Integrated Science Assessment for the Upper Muddy River, Clark County, Nevada

Wetland downstream of the Muddy River & California Wash junction. Photo: Louis Provencher, 2003

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by

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1. EXECUTIVE SUMMARY

The Muddy River is one of the Mojave Desert's most important areas of biodiversity, providing habitat for 4 rare and endemic fish species, 7 species of rare invertebrates, 76 breeding bird species, and a unique assemblage of Mojave Desert riparian vegetation**.** Of particular concern is the endangered Moapa dace (*Moapa coriacea*), which only inhabits the warm headwaters of this river system.

The Nature Conservancy was contracted to develop and write a comprehensive upper Muddy River watershed assessment that will address restoration and land management issues on the Moapa Valley National Wildlife Refuge and elsewhere on the upper Muddy River. The contract, which is for two years, has two components—a geomorphic assessment and an integrated science plan. Although the final outcome of the contract is to propose a set of conservation alternatives based on scientific and social considerations and a list of research needs, the first year objectives are to; 1) review the scientific literature; 2) document the history of water developments; 3) characterize basins and sub-basins; 4) summarize physical and ecological information about the upper Muddy River's priority systems; 5) identify priority research and management questions that limit restoration on the upper Muddy River; 6) present modeled (HEC-RAS software) flow results for the current channel shape; and 7) list preliminary restoration options. Because this document was conceived as a progress report, each section contains information synthesized from deliverables received from the Conservancy's contractor, Otis Bay Inc, as well as information amassed by the Conservancy during a technical workshop process. Therefore, a large body of technical material is presented in the appendices.

The scientific literature review revealed many interesting facts, but the following have more immediate and practical implications:

- Spring discharge is decreasing steadily because of water withdrawals from the (regional) carbonate aquifer. The Moapa dace and other thermal endemics are predicted to be directly affected by this reduced discharge;
- The floodplain has been disconnected from the upper Muddy River for at least a century due to deep entrenchment and straightening;
- Non-native invasive plant and animal species occupy most ecological communities;
- Riverine restoration options are greatly limited by land ownership patterns;
- On the more hopeful side, a rich diversity of animal species of concern is still supported in primarily four areas retaining remnant plant communities upstream of Interstate 15;
- The limited length of the upper watershed spatially bounds exotic species control within the realm of (long-term) feasibility;
- Exotic species removal and land acquisition for conservation are on-going activities laying down the fundamental actions for future restoration;
- Many species of concern have common ecological requirements that could be met with generalized restoration and management approaches; and,
- A core of local stakeholders have demonstrated success and interest in the conservation of the upper muddy River.

The scientific literature review also identified issues where species of concern depend on human-caused habitat features that could be affected by riverine restoration:

- Vermilion Flycatchers require open water and, as a result, utilize the irrigation ditches adjacent to mesquite bosques, riparian shrublands, and open riparian forests;
- Although tamarisk removal is desirable, its wholesale removal may result in the temporary loss of all habitat structure for bird species unless some thought is given to the rate and shape of removal (the current rate of removal is small) and native plant revegetation; and,
- The only population of yellow bat (*Lasiurus xanthinus*) in Nevada is found exclusively in fan palms of the upper Muddy River, including at the Moapa Valley National Wildlife Refuge. While this species is more common south of Nevada, a subset of stakeholders value the presence of a disjunct occurrence of the species and wish to manage it for long term viability.

To facilitate the formulation of future conservation alternatives, the upper Muddy River was divided into nine segments representing sufficiently homogeneous river reaches based on channel pattern, valley confinement, and sinuosity. HEC-RAS modeled flow results using 2, 5, 10, 25, 50, and 100-year flood recurrence intervals within the current surveyed channel morphology per segment showed that all but the largest flood events (100 and 50-year) never exceeded the banks of river.

A synthesized list of 30 ranked priority research and management questions (from 101 original ones) were developed by experts during a July 2002 technical workshop. These questions identified the critical information needed by the public and members of the CCMSHCP Implementation and Monitoring Committee to justify future applied research, management actions, and associated spending for the upper Muddy River. Presentation of hydrologic and ecological facts would be required to initiate discussions with non-technical stakeholders from the Muddy River valley and surrounding area. Questions were developed after experts had presented the key points of their fact sheets. Question importance was ranked by the participant’s votes. The most highly ranked question was directed to the regional threat of reduced spring discharge to thermal endemics. Three additional high priority generic questions that emerged were: What is the minimum effort that will restore the river’s biota, and sustain it?; What are the consequences of restoration options for species using human-made habitat features?; and Do we know enough about the requirements of many species of concern?

Preliminary restoration options are proposed as a list of possible actions per river segment with relative (qualitative) costs and benefiting target systems. These options are meant to encourage discussion, however all restoration options will receive more in depth analysis in the second year with the understanding that a) the highest priority is the recovery of the Moapa dace and conservation of other endemic species because of their irreplaceability, and b) other conservation activities cannot preclude recovery of the Moapa dace or long term viability of endemic species. Future presentation of conservation options will likely be framed as the easiest, intermediate, and ambitious alternatives. The restoration of processes, such as restoring the connection between the channel and floodplain, is expected to play an important role in these alternatives while other necessary activities of exotic species control and protection of the floodplain and water flow are pursued. This contract's technical information will ultimately be used within the context of Clark County's Multiple Species Habitat Conservation Plan to develop a conservation management strategy to shape the decisions that will be required to fulfill vision for the upper Muddy River.

2. INTRODUCTION

2.1. Study Area and Conservation Significance

The upper watershed of the Muddy River, also known as upper Moapa Valley, is located approximately 60 miles (96.5 km) northeast of Las Vegas in the unincorporated towns of Moapa (282 mi^2 or 730.4 km^2) and Glendale (0.4 mi^2 or 1.04 km^2) in Clark County, Nevada, and upstream of the Interstate 15 Bridge for approximately 14 miles (22.5 km) of the Muddy River (Fig. 1). The Muddy River begins as a series of thermal springs in the upper Moapa Valley and flows 26 miles (41.8 km) before reaching Lake Mead (which submerges the lowest 7 river miles [11.2 km]). Prior to the construction of Hoover Dam, the Muddy River flowed into the Virgin River just upstream of the confluence of the Virgin and Colorado Rivers.

The Muddy River is one of the Mojave Desert's most important areas of biodiversity, providing habitat for 4 rare and endemic fish species, 7 species of rare invertebrates, 76 breeding bird species, and a unique assemblage of Mojave Desert riparian vegetation**.** Of particular concern is the endangered Moapa dace (*Moapa coriacea*), an endemic fish species restricted to the warm headwaters of this river system. The Clark County Multiple Species Habitat Conservation Plan (CCMSHCP 2000) and The Nature Conservancy's (TNC) Mojave Desert Ecoregional Assessment (TNC 2000a) have both identified the Muddy River as one of the region's most ecologically important and threatened riparian landscapes.

The Conservancy described six priority conservation targets for the upper Muddy River (TNC 2000b); warm spring/stream aquatic assemblage (i.e., the thermal endemic noted above), Muddy River aquatic assemblage (biota of colder waters), riparian woodland, riparian shrubland, riparian marsh, and mesquite bosque. These ecological communities each contain several species of concern (TNC 1999).

Since Mormon settlement during the mid 1800s, the river has become deeply entrenched and channelized, water is diverted for irrigation, domestic supply, and power generation, land conversion has and will continue to result in loss of habitats and ecological communities, and non-native species continue to invade the river and its floodplain. The Conservancy considers its Upper Muddy River (UMR) ecoregional portfolio site as irreplaceable because it contains at least one species or ecological community found nowhere else in the world (TNC 2000a). In the case of the upper Muddy River, this is the warm spring/stream aquatic assemblage that includes the Moapa dace.

2.2. Objectives

The Nature Conservancy was contracted to develop and write a comprehensive upper Muddy River watershed assessment that will address restoration and land management issues on the Moapa Valley National Wildlife Refuge and elsewhere on the upper Muddy River. The contract, which is for two years, has two components—a geomorphic assessment and an integrated science plan. This report fulfills the Conservancy's deliverables for the first year.

