essential flows in the Amargosa springs and streams is accordingly difficult.

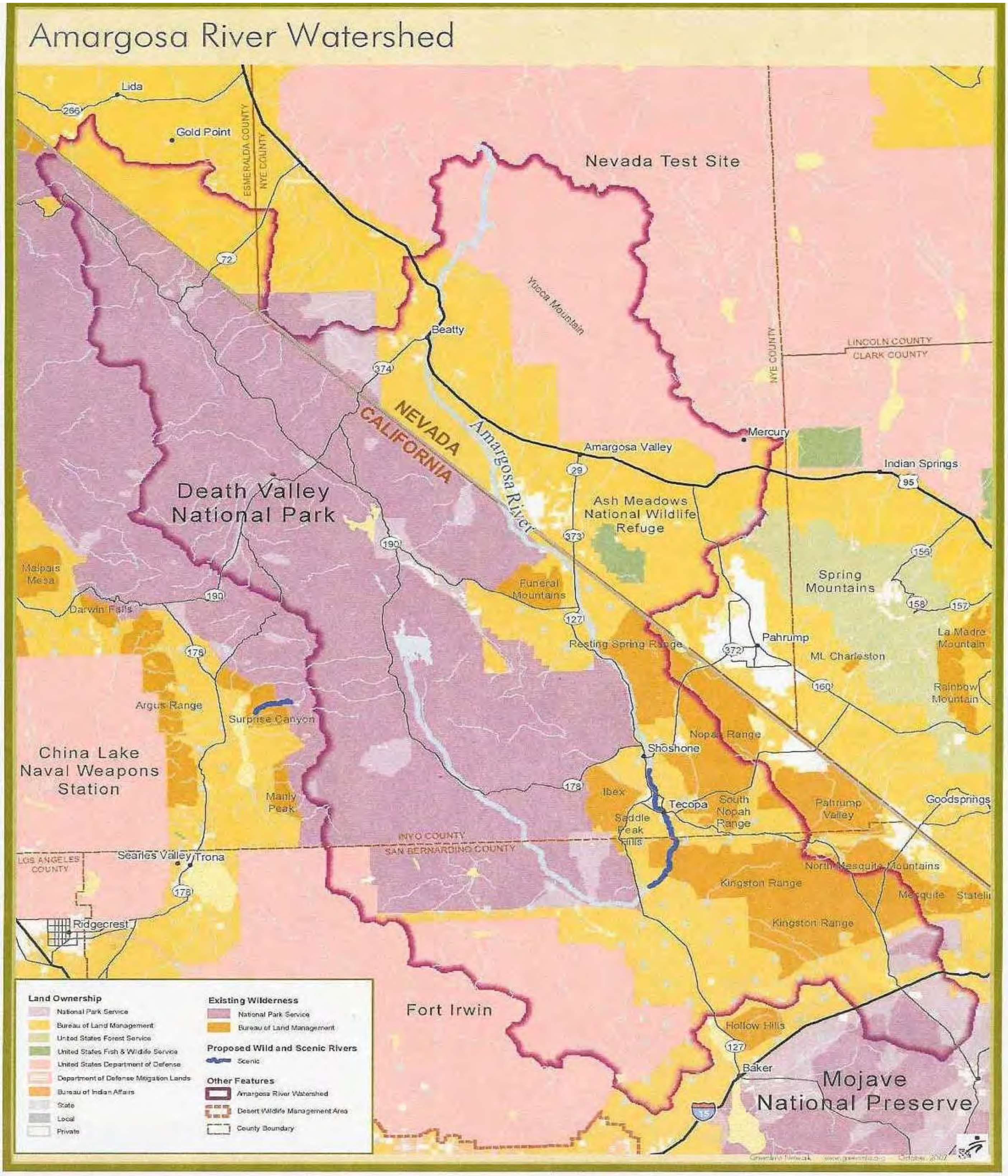
The water rights laws that control the allocation of the water resources of the Amargosa system have traditionally given priority to uses of water, which are usually defined to preclude or minimize consideration of the importance of in-stream flows and ecosystem needs. Moreover, in Nevada, water rights in the region are overallocated, and in California, they are virtually unregulated.

More importantly, no method for the cross-border coordination or allocation of water resources currently exists. Unlike the bi-state Lake Tahoe watershed and recent federal legislation establishing a process for Nevada and Utah to settle boundary water disputes, California and Nevada do not have any mechanism to consider the interests of the neighboring state in making decisions about the Amargosa River's water resources. This unfortunate situation is leading inevitably to a beggar-thy-neighbor race to claim and extract water as the population of the region expands.

Since allocation of water resources is largely left to state law, the role of the federal government is limited to maintaining water for federally owned areas like national parks and wildlife refuges. Actions by the National Park Service and the Fish and Wildlife Service to protect the Amargosa's resources, and actions by BLM in managing Wilderness Areas and Areas of Critical Environmental Concern such as Amargosa Canyon and the Grimshaw Lake complex, have aided significantly in deflecting harm to the water dependent species in the Amargosa area, Ash Meadows National Wildlife Refuge and Death Valley National Park. However, existing federal authority is not sufficient to avert the threatened large scale diversion of water resources and serious long term harm to the river system.

Action by Congress, in combination with state-level action by Nevada and California, authorizing a bi-state process to allocate water resources, would provide a badly-needed means for addressing the threats to the Amargosa system. While such a bi-state process itself will not guarantee the Amargosa River and its surface and underground tributaries will continue to flow, that legislation, along with Wild and Scenic status for the river, would offer significant help in keeping this unique desert river alive.

The Amargosa river system is a truly unique and irreplaceable desert resource. Without increased recognition of its value to the human, plant and animal communities dependent upon its scarce resources, the Amargosa may soon cease to be a life-sustaining resource in the Mojave Desert. Protective action is needed now to avoid its loss.



The Amargosa Area

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INTRODUCTION--THE AMARGOSA—A LAND OF OASES

As recently as 15,000 years ago, during the colder and wetter geologic time known as the Pleistocene, or Ice Ages, the Amargosa region was humid and temperate. Lakes filled many of the valleys, including Death Valley, and rivers connected the region with the Colorado River and the Gulf of California. As the climate warmed, the region turned to desert. Surface waters gradually disappeared. Perennial surface water became primarily confined to a series of oases, where the underlying geology forces water to the surface in springs, seeps, small creeks and in portions of the Amargosa River.

The Amargosa River system is located in the Mojave Desert, one of the hottest and driest regions in the United States. Rainfall across most of the area averages less than 4 inches per year, and most precipitation arrives in the winter with Pacific storms and from an occasional summer monsoonal rainfall.

The Amargosa River, from its beginnings north of Beatty, Nevada to its termination in the Death Valley playa, flows for over 125 miles, mostly below ground, except when rare heavy rain events briefly fill its dry surface channel. There are, however, several short stretches where the river flows above ground all year long. These areas, and other oases supported by springs, are separated by harsh desert, and persist as harbors of biological diversity and islands of incredible beauty.

These important oases and short stretches of perennial river flow—are few in number: the spring outflows and Amargosa River corridor in Oasis Valley, Nevada; the spring pools and wetlands of Ash Meadows, Nevada; the thermal springs of the Grimshaw Lake, Shoshone and Tecopa area in California; the perennial flow in the Amargosa River from Shoshone through the Amargosa Canyon, Willow Creek near Tecopa, and the springs and playa lake in Death Valley National Park, all in California.

The water flowing in the Amargosa system comes from a combination of local precipitation, especially in higher elevations, which percolates through valley fill aquifers, and from a very large regional carbonate rock ground water flow system which underlies almost 16,000 square miles in portions of eastern California, Nevada and southwest Utah. (See map of regional groundwater system: Figure 1). Because this regional aquifer extends mostly below the surface of the earth in an area of extremely complex geology, the full extent and configuration of the carbonate flow system is unknown. While it is clear that the carbonate aquifer provides considerable water to the Amargosa system, the complexity of the geology and the remoteness of the region have meant that an adequate understanding of the hydrogeology has yet to emerge.

Elevations in the area vary widely: from 200 feet below sea level in Death Valley, the lowest point in the United States, to peaks in the Spring Mountains, which rise to almost 12,000 feet. Except where water is at or near the surface, vegetation is limited to desert plants and shrubs, such as creosote, yuccas and salt bush. The limited areas of surface flow and shallow groundwater support a diverse array of plants, including cottonwoods, willows, and mesquite. High elevations feature pine and juniper species.

The wetlands and riparian areas in the Amargosa River system are crucially important in maintaining the unique array of endemic and sensitive species that have evolved to live in this environment. As the region's surface water disappeared following climate changes, species that thrived in the formerly linked water bodies rapidly and separately evolved. Today the region harbors scores of unique species dependent upon the water provided by the Amargosa. These rare species—along with virtually all other life—are increasingly threatened with extinction as the existing water supply becomes stressed.

These are not merely theoretical risks: a number of extinctions have already occurred in the Amargosa River watershed and nearby areas of the Mojave Desert where groundwater withdrawals dried up springs or surface water was diverted. Species that evolved and lived only in those specific aquatic or wetland locations disappeared forever. These species include the Tecopa pupfish and a number of aquatic and riparian taxa in the Pahrump and Las Vegas Valleys. In the unique Devil's Hole, a cave filled with water that is part of the Amargosa system, the federally endangered Devil's Hole pupfish is presently in danger of extinction, which may be due to a drop in water levels in the cave limiting water depth over a rock shelf important to fish reproduction.

A 1998 study of wetland and riparian resources of Death Valley National Park by the National Park Service found that "Substantially reduced spring flows in the Park would impact as many as 58 species that have limited distributions or are listed as endangered/threatened. The diversity of these water dependent organisms is broad based, and includes several mammal, fish, amphibian, bird, mollusk, aquatic invertebrate, and plant species."[1] The wet areas of Death Valley National Park described in the study are the terminal sections of the Amargosa River system; an evaluation of other areas supported by the Amargosa River system would significantly augment the number of at-risk species.

The importance of water to the existence of all desert plants and animals is evident. As one ecological evaluation of the Amargosa Canyon area noted:

> The year round supply of water offers a refuge for many species of fauna. This factor is of prime importance to all forms of desert wildlife. It is possible for fauna from surrounding ecosystems to come to the canyon for food and water. It cannot be stressed strongly enough that this refuge is particularly important to fauna in periods of drought. As the drier, more barren surrounding ecosystems provide less and less food and water for fauna in periods of drought, the fauna can come into the canyon and thus survive these periods of drought. The canyon is a reservoir of life…The springs provide fresh water for those species needing good water. The spring flow helps maintain an acceptable level of salinity in the river for other species. Nothing must be permitted to happen which would affect the water flow and quality in the springs, the creek and river.[2]

[1] Wetland and Riparian Resources of Death Valley National Park and their Susceptibility to Water Diversion Activities, Threloff, 1998, at 1
[2] Amargosa Canyon-Dumont Dunes Proposed Natural Area, Romero, et al, at 53

Periodic droughts have afflicted the Mojave Desert area. If, as a number of recent studies on climate change have suggested, the desert will be even drier in the future, the importance of keeping existing perennial sources of water flowing--for all life--is apparent. Like pupfish, voles, and mesquite, the steadily increasing population of human dwellers in the Mojave Desert also depends upon a reliable supply of groundwater.

Despite the harsh climate and difficult terrain of the Mojave Desert, humans have occupied the Amargosa region for millennia. Archeological investigations have uncovered evidence that Native Americans occupied the area as early as 10,000 years or more ago, and their successors continue to reside in the Amargosa region today. The presence of human life in the area has always centered around those few reliable sources of year-round water supplies.

Beginning in the 1830's, Europeans explored and occupied the Amargosa area. Spanish traders from Santa Fe New Mexico opened a route to the Southern California coastal missions and ranches. This Spanish Trail passed through the Amargosa area, relying on water in the springs and creeks of the region to cross the Mojave Desert. Later, American frontier explorers, Mormons migrating to the California coast, and then gold-seeking 49ers passed through the region. Mining in the Death Valley region began in earnest in the 1870's, and small communities formed—and dissolved—as the mines opened and then closed as ore bodies were exhausted. Water diversions in the Amargosa watershed began during the mining era to support mining operations as well as farming and ranching needed to feed the mining communities.

While some mining remains in the Amargosa region today, it is now a minor feature of the region. However, the resident population in portions of the region—especially in the Nevada communities of Pahrump and Amargosa Valley--has soared. Further large increases are expected on both sides of the California-Nevada border, all dependent on the sparse groundwater resources in the Amargosa region. Agriculture in the Nevada portion of the Amargosa watershed is a very large user of groundwater, with wells servicing large dairies and alfalfa fields. For the last several decades, the Las Vegas Valley, just to the south and east of the Amargosa watershed, has been one of the fastest growing urban areas in the nation.

Land ownership in the Amargosa region is a varied mix of federal, state and private landholdings. (See land ownership map: Figure 2.) As is true throughout the southwest, much of the dry desert upland is in federal ownership. A number of different federal agencies own significant acreage. The Bureau of Land Management is the largest landowning entity within the Department of the Interior, followed by its sister organizations: the National Park Service (Death Valley National Park and Devil's Hole) and the Fish and Wildlife Service (Ash Meadows National Wildlife Refuge). The U.S. Defense and Energy Departments own significant tracts of land, principally in Nevada, in Nellis Air Force Base and the Nevada Test Site and Yucca Mountain. The U.S. Forest Service manages most of the Spring Mountains, a significant source of water recharge into the Amargosa system. The states of California and Nevada own scattered sections of land throughout the area. The Timbisha Shoshone Tribe owns several large tracts of land in the area. Private ownership is primarily focused around towns ranging from Pahrump, Nevada (population in excess of 35,000) to the tiny entities of Shoshone and Tecopa, California (combined population less than 1000), although other concentrations of private land ownership exist in still undeveloped areas such as Charleston View, Chicago Valley, California Valley, Amargosa Valley, and in significant areas of patented mining claims. With the exception of most of Ash Meadows and significant stretches of the Amargosa Canyon, most of the desert's oases and wet areas are privately owned.

Growth in the human population of the area is occurring and further expansion is a given, placing stress on groundwater resources. Long term plans to augment the water supplies of Las Vegas and the more adjacent communities of Pahrump and Amargosa Valley include increased withdrawals of groundwater from the regional carbonate aquifer which is linked to the Amargosa system. Groundwater levels in the Pahrump area have already dropped significantly, and groundwater withdrawal has caused land subsidence, creating problems for roads and building foundations.

Governmental activities in the region have also led to possible adverse effects on the Amargosa watershed. The Nevada Test Site, where hundreds of the nation's nuclear device tests occurred from the 1950's until the cessation of detonations in the 1980's, is located in the Amargosa watershed. Groundwater contamination of Amargosa system water from activities at the Test Site, as well as from transport and storage of high level nuclear wastes at the nearby waste repository proposed at Yucca Mountain, are of concern. Studies to define probable routes and the timing of the transport of contaminants through the Amargosa region have begun.

The Amargosa watershed contains some of the most beautiful and unique natural areas in the American southwest attracting substantial numbers of tourists. These include Death Valley National Park, Ash Meadows National Wildlife Refuge, the Amargosa Canyon and Grimshaw Lake protected areas, and a number of large wilderness areas in the surrounding mountains and desert. The small California desert communities of Shoshone and Tecopa Hot Springs, which thrive because of ample flow from thermal springs, now principally rely on tourism for their economic existence.

SIGNIFICANT BIOLOGICAL RESOURCES OF THE AMARGOSA WATERSHED

The 3 million acre Amargosa watershed region was characterized by The Nature Conservancy in a 2001 study as a network of biologically rich and viable places, strung like pearls on a necklace along the 125 mile long Amargosa River, highlighted for their outstanding ecological value, as "one of the most impressive suites of endemic, isolated, and imperiled aquatic species in the world." [3]

The region contains a vast watershed and groundwater basin that supports a wide variety of rare and unique species and habitats. The landscape consists of patches of unique and isolated dunes, mesquite bosques, springs, seeps, marshes, and riparian habitats, interconnected by expanses of largely intact Mojave Desert upland scrub—including creosote, shadscale, blackbrush, big sagebrush, and mixed desert scrub.

The biological value of these rich desert oases has long been recognized. For example, Ash Meadows, Nevada, whose seven major and many minor springs contribute in excess of

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[3] The Nature Conservancy, Amargosa River Project: Initial Assessment and Conservation Strategies, 2002 at 3.

17,000 acre feet of water annually to the Amargosa system, was in 1986 declared to be wetland of international importance. Ash Meadows contains the greatest concentration of endemic species (24 species) of any local area in the US and the second greatest in North America. Of the 24 endemic species, 12 are federally listed as endangered or threatened. [4]

In Death Valley National Park, the terminus of both the Amargosa River and the location of many of the regional carbonate aquifer springs, a total of 58 sensitive or listed species are currently known to exist in the Park's wetland or riparian habitats, all receiving water from the regional aquifer. In the Amargosa River and spring outlet area in the vicinity of Shoshone and Tecopa, California, there are a number of endemic plants and animals dependent upon the perennial water supply, including the federally listed Amargosa vole, the Shoshone pupfish, Nevada speckled dace, and several listed plants.

The Importance of Aquatic, Wetland and Riparian Areas

Wetland and riparian areas are extremely rare in the southwest desert landscape. For example, in Death Valley National Park, only 0.3% of the area of the park is considered wetlands. Nationally, the areal extent of wetlands has declined precipitously in the western United States. California has lost an estimated 91 per cent of the wetlands that were present in colonial times. Many wetlands of the Amargosa watershed have been substantially modified and degraded; some have been lost entirely due to channeling and filling, as in case of Ash Meadows and the adjacent Carson Slough area of California. Once altered, wetlands and riparian and aquatic habitat are usually exceptionally difficult and very expensive to restore.

Wetlands and riparian habitats are rich areas of biodiversity, inhabited by plants and animals that cannot survive in arid environments—fish, amphibians, some birds, and numerous aquatic invertebrates are examples of species wholly dependent upon perennial supplies of water. Many species occur in habitats that are very small in size, and are thus quite vulnerable to any natural or anthropogenic disturbance.[5]

The presence of wetland and riparian areas in deserts greatly increases the overall biodiversity and animal abundance in those and the surrounding areas. This is especially true in the harsh xeric conditions prevailing throughout much of the Amargosa watershed. Studies of bird abundance and activity in the Mojave Desert have shown that wetland and riparian areas with a well developed tree canopy have a significantly greater number of bird species and bird densities than areas without an overstory, emphasizing the great importance of retaining an adequate flow of water in the system to maintain corridors of native riparian willows and cottonwoods.[6]

Fish, frog and toad species in the area are completely dependent on wetland habitats and cannot persist in areas without permanent water. The various forms of pupfish and speckled dace are only present in those few areas where water flows year around. And, in spite of their

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[4] Id

[5] These initial paragraphs and much of the following discussion about the value of wetlands draws heavily upon the excellent National Park Service monograph by Threloff, "Wetland and Riparian Resources of Death Valley National Park and their Susceptibility to Water Diversion Activities", 1998, especially pp 9-17.

[6] Id. at 11

small size, aquatic insects and mollusks are significant biological components in desert wetland environments. Many species of beetles, crawling insects, and springsnails are strictly confined to water and quickly die if exposed to desiccating conditions.[7] A number of rare and listed plants, such as the Amargosa niterwort, the Ash Meadows milk-vetch, and the century plant, are also dependent upon habitats featuring a perennial water supply.

Because the wet areas are disconnected, limited to small geographic areas, and the resident species have evolved separately, wetland and riparian areas in the Amargosa watershed possess a disproportionate number of threatened, endangered and rare species. As noted previously, Ash Meadows and Death Valley National Park contain scores of listed and sensitive species in their riparian and wetland areas. These protected areas constitute, along with the rest of the Amargosa basin's privately owned wet habitats, an extremely valuable set of isolated ecosystems, highly vulnerable to disturbance, desiccation, and the introduction of non-native species.

The Amargosa watershed's wetland and riparian areas also have unique scientific value as a laboratory of plant and animal evolution. The relatively recent change to a desert climate from a temperate region of interconnected lakes and marshes less than 15,000 years ago resulted in the confinement of then widespread aquatic species to remnant but persistent wetlands that became separated by arid land. This, as Threloff argues, has meant that the Amargosa's wet habitats offer an important scientific opportunity to study evolution.[8]

> The presence of the unique suite of pupfish taxa along the Amargosa River is analogous to the presence of land tortoises and Darwin's finches on the Galapagos Islands. Both animal groups originally colonized their respective areas thousands of years ago and became isolated in separate habitats that possess different environmental conditions. Through time, natural selection and isolation transformed a limited number of ancestral lines into several unique varieties….Speciation differentiation was facilitated by the separation of populations that could not cross inhospitable habitats.[9]

Nine pupfish species and subspecies exist in the various Amargosa basin aquatic habitats. The fish have developed an ability to survive in saline and warm desert waters that are up to 2.5 times as salty as the ocean, and in temperatures up to 107 degrees Fahrenheit. Each pupfish taxa is morphologically (body shape and size) and genetically distinct, and displays characteristic breeding and feeding behavior. The variation in genetic and physical characteristics appears to depend on the distinct environmental conditions in each separate spring or stream, making each desert wetland community function as an "evolutionarily significant unit."[10]

This genetic variability is not limited to pupfish. Other fish—speckled dace—springsnails, naucorids, and plants, in short, any species that is dependent on water and unable to migrate across arid lands to other wet places has become endemic and unique to its specific wetland location. Studies of these phenomena may well hold the future key to "understanding

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[7] Id at 12.
[8] Id at 14-15
[9] Id at 15
[10] Id at 15

how fast evolution takes place, as well as how plants and animals adapt physically, behaviorally, and physiologically to their immediate surroundings."[11]

Further, the relatively isolated Amargosa watershed has fairly recently been the subject of more intense scientific studies. This work has revealed a number of new species such as springsnails, riffle beetles, amphipods, and plants. "The discovery of …(new species) suggests that as springs are more carefully studied new taxa in several different groups will be recognized, and the scientific value of local wetlands will further increase."[12]

Destruction and alteration of wetlands and diversion or draining of springs in the Amargosa watershed threatens the loss not only of the endemic plants and animals specialized to live in a specific wet area, but a whole spectrum of other plants and animals that are less localized but have some need for water. These include reptiles, birds, mammals, and plant communities such as mesquite bosques and willow-cottonwood corridors so critical to the survival of dozens of other species.

It is not only the total loss of wetlands and riparian habitat that is significant. The biodiversity and abundance of plants and animals depends directly on the flow and quality of water and the size of wet areas. Smaller areas and shorter spring outflows support fewer and less diverse arrays of species. Reductions in water tables and spring flows have dramatic effects on biological functions. Changes in these functions can ripple adverse effects through a wetland and riparian system, since biologic species and physical and hydrologic aspects interact in a synergistic and integrated manner. And, once altered, "[i]t is difficult or impossible to recreate or rehabilitate wetlands which have been affected by anthropogenic activities….because wetlands are complex systems and there is a lack of inventories which document which components are present and how they interact when they are together."[13]

Wetland and Riparian Species

Comprehensive listings of all of the plant and animal species dependent upon the aquatic, wetland and riparian habitats of the Amargosa watershed exist in, for example, the California Natural Diversity Database and the Nevada Natural Heritage Program files. In addition, a number of both governmental and privately conducted studies and analyses of large sections of the Mojave Desert, as well as studies of discrete habitat features and individual species or assemblages of species, supplement the large-scale geographic databases. Notable examples of reports targeting the Amargosa region include the BLM's Northern and Eastern Mojave Desert Management Plan (NEMO Plan), which covers the sections of the Amargosa watershed located in California; studies and reports conducted by the US Fish and Wildlife Service of the unique Ash Meadows springs and associated species; The Nature Conservancy's conservation plans for the bi-state Amargosa region; reports and studies done by the National Park Service of Death Valley National Park flora and fauna, including those highlighting Devil's Hole; studies done under contract for the US Department of Energy's Yucca Mountain Project; and monographs by the California Native Plant Society and the Desert Fishes Council.

[11] Id
[12] Id at 16
[13] Id at 37

As noted previously, and largely because of its desert-oasis configuration, the Amargosa watershed is rich in endemic, rare and state and federally listed and sensitive species. The waters of the Amargosa also support a broad array of more common species of plants and animals.

Two water/wetland dependent endangered species—a pupfish and a bird—serve to illustrate the importance of retaining flowing water in existing wet habitat in the Amargosa watershed. The Devil's Hole pupfish is an endangered species with perhaps the most limited range of any vertebrate in the US—a small water filled cavern included as a separate unit of Death Valley National Park, located adjacent to Ash Meadows National Wildlife Refuge in Nevada. The fishes' spawning habitat is limited to a shallow shelf covered by only 3 to 20 inches of water, and that water is derived from the regional carbonate aquifer, which has been subjected to groundwater pumping in the vicinity. In recent years, the water level over the spawning shelf has slowly dropped. While the cause is not entirely clear, the population of the Devil's Hole pupfish has decreased to levels which threaten its extinction. In the past, the National Park Service has taken aggressive steps to defend the water supply to the cavern, including successfully pursuing a case to the US Supreme Court to stop groundwater withdrawals less than a mile away from the cave. Now, even though the Park Service continues to protest groundwater pumping and the further grant of water rights in the vicinity, proof that the decrease in water levels is related to specific pumping activities, especially those more distant from Devil's Hole, is very difficult to muster.

The southwest willow flycatcher is a federally endangered bird which is known to breed in only about 75 riparian sites throughout the southwest, including the Amargosa area. In the southwest, there is a breeding population thought to amount to just 300-500 pairs. The bird nests only in dense riparian vegetation associated with streams, rivers, lakes, springs and other watercourses. The most significant factor in the decline of the willow flycatcher is the extensive loss, fragmentation, and modification of riparian breeding habitat. Large scale losses of wetlands have occurred, particularly willow-cottonwood riparian habitat. The Amargosa watershed still contains fairly large intact stretches of willow cottonwood corridor, and nesting pairs of the flycatcher have been spotted in Amargosa Canyon and other riparian areas. A decrease in groundwater levels, river perennial flows or spring outflows would be likely to cause these riparian corridors to shrink or disappear. Other threatened and endangered species of birds (e.g., the least Bell's vireo, the yellow-billed cuckoo), as well as over a hundred varieties of neotropical migrating birds, depend upon the same riparian habitat for reproduction, feeding, and rest.

Historical Lessons of Wetland and Riparian Loss

The southwest offers a number of poignant examples of the wholesale loss of wetlands and riparian vegetation due to the diversion or withdrawal of surface and groundwater water supplies. Surface water diversions from the Owens River and from the Colorado River upstream of its delta in Mexico are two well known examples of wholesale modification and destruction of wetland and riparian habitat. The Amargosa watershed and nearby areas offer similar examples of the loss of habitat and associated species through groundwater pumping, water diversions and channeling of springs and streams.

Near the town of Tecopa, California, modification of the wetland habitat supported by thermal springs was so complete that it resulted in the extermination of the Tecopa pupfish in the 1970s. The original spring source that supported the pupfish is now the water supply for a public bathhouse. This fish was the first creature to be declared officially extinct under the provisions of the federal Endangered Species Act.

In the Las Vegas and Pahrump Valleys, development of groundwater resources for agricultural and residential uses resulted in the virtual elimination of a number of large surface springs and their outflow. Sizable outflows from Manse Spring and Bennetts Spring in the Pahrump Valley, both historically thought to be linked to the Amargosa watershed, were eliminated. With their elimination populations of endemic fish and extensive corridors of riparian vegetation disappeared.

In the Las Vegas Valley, large artesian springs were similarly eliminated by groundwater pumping and diversion, resulting in the extinction of at least one amphibian, one fish, and an unknown number of invertebrate species.

As one report commented:

> Over the past 35 years, man's disruption in the Death Valley area has resulted in the extinction of one fish species (Ash Meadows killifish) and three or four of the 11 recognized subspecies (Raycraft Ranch killifish, Pahrump Ranch killifish, Shoshone pupfish, and Tecopa pupfish)…None of the fishes of the Death Valley System have been unaffected by man, and, at most, only five can be considered healthy and undepleted.[14]

The lessons taught by the excessive withdrawal of groundwater and destruction and diversions of desert wetlands are harsh. If springs and streams no longer flow, a cascading series of ecologically destructive events occurs, bringing with it the extinction of unique endemic species.

<u>WATER, THE DEATH VALLEY REGIONAL GROUNDWATER FLOW SYSTEM AND GROUNDWATER PUMPING</u>

To understand the groundwater system in the Amargosa area it is important to describe the setting and the hydrologic characteristics of the area. The Amargosa River watershed is in the Mojave Desert portion of the southern Great Basin and Range province ("Great Basin"). The Great Basin is an area that covers most of Nevada and western Utah, from the eastern side of the Sierra Nevada mountains in California to the Wasatch Range in Utah. The area comprises north-northeast trending mountain ranges separated by broad desert valleys. The Amargosa area includes several large valleys including the Amargosa Desert, Pahrump Valley and Death Valley. The region also includes several major mountain ranges including the Spring Mountains and the

[14] Soltz and Naiman, 1978. The natural history of native fishes in the Death Valley System, Nat. Hist. Mus. Los Angeles, Science Series, at 30, quoted in Threloff at 17.

Panamint, Sheep, Amargosa, Kawich, Kingston, Pahranagat, Timpahute, Nopah and Last Chance Ranges.

The Great Basin consists mostly of bedrock and sedimentary basin fill. Bedrock is exposed in mountains or underlies basin fill deposits throughout much of central and southeastern Nevada. Bedrock is either consolidated carbonate rock (such as limestone) or noncarbonate rock (including gneiss or schist, granite, shale and volcanic deposits). Basin fill largely consists of material eroded from the mountains (such as sand, gravel and clay).