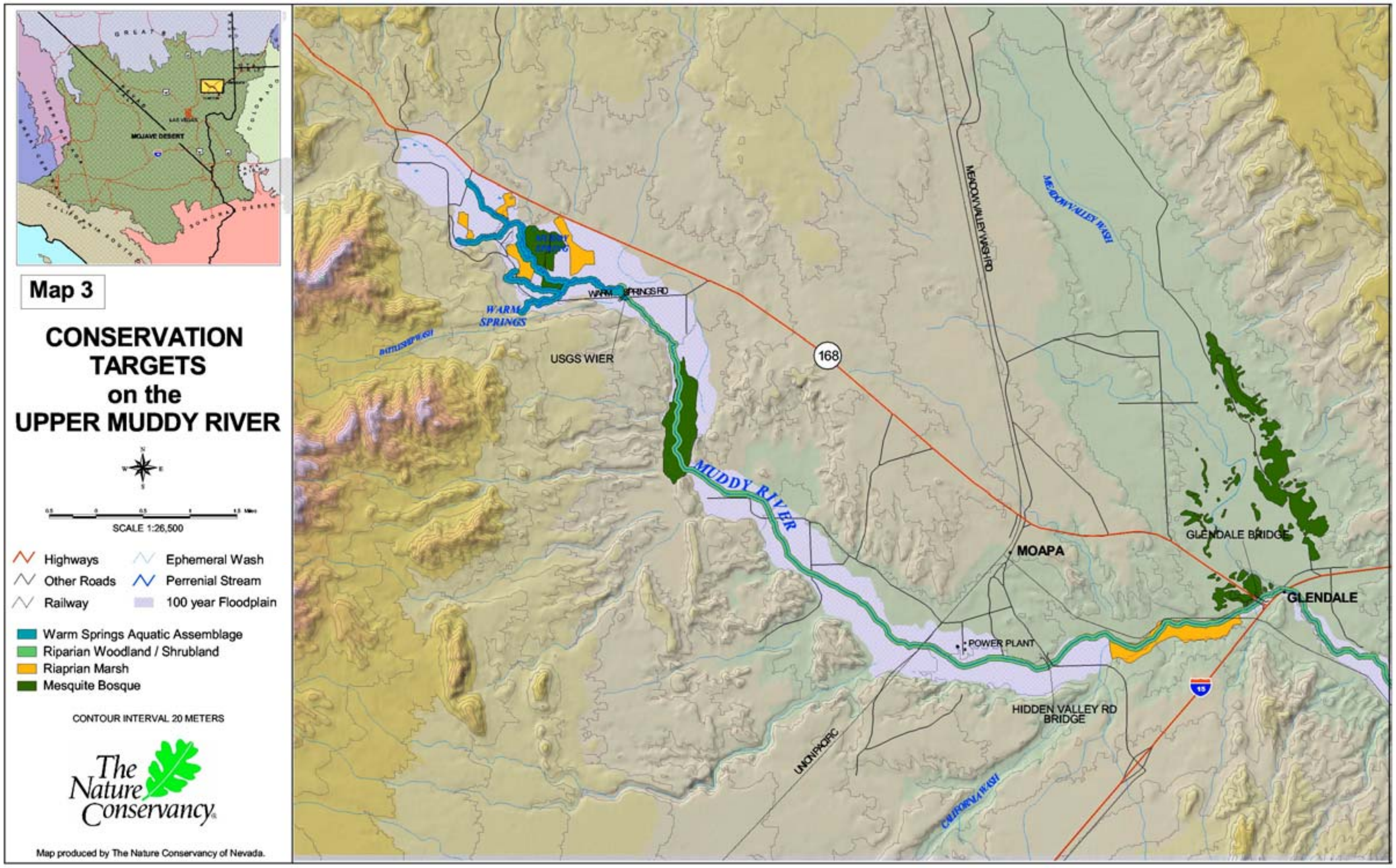

Figure 1. Upper Muddy River watershed, Nevada (TNC 2000b).

- The *geomorphic assessment* will include a review of the existing hydrologic, geologic, geomorphic, and groundwater data as they relate to conservation goals on the upper Muddy River. Field work includes characterization of river reaches along the main stem for channel geometry, slope, particle size distribution of streambed, sinuosity, etc. and analyzed using a hydrologic model (HEC-RAS). In conjunction with scientists specializing in adaptive management, the geomorphologists are assessing habitat enhancement options for target conservation work and will provide recommendations for habitat and riverine restoration. Riverine consultants from Otis Bay, Inc., who specialize in Intermountain West desert rivers and springs, were subcontracted to develop the geomorphic assessment.

- The *integrated science plan* will a) integrate existing scientific data and initial direction from the CCMSHCP adaptive management process as it relates to key conservation targets, b) develop restoration goals for species and communities, and c) define long-term management practices for the Moapa Valley National Wildlife Refuge and other agency parcels on the upper Muddy River. These prescriptions will be available for private landowners upon request. The Nature Conservancy staff will prepare the watershed assessment in coordination with agency partners, as well as assisting in the coordination of the many scientific efforts on the upper Muddy River.

This report's contents reflects these two components. The first four milestones of the geomorphic assessment by Otis Bay form the bulk of the background information presented here. Another part of the background information is the 18 hydro/geological and ecological fact sheets written and reviewed by experts, and 30 priority scientific and management questions identified by experts during the Conservancy's integrated science workshop held during 17-19 July 2002. In addition to background information, preliminary restoration options are outlined using Otis Bay's partial completion of its fifth milestone and some of the restoration options identified by experts during the July 2002 workshop.

Because the information collected for this report is large and assembled in self-contained documents, which became appendices, we synthesized the material. We opted to frame each section of the report as a summary wherein the information most relevant to the future of the upper Muddy River is highlighted.

3. Background Information

3.1 Scientific Literature Review

The upper Muddy River is the focus of conservation and development efforts because its headwater springs discharge a relatively constant flow of warm water in a desert. If accidents of geology had created cold springs, conservation issues might have been less intense, however this was not to be the case; indeed, the dissipation of heat as warm water flows downstream from springs created a unique assemblage of thermally isolated animals that are today threatened by past and current human activities. The human use of water is driven more by the constancy of its discharge and much less by its temperature, except for the recreational development of thermal springs that has resulted in direct habitat alterations and destruction for the rare heat-loving species. The constant discharge and water table are nonetheless important to a whole suite of rare to uncommon riparian dependent species and ecological communities that would in themselves make the upper Muddy River ecologically remarkable within the Mojave Desert.

Ownership of water rights and their management, therefore, are central topics with regional ramifications. Restricting the conversation strictly to hydrology would be shortsighted because even aquatic species depend on the interaction among water, the surrounding land, and other species. Therefore, the topics of land ownership and use, geomorphology, and species composition are especially relevant to threat abatement. The following bulleted list of facts, extracted and edited from Appendices I and IV, contains information on the above topics that may have practical conservation implications.

Ownership and Land Use

- Approximately 3,491.6 acres (1,413.6 ha) of 100-year floodplain are present along the upper Muddy River upstream of the Interstate 15 Bridge. The Moapa River Indian Reservation encompasses more than 71,000 acres (28,745 ha), of which 590.2 acres (238.9 ha) are irrigable 100-year floodplain. Public lands administered by the Bureau of Land Management (BLM) surround the upper Muddy River and BLM also manages a 400-acre (162-ha) parcel (Perkins Ranch) that is situated within the floodplain. In 2000, the floodplain intersected 219 parcels that were owned by 96 private entities (TNC, 2000b). The private lands within the upper Muddy River, which include the unincorporated towns of Moapa and Glendale, are under Clark County jurisdiction.
- Current zoning emphasizes the rural and agricultural lifestyle. According to the 1994 county land use plan, private land zoning is rural agricultural (over 1,300 acres or 526 ha), low density residential (under 100 acres or 40.5 ha), commercial-tourist (2.5 acres or 1.01 ha), industrial (40 acres or 16.2 ha), mineral use (46 acres or 18.6 ha), and public facilities (20 acres or 8.1 ha). Plans to develop the Warm Springs Ranch would increase the acreage of either low density residential or create high density residential areas.

Hydrogeology

- The Muddy River Springs Area is the terminal point of discharge for a regional groundwater flow system of basin-fill and carbonate-rock aquifers that extends more than 200 miles (320 km) from Ely, Nevada and includes both the White River and Lower Meadow Valley Wash Flow Systems. In addition, a portion of the groundwater within this regional flow system may be transmitted to Ash Meadows (USGS 1995), although current research is investigating this connection. Ash Meadows is recognized by the Conservancy and its partners another important desert riparian system in the Mojave Desert (TNC 2000a).