In the Great Basin, most of the groundwater originates from rain and snow that that falls on the higher mountains. (See map showing precipitation: Figure 3.) Runoff from the rain and snow directly enters fractures in the bedrock that comprises the mountains, or flows down from the mountains in streams and percolates into the sedimentary fill that comprises the valleys. Water that percolates downward and reaches the water table is commonly referred to as recharge. The water table is the point where the subsurface material is saturated—that is, all of the space between the subsurface materials is occupied by water. The water-bearing basin fill and carbonate rock into which the runoff percolates are called aquifers.

Depending on its composition and structure, non-carbonate rocks may or may not confine or restrict groundwater movement. Non-carbonate rocks are often much less permeable than carbonate rock or basin fill sediments, posing a barrier to groundwater movement.

Groundwater often moves through fractures and joints in the carbonate rocks created by the solution of the rock by groundwater (the same process that forms caves and caverns). Water also moves readily through most basin fill sediments. Considered together, the carbonate rock and linked basin fill deposits constitute the principal regional aquifer system. Carbonate bedrock potentially constitutes a very large water reservoir in the Great Basin—carbonate formations extensively underlie much of the Great Basin and can be quite thick, with estimates ranging from 5,000 to 30,000 feet, depending on the area. However, because of the complexity of Great Basin geology, we do not understand well how much, how fast, or how far groundwater water moves through the region.

Where connections do exist between a basin-fill aquifer and the underlying carbonate aquifer, groundwater pumping from a basin-fill aquifer may limit groundwater recharge to the carbonate aquifer. Similarly, pumping from a carbonate aquifer may decrease water levels in an overlying basin-fill aquifer. Also, groundwater pumping may affect the flow from one basin to another.

In several areas of the Great Basin, we also know that adjacent basins are connected and the basin-fill aquifer and the carbonate aquifer that underlies one basin can transmit groundwater to adjoining basins. However, again, due to the geologic complexity of the system (faulting, fracturing, etc.) to groundwater flow, etc.), the speed and direction of movement of groundwater from one basin to another is highly variable and is not well defined or understood.

At present, most groundwater in Nevada is pumped from basin-fill aquifer systems; however, water suppliers expect to extract water from the carbonate aquifer systems to meet an increasing demand for water. Many important springs and aquatic areas in the Amargosa region derive water from the carbonate aquifer system--where carbonate rocks reach the surface.

<u>The Death Valley Regional Ground Water Flow System</u>

A regional groundwater flow system in the Great Basin extends over a wide area from Utah across central and southern Nevada to Death Valley and south to the Colorado River. The overall flow system has been subdivided into several regional flow systems. The Death Valley Regional Flow System is one of those regional systems. It is described by the area to the west of the Pahranagat Range in central Nevada, which generally is thought to divide flow into the Amargosa system from flow into the Colorado River system.[15]

In 2004, the United States Geological Survey ("USGS") released an extensive report on and model of the Death Valley regional groundwater flow system.[16] The model presents the current understanding of the regional groundwater flow system.

The USGS prepared the report for the U.S. Department of Energy programs at the Nevada Test Site and at Yucca Mountain. One principal purpose of the work was to develop a computer model of the groundwater flow in the region. In developing the model, the USGS incorporated decades of study of the groundwater flow system, previous models and new information, including groundwater pumping data from the area extending from 1913 (before pumping existed in the area) to 1998.

The USGS model described groundwater in the region moving through permeable rock zones under the influence of hydrologic gradients (or pressure) from areas of recharge to areas of discharge. However, the system is quite complex. There are numerous subsystems within the regional flow system. Because of the complexity of these subsystems, water that recharges an aquifer at one point may be discharged in the nearest subsystem, or may be transmitted to a distant discharge area. Thus, regional groundwater flow patterns do not always coincide with local topographic basins or surface water drainages. Instead, for example, water may follow a path through conduits in the carbonate rock from the point of recharge in the mountains to the lowest point in the region at Death Valley. (See map showing directions of groundwater flow: Figure 4.)

While the system is complex, the USGS believes that most groundwater flows between recharge areas in the mountains of central and southern Nevada and discharges in the springs,

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[15] It should be noted that due to the hydrogeologic complexities of the system and the relative lack of data and studies, the extent of the hydraulic connection between the regional systems, including the extent of the hydraulic connection between the Death Valley regional flow system and the regional flow systems to the east of the Pahranagat Range, remains uncertain.

[16] The title of the report is: Belcher, W.R., editor, 2004, *Death Valley Regional Ground-water Flow System, Nevada and California—Hydrogeologic Framework and Transient Groundwater Flow Model*; U.S. Geological Survey Scientific Investigations Report 2004-5205, 408 pages. The report is available online at http://pubs.water.usgs.gov/sir2004-5205. In preparing this report, unless otherwise noted, the descriptions of the groundwater flow system and the figures are taken from the USGS report. (See map of the model area: Figure 5.)

seeps and wet playas in the Amargosa Desert, the Pahrump area, the Shoshone-Tecopa area and Death Valley.[17] (See map showing groundwater discharge areas: Figure 6.)

<u>Overview of Groundwater Pumping in the Amargosa Basin</u>

There is a significant amount of groundwater pumping that currently affects the Amargosa watershed. In the Amargosa Basin, groundwater pumping started around 1913 in the Pahrump Valley to support a small agricultural community. From only a few wells in 1913, nearly 9,300 wells had been drilled in the Amargosa region by 1998. The pumped groundwater has supported agriculture, mining, industry, military uses and rural and urban growth. About 97 percent of the present wells are concentrated in the southern part of the Amargosa Desert (at Ash Meadows and at Amargosa Farms) and, most notably, in Pahrump Valley. (See map showing locations of wells: Figure 7.) USGS estimates that approximately 75,800 acre-feet of groundwater was pumped in 1998 from throughout the Death Valley regional flow system.[18]

Although nearly 93 percent of the wells are for domestic use, about 90 percent of the water pumped from 1913 to 1998 was for irrigation. (About 75 percent of the total groundwater extracted was used to irrigate alfalfa). Over the 1913 to 1998 period, the amount of groundwater pumped for irrigation declined and the amount of water used for domestic purposes increased from about 2 percent to more than 7 percent. The trend in the declining use of groundwater for irrigation and the increase in its use for domestic, public supply, and commercial purposes is expected to continue as the population of the Pahrump Valley and the Amargosa Desert increases.[19]

The USGS estimates that, prior to the commencement of groundwater pumping, the natural discharge from springs and ET from the Death Valley Regional Flow system was approximately 93 percent of the total discharge. By 1998, the USGS estimated that pattern had reversed and groundwater pumping accounted for about 70 percent of the total discharge from the system with the source of the water being pumped was mostly groundwater in storage. When the water in storage is removed from the flow system, there is a decrease in the natural discharge through ET and spring flow. Thus, less water flows from springs and seeps, and less water is available to sustain phyreatophytic and riparian vegetation.

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[17] As noted above, the groundwater that naturally discharges at springs and seeps sustains unique riparian and aquatic ecosystems. Other groundwater discharge occurs by evapotranspiration (ET--a combination of direct evaporation from the ground surface and water transpired from vegetation) in areas of phyreatophytic vegetation (phyreatophytes are plants whose roots extract groundwater from the water table or from the soil immediately above the water table), evaporation from playas (such as in Death Valley), and as a result of groundwater pumping.

[18] An acre-foot is one acre covered to a depth of one foot with water. An acre is about the size of a football field. There are 325,900 gallons in an acre-foot. An acre-foot of water will supply the dwellings of two average families for one year.

[19] The present population of Pahrump is about 35,000, expected to reach 150,000 in several decades. Most households are served by individual wells, and water levels in the basin fill aquifer are dropping rapidly. To the north of Pahrump, the Amargosa Desert area has been an agricultural region, but development pressures are extending there as well.

Historic and Future Groundwater Pumping

As a result of past, current and likely future groundwater pumping, the groundwater system in the Amargosa River watershed and the entire Death Valley Regional Flow System is not in equilibrium with the current climate. That is, groundwater withdrawals currently exceed recharge rates. Groundwater flow has already been modified by the groundwater pumping in Pahrump Valley, Amargosa Desert, the Nevada Test Site and other areas, and future groundwater withdrawals seem likely to increase significantly.[20]

As noted previously, most of the land in the Amargosa region is owned by the United States Government and is managed by federal agencies. However, much of the land with access to plentiful, good quality groundwater, springs, and perennial surface flow is in private ownership. These lands are located primarily in the Pahrump Valley, near the agricultural areas of the Amargosa Desert, in the historic mining community of Beatty, Nevada, in the communities of Shoshone and Tecopa in California, and in the resort area of Furnace Creek in Death Valley. Historically, water has been used in these communities for domestic, commercial, agricultural, livestock, and mining purposes. Water has also been used on federal land for military purposes. Following is a brief evaluation of those areas where current or future groundwater pumping is stable or seems likely to increase significantly.

Oasis Valley. In the Oasis Valley, groundwater has been pumped for irrigation, mining, domestic and public supply in the upper portion of the valley. Also, since the 1950s, groundwater pumping occurred periodically on the Pahute Mesa-Oasis Valley basin part of the Nevada Test Site for water supply and for testing purposes. USGS reports that most of this pumping has been small in scale and has had little effect on the groundwater flow system. This has also been the case with the relatively small amount of pumping that has occurred in the upgradient Penoyer Valley for irrigation. The USGS reports that there does not appear to be serious threat on the horizon of an increase in groundwater pumping in Oasis Valley.

Ash Meadows/Amargosa Desert/Alkali Flat-Furnace Creek Basin. The Ash Meadows/Amargosa Desert area has been the site of considerable controversy over groundwater pumping in the past, including the fight to protect water levels in Devil's Hole from nearby agricultural pumping. Controversy continues. Water levels are dropping and the basin is over appropriated. Federal agencies protest each new or changed application for water rights. The Nevada State Engineer is in the process of deciding a number of applications for new and altered water rights which may affect this subbasin, including applications filed by Nye County and the Southern Nevada Water Authority for potential export to other basins. Agricultural pumping continues, but, increasingly, water use in the basin will shift to commercial and residential uses as development proceeds north from Pahrump.

In the Amargosa Desert and Ash Meadows area, the earliest sources of fresh water were the naturally flowing artesian springs at Ash Meadows. The first well was dug in 1852. But it was only in the late 1940s and early 1950s, partially as a result of federally sponsored desert

[20] The USGS describes evidence that higher groundwater levels existed in the past resulting from a wetter climate. Therefore, some of the groundwater in the area may be a relic of past climates. If this water is withdrawn, it will not be replaced by recharge under the current, drier climate.

reclamation programs, that groundwater pumping to supply agriculture began to significantly increase.

According to figures from the Nevada State Engineer, in the early 1990s groundwater pumping in the Amargosa Valley was approximately 15,000 acre-feet per year, but by 2002, groundwater pumping in the vicinity of Ash Meadows and the Amargosa Farms had decreased to approximately 12,000 acre-feet per year. During the same period, irrigation decreased from approximately 11,000 acres to approximately 9,000 acres.[21]

On the Nevada Test Site, groundwater is pumped to supply about 50 percent of the water demand at the site. According to USGS figures, from 1960 to approximately 2000, groundwater pumping to supply the test site ranged from less than 500 acre-feet per year to as high as almost 4,000 acre-feet per year. The USGS has estimated that the total of groundwater pumping from the overall Amargosa Desert area in the late 1990s was as high as approximately 25,000 acre-feet per year.

The wells in the vicinity of Ash Meadows and Amargosa Farms areas predominately pump from the basin-fill aquifers that overlie and are adjacent to the carbonate aquifer. In the early 1970s, groundwater pumping from the basin-fill aquifer near Devil's Hole in an amount as high as approximately 7,000 acre-feet per year caused a water level decline in Devil's Hole and a decrease or cessation of flow in several major springs in the area flowing from the carbonate aquifer. After the groundwater pumping was reduced in the 1970s, then halted in 1982, spring flows gradually recovered and the water level in Devil's Hole gradually rose, but did not recover to the pre-pumping level.[22]

In order to legally pump groundwater in Nevada, a permit must be first obtained from the Nevada State Engineer. The Nevada State Engineer has concluded that water levels in wells in the Amargosa Desert have generally declined since the 1970s. In 1985, as a result of the declining groundwater levels in the Amargosa Valley and other factors, the Nevada State Engineer declared irrigation to not be a preferred use in the Amargosa Valley, and declined to permit new applications for agricultural withdrawals.

Although it appears that the Nevada State Engineer will not approve new applications to pump groundwater from the Amargosa Valley for use in irrigation, several applications to change the place of use of groundwater that is now being extracted and used in the Amargosa Basin have been submitted to the State Engineer. Many of the changes requested would allow

[21] It should be noted that there is some uncertainty in the amount of groundwater pumping in the Amargosa Desert area because many of the non-domestic wells were not being metered at the time of the figures released by the State Engineer. In December, 2004, the Office of the Solicitor, Department of the Interior sent a letter to the State Engineer requesting that all non-domestic wells in the area be metered. At the time of the writing of this report, it appears that some metering of the non-domestic wells has been commenced.

[22] In 1988, the water level in Devil's Hole once again began to fall—a trend which is continuing. It is suspected that pumping from wells located further away from Devil's Hole in the Amargosa Desert is causing the decline, but there is some disagreement among the experts on the cause of the decline. Groundwater pumping in the Amargosa Valley has had differing effects on individual springs which may be due to a varying degree of hydraulic conductivity between the basin-fill and carbonate-rock aquifers in the area and/or due to faulting; thus, it is difficult to accurately predict the effects of pumping from an individual well on a spring.

groundwater now being pumped for irrigation to be used on lands that are not currently being irrigated.

Groundwater pumping potentially affects the water level in Devil's Hole, springflow at Ash Meadows, and the Amargosa River. The USGS also believes that it is probable that groundwater pumping in the Armagosa Desert will eventually reduce the discharge from springs in Death Valley. Because of potential impacts on Devil's Hole and the springs in Death Valley, the National Park Service is protesting virtually all applications for new or changed use of existing rights.

Several new applications to pump groundwater from the area designated by State Engineer as the Amargosa Desert Hydrographic Basin have been submitted to the State Engineer. Five of the applications were submitted by Nye County, Nevada for the purpose of pumping groundwater for municipal purposes. The place of use identified in Nye County's applications includes most of the Amargosa Valley and most of the Pahrump Valley. Nye County is seeking to appropriate and pump more than 18,000 acre-feet of water per year. The Department of Energy, the National Park Service and the U.S. Fish and Wildlife Service are protesting four of Nye County's applications. The National Park Service and the U.S. Fish and Wildlife Service are protesting the fifth application by Nye County. The Nevada State Engineer denied these applications in 2007 on the ground that there is no unappropriated water in the Amargosa Desert Hydrographic Basin.

In addition to the Nye County applications, another application which seeks to appropriate and pump up to 400 acre-feet of groundwater per year for quasi-municipal purposes and an application to appropriate and pump 3.0 cubic feet per second of groundwater (approximately 2,200 acre-feet per year) for irrigation and domestic purposes were submitted to the State Engineer. The National Park Service and the U.S. Fish and Wildlife Service both are protesting the application involving the use of water for irrigation and the National Park Service by itself is protesting the other application. The Nevada State Engineer denied these applications in 2007 on the ground that there is no unappropriated water in the Amargosa Desert Hydrographic Basin.

In a letter to the applicants dated March 6, 2006, the State Engineer noted that in the hydrographic basins that include and surround the Amargosa Desert Hydrographic Basin (basins designated 225 to 230 by the State Engineer), the combined perennial yield from the basins is considered to be 24,000 acre-feet per year and, at present, more than the perennial yield, 27,192.87 acre-feet annually is committed for use from the groundwater resource. The State Engineer's letter notes that in the Amargosa Desert Hydrographic Basin alone, 24,308.91 acre-feet annually are committed for use. (See map showing hydrographic units: Figure 8.)

In what portended a major change for Great Basin, in 1989 the Las Vegas Valley Water District filed 146 applications in 26 groundwater basins in central and southern Nevada for the appropriation and pumping of up to 800,000 acre-feet per year of groundwater for export to and use in the Las Vegas area. (In 1991, the applicant was changed from the Las Vegas Valley Water District to the Southern Nevada Water Authority.) Over time, the applicant withdrew many of the applications; thus, the number of affected basins was reduced, as was the amount of potential groundwater pumping. The applicant currently states that it intends to pump a total of approximately 180,000 acre-feet per year. Most of the applications would involve the pumping of groundwater from the Colorado River regional groundwater flow system and other regional flow systems east and north of the Pahranagat Range rather than from the Death Valley regional groundwater flow system.

However, seven of the applications are within the Death Valley regional groundwater flow system and thus may affect the Amargosa Basin and Death Valley. In January 2005, these five applications in the Tikapoo and Three Lakes Basins were approved by the State Engineer in the combined total of 8,905 acre-feet per year. In approving the seven applications, the State Engineer recognized in Ruling 5465 that "…groundwater from the Tikapoo and Three Lakes basins flows through the carbonate rock aquifer and eventually discharges at Ash Meadows, Death Valley, and perhaps to the White River Flow System." However, the State Engineer found that "due to the great distance between the proposed pumping and the discharge areas, any impacts will be far in the future and minimal in magnitude."

Another action that could result in an increase in groundwater pumping in the Amargosa Desert area is the release of federal land to private use. Under the Federal Land Policy and Management Act, the BLM must develop resource management plans for lands managed by the BLM. The BLM Las Vegas District Resource Management Plan identifies approximately 32,000 acres in the Amargosa Desert area as being available for disposal. Most of the area is located in the Amargosa Valley adjacent to Death Valley National Park in an area where significant groundwater pumping is already occurring. Should the BLM dispose of these lands, there is a risk of further groundwater pumping to supply the lands with potential impacts to the water level in Devils Hole, the springflows and Ash Meadows and Death Valley and to other resources.

Southern Death Valley Subregion

The population of Pahrump, the major population center in this subregion, has expanded rapidly to its current size of 35,000 people. Within several decades, the population may grow to 150,000, most of whom will be served with individual wells. The basin is grossly over appropriated, and groundwater withdrawals are already well above perennial yields, resulting in steadily dropping water levels and land subsidence. As Pahrump expands, it will look to export water from other nearby basins. California shares the Pahrump basin with Nevada, and plans have been announced for a major development in the Charleston View area which would depend on unregulated groundwater withdrawals in California.

In the Pahrump Valley, groundwater pumping began around 1913 to support a small agricultural community. Groundwater pumping increased over the years to supply expanding agriculture in the area. Historically, Manse and Benetts Springs discharged an estimated 9,500 acre-feet of water per year along the base of the broad alluvial fans at the foot of the Spring Mountains. After 1945, increasing groundwater pumping in the valley caused Bennetts Spring to stop flowing in 1959, and Manse Spring stopped flowing in 1977—although, since then, small intermittent flows in the winter season have been reported from Manse Spring. In addition to the impacts on the springs, the increased groundwater pumping in the Pahrump Valley has caused the ground level in certain areas of the valley to subside resulting in fissures in the ground surface which has damaged houses, building and roads. Groundwater levels in the valley continue to drop by a foot or more per year.

The USGS estimates that recharge to the Pahrump Valley is as high as 20,000 to 23,000 acre-feet per year; however, in contrast, the Nevada State Engineer estimates the perennial yield to be as low as 12,000 acre-feet per year. (The Nevada State Engineer defines the perennial yield is the amount of natural discharge that can be salvaged for beneficial use, but the perennial yield can never be more than the natural recharge.) Although the perennial yield is a low as 12,000 acre-feet per year, existing water rights in the Pahrump Valley would allow the pumping of more than 64,000 acre-feet per year. The USGS estimates that actual groundwater pumping in 1998 was approximately 23,000 acre-feet.

As the population of the Pahrump Valley has increased, water use has been converting from agriculture to domestic. The population has quadrupled over the past 15 years. It is estimated that that the population of the valley increases between 2,500 and 3,000 people per year. There are approximately 33,000 vacant residential parcels in the valley and there are several large permitted subdivisions. By some estimates, given the amount of available property, the population could increase to as high as 150,000. Even with a population of only 64,000, which at current growth rates could occur in ten years, it is estimated that water use would increase from the approximately 23,000 acre-feet per year used at present to 37,000 acre-feet per year—but the perennial yield of 12,000 acre-feet per year will remain that same.

To complicate matters, the Pahrump Valley is bisected by the Nevada—California state line. Historically, almost all of the agriculture and growth--and accompanying water use--has occurred in the Nevada portion of the valley. This pattern could dramatically change in the future. In the southwestern portion of the valley which is located in California, there is an area called Charleston View, where there are approximately 17,000 acres of privately owned land.

Developers have approached the County of Inyo with plans that together could transform Charleston View into a city with as many as 150,000 people. Charleston View shares the same groundwater basin with Pahrump, but in California, unlike Nevada, there the requirements that a landowner obtain a permit to extract groundwater from beneath his land are limited to certain circumstances. Compounding the situation, a large portion of approximately 5,000 acres in the area were subdivided into residential lots shortly after the turn of the 20th century. These lots can be developed without review under California's subdivision law and, theoretically, a well could be drilled on each of these lots.

If continued growth in the Pahrump area and potential growth in the Charleston View area leads to even more groundwater pumping and to even greater depletion of groundwater in Pahrump Valley, not only will the valley be adversely affected, but, groundwater outflow from the Pahrump Valley to the Chicago Valley, Shoshone/Tecopa, California Valley and to other areas will decrease or may completely halt in the future. Such a reduction in groundwater outflow can be expected to reduce discharge from springs as well as reducing evapotranspiration from groundwater dependent vegetation. If there is groundwater flow through Stewart Valley from the Pahrump Valley to the Ash Meadows/Amargosa Desert/Alkali Flat areas, groundwater flow from Pahrump Valley to these areas could be reduced or stopped.

It has been suggested that water be imported to Pahrump Valley. As previously noted, Nye County is seeking permits to pump groundwater from the Armagosa Basin and to use it in the Pahrump Valley. Another suggestion for importation is to construct a pipeline from Lake Mead and transport water from the Colorado River. Such a use of the Colorado River faces formidable legal, political and institutional obstacles in part because the Las Vegas area already uses all, or nearly all, or Nevada's entitlement to the Colorado River.

Chicago Valley which is located in California between the Pahrump Valley and the Shoshone/Tecopa area is mostly vacant land. However, there are approximately 1,200 acres of land in private ownership in Chicago Valley. Should this land develop, and should groundwater pumping commence in the area, groundwater flow from Pahrump Valley to the Shoshone/Tecopa area could be further reduced.

With regard to the Shoshone/Tecopa area, there is little information available concerning the historical amount of springflow and the amount of groundwater pumping in the area. In part, the lack of data is a result of the use of unmetered springs for domestic use instead of the use of wells. Despite the lack of information, the USGS estimates that several regional springs in the area discharge more than 360 acre-feet of water with temperatures of greater than 30 degrees Celsius per year from the regional aquifer system.

OTHER THREATS TO THE AMARGOSA WATERSHED

Existing and Potential Water Pollution

In addition to actual and potential depletion of the water resources of the Amargosa Basin from groundwater pumping, water pollution is a current problem in the watershed, and potentially presents a dangerous threat in the future.

A current pollution problem exists in the Tecopa area. At present, sewage from a sewage lagoon in the Tecopa Hot Springs area is leaking into Grimshaw Lake and the surrounding wetlands that are adjacent to the Amargosa River. The lagoon holds sewage from the campground operated by the County of Inyo and from other properties in the area. The Lahontan Regional Water Quality Control Board has ordered that a remediation plan be implemented if use of the lagoon is discontinued. The County of Inyo reports that it is preparing a remediation plan, but development of the plan is hindered by a lack of funds; consequently, the leaking lagoon has yet to be repaired.

In an incident in 1998, 1.7 million gallons of manure was released into the Amargosa River from a dairy in the Amargosa Farms area. The manure washed approximately 15 miles downstream. The Barstow Field office of the BLM is working with the State of Nevada and the U.S. Environmental Protection Agency in an effort to prevent similar releases in the future.

A dangerous future contamination threat is posed by the proposed facility at Yucca Mountain, which is to be the site of the only high level nuclear waste repository in the United States. The proposed repository is to be located in an unsaturated zone of volcanic rock, but the carbonate aquifer lies approximately 6,000 feet under the proposed repository. As noted above, there are a number of areas where groundwater discharges from the carbonate aquifer in the Amargosa Basin and from springs in Death Valley so that if contamination were to reach the carbonate aquifer, radioactive materials could pollute surface water or wells.

The proposed repository is designed to have multiple barriers, both engineered and natural, to impede the movement of contaminants. One natural barrier is an upward hydraulic gradient in the volcanic rocks from the carbonate aquifer. It has been suggested by the Hydrodynamics Group and the USGS that the upward gradient would act as an important barrier to impede the movement of contaminants through the volcanic rocks into the carbonate aquifer. However, any potential future groundwater pumping could reduce or eliminate the upward gradient and thus reduce or eliminate the barrier to downward mitigation of the contaminants.

The transport of radioactive material to the proposed repository also presents a threat to the water resources of the area. Currently, it is planned that much of the material sent to the repository will travel by railroad on a new rail line. The actual location of the line remains uncertain; however, the route may overlie the regional flow system, and may even transverse a portion of the watershed of the Amargosa River. Thus, an accident or sabotage could result in high level radioactive contamination. Moreover, some of the material may travel by truck to the site along the Amargosa River on Highway 127. As with rail transport, an accident or sabotage could result in disastrous contamination.

On a positive note, controversy over the proposed repository has generated significant funding to various researchers to study the site and the underlying regional flow system. This research has greatly expanded knowledge of the groundwater flow system and has assisted in assessing the threats from groundwater pumping to the resources of the Amargosa Basin. Nye County, Nevada and Inyo County, California have received funds to research the potential risk of migration of contaminants through groundwater from the repository and other risks, including those posed by the transport of high level nuclear waste to the site.

In addition to the Yucca Mountain repository, radioactive contamination risks to groundwater resources are also posed by past operations at the Nevada Test Site. Hundreds of nuclear devices (bombs and other weapons) were tested in both above ground and underground explosions at the site over several decades. Nye County has several applications pending before the Nevada State Engineer for permits to extract groundwater from wells near the test site. There is the potential that groundwater pumping from the wells could cause groundwater contaminated by the testing to migrate toward the Nye County wells from the test site. Should this occur, there is potential that the radioactive water could contaminate the groundwater in the Amargosa Basin.

Serious threats to the water resources cannot be properly assessed because of the current lack of adequate data and information to accurately assess the potential effects of proposed actions on the water resources of the basin. As is discussed in Section VII, efforts are underway to improve this situation, but a lack of funds, and legal, political, regulatory complexities impede this effort.

Other Threats

In addition to direct threats to the water resources, there are several other threats to the resources of the Amargosa Basin. Aquatic habitats in the basin are adversely affected by tamarisk, an invasive plant species from Eurasia (also commonly called salt cedar). If uncontrolled, tamarisk can successfully complete with native riparian species such as cottonwood and willow, ultimately leading to diminished habitat and a monoculture in riparian areas. BLM and The Nature Conservancy are undertaking a salt cedar control program in the Amargosa Canyon, Shoshone, and Willow Creek areas. The U.S. Fish and Wildlife Service has undertaken other control efforts elsewhere in the basin. Other non-native plant and animals that present problems in the basin are mosquito fish, bullfrogs, crayfish, house mice, and free roaming domestic cats.

Apart from invasive plants and animals, impacts from increased human visitation, including incompatible recreational activities such an illegal off-highway vehicle use within wilderness and within sensitive habitat, vandalism, and illegal development and trespass are common in some areas. As previously noted, relatively rapid population growth in the Amargosa Basin region adversely affects not only the quantity and quality of the water resources, but also, land, air quality, and other resources. If activities increase at either Yucca Mountain or the Test Site the resulting increased employment will further swell the rapidly growing population in the area.

THE LEGAL, POLITICAL AND REGULATORY SYSTEM

The Death Valley regional groundwater flow system supplies flow to the Amargosa River, supports regional springs and seeps, riparian vegetation and human uses in the Amargosa Basin, and extends over an even larger area than the river's watershed. Like the river, the regional flow system crosses the state boundary, and includes portions of Nye, Clark, Lincoln and Esmeralda Counties, Nevada and Inyo County, California. It underlies federal and privately owned lands that include Death Valley National Park, the Nevada Test Site and the proposed high level nuclear repository at Yucca Mountain.[23]

Protection of the water resources in the Amargosa Basin is significantly complicated by the separate—and incompatible-- water laws of the two states, and by the presence of multiple local governmental entities and federal agencies with separate jurisdictions and authority.

Water Law in California and Nevada

Nevada and California have different water laws and different procedures for obtaining water rights. To further complicate matters there are no formal pathways for reconciling water issues in the Amargosa Basin that extend across the state line.[24] In addition, establishing in-stream flow rights—that is, protecting the flow of water in either state for the purpose of maintaining the watercourse itself is difficult.

In the western US, water rights are customarily governed by the principle of priority of appropriation—more simply, the first person to divert water and put it to a productive use gains the right to use the water. Another principle, called riparian rights, is derived from the eastern states.

[23] The Amargosa River itself flows over and below the surface of lands owned by the federal government and private parties. Originating in Nye County, Nevada, it flows into Inyo County, California, passes through a small section of San Bernardino County, California and then enters Death Valley National Park.
[24] There are certain, very limited exceptions: effective cross border cooperation on allocation of water rights will require actions by the state legislatures and Congress to set up that cooperation.

A riparian right is the right to the use of water by owner of property that abuts a natural watercourse. This right permits the use of a reasonable share of water from the watercourse on the abutting property. An appropriative right is the right to divert and use a specific quantity of water in a specific location. Unlike a riparian right, in which users share water from a watercourse even during times of shortage, an appropriative right is subject to the doctrine of "first in time, first in right." Therefore, an established appropriative use of water is superior to that of a later appropriated use. During a water shortage, a later appropriator may be without any water.