- Because of higher altitudes and precipitation, and lower temperatures in the northern half of the White River/Muddy River Springs drainage area, approximately 70 percent of the groundwater recharge is estimated to be in the northern half of the area. Based on measurements of spring discharge, approximately 62 percent of the groundwater discharge of the system has been determined to be in the Pahranagat and upper Moapa Valleys in the southern half of the area (USGS 1995). In addition, the location of faults throughout the groundwater basin indicates that the Sheep Range is an important source of recharge for the Muddy River Springs. Carbon-14 dating indicates that the average age of groundwater discharging at the Muddy River Springs is 6,100 years (Thomas et al. 1996).
- The effect of potential (water) developments upon the aquifer and springs remains controversial. More information about the aquifer system, particularly data pertaining to aquifer boundaries, is needed in order to accurately determine the potential effects of development (USGS 1995).

Hydrology

- The Nevada Division of Water Resources classifies the Muddy River Springs Area as a Designated Groundwater Basin, a definition which indicates that the permitted groundwater rights within the subarea approach or exceed the annual recharge and that the resource is being depleted or requires additional administration (NDWR 2003).
- In general, approximately 30-40% of the total Muddy River flow is derived from the discharge of numerous springs in the headwater area while 60-70% is derived from groundwater seepage (SNWA, *unpublished data*). Spring discharge is gaged by the USGS at three locations: 1) the Muddy Springs located on Warm Springs Ranch; 2) Warm Springs West; and 3) Pederson Spring on the Moapa Valley National Wildlife Refuge. Flow at the springs varies daily, seasonally, and annually (Fig. 2). Monthly average flows at the Muddy Springs, Warm Springs West, and Pederson Spring are less then approximately 7 to 8 cubic feet per second (cfs), 3 to 4 cfs, and, 1 cfs respectively.
- Three USGS river flow gages are present along the Muddy River; 1) the Moapa gage near the Warm Springs Road crossing; 2) the Glendale gage approximately 2 miles (3.2 km) downstream from the town of Glendale; and 3) the Overton gage approximately 1.5 miles (2.4 km) upstream of Lake Mead. The SNWA estimates the evapotranspiration to be approximately 9,000 acre-feet per year (afy) between the Moapa and Glendale gages (SNWA, *unpublished data*).
- More than 20 springs surface in the upper Moapa Valley, within a radius of approximately 1.5 miles (2.4 km), and converge to form the Muddy River (Fig 2). For descriptive purposes, the headwaters are here defined as the point of convergence of the North and South forks. Three additional sources of discharge in the headwater area include the Muddy Spring and channel, Apcar Stream, and the Refuge Stream. The combined mean discharge of the numerous springs in the headwater area for 25 years from 1914 to 1962 was 46.5 cfs (approximately 34,000 afy) (Eakin and Moore

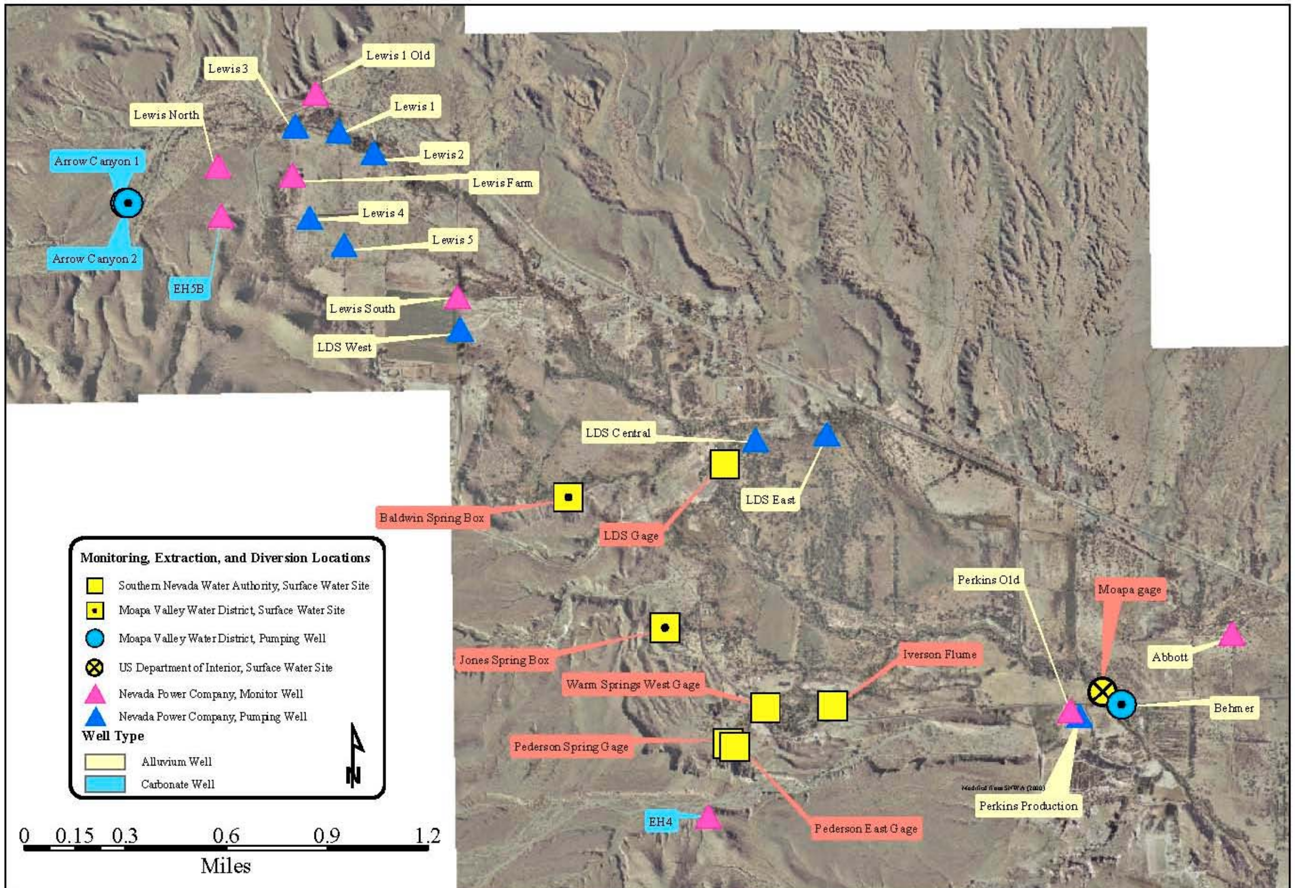

Figure 2. Groundwater and surface water monitoring, extraction, and diversion locations.

Modified from SNWA (2000)

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1964). Current mean discharge at the Moapa gage is approximately 25,000 afy (SNWA, *unpublished data*).

- Established by the State Engineer in 1920, the Muddy River Decree adjudicated the entire surface flow of the Muddy River and Springs. Within the upper Muddy River valley, the Moapa Valley Water District (MVWD) diverts 3 cfs from Baldwin and 1 cfs from Jones Springs for a total of 2,900 afy; the Nevada Power Company (NPC) diverts up to 3,000 afy during the winter from a point immediately upstream of the Moapa Gage for the Reid Gardner Station, a coal-fired power plant approximately 5 miles (8 km) downstream; and the Paiutes divert water at the upstream end of the reservation for agricultural use (Fig. 2).
- In addition, numerous groundwater rights exist within the upper Muddy River. The NPC and the MVWD are the primary users of groundwater within the upper Muddy River valley (Fig. 2). The NPC extracts groundwater from the alluvial aquifer at the Lewis well field, LDS wells, and Perkins and Behmer wells, primarily during summer months. The MWVD operates year-round groundwater extraction from the carbonate aquifer at the Arrow Canyon and MX-6 wells (SNWA, *unpublished data*). Several agencies are currently monitoring both surface and groundwater levels in order to monitor and minimize the potential effects to the groundwater system that may occur due to continued or increased withdrawals.
- Based on USGS gage records at the Moapa gage, discharge from springs in the upper Muddy River is approximately 36,000 to 37,000 afy (Eakin and Moore 1964). This value was based on a 25-year average flow between 1941 and 1962 of 34,000 afy (47 cfs). Eakin and Moore estimated losses to evapotranspiration to be approximately 2,000 to 3,000 afy resulting in a spring discharge of 36,000 to 37,000 afy.
- Annual peak and annual mean discharge at the Muddy River gage (located at the Warm Springs Road Crossing) for the years 1913 through 1917 and 1945 through 2000 show events of peak discharge exceeding 1,000 cfs occurred in 1945, 1960, 1967, 1976, 1979, 1984, 1990, and 1993 (Fig. 3). Flood events exceeding 100 cfs occur during most years and commonly occur more than once each year. Flooding events between 1918 and 1944 are uncertain and based on historical accounts and interviews.
- According to the SNWA, flow at the Moapa gage has decreased from 34,000 afy in the 1950s to 25,000 afy at present, primarily due to surface water diversions and groundwater extraction (Fig. 3). Since 1998, a two foot (0.61 m) decline in water surface elevation has been observed within the carbonate aquifer underlying the upper Muddy River as well as in Coyote Spring Valley. Beginning in 2002, the Nevada State Engineer issued a five year abeyance on the granting of additional groundwater rights for the carbonate aquifer while additional groundwater studies and aquifer tests are completed (SNWA 2002).