In Nevada, except for domestic wells,[25] a water right must be obtained from Nevada State Engineer to use water--whether surface water or groundwater.

In contrast, in California, while a permit is required to divert surface water, property owners require no state-issued water right permit to pump groundwater. Additionally, in California, riparian rights exist alongside prior appropriation rights.[26] In Nevada, only the doctrine of prior appropriation governs the use of both surface and groundwater.

In California, protecting instream flow has special rules. Individuals, firms, associations, organizations, partnerships, federal, state and local agencies and others may appropriate water (See California Water Code 1252 and 1252.5), but any water diverted, whether under a riparian or an appropriative right, must be put to a reasonable and beneficial use. Beneficial uses in California are defined to include recreation, fish and wildlife preservation and enhancement; however, California does not allow the initial appropriation of water for instream uses. This is the rule because the law has always required a diversion from the stream and some physical control of the water as an essential requirement of an appropriative right in California. (See *Fullerton v. State Water Resources Control Board* (1979) 90 Cal.App.3d 590.) However, California Water Code section 1707 allows any person who has an already established right to water (regardless of whether the right is riparian, appropriative or another right) to petition the State Water Resources Control Board for a change in the use of the water for the purposes of preserving or enhancing wetlands habitat, fish and wildlife resources or recreation in, or on, the water.

In Nevada, individuals, firms, associations, organizations, partnerships, federal, state and local agencies also may all appropriate water. Like California, in Nevada, the water must be put to a beneficial use, and recreation, wildlife and fisheries are recognized as beneficial uses. Further, since 1991, an initial water right may be obtained in Nevada for an instream flow for "maintaining the necessary habitat for a threatened species…."

In Nevada, individuals, federal, state and local entities and other organizations may protest the issuance of water rights in state proceedings and to intervene in such proceedings. In California, there is an administrative procedure for protesting the issuance of a permit to divert surface water but no procedure for protesting the extraction of groundwater, since no permit to

[25] To be exempt, domestic wells must pump less than 1800 gallons per day (2.02 acre-feet per year) and the water must be for use on the property where the well is located, but these wells are not metered.
[26] See *United States v. State Water Resources Control Bd*. (1986) 182 Cal.App.3d, 82, 101. When appropriative and riparian rights conflict, complex rules apply to determine the right to use the water.

extract groundwater is required. Although there is no administrative procedure in California for protesting the granting of rights to groundwater, a challenge to the water right or to the amount of groundwater used may be brought through the judicial system.

Nevada Water Law

The State Engineer must find that a water right is in the public interest,[27] but has wide latitude to determine what constitutes the public interest, including water quantity and quality, and environmental impacts. The public interest requirement has been used by the State Engineer in past decisions to deny permits to pump groundwater from near Devil's Hole, for irrigation in the Amargosa Desert, to establish an instream flow right to maintain threatened species, and to deny applications to change the location of groundwater pumping from one hydrographic basin to another.

While the State Engineer has wide latitude to determine what is detrimental to the public interest, there is some uncertainty about how requests for water rights to support recreation, wildlife and fisheries will fare against other uses.[28]

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In addition to his authority to interpret what is detrimental to the public interest, the State Engineer has authority to require monitoring and mitigation as a condition of issuing a permit to pump groundwater. In his ruling approving the applications of the Southern Nevada Water Authority to pump groundwater from the Tikapoo and Three Lakes basins, the State Engineer stated:

> "…future impacts to water levels and spring discharge will ultimately result from development of the basin fill aquifers overlying the carbonate-rock aquifer(s) or the development of the carbonate-rock aquifer(s) directly. However, these impacts may not be significant or even measurable.…[d]ue to the great uncertainty…caution is warranted as it cannot definitively be said that there will or will not be unreasonable impacts, or if those impacts would continue for an unreasonable period of time if pumping were ceased. The State Engineer finds, in order to gather the necessary information to more accurately predict the effects of pumping, the appropriation of some water will be permitted accompanied by significant monitoring and curtailment of pumping if unreasonable impacts are seen or likely."

A monitoring plan has yet to emerge from the State Engineer's ruling on those applications.[29] When it is issued, the plan will undoubtedly disclose important aspects of how

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[27] (See Nevada Revised Statutes, Section 533.70)

[28] Although recreation, wildlife and fisheries are recognized beneficial uses in Nevada, if no permit has been previously issued for such uses, the question arises whether the uses will receive the same level of protection under the public interest standard that they would receive if a water right had been previously issued for the uses. However, protection of the recreational, wildlife or fishery uses will depend on the seniority of the right, the scope of the water right, and competing uses--the establishment of the right may certainly be protested by groundwater developers.

[29] The County of Inyo, the Sierra Club, the BLM, the National Park Service and the U.S. Fish and Wildlife Service each requested to participate in the development of the monitoring plan. By letter dated March 2, 2005, because each of the entities had protested the applications, the State Engineer ruled that the applicant must provide each of the entities with the proposed monitoring plan and that the entities will have 60 days to provide comments on the plan. At the time of the writing of this report, no monitoring plan has been developed.

Nevada water law will operate in conditions of uncertainty when proposed groundwater withdrawals potentially have serious adverse effects on ecological uses of the water. Two key issues are the structure of the monitoring requirements and how the plan deals with the cessation or curtailment of pumping when adverse effects are detected.

The Federal Government and Water in the Amargosa Basin

Federal agencies may seek and obtain water rights for many purposes, including the protection of ecologically sensitive areas and species. As a matter of policy, federal agencies typically use state law in both California and Nevada to obtain water rights as long as federal purposes can be achieved through the use of state law.[30] In limited cases, federal law may be used to obtain water rights where the state system does not adequately protect important federal property interests, but, for the most part, federal agencies participate in the same state water rights priority scheme as private parties.

Federal Riparian Water Rights in California. In California, federal agencies must seek a state permit to appropriate surface water. If the agency seeks to protect instream flow, however, California does not allow an initial appropriation because a diversion from the stream and physical control of the water is an essential requirement of an appropriative right. However, if the federal agency owns property along a natural watercourse, it has a limited riparian right to use water, which includes the right to protect instream flows.

In the case of *In re Water of Hallett Creek Stream System v. United States* (1988) 44 Cal.3d 448, the California Supreme Court held that the federal government possesses riparian rights on federal reserved land (that is, land that has been set aside in the federal system for specific purposes in which water serves as a central element) in California. The federal riparian right under California law, though, is usually subservient to prior appropriative water rights, so can be of limited value.[31]

Federal Reserved Water Rights. Another aspect of federal law can provide water rights to federal agencies in both California and Nevada, including instream flow rights. When federal law reserves land for specific purposes—a wildlife refuge or national park for example—in which water plays an important role, that reservation creates a “federal right” to unappropriated water (water that not subject to an already vested water right under state law). The reserved

[30] Federal agencies may also protest the granting of permits to other entities for the use of surface water in both states, and, in Nevada, may also protest the issuance of permits for groundwater rights. (As noted above, outside urban basins, California does not control groundwater withdrawals nor issue groundwater permits.)

[31] The Court held that the United States must apply to the State Water Resources Control Board before it exercises a riparian right so the SWRCB can determine whether the proposed use should be permitted. While, on its face, the holding in the *Hallet Creek* case would seem very promising for wildlife enhancement purposes, the California Supreme Court severely limited the federal riparian water right when it concluded that the following proviso from a case previously decided by the Supreme Court, *In re Waters of Long Valley Creek System* (1979) 25 Cal.3d 339 applies to federal riparian rights:

> “Although, as the Board [SWRCB] points out, the federal government’s riparian rights may have theoretically “attached” when the land was reserved from the public domain, the Board may nevertheless order such rights subordinated to appropriative “rights currently being exercised,” and may further “determine the future riparian right [of the federal government] shall have a lower priority than any uses of water it authorizes before the riparian in fact attempts to exercise his right.”(25 Cal.3d. at p. 359)

water right has a priority date as of the date of reservation, whether or not the water is put to immediate use. A federal reserved right may be expressly created by federal statute or may be implied in a statute.

Devil's Hole offers an example of how federal reserved water rights have been used to protect water resources. Devil's Hole is a deep cavern on federal land near Ash Meadows containing an underground pool inhabited by a unique species of desert fish, the Devil's Hole Pupfish. In 1952, Devil's Hole was reserved as a detached component of Death Valley National Monument.

Groundwater pumping on a large ranch located about 2½ miles from Devil's Hole caused a decline in the water level of the pool in Devil's Hole threatening the survival of the pupfish. The National Park Service obtained an injunction in the U.S. District Court to limit groundwater pumping on the ranch. The injunction was ultimately upheld by the U.S. Supreme Court in the case of *Cappaert v. United States* (1976) 426 U.S. 128. The Supreme Court found that he purpose of the reserving the Devil's Hole monument was to preserve the pool. Therefore, the pool had to be preserved to the extent necessary to preserve its scientific value as the natural habitat of the pupfish.[32]

Another important example of federal reserved rights is found in the National Wild and Scenic Rivers System. Congress established the system in 1968 to protect the free flowing condition of designated rivers, to protect water quality and to fulfill other vital nation conservation purposes.[33] The heart of river protection, and the essence of the Act, is protection of a river's free-flowing character.

In 2001, the BLM identified a 26 mile segment of Amargosa River as eligible for consideration as a wild and scenic river, and legislation to implement the BLM's recommendation has been introduced in Congress in the last two years.[34]

The Wild and Scenic Rivers Act creates an express federal reserved water right that encompasses some or all of the instream flows of designated rivers or river segments in an amount necessary to achieve the purposes of the Act, which is to preserve the free-flowing condition of the river and those values for which the river was protected.

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[32] Although the Court did not directly answer the question of whether federal reserved rights apply to groundwater, it found that the water in the pool was surface water, but because the pumping of groundwater was causing the level of water to drop, the groundwater pumping causing the drop could be enjoined. The Court stated: "…since the implied-reservation of rights doctrine is based on the necessity of water for the purpose of the federal reservation, we hold that the United States can protect it water from subsequent diversion, whether the diversion is surface or ground water." (*Cappaert*, page 142.)

[33] P.L. 90-542, 16 U.S.C. §§ 1271-1287; Rivers may be added to the system by an act of Congress or by nomination by a state governor with approval by the Secretary of Interior. To qualify, a river or river segment must be in a free-flowing condition and must be deemed to have one or more "outstandingly remarkable" scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar value.

[34] In April, 2006, the Eastern Sierra Rural Heritage and Economic Enhancement Act (H.R. 5149, S. 2567), was introduced in Congress by Representative Buck McKeon (CA-25) and Senators Barbara Boxer and Dianne Feinstein which would have added the identified segment of the Amargosa River to the National Wild and Scenic Rivers System. The bill did not pass; however, in February 2007 new legislation, HR 860, was introduced which would add the segment of the Amargosa to the system.

In addition to the Wild and Scenic Rivers System, a federal reserved water right may be created by Congress as part of the establishment of a wilderness area. In 1994, as part of the California Desert Protection Act, in the Amargosa basin drainage, the Kingston Range Wilderness and the Resting Spring Range Wilderness, each managed by BLM, were created by Congress. The Kingston Range Wilderness includes 3 miles of the Amargosa River designated as eligible for wild and scenic river status. The Resting Spring Range Wilderness also includes a portion of the river. The California Desert Protection Act expressly reserves water rights for these wilderness areas in a quantity sufficient to fulfill the purposes of the reservation.

Although a reserved federal water right is established when a river is included in the federal system or is created by an act of Congress, neither the inclusion of a river in the system nor the reservation by Congress automatically confers protection of natural flow conditions. Additional action by the federal agency responsible for managing the river is necessary to establish the protection of instream flow.

Condemnation by the Federal Government of Water Rights. Condemnation of water rights is authorized by Section 13(b) of the Wild and Scenic Rivers Act. However, no water right has ever been condemned by a federal agency under the Wild and Scenic Rivers Act.[35] The use of eminent domain (condemnation powers) by the federal government to obtain water rights is a contentious issue and is not a favored land or water protection tool. The use of condemnation almost ceased after the early 1980s.

ACTIVITIES AND ACTIONS TO PROTECT THE WATER RESOURCES OF THE AMARGOSA

This concluding section describes activities that are being employed or could be undertaken to better protect the water resources of the Amargosa Basin. There is a threshold problem because many aspects of the water resources of the Amargosa Basin are poorly understood, especially the regional groundwater flow system. In order to better protect the water resources of the basin from potential increases in groundwater pumping spurred by increasing population growth, more data, research, and groundwater modeling are necessary.[36]

Ongoing and Potential Studies

Update and Enhance the Resolution of the USGS Death Valley Regional Flow System Model. In 2004, the USGS completed a calibrated numerical model to simulate transient groundwater flow conditions in the Death Valley regional groundwater flow system from 1913 through 1998. The model, constructed to address regional concerns, is a valuable tool that can assist to some extent in managing the scarce water resources in the region. However, the

[35] See Congressional Research Service Report for Congress, "*The Wild and Scenic Rivers Act and Federal Water Rights*" by Pamela Baldwin, January 18, 2001, at page 7.

[36] Without question, the funding that has become available as a result of the proposed siting of the high level nuclear repository at Yucca Mountain has been used to conduct valuable research and studies of the flow system, especially in the northern areas adjacent to Yucca Mountain. To understand the system as an integrated entity, the southern sections badly need the application of similar efforts—including data collection and fine scale modeling.

model's resolution is too coarse to accurately simulate drawdown near pumping wells and cannot be used to understand or make decisions on discrete water uses.

In 2005, the USGS proposed a study which included improving on the coarse scale model for the northern section of the Amargosa drainage.[37] A key reason for proposing the study is the acknowledged potential for conflict over the water resources of the area, particularly proposals to increase groundwater pumping to meet the needs of the rapidly growing areas of Las Vegas and Pahrump Valley, and to meet the needs of agriculture and population growth in the Amargosa Farms area.

The primary product of the study will be a model that will be updated and "embedded" in the existing Death Valley regional groundwater flow model and have a finer resolution than the more coarse regional flow model. The embedded model will provide a better tool to understand the effects of increased groundwater pumping from existing and proposed new wells, including predicting the impacts on water dependent ecosystems by reducing groundwater discharge and lowering water tables.[38] Work on the four year effort to develop the embedded model began in July 2006.

Due to a lack of data, information, and current funding resources, the USGS is not able to commit to extending the embedded model to the Shoshone/Tecopa area or to the Pahrump Valley. The USGS would like to be able to complete the fine scale modeling of the integrated flow system, but needs to find funding to collect additional water monitoring data and extend the model.[39]

Proposal to Establish a Coordinated/Unified Groundwater Monitoring System. Closely related to the previous item, the USGS has developed a draft proposal to establish a comprehensive hydrologic monitoring network for the Amargosa Desert and Pahrump Valley. The proposed network would (1) provide baseline data on seasonal and long-term variability of groundwater level and spring discharge, (2) provide an early warning of potential impacts to water resources in areas of concern such as Ash Meadows, Devil's Hole, Death Valley National Park, Carson Slough, Tecopa Springs and the mesquite bosque in Stewart Valley, (3) assist in identifying the possible causes of fluctuations in water levels and discharge and (4) identify critical areas where future wells and water level observation wells are needed because data are sparse or lacking. At present, commitment to fund the proposal is lacking. Conducting this

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[37] USGS proposed a cooperative study with the BLM, the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Forest Service and Nye County to evaluate groundwater conditions in the Amargosa Desert—the northern and central portions of the Amargosa basin. The study area would include Ash Meadows National Wildlife Refuge, Amargosa Farms, Devil's Hole and Stewart Valley, but would exclude Pahrump basin in Nevada, and all of the river basin in California.

[38] The areas of particular concern that will be covered by the study include:

- The potential effects of groundwater pumping on aquatic species and riparian habitat as Ash Meadows, Devil's Hole and reaches of the Armagosa River;
- The potential hydraulic connection between the Amargosa Desert and the Pahrump Valley through Stewart Valley;
- The hydraulic connection between Devil's Hole and the Amargosa Farms area;
- The potential effects of groundwater pumping on federal water rights allocations;
- The potential effects of groundwater pumping on mesquite woodland habitat.

[39] The contact for the proposed study is Wayne R. Belcher, USGS, Henderson, Nevada, wbelcher@usgs.gov

study, especially linked to extension of the fine scale modeling, would materially assist in advancing the protection of the water resources of the Amargosa Basin.[40]

Since the California portion of the Amargosa basin is not included in this existing USGS proposal, it is equally important to develop and implement a monitoring system similar to the system proposed for the southern Amargosa Desert and the Pahrump Valley for the Shoshone/Tecopa area. Because the hydrology of the Shoshone/Tecopa area is poorly described, it will be necessary, after initial studies, to monitor flow from existing springs and water levels in existing wells and to construct new observation wells in areas where critical data is needed. Ultimately, using the new information, this area can be added as the final component of the fine scale embedded hydrologic simulation model covering the entire flow system.

Basin and Range Carbonate Aquifer Study (BARCAS). Another recently funded federal study will provide information concerning the extent of the hydraulic connection between the regional flow system to the east of the Pahranagut Range and the Death Valley regional flow system. This information should indicate whether the Amargosa basin will be affected by significant groundwater withdrawals in northern and eastern proposed by the Southern Nevada Water Authority.[41]

The goal of the study is to help water resource agencies and stakeholders make informed decisions about future water supply issues by providing needed information on the aquifer system, including hydrologic characteristics and the factors that influence inflow and outflow from the system, which extends as far as Death Valley.

Studies Related to the Proposed Yucca Mountain Nuclear Repository. The County of Inyo, California, Nye County, Nevada and other entities, as units of local government potentially affected by the proposed high level nuclear repository at Yucca Mountain, receive funds from the U.S Department of Energy under the Nuclear Waste Policy Act of 1987. Using these funds, the entities have conducted, and will continue to conduct, investigations of the potential impacts of the repository and of the regional groundwater flow system.

The studies and investigations have yielded important information not only on the risks posed by the repository, but also, information needed to make informed decisions concerning the potential impacts of groundwater pumping on the water resources of the Amargosa Basin. In the future, Nye County plans to use these funds to participate in the update of the USGS's model of the Death Valley regional flow system, described above. Inyo County plans to continue to investigate the hydrological connection between the Amargosa Desert and Death Valley and the

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[40] The contact for the proposal is Daniel Bright, USGS, Henderson, Nevada, djbright@usgs.gov

[41] In 2004, Congress adopted the Lincoln County Conservation, Recreation and Development Act. In response to the Southern Nevada Water Authority's applications to pump and export groundwater from Lincoln and White Pine Counties in Nevada, the act provides for a right of way across federal land for a pipeline to convey water through Lincoln County into Clark County. The act also provides that the Secretary of Interior, acting through the USGS, the Desert Research Institute, and the Utah State Engineer's Office will conduct a study to investigate groundwater quantity, quality, and flow characteristics in the deep carbonate and alluvial aquifers of White Pine County, and any other groundwater basins that are located in White Pine County, or Lincoln County, and adjacent areas in Utah. As noted previously, the Death Valley regional flow system is connected to, and draws water from, the deep carbonate aquifer. A draft of the study was released for public review and comment in June 2007. The contact for the study is Alan Welch, USGS, Henderson, Nevada, ahwelch@usgs.gov

risks of transporting the high level nuclear waste to Yucca Mountain. It would be beneficial to the water resources of the Amargosa Basin to continue the funding of these programs.[42]

Activities of Non-Government Organizations

The Nature Conservancy—Amargosa River Project. The Nature Conservancy's Amargosa River Project seeks to protect a Mojave Desert landscape of nearly 3 million acres by working with local stakeholders to preserve critical habitats, open spaces and water resources. The highest priorities are areas along the Amargosa River where water surfaces to support numerous unique and sensitive species and communities. Twenty years ago, The Nature Conservancy protected Ash Meadows. Further south, the Conservancy has secured 1,320 acres in the Amargosa Canyon and has partnered with the BLM in the creation of the Amargosa River Preserve. In recent years, the Conservancy has been promoting community based conservation in Oasis Valley where the Conservancy has secured more than 650 acres of spring and marsh habitat, and in the Shoshone/Tecopa area, where an additional 2,500 acres of valuable riparian lands have been protected.[43]

The Amargosa Conservancy. The recently formed non-profit organization, the Amargosa Conservancy, seeks to protect the land, water, and beauty of the Amargosa region. This new organization has focused on making the Amargosa Basin a priority for government land managers and on partnering with them on projects of common interest, such as removing invasive tamarisk trees along the Amargosa River. The organization recently purchased a 160-acre parcel in the headwaters of one of the Amargosa River's major tributaries, and is seeking to set up a spring monitoring system in the region. The Conservancy supports the proposed designation of a segment of the Amargosa River as part of the National Wild and Scenic Rivers System.[44]

Activities to Coordinate Actions of Governmental Entities and Interested Stakeholders

Given the extent and the complexity of the natural system, the involvement of two states, many counties, and several governmental entities, the pattern of land ownership and management, and the proposals to pump and export groundwater, it is very important for the involved government entities, together with concerned stakeholders, to have opportunities to share information and collaborate on protecting and allocating water resources. . Fortunately, many such coordinating activities are underway and several new activities are proposed. This section describes some of the important ongoing activities and the some of the proposals for additional activities.

The Department of Interior Amargosa Basin Coordinating Group. In the early 2000s, agencies of the Department of Interior recognized the need to share information and coordinate their activities with regard to the study and management of the Armagosa Basin. By 2004, the semi-annual meetings of the group had been opened to other agencies and interested stakeholders. The meetings of this group provide invaluable information concerning scientific

[42] Contacts: Inyo County Yucca Mountain Repository Assessment Office, Bishop California, inyoyucca@qnet.com; and Nye County Nuclear Waste Repository Office, Las Vegas, Nevada, jmarble@nyecounty.net
[43] Contact: Bill Christian, bchristian@tnc.org. 626-441-8171
[44] Contact: Brian Brown, dates@chinaranch.com. 760-852-4403.

investigations of the basin's resources, including the groundwater system, as well as discussions of management options and of other issues affecting the basin.[45]

Annual Devil's Hole Workshop. For many years the annual Devil's Hole Workshop has been held in Death Valley or in nearby areas. At each workshop, researchers and others present the results of investigations and work on topics that include Devil's Hole, Yucca Mountain, the regional groundwater hydrology, the Pahrump Valley, the proposed Southern Nevada Water Authority groundwater project, Death Valley and other topics relevant to the protection and management of the resources of the Amargosa Basin. The workshop is an extremely valuable source of information and an excellent opportunity to discuss issues with concerned scientists and others.

Central Nevada Regional Water Authority. Representatives from Elko, Esmeralda, Eureka, Lander, Nye and White Pine Counties, Nevada began discussions in February, 2005 which led to the creation of the Central Nevada Regional Water Authority. The Authority is a separate legal entity formed pursuant to Nevada's Interlocal Cooperation Act (Nevada Revised Statute 277). The stated mission of the Central Nevada Regional Water Authority is to prepare communities in central and eastern Nevada for sound water-resource decisions that promote prosperous economies and strong civic institutions in a healthy natural environment.[46]

Memorandum of Understanding—Management of the Carbonate Aquifer. A draft memorandum of understanding ('MOU") between Nye County, Nevada and several U.S. Department of Interior agencies (USGS, National Park Service, U.S. Fish and Wildlife Service, and BLM) is under consideration by those entities. The goal of the MOU is to improve communication, coordination, cooperation and sharing of information between Nye County, its citizens and the federal agencies.

The objectives of the MOU are:

- To protect water-related resources in the Amargosa Basin while allowing sustainable water use from the Death Valley regional groundwater flow system to the extent that the water-related resources and not impacted;
- Coordinate the sharing of data and information;
- Implement a process where proposed water use changes and new water uses are reviewed early to potentially avoid protests by the federal agencies to such changes and uses; and
- Improve citizen understanding of regional flow system and of the benefits of implementing water conservation measures.

Great Basin Water Network. The Great Basin Water Network is an informal group of non-governmental entities and individuals who are concerned with surface and groundwater

[45] Contact: Russell Scofield, BLM Desert Manager's Group, Yucca Valley, CA Russell_scofield@blm.ca.gov
[46] Contact: Joni Easley, Nye County Commissioner, 775-482-8191 or Jon Hutchings, Eureka County Natural Resources Manager, 775-237-6010

exportation proposals across Nevada. The group maintains an excellent email system to provide up to date information on water-related issues.[47]

MEANS TO IMPROVE PROTECTION OF THE RESOURCES OF THE AMARGOSA AREA

This section identifies actions that could be taken by Congress, state legislatures, local government, and by legal action to better protect the water resources of the Amargosa Basin.

Interstate Compacts and Congressional Apportionment. Because the Amargosa River flows from Nevada into California and because diversions from the river and/or groundwater pumping in one state may adversely affect river flow in the other state, one means of protecting the free-flowing character of the river is an interstate compact.

A compact between two states is both a federal law and a contract among the signatory parties. Congressional ratification under Article I Section 10 of the US Constitution is necessary to give effect to a compact. Existing interstate compacts deal with water allocation, pollution control, project development, aquatic biodiversity protection, and basin planning in interstate waters.[48] Generally, the negotiation of a compact begins with Congress authorizing negotiation. A federal representative may be directed by the legislation to participate in the negotiations. Negotiations may take many years, and agreement is not always achieved.

One example of an attempted water allocation compact to allocate water between California and Nevada concerns the Truckee and the Carson Rivers. These rivers originate on the eastern slope of the Sierra Nevada Mountains in California and flow into Nevada. California and Nevada began compact negotiations in 1956, negotiated a compact in 1965 and both states ratified the compact in 1969-1970. Although Congress did not ratify the compact,[49] in 1990, Congress adopted the Truckee-Carson-Pyramid Lake Water Rights Settlement Act (43 U.S.C.A §1501) which apportioned the waters of the two rivers using the same allocation of the river water as was contained in the compact. Thus, the allocation of the water was accomplished not by compact, but instead by Congressional apportionment.

A second example of an interstate compact is the compact that created the first bi-state regional environmental planning agency at Lake Tahoe. In the late 1960s, after two decades of rapid growth, the governors and lawmakers in California and Nevada approved a bi-state compact that created a regional planning agency to oversee development at Lake Tahoe. In 1969, the United States Congress ratified the agreement and created the Tahoe Regional Planning Agency (TRPA). The Compact, as revised in 1980, gave TRPA authority to adopt environmental quality standards, called thresholds, and to enforce ordinances designed to achieve the thresholds. The TRPA Governing Board adopted the thresholds in 1982.

Theoretically, an interstate compact between California and Nevada focusing on water or on bi-state planning in Amargosa River region could be negotiated. However, it would appear

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[47] Contact: Susan Lynn, sblynn@sbcglobal.net
[48] See Tarlock, *Law of Water Rights and Resources*, West, Thomson Business, (2003, 2004), pages 10-35.
[49] See Kramer, *Lake Tahoe, The Truckee River, and Pyramid Lake: The Past, Present and Future of Interstate Water Issues*, 19 Pacific L.J. 1139 (1988)

that much more information concerning groundwater hydrology of the area and other key issues would be necessary before such negotiations, and Congressional approval, would likely be successful.

State Actions. In California, joint powers agencies can be created by agreement of willing governmental entities.[50] A shortcoming of joint powers agencies is that the agencies possess only the authority to exercise powers that are already held by the entities that are part of the joint powers agreement. Thus, such an agency may lack the authority to effectively deal with regional water and planning issues.

California law allows the creation of water districts that have the authority to conduct certain groundwater management activities. However, districts created under general laws frequently lack authority to limit groundwater extractions. Also, as is often the case, such districts are hindered because they frequently have jurisdiction over only portion of a groundwater basin.[51]

In California, special groundwater management agencies may be created by action of the State Legislature. These agencies have the powers that are granted in the enabling act, and the powers and organization of the agency can be customized for the individual political and technical realities of the area of concern.

One such special groundwater management authority that could serve as a model for action in the Amargosa region is found in the Long Valley Groundwater Basin. Like the Amargosa River, the basin is located in both Nevada and California. The basin is located in Lassen and Sierra Counties in California and in Washoe County in Nevada. In 1980, the Legislature authorized the County of Lassen and the County of Sierra to jointly enter into an agreement with the State of Nevada or the County of Washoe, or both, for purposes of groundwater management with the Long Valley Groundwater Basin. The Legislature also authorized the two California counties to enter into a joint powers agreement to exercise certain enumerated powers in the basin.[52]

In Nevada, legislation was approved creating the Nye County Water District. Under SB 222, a county-wide district with a seven member governing board was created to secure and develop sustainable sources of water. The district has the power to levy taxes and to store, conserve, distribute and sell water within and outside of the district. A primary purpose of the district may be to obtain an additional water supply for the community of Pahrump.

Cooperative Agreements. Agreements between willing governmental entities are possible--provided that legal authority exists for the entities to enter into such agreements. With regard to California and Nevada, an example of such a cooperative agreement is Nevada Assembly Bill 447. The bill was introduced during the 2007 session of the Nevada Legislature to create a bi-state commission to address important issues of

[50] (See California Government Code Section 6500 et seq.)
[51] (See Bachman, Hauge, Neese and Saracino, *California Groundwater Management, Groundwater Resources Association of California* (1997) page 102.)
[52] See California Water Code Appendix, Sections 119-1301 and 119-1301.

interest that are common to Clark and Nye Counties in Nevada and Inyo and San Bernardino Counties in California. AB 447 was not approved by the Nevada Legislature.

Local Governmental Action. In California, state law requires counties to adopt general plans that address the conservation and use of water. The conservation element of the general plan is a policy guide for County land-use and other decisions. Water is such a critical resource to the economic and environmental well being of the state, the in its most recent edition of the General Plan Guidelines, (2002; pages 101-108), the Governor's Office and Planning and Research recommended the inclusion of a Water Element as an optional component of a community's general plan. Such an element could include policies for protection of natural water features such as wetlands, streams riparian corridors, and recharge areas.