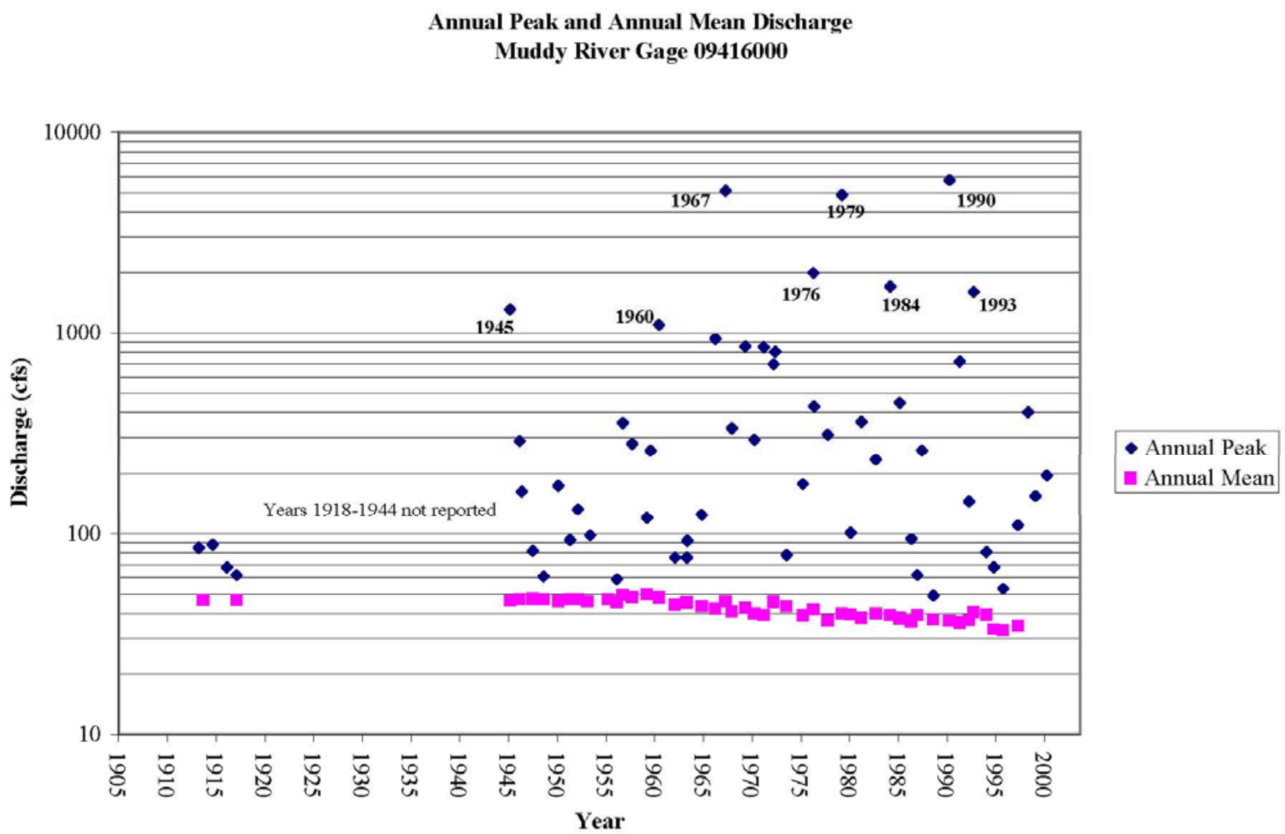

Figure 3. Annual peak and annual mean discharge at Muddy River gage 09416000 (Moapa gage).

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River Alterations

- Since Mormon settlement of the Moapa Valley in 1865, the Muddy River system has been significantly altered by the excavation of spring-fed tributaries and the replacement of natural channels by earthen or concrete ditches. Numerous springs have been capped for pumping purposes while others have been diverted for agricultural use. Much of the river between the White Narrows and Glendale has been channelized and straightened.

- Beginning in 1865, a great degree of impact upon the channel would have occurred, although uncertainty remains regarding the earliest human impacts to channel morphology because the upper Muddy River had agricultural and irrigation activities by Native Americans for corn, beans, and gourds as early as 500 AD (Fowler and Madsen 1986). The channel of the river has been straightened and moved to the margin of newly cleared agricultural fields to maximize the irrigable acres thus increasing the slope and stream power leading to channel incision and the upstream migration of headcuts. This process began in the late 1800's following settlement, and continued through the 1900's as larger scale channelization, drainage, and land development activities progressed. Channel incision was evident by 1923 based on general descriptions during the 1923 soil survey (Youngs and Carpenter 1923). Historic accounts of flooding by early settlers indicate that much of the channel incision observed today occurred shortly after 1880 following a period of unusual and intense flooding (Longwell 1928, Gardner 1968).

Biogeography and Ecological Systems

- The Muddy River is included in the Vegas-Virgin Freshwater Ecoregion of the Colorado River Complex (Abel 2000). This freshwater ecoregion is distinguished by the fact that 50-64% of its fish species are at risk, 100% of its endemic fish species are at risk, 25-36% of its herpetofaunal species are at risk, and 100% of its endemic herpetofaunal species are at risk. Thus, as riparian systems are lost from the Colorado River Complex, the Muddy River, especially in the upper Moapa Valley, becomes relatively more threatened and contributes more to the continued ecological health of the Virgin-Muddy River system (Grand Canyon Trust 1997).

- Six primary vegetation communities dominate the upper Muddy River: creosote bush shrubland, saltbush shrubland, desert riparian forest, desert riparian shrubland, wetlands marshes and seeps, and mesquite bosque (TNC 1999, 2000b). Riparian communities, wetlands, and mesquite bosque are perhaps the most threatened and host the majority of the species of concern.

- Descriptions of the terrestrial vegetation along the upper Muddy River by Carpenter in 1915 included greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), creosote bush (*Larrea tridentata*), and mesquite (*Prosopis* spp.). Streamside habitats were naturally dominated by Fremont cottonwood (*Populus fremontii*) and willows (*Salix* spp.), including Goodding's willow (*S. gooddingii*), coyote willow (*S. exigua*), as well as mesquite, acacia (*Acacia* spp.), velvet ash (*Fraxinus velutina*), and arrow weed (*Pluchea sericea*) with various understory species.

- Non-native phreatophytes (water-loving species of plants) have largely overtaken these habitats throughout the region, particularly saltcedar (*Tamarix ramosissima*) and athel (*Tamarix aphylla*). Fan palms (*Washingtonia filifera*) dominate the springs in the upper Muddy River and are generally considered by scientists to be invasive and destructive to Moapa dace habitat. The presence of fan palms is an issue because of the preferences of valley inhabitants, use of the palms as roosting areas by the only yellow bat (*Lasiurus xanthinus*) population in Nevada, and the documentation of birds feeding on fan palm fruit. Other important non-native plant species in the Muddy River basin include Russian knapweed (*Acroptilon repens*), brome grasses (*Bromus* spp.), Bermuda grass (*Cynodon dactylon*), Ravenna grass (*Saccharum ravennae*), and numerous mustards (e.g., *Brassica* spp.).
- Although many fish species native to the Colorado River basin have been observed within the Muddy River, four species are native to the Muddy River including two species (Moapa dace and Moapa White River springfish [*Crenichthys baileyi moapae*]) that are thermophilic and endemic to the Warm Springs area. Moapa speckled dace (*Rhinichthys osculus moapae*) is a third endemic that occupies cooler water downstream from the Warm Springs area (Scoppettone et al. 1998). Virgin River chub (*Gila seminuda*) is the only native fish that is not found exclusively in the Muddy River and occurs also in the Virgin River.
- Thirteen non-native fish species have been observed in the Muddy River including shortfin molly (*Poecilia mexicana*), mosquitofish (*Gambusia affinis*), carp (*Cyprinus carpio*), red shiner (*Notropis lutrensis*), golden shiner (*Notemigonus crysoleucas*), black bullhead *(Ictalurus melas*), channel catfish (*Ictalurus punctatus*), fathead minnow (*Pimephales promelas*), largemouth black bass (*Micropterus salmoide*), green sunfish (*Chaenobryttus cyanellus*), rainbow trout (*Salmo gairdneri*), and blue tilapia (*Oreochromis aurea*) (Deacon and Bradley 1972, Cross 1976, Scoppettone et al. 1998).
- Established in 1979, the Moapa Valley National Wildlife Refuge was created in historic habitat at the southern edge of the Warm Springs area for the purpose of preserving the endangered Moapa dace (Scoppettone et al. 1992). The approximate 1,500 foot (457.5 m)-long section of spring channel within the refuge has supported up to 500 Moapa dace and more than 10,000 White River springfish. Prior to the establishment of the refuge, the Moapa dace population had been precluded from the headwater springs due to habitat alteration and chlorination during the use of the property as a resort. The population was reestablished in 1984 with the introduction of 150 larvae and 40 adults (Scoppettone et al. 1998). The current Moapa dace population is limited to approximately 1,000 due to predation by tilapia. In 1994, a very hot fan palm fire at the Refuge killed many Moapa dace individuals. The native fish population within the refuge is currently separated from non-native fishes by an artificial barrier. The greatest looming threat to the viability of the Moapa dace on the Refuge is a decrease in spring discharge because these springs have the highest elevation in the valley, and thus are more susceptible to water withdrawals from the carbonate aquifer.