In addition to authority available to counties under general planning laws, the County of Inyo has adopted a groundwater management ordinance that requires a permit from the County for groundwater exports out of groundwater basin or out of the County. San Bernardino County has also adopted a groundwater ordinance.

Adjudications. In California, adjudication involves a lawsuit where a court determines and quantifies water rights. In a groundwater adjudication in California, the court is usually guided by the five prior years of pumping by each user. Adjudications in Nevada are conducted by the State Engineer with a right to appeal a decree of the State Engineer to the courts. (See Chapter 533.090 et seq. of the Nevada Revised Statutes.) Interstate adjudications are conducted in federal court. Adjudications usually are slow, complicated and expensive.

CONCLUSION

Action by Congress, in combination with state-level action by Nevada and California, authorizing a bi-state process to allocate water resources, would provide a badly-needed means for addressing the threats to the Amargosa system. While such a bi-state process itself will not guarantee the Amargosa River and its surface and underground tributaries will continue to flow, that legislation, along with Wild and Scenic status for the river, would offer significant help in keeping this unique desert river alive.

The Amargosa river system is a truly unique and irreplaceable desert resource. Without increased recognition of its value to the human, plant and animal communities dependent upon its scarce resources, the Amargosa may soon cease to be a life-sustaining resource in the Mojave Desert. Protective action is needed now to avoid its loss.

FIGURE 1: Regional Carbonate Aquifer System

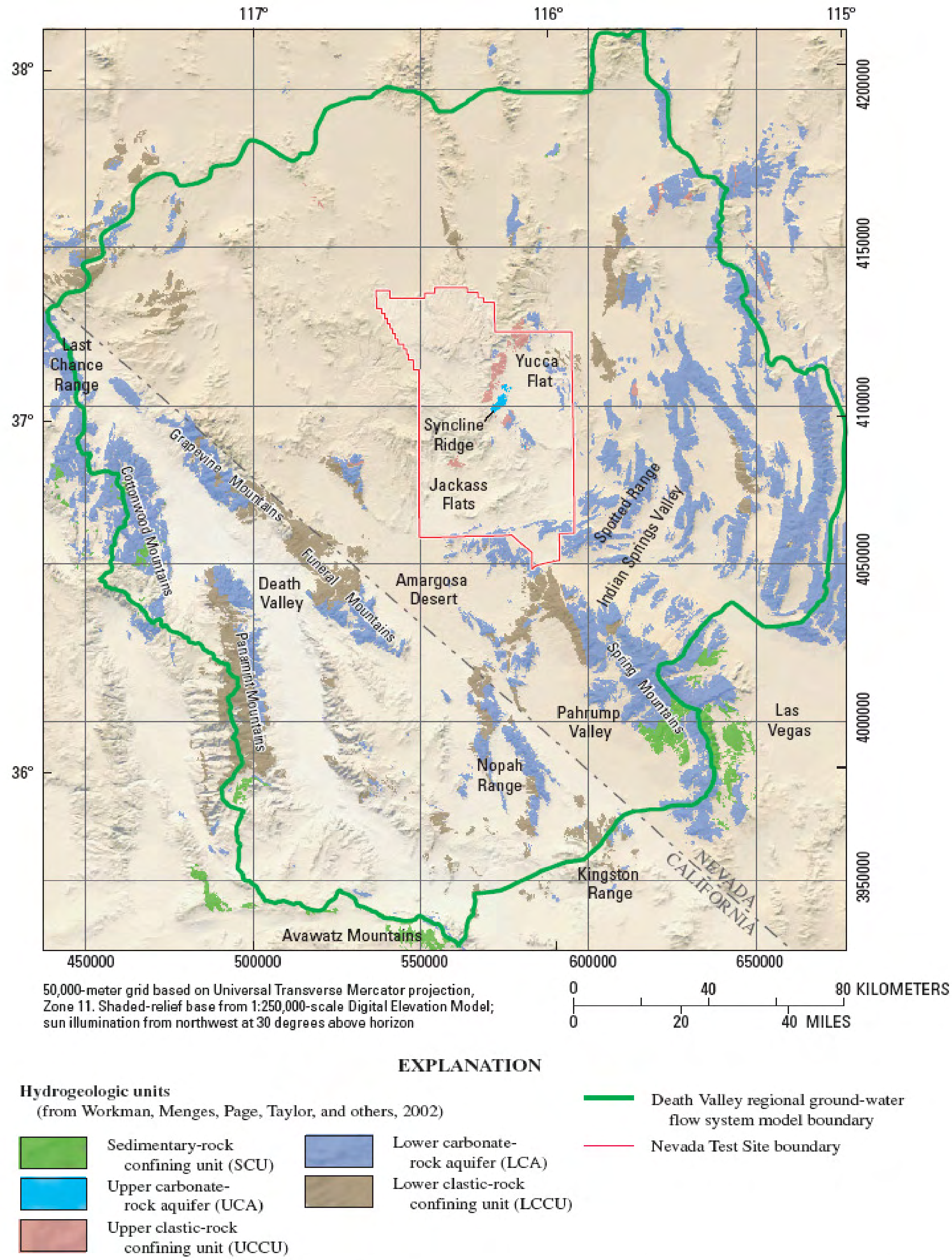


Figure B–25. Outcrop distribution of hydrogeologic units associated with Mesozoic, Paleozoic, and Late Proterozoic sedimentary rocks.

FIGURE 2: Land Ownership in the Amargosa Region

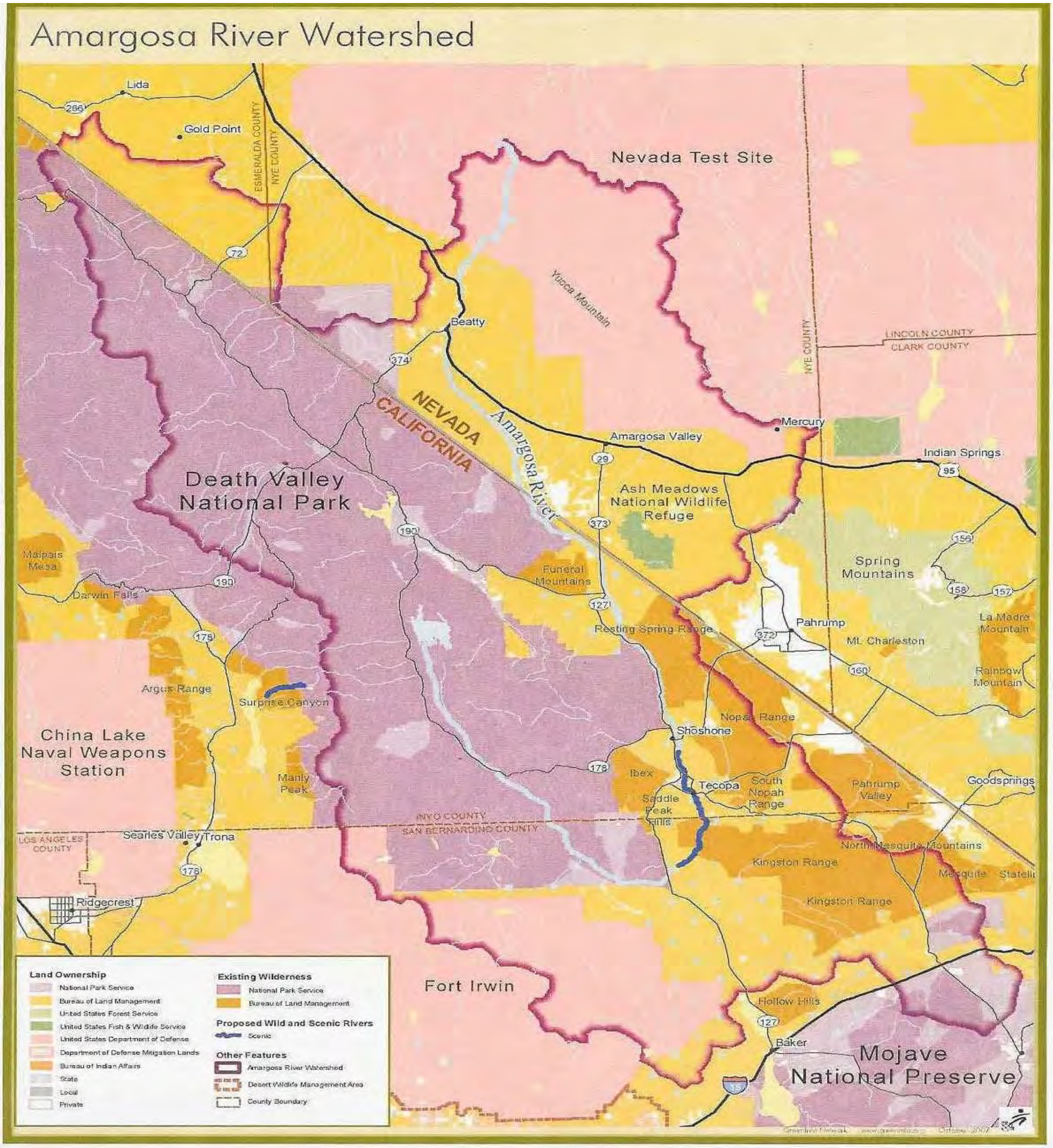


FIGURE 3: Precipitation

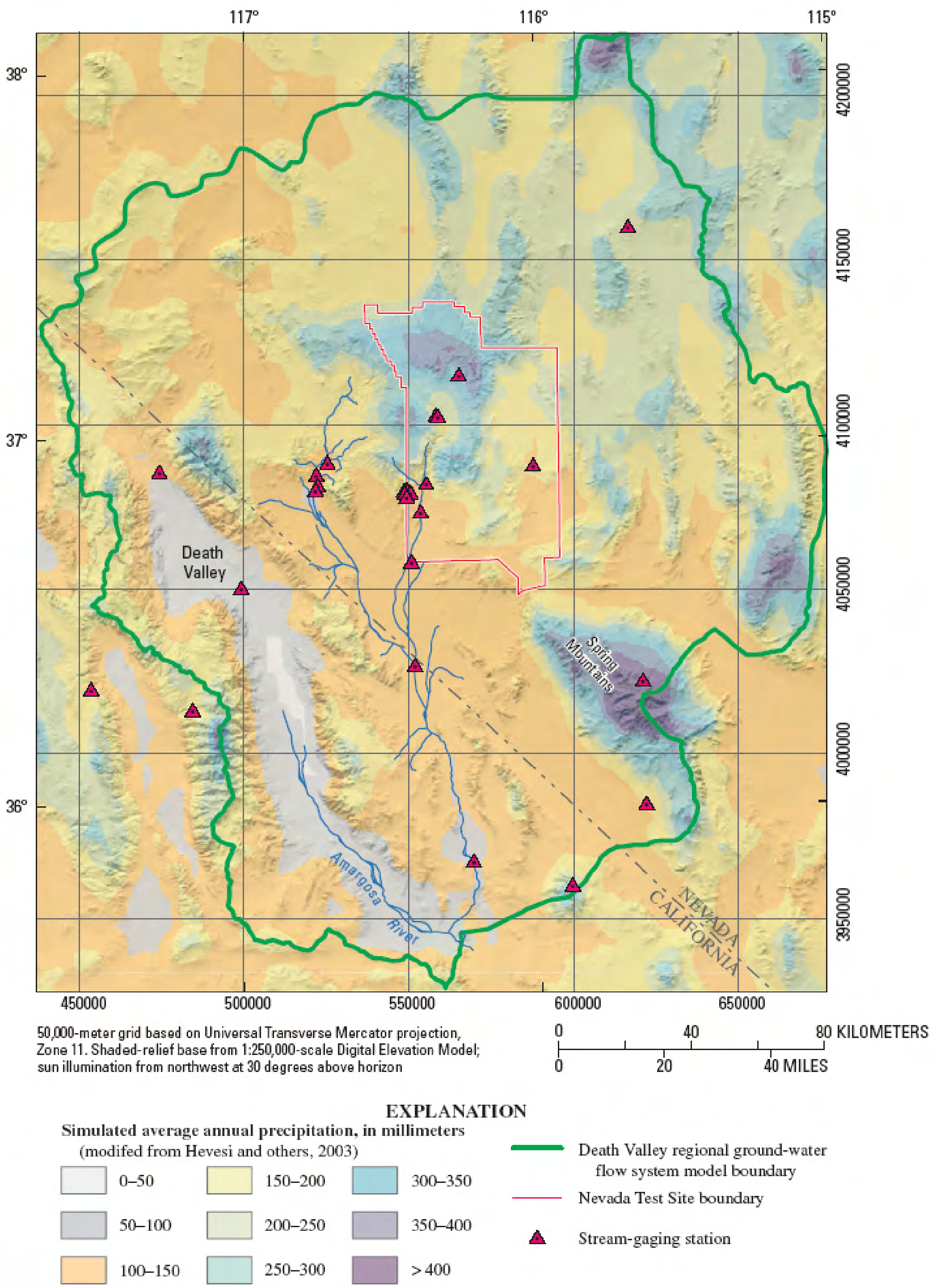


Figure C–7. Simulated average annual precipitation and stream-gaging stations used to calibrate the net-infiltration model in the Death Valley regional ground-water flow system model region.