- Both the Moapa dace and White River springfish inhabit waters ranging from 26 to 32 °C and reproduce in temperatures ranging from 30 to 32°C, typically within 500 feet (152.5 m) of the springs. Due to their thermophyllic nature, both species are restricted to the uppermost section of the river and smaller headwater tributaries. Smaller Moapa dace adults inhabit the spring channels while the largest adults inhabit the Muddy River. The Moapa dace are drift feeders and have been observed congregating in eddy areas where slower water persists while White River springfish are thought to be omnivorous (Williams and Williams 1982, Scoppettone et al. 1992, Scoppettone et al. 1993).

- Over 100 aquatic macroinvertebrate species have been described from the thermal springs and headwaters of the Muddy River. Several species are globally rare (a water strider [*Rhagovelia becki*], creeping water bug [*Ambrysus mormon*], *Pelocoris biimpressus shoshone*, grated tryonia [*Tryonia clatharta*]) while four are endemic (Pleasant Valley springsnail [*Pyrgulopsis avernalis*], Moapa warm springs riffle beetle [*Stenelmis moapa*], Warm Springs naucorid [*Limnocoris moapensis*], and Moapa skater/waterstrider [*Microcylloepus moapus moapus*]). These species are most abundant within the spring and spring channels and are scarce or absent further downstream where species better adapted to harsh environmental conditions comprise the macroinvertebrate community (Sada 2000).

- Historical amphibian species likely included populations of relict leopard frog (*Rana onca*), Pacific tree frog (*Hyla regilla*), red-spotted toad (*Bufo punctatus*), and southwestern toad (*Bufo microscaphus microscaphus*). The present amphibian population is dominated by non-native bullfrogs (*Rana catesbeiana*), Pacific tree frogs, and a hybrid toad complex (likely *Bufo woodhousii*, *B. m. microscaphus*), dominated by *Bufo woodhousii* (Hoff, *unpublished data*).

- The upper Muddy River contains a bird community with one of the highest number of bird species within Clark County. Lund (*unpublished data*) reported 230 bird species over a 4-year period, of which 162 were recorded at least 5 times in 4 years. During 2001, Fleishman et al. (2003) detected a total of 125 bird species in the Muddy River drainage, of which 76 were considered to be breeding species. In this study, bird species richness was closely related to total vegetation volume, whereas bird species composition was related to floristics (plant species composition).

- Lund (*unpublished data*) categorized birds within the conservation targets presented by TNC (2000b). Eighty-six species were associated with riparian woodland habitat including the following neotropical migrants; Yellow-billed Cuckoo, Summer Tanager, Blue Grosbeak, Yellow Warbler, Lucy’s Warbler, and Western Kingbird. Seventy-nine species were observed in the Riparian Shrubland including Yellow-breasted Chat, Blue Grosbeak, Indigo Bunting, Bullock’s Oriole, Loggerhead Shrike, and Crissal Thrasher. Thirteen species were observed in the relatively small Riparian Marsh including Virginia Rail, Sora, and Marsh Wren. Sixty species were associated with the Mesquite Bosque including Phainopepla, Lucy’s Warbler, Verdin, and Vermillion Flycatcher. Numerous additional species were also observed in human-made habitats such as open-water ponds, sewage lagoons, flood irrigation waters/agricultural fields, and livestock pastures. Phainopepla, Vermilion Flycatcher, and Yellow-billed Cuckoo, respectively, are subjects of research by Cali Crampton, Polly Sullivan, and Murrelet Halterman. The Nevada Department of Wildlife tracks numbers of Southwestern Willow Flycatcher in the upper Moapa Valley. During the last breeding season, the Nevada Department of Wildlife detected the first pair of Southwestern Willow Flycatcher nesting in the upper Muddy River on Warm Springs Ranch (NDOW 2003).

- While most mammals are typical commonly found Mojave Desert species, the desert pocket mouse (*Chaetodipus penicillatus*) is the rarest species in the upper Muddy River. It is found in desert riparian shrubland vegetation, transitional between riparian and desert vegetation where soil is stabilized alluvial sands with <2 mm particle size (Marshall and Micone, *unpublished data*).

3.2. Basin and sub-basin characterization

An important goal of the Conservancy's contract is to identify site specific restoration options for the upper Muddy River. In the case of fluvio-geomorphic restoration, actions may be applied at specific locations but their locations are often determined by the characteristics of the larger river reach within which they are contained. Otis Bay identified nine river segments that represent sufficiently homogeneous river reaches based on channel pattern, valley confinement, and sinuosity:

Table 1. Upper Muddy River segments.

Segment	Start Point Feature	Endpoint Feature
1	I-15 Bridge	Power Station RR Bridge
2	Power Station RR Bridge	White Narrows
3	White Narrows	Warm Springs Road
4	Warm Springs Road	Warm Springs-Muddy Confluence
5	Warm Springs-Muddy Confluence	North-South Fork Confluence
6	Warm Springs-Muddy Confluence	Warm Springs
7	North-South Fork Confluence	North Fork Headwaters
8	North-South Fork Confluence	South Fork Headwaters
9	North Fork Headwaters	Arrow Canyon

Hydrologic modeling and the assessment of various restoration options will be conducted for each of the nine segments, therefore segments are a central concept of this Integrated Science Assessment. Although the most important features of each segment are highlighted below, the reader is invited to peruse a more complete and interesting narrative by Otis Bay in Appendix II.

Segment #1—I-15 Bridge to Power Station RR Bridge

- Compared to most upstream segments, segment 1 is relatively confined between canyon walls. The channel is entrenched approximately 10 feet (3.05 m). The lower half of segment 1 exhibits a sinuosity possibly approximating that of pre-disturbance conditions.

- Downstream of the California Wash junction, a spring-fed, constructed pond surrounded by spring-fed wetlands is the most important feature, relative to riparian vegetation, within segment 1. The pond is surrounded by numerous native wetland species and likely hosts wetland plants and animals that formerly had a much wider distribution within the upper Muddy River (see photo on cover of report).
- California Wash enters the UMR valley in the vicinity of the Hidden Valley Dairy and likely plays a significant role in flooding within the lower half of segment 1.
- The upper half, extending from the Hidden Valley Dairy to Reid Gardner Station has been straightened and dredged.
- The Hidden Valley Dairy is the dominant land owner.

Segment #2— Power Station RR Bridge to White Narrows

- The channel, which flows across a broad floodplain, has been extensively straightened, channelized, and moved to the south side of the valley for agricultural purposes.
- Land within segment 2 is owned primarily by the Moapa Band of Paiutes.

Segment #3—White Narrows to Warm Springs Road

- Although a limited amount of sinuosity exists in the upper half of this segment, the channel is straight and entrenched approximately 10 feet (3.05 m).
- A series of step pools are caused by erosion-resistant deposits (carbonate calcium), which likely function as grade control.
- Mesquite and other species are reestablishing in the old agricultural fields of the former Perkins Ranch.
- Most of the land within segment 3, which is undeveloped, has recently been purchased by the BLM (the 400-acres [162 ha] Perkins Ranch, formerly owned by the Nevada Power Company) and, with the exception of the Warm Springs Road at the upper end and two minor road crossings at the downstream end of the segment, very few obstructions exist within the floodplain.

Segment #4—Warm Springs Road to Warm Springs-Muddy Confluence

- The channel has been straightened for 1,000 feet (305 m) upstream and 2,000 feet (610 m) downstream of the Warm Springs Road crossing, while a more sinuous channel exists throughout the remainder of the segment. Meander bends within the channel contain pools up to 6 feet (1.83 m) deep.
- The channel bed is entrenched approximately 10 to 15 feet (3.05 to 4.6 m).
- Although large cut banks are present throughout the segment, thick vegetation covers even the steepest of banks.

- Land ownership within this segment is currently held by the South 15 Investment Group (Warm Springs Ranch). Currently inactive agricultural fields and horse pasture border the channel.

Segment #5—Warm Springs-Muddy Confluence to North-South Fork Confluence

- Entrenchment is approximately 10 to 15 feet (3.05 to 4.6 m) deep and steep cut banks border the channel.
- Although entrenchment is significant, segment 5 exhibits sinuosity that likely approximates that present prior to channelization activities throughout the remainder of the UMR valley.
- Muddy Spring, located on the LDS Recreation Center property on the Warm Springs Ranch, enters the main stem of the river at the approximate midpoint of segment 5.
- Similar to segment 4, all of the land bordering the river is currently owned by the South 15 Investment Group.

Segment #6— Warm Springs-Muddy Confluence to Warm Springs

- Segment 6 includes the warm springs channels associated with the Plummer, Pederson, and Apcar warm springs located on the Moapa Valley National Wildlife Refuge.
- These springs issue from the base of low hills on the south edge of valley and the channels provide habitat for thermal endemic species.
- Fan palms occupy the warm spring channels on Refuge land and on the South 15 Investment Group's property. A hot fan palm fire killed many Moapa dace in 1994. Fan palms were not killed by the fire. During 2003, 150 fan palms growing in the channels were cut to control hazardous fuel loads. Many fan palms remain on the Refuge land.
- Because of recent interagency efforts, these channels are currently free of tilapia and a gabion barrier is located directly downstream from the confluence of the Apcar and Plummer/Pederson channels.

Segment #7—North-South Fork Confluence to North Fork Headwaters

- Entrenchment is approximately 5 to 8 feet (1.52 to 2.44 m).
- A 5 to 6 foot (1.83 m) tall headcut is present approximately 1,500 feet (457.5 m) upstream from the uppermost headwater spring. The presence of this headcut upstream from any perennial flowing stream indicates either that perennial flow above the headcut has ceased, or that flood flows from Arrow Canyon provide the erosive force necessary to create the headcut.
- The headwaters of the North Fork consists of a series of springs within and adjacent to the channel and located on private land.

- During summer 2003, the channel area, dominated by fan palms, burned in a wildfire. While native shrubs died, fan palms survived the fire, tamarisk reprouted, and mineral soil dominates the ground cover.
- The majority of the floodplain is primarily unused agricultural fields and horse pasture.

Segment #8—North-South Fork Confluence to South Fork Headwaters

- Segment 8 consists of the South Fork of the Muddy River, with its headwaters located directly upstream from the Baldwin Spring Box where several springs emerge.
- Vegetation patterns appear to provide evidence of a more extensive wetland area (than the current one) extending from the current location of the spring box to the Cardy Lamb pool. However, the majority of the flow within segment 8 is discharged from the Baldwin Spring Box and flows into a narrow and channelized stream that borders agricultural fields. The channel is essentially a narrow ditch that dissipates into marshes and occasionally reforms until discharging into the mainstem of the river.

Segment #9—North Fork Headwaters to Arrow Canyon

- Segment 9 includes the ephemeral channel upstream from the North Fork headwater springs and extends into Arrow Canyon.
- A high degree of entrenchment has occurred.
- Several homes are located throughout the 100-year floodplain within this segment.

In addition to the above segment descriptions, an overall ecological characterization was conducted. The following four points summarize the findings of this effort:

- Strong zonation of vegetation exists;
- Non-native saltcedar strongly dominated the entire drainage, and fan palm has invaded and is strongly dominant in the headwaters reaches;
- Entrenchment is sufficiently severe that little normal riparian plant recruitment is taking place in the lower riparian zone; and
- Native tree populations (i.e., ash, cottonwood, and Goodding willow) are declining, with little recruitment in most reaches.

3.3. Expert assessment of the condition of ecological communities and priority species

During 17-19 July 2002, a technical workshop composed mainly of resource management and scientific experts (Appendix III) was convened by the Conservancy to achieve three goals: 1) Create concise fact sheets about species and ecological communities of concern found on the upper Muddy River; 2) Share critical information from the fact sheets with workshop participants; and 3) Based on the fact sheets and presentations/discussions, build a short list of synthesized priority research and management questions ranked by workshop attendees. In addition to the biological fact sheets, hydrogeologists wrote a hydrogeological fact sheet. Priority research and management questions generated through this process are discussed in the next section of this report.

Each fact sheet was assigned to one or more experts to write, on a volunteer basis. Each fact sheet was then reviewed by at least two other experts, and the final, edited fact sheets were distributed to all workshop participants prior to the workshop. The format and content of fact sheets were standardized, although they varied in detail between species and communities: 1) table of minimum, intermediate, and ambitious alternative desired future conditions for the species or community; 2) brief biological description of the system's natural history and biogeographical context; 3) list of associated communities for species or embedded communities for the target communities; 4) for communities only, current status as defined by percentage of system in high, high-medium, medium, medium-low, and low quality states; 5) bulleted list of desired structure, composition, and landscape context and configuration; 6) bulleted list of challenges to reaching and maintaining sustainable population/system; 7) bulleted list of potential management options to reach desired future conditions (pros and cons); 8) bulleted list of ecological and management uncertainties, and 9) information sources and reviewers of the fact sheet.

Fact sheets were written for the following systems, which included Clark County priority species (original fact sheets in Appendix IV):

Hydrogeology and hydrology

1) Muddy River Springs Area by Jeff Johnson, SNWA;

Plant communities

2) Wetland marsh and seep by David Charlet, Southern Nevada Community College;
3) Desert riparian forest by David Charlet;
4) Desert riparian shrubland by David Charlet;
5) Mesquite bosque by David Charlet;
6) Saltbush shrubland matrix by David Charlet;
7) Creosote-mixed scrub matrix by David Charlet;

Vertebrates

8) Moapa dace by Gary Scoppettone, USGS-BRD;
9) Amphibian species assemblage by Karin Hoff, independent scientist;
10) Upper Muddy River bird community by Bruce Lund, local resident and TNC;
11) Yellow-billed Cuckoo by Murrelet Halterman, Sierra Research Station;
12) Phainopepla by Cali Crampton, University of Nevada, Reno;
13) Vermilion Flycatcher by Polly Sullivan, contractor;
14) Southwestern Willow Flycatcher by Louis Provencher, TNC (with information from Cris Tomlinson, NDOW and NatureServe©);
15) Bat species assemblage by Jason Williams, University of Nevada, Las Vegas;
16) Desert pocket mouse by Zane Marshall and Kerstan Micone, University of Nevada, Las Vegas;

Invertebrates

17) Aquatic macroinvertebrate community by Donald Sada, Desert Research Institute; and,
18) Butterfly species assemblage by George Austin, Nevada State Museum.

Key points generated through development and review of the fact sheets includes the following:

- Recovery of the Moapa dace is paramount to the conservation efforts because of its irreplaceability, and, therefore, should be considered the highest priority and a fundamental step in improving the integrity of the aquatic ecosystem.
- Conservation needs of Virgin River chub, two other desert fishes, and a suite of endemic species must also be considered a high priority in restoration plan.
- Other conservation activities cannot preclude recovery or long term viability of endemic species.
- Three areas in particular are biologically rich in species and communities of concern: Warm Springs Ranch (property owned by the South 15 Investment Group), Moapa Valley National Wildlife Refuge, and Hidden Valley Dairy wetland corridor.
- The Perkins Ranch, formerly owned by the Nevada Power Company and recently acquired by the BLM, has great potential for passive and active restoration of what could become the largest mesquite bosque on the river.
- With noted exceptions, the ecological needs of most species of concern are congruent and may be summarized by a) maintaining or increasing groundwater discharge available to natural systems, b) reconnecting the river to the floodplain, and c) restoring natural plant communities.
- A few species, such as the yellow bat and the Vermillion Flycatcher, appear to exist in the watershed because of human-made habitat features (fan palms, flooded ditches, and so on) and there are questions about their fate in the context of desired future conditions.
- River entrenchment, non-native plant and animal species, and additional habitat loss/degradation are major local threats to the river's biota, although decreasing spring discharge is a looming regional threat.
- It is recognized by all biological experts that social pressures and vision will eventually determine the desired future condition for the upper Muddy River.