FIGURE 4: Directions of Groundwater Flow

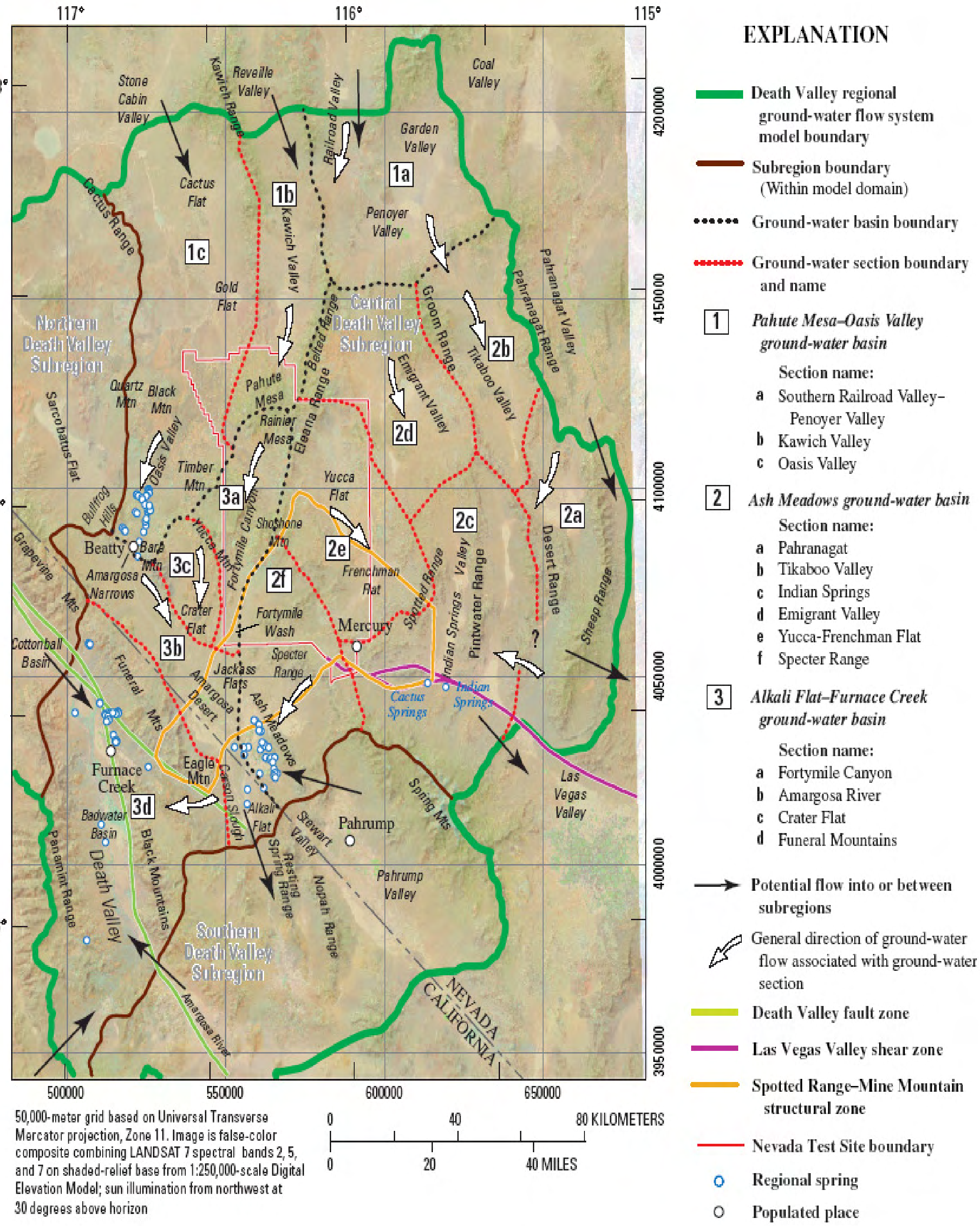


Figure D–7. Central Death Valley subregion of the Death Valley regional ground-water flow system showing ground-water basins, sections, and flow directions.

FIGURE 5: Area of Death Valley Regional Groundwater Flow Model (Outlined in Green)

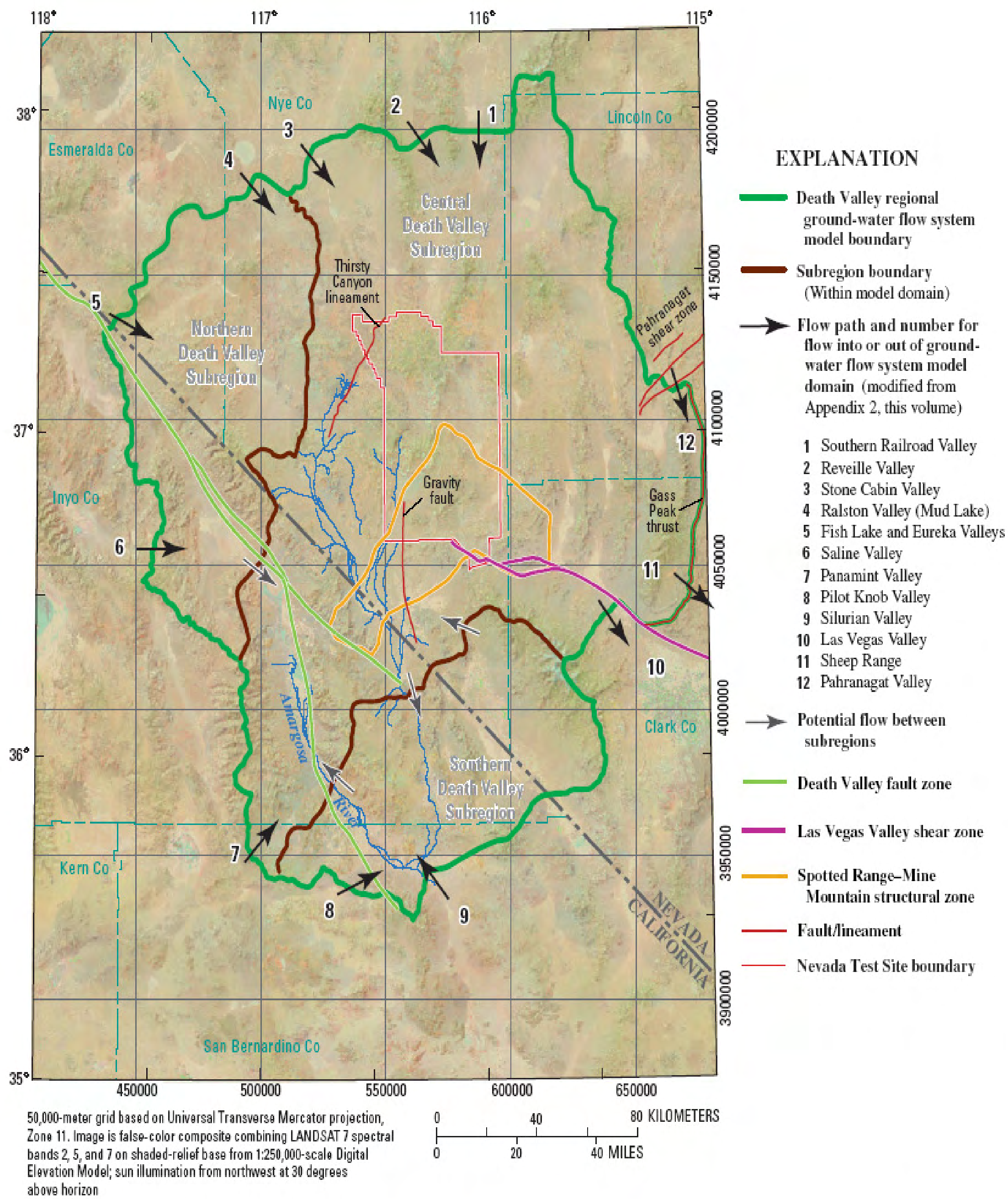
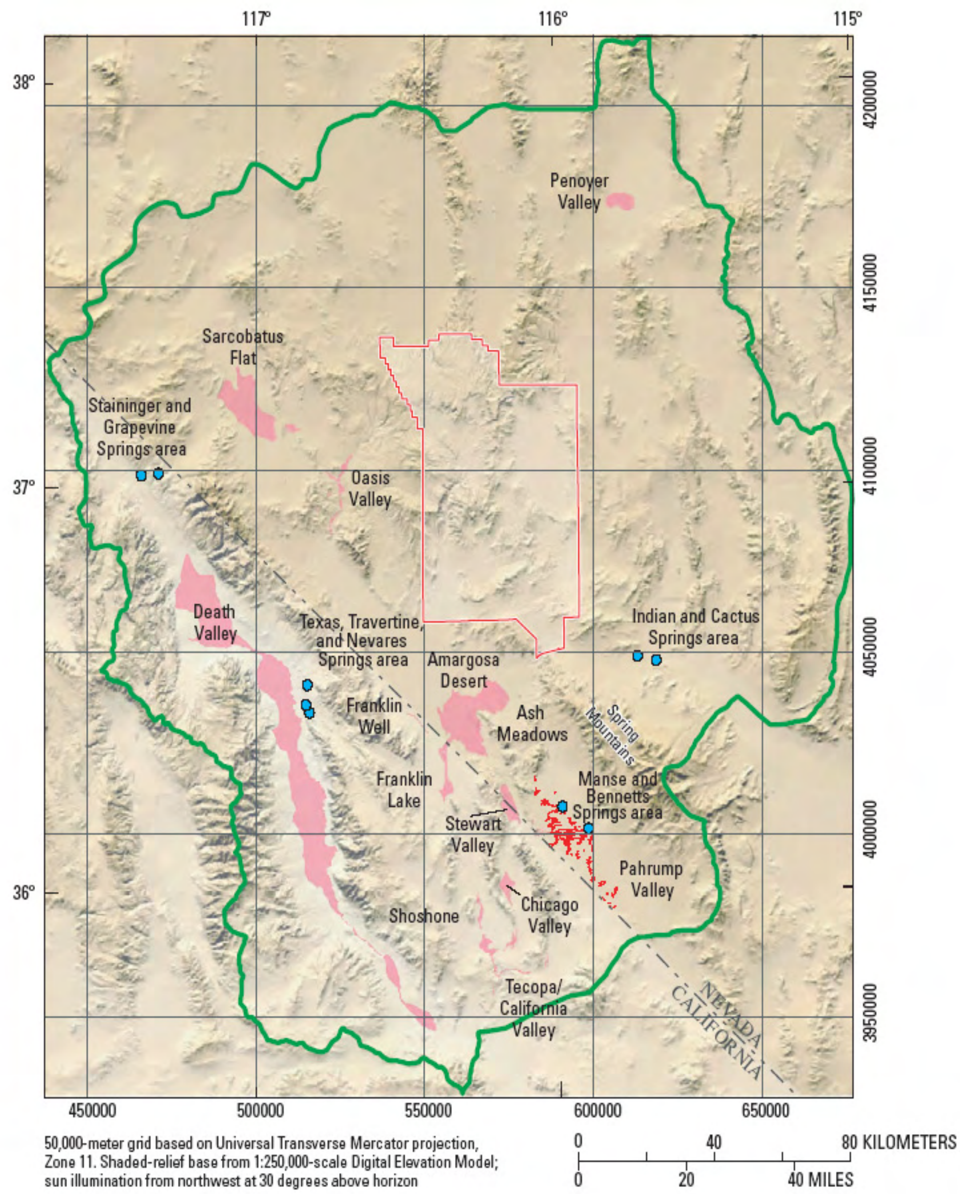


Figure D–5. Subregions and associated flow paths of the Death Valley regional ground-water flow system region.

FIGURE 6: Major Areas of Groundwater Discharge



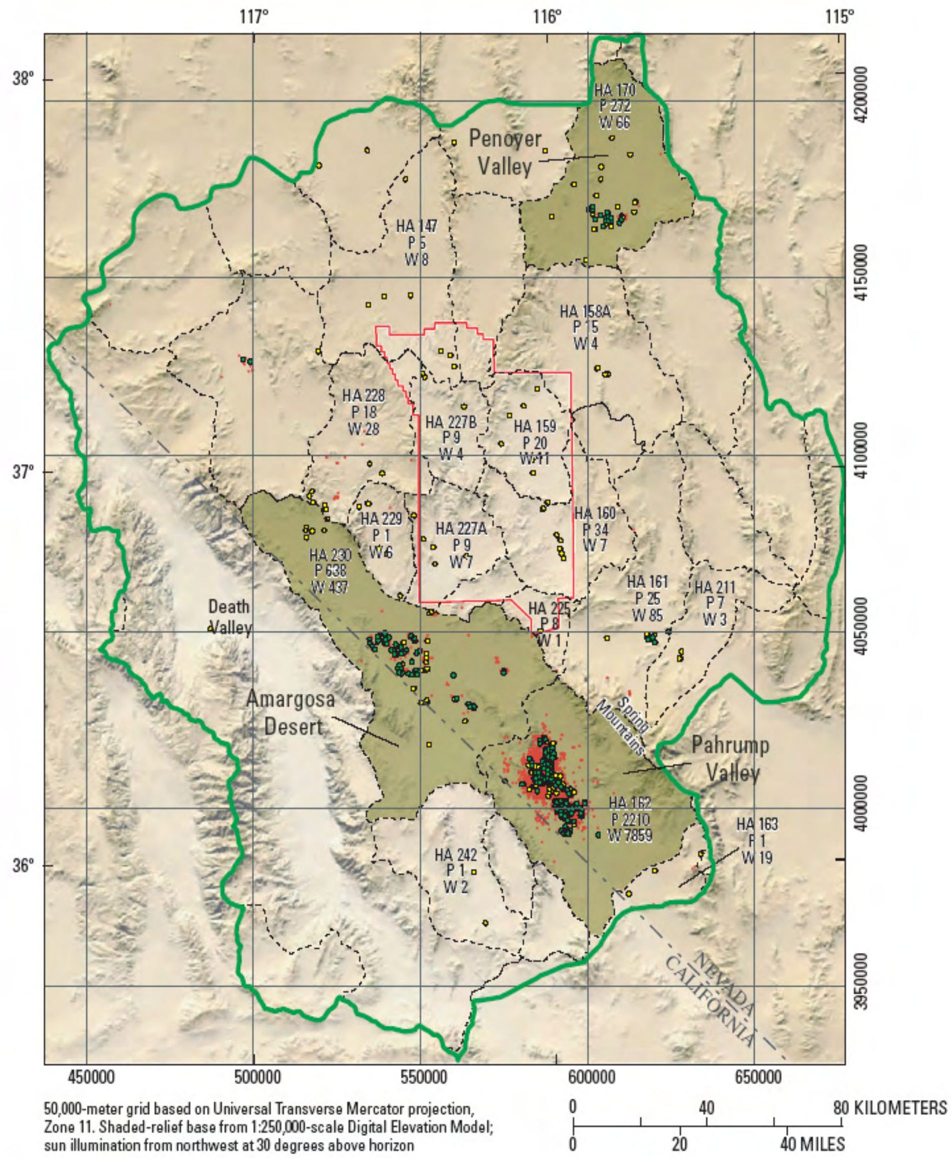
EXPLANATION

Area of natural ground-water discharge

- Evapotranspiration-based discharge estimate, assumed prepumped conditions (Van Denburgh and Rush, 1974; Laczniak and others, 2001; Reiner and others, 2002; DeMeo and others, 2003)
- Evapotranspiration-based discharge estimate, 1959–61 conditions (D'Agnese and others, 2002)
- Death Valley regional ground-water flow system model boundary
- Nevada Test Site boundary
- Spring-flow-based discharge estimate

Figure C–2. Major areas of natural ground-water discharge in the Death Valley regional ground-water flow system model domain.

FIGURE 7: Location of Pumping Wells in the Amargosa Area



50,000-meter grid based on Universal Transverse Mercator projection, Zone 11. Shaded-relief base from 1:250,000-scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon

EXPLANATION

- Hydrographic areas where pumpage exceeds 100 million cubic meters (Mm^3)
- HA 242 P 1 W 2 — Hydrographic areas where pumpage exceeds 1 Mm^3— HA, hydrographic area; P, total pumpage in Mm^3; W, number of wells.
- ------ Hydrographic area boundary (modified from Cardinalli and others, 1968)
- Death Valley regional ground-water flow system model boundary
- Nevada Test Site boundary

Pumping wells by water-use class (Moreo and others, 2003)

- Domestic
- Mining, public supply, and commercial
- Irrigation

Figure C–4. Spatial distribution of pumping wells by water-use class and total pumpage for 1913–98 by hydrographic area.

FIGURE 8: Hydrographic Units—As Designated by Nevada State Engineer

Figure D–9. Hydrologic units for the Death Valley regional ground-water flow system.