3.4. Key research and management questions

From a technical point of view, the list of ranked priority research and management questions was the most important outcome of the 2002 workshop because they identified the critical information needed by the public and members of the CCMSHCP Implementation and Monitoring Committee to justify future applied research, management actions, and associated spending for the upper Muddy River. Presentation of hydrologic and ecological facts would be required to initiate discussions with non-technical stakeholders from the Muddy River valley and surrounding area.

During the workshop, Conservancy facilitators recorded all applied questions that were relevant to resource management and future development of conservation management strategy for the upper Muddy River. Basic questions that did not have an obvious connection to management were not recorded and experts were asked to avoid these questions during their presentations. A list of 101 questions was generated during the workshop (Appendix V). During the last day of the workshop, participants were divided into four theme groups (see Table 2 below) that synthesized questions to the lowest possible number (30; Table 2). A spreadsheet or text file of all questions was emailed to each workshop participants shortly after the workshop. During a period of three weeks, participants voted electronically on the questions and returned their votes to The Nature Conservancy. Some participants did not vote, including the three Conservancy staff in attendance. To encourage full meeting attendance and insure that participants voted on topics they heard about during presentations and discussions, the number of total votes per person varied with the number of days of participation. Participants were asked to use 20 votes total if they had attended the whole two-day workshop, whereas only 10 votes total were allowed for those that had attended only one day. The maximum number of votes one could assign to a question was 5 and participants were not required to vote on all questions (blanks, therefore, were acceptable and expected). Votes were totaled and the percentage of votes per question determined its rank (i.e., perceived importance). The questions, as seen by the attendees, and their ranks are presented in Table 2 with votes ranked in decreasing numerical order per theme.

Table 2. List of ranked priority research and management questions.

Hydrology / Geomorphology	
1. If water level changes (+/-) (and hits triggers), what is the effect on fishes & other biological responses? OR: What are the ecological consequences of reduced water levels?	19.3%
2. Is the entrenchment of the UMR human-caused or natural? (Need to understand channel morphology, including the effect of impoundment from Arrow canyon.)	5.6%
3. How much restoration needs to be done to keep the UMR system (springs & streams) viable?	5.6%
4. How big an area is needed for channel evolution/migration?	4.6%
5. What is effect of Upper White River system on lower Colorado Flow System?	2.4%
6. What are the consequences of flow augmentation to springs as a mitigation strategy?	2.0%
subtotal	*39.5%*
Desert Fishes / Aquatic Inverts / Amphibians	
7. To what extent can restoration of natural hydrologic processes protect native biota?	7.1%
8. What are the tradeoffs for maintaining artificial habitats/conditions versus natural processes/condition (e.g., fan palm/yellow bats vs. "natural" fire regimes & natural forests)?	6.8%
9. To what extent can exotic species (bullfrogs, crayfish, softshell turtle, tilapia, plants, etc) be controlled by restoration of natural processes?	5.4%
10. What are the basic habitat requirements, and suitable adaptive management needs, for selected taxa (*Rana onca*, etc)?	2.9%
subtotal	*22.2%*
Vegetation / Butterflies / Tamarisk / Desert Pocket Mouse	
11. What are the native plant communities over time?	6.1%

12. Can we replace "artificial" wildlife enhancing features with more sustainable and stable "natural" features and processes which support equivalent wildlife (i.e., replace irrigation ditches w/ river side channels, or replace irrigated meadows w/ native wet meadows)?	6.1%
13. How will we manage for weeds?	3.7%
14. What are the plant communities today (distribution, composition, & complete flora)?	2.9%
15. How do we ensure that multiple seral stages of all natural communities are present?	2.2%
16. What is appropriate size, geometry, and location of restoration projects - especially tamarisk removal?	1.5%
17. Do we understand tamarisk invasion and succession in this system?	1.0%
18. What is the succession following tamarisk removal in all communities?	0.7%
19. Can we get permission to release tamarisk beetles?	0.5%
20. How will we monitor chemical applications for effects on non-target species?	0.2%
21. What plant species will best colonize bare ground after tamarisk removal (e.g., as part of an artificial planting program for butterflies)?	0.2%
22. Where are the populations, what are their sizes, and what are their demographic characteristics?	0.2%
23. How do they interact with non-native plants (both ways: encroachment and seed caching)?	0.2%
24. What are the habitat characteristics of the desert pocket mouse?	0.0%
subtotal	*25.6%*
Birds (community, Yellow-Billed Cuckoo , Southwestern Willow Flyctacher, Vermilion Flycatcher, Phainopepla) / bats	
25. What are the consequences of managing for natural systems (dace, downstream vegetation) with respect to bird species diversity that use/depend on artificial habitats (including species covered in MSHCP)? Need to consider: 1) Southwestern Willow Flycatcher, grazing, fire management; Vermilion Flycatcher, ditches, open spaces; 3) Yellow-billed Cuckoo, cottonwoods, ditches, and flooding; original condition of river.	7.1%
26. What are specific roosting preferences of tree-roosting bats, including microclimate preferences (including tree- & stand-level investigation)?	2.4%
27. What are the details of Yellow-billed Cuckoo biology on Muddy River and how do they compare to rest of range? Especially a) preferred composition, structure, and nesting habitat vs. available habitat (relict habitat?); b) limit of range; and c) prey sources.	1.0%
28. What kind of restoration/habitat condition would allow colonization by Southwestern Willow Flycatcher?	1.0%
29. What are the correlations among Phainopepla abundance, mistletoe abundance, and mesquite stands of different size, age, structure, composition over the long term? Must include assessment of population size, growth rate, and movement patterns of all 3 components.	1.0%
30. What are the quantitative/mechanistic habitat requirements for Vermilion Flycatcher (in particular, use of moving water, use of springs) in UMR vs. rest of range? Must examine preferred vs. available habitat (relict?).	0.2%
subtotal	*12.7%*
total	*100.0%*

It is clear that the first question garnered disproportionately more votes than any other question and was directed to the regional threat of reduced spring discharge to thermal endemics. It is also worth noting that questions #2, 3, 4, and 7 are specifically addressed by this contract. Three generic questions that emerged within the various themes were:

- What is the minimum effort that will restore the river's biota, and sustain it?;
- What are the consequences of restoration options for species using human-made habitat features?; and
- Do we not know enough about the requirements of many species of concern?

3.5. Hydrologic modeling (HEC-RAS) and predicted flows

The potential for river restoration hinges on flow behavior predicted for different flood events. For example, it may be useful to know if a river reach is prone to flooding. An established modeling software for flows is HEC-RAS (Hydraulic Engineering Center - River Analysis System; U.S. Army Corps of Engineers 2003). The program performs one-dimensional flow calculations for both steady and unsteady flow. HEC-RAS modeling for 2, 5, 10, 25, 50, and 100-year flood recurrence intervals was applied to the current channel of the upper Muddy River. Results will quantify the severity of the river entrenchment problem and technical challenges to elevate non-flood water surface closer to the upper banks.

Basic geomorphic data were collected from five channel cross sections for each of segments 1, 3, 4, 5, 8, and 9 to populate the HEC-RAS model (see Appendix VI for the locations of channel cross sections). Segments 6 and 7 are spring channels or spring channel complexes and were not included in detailed surveys as HEC-RAS modeling may not be appropriate tool for these small channels. Access to the Moapa River Indian Reservation (segment 2) was not granted until November 18, 2003. Therefore, channel, invertebrate, or vegetation surveys were not completed within Segment 2. However, reconnaissance level surveys were completed following the granting of access and sufficient information was gathered in order to provide recommendations throughout the entire upper Muddy River valley. Collected data were surveyed elevation, surveyed water surface elevation, approximate roughness values based on channel and floodplain characteristics, and a measured discharge or approximate discharge based on stream gage records at the Moapa gage station (#09416000). A discharge of 30.0 cfs was used as an approximation of the flow during channel cross section survey activities for segments 1, 3, and 4 while measured discharges of 21.0 and 4.0 cfs were used to model flows for segments 5 and 8, respectively. As a final caveat, model results should be interpreted with caution when the predicted water surface elevation is higher that floodplain ground elevation, as was often the case for 100-year flood events.

In most cases, flood events, except the 100-year event, are contained within the entrenched channel (Fig. 4 as a typical example selected from Appendix VI). As entrenchment decreases, the 100, 50, and 25-year flood recurrence intervals show overbank flow.

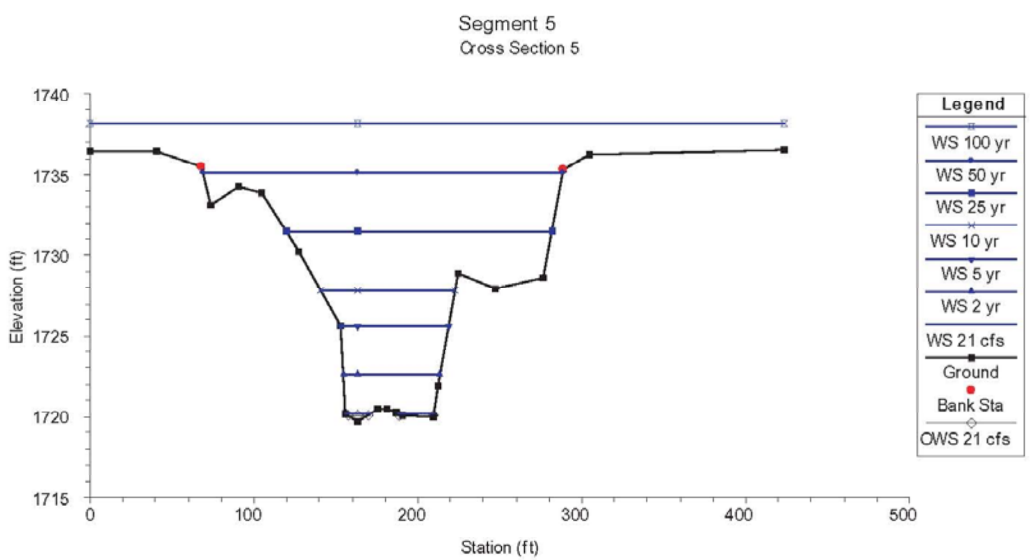

Figure 4. HEC-RAS modeling results for 21 cfs and the 2, 5, 10, 25, 50, and 100-year flood recurrence intervals at segment 5 cross section 5.

4. Preliminary assessment of restoration options per river segment

This preliminary presentation of management/restoration actions is meant to encourage discussion and lay out the magnitude of the challenge of creating a common vision for a more ecologically functional upper Muddy River landscape. Conservation/restoration recommendations will be featured in the final report. Nonetheless, options are included here; therefore the emphasis is on the word *preliminary*. At this early stage of the assessment when modeled flow results for various riverine management scenarios are not available, being specific is premature.

It is expected that a more advanced plan for management will feature 2-3 alternatives or desired future conditions that could be coined as easiest, intermediate, and ambitious. Although the easiest and ambitious alternatives, respectively, might translate into the cheapest and most expensive alternatives, different permutation of actions forming an alternative will not have equal ecological returns on the investment because priority will be given to the recovery of thermal endemic species and some actions alone might benefit more species/communities of concern than a cluster of actions for comparable financial costs. Also, many management actions are conditionally linked, therefore action X should not be undertaken unless action Y occurs. A good example of linkage would be to plant native riparian trees in a formerly degraded floodplain after first elevating the water table and allowing historic overbank flow, which involves geomorphic restoration. The availability of land to plant riparian trees might itself depend on land acquisition or securing a conservation easement with a willing seller.

The preliminary restoration options discussed below are not framed as alternatives, but simply as a list of possible actions per segment with relative (qualitative) costs and benefiting target systems. There are two sources of restoration options: The fact sheets written for the 2002 workshop and Table 3 (below), which is based on the on-going geomorphic assessment. A list of management actions based on these two sources of information would be much longer than Table 3 and include activities such a law enforcement to prevent unregulated cutting of mesquite for firewood to massive fluvio-geomorphic earth-moving activities. We chose to limit the number of actions to Table 3. At this stage, however, removal of exotic invasive species by the Muddy River Regional Environmental Impact Alleviation Committee (MRREIAC) and the Moapa Valley National Wildlife Refuge, and land acquisitions have been on-going projects conducted by various organizations. These activities were identified as fundamental (TNC 2000b) and are reflected in Table 3.

As a preliminary effort, six conservation objectives are proposed to restore suitable conditions for the priority conservation targets (Warm Spring/Stream Aquatic, Muddy River Aquatic, Riparian Woodland, Riparian Shrubland, Riparian Marsh, and Mesquite Bosque assemblages; TNC 1999, 2000b):

- Improve riparian habitat by increasing the riparian corridor width where possible;
- Restore the hydraulic connection between river and floodplain where possible;
- Increase biological productivity and diversity, with emphasis on target species;

- Restore and improve hydraulic habitat for native aquatic species;
- Restore a mosaic of riparian, transitional, and wetland aquatic habitat types; and
- Provide public access to the river and other natural features for low-impact recreational activities.

These conservation targets, which contain species of concern, represent distinct community types that require similar ecological and physical processes for sustainability. These objectives can be accomplished, primarily, by the restoration of processes such as restoring the connection between the channel and floodplain (Table 3). However, physical limitations to the restoration of process may exist in the form of agriculture, housing, and lowering of the alluvial aquifer water table due to groundwater extraction. Moreover, coordination with the Clark County Regional Flood Control District will be necessary as it is responsible for the flood control on the Muddy River downstream of California Wash.

Table 3. Preliminary habitat conservation and restoration recommendations for the upper Muddy River.

Segment	Relative Level of Effort and Cost	Recommendation	Priority Conservation Targets Captured*
1 - I-15 Bridge to Reid Gardner RR Bridge			
	Low	Continued invasive vegetation control (manual and goat grazing)	3, 4, and 6
	Medium	Revegetation following invasive vegetation removal activities	3, 4, and 6
	Medium	Coarse substrate augmentation within present channel	2
	Medium	Conservation easement for ponds / wetlands	3, 4, and 5
	Medium	Conservation easement for floodplain real estate	3, 4, 5, and 6
	High	Acquisition of functional ponds / wetlands from willing sellers	3, 4, and 5
	High	Small scale channel reconstruction and demonstration sites	2, 3, 4, and 5
	High	Acquisition of floodplain real estate from willing sellers	3, 4, and 6
	High	Excavation / construction of floodplain within present incised channel	2, 3, 4, and 5
	High	Complete reconstruction of channel within acquired/easement property	2, 3, 4, 5, and 6
2 - Reid Gardner RR Bridge to White Narrows			
	Low	Continued invasive vegetation control (manual and goat grazing)	3 and 4
	Low	Formation of partnership / agreement and cost sharing of conservation efforts with Tribe	variable
	Medium	Revegetation following invasive vegetation removal activities	3 and 4
	Medium	Coarse substrate augmentation within present channel	2
	Medium	Construction of permanent grade control structure and fish barrier at White Narrows	1 and 2
3 - White Narrows to Warm Springs Road			
	Low	Invasive vegetation removal (manual and goat grazing)	3, 4, and 6

Medium	Conservation easements for remaining floodplain real estate	3, 4, 5, and 6
Medium	Coarse substrate augmentation within present channel	2
Medium	Acquisition of remaining floodplain real estate from willing sellers	3, 4, 5, and 6
High	Small scale channel reconstruction and demonstration sites	2, 3, 4, and 5
High	Excavation/Construction of floodplain within present incised channel	2, 3, 4, and 5
High	Complete reconstruction of channel within BLM property	2, 3, 4, 5, and 6
High	Removal of flood/silt control dams on tributary washes	2, 3, and 4

4 - Warm Springs Road to Warm Springs-Muddy River Confluence

Low	Invasive vegetation removal	3 and 4
Medium	Invasive fish exclusion above Warm Springs Road	1 and 2
Medium	Coarse substrate augmentation within present channel	2
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

5 - Warm Springs-Muddy River Confluence to North-South Fork Confluence

Low	Invasive vegetation removal	3, 4, and 6
Medium	Conservation easements for riparian habitat	1, 2, 3, 4, 5, and 6
Medium	Conservation easements within Muddy Spring area / LDS recreation area	1, 2, 3, 4, 5, and 6
Medium	Coarse substrate augmentation within present channel	1 and 2
Medium	Construction / enhancement of wetlands	3, 4, and 5
High	Acquisition of water rights and / or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

6 - Warm Springs-Muddy River Confluence to Warm Springs

Low	Continued invasive vegetation removal	1, 2, 3, 4, and 5
Medium	Defined instream flows for Moapa Valley NWR spring channels	1 and 2
Medium	Defined instream flows for Apcar channel	1 and 2
Medium	Spring channel habitat enhancement with conservation easements off NWR	1, 2, 3, 4, and 5
Medium	Spring pool and channel enhancement/restoration within Moapa Valley NWR	1, 2, 3, 4, and 5
High	Restoration of remaining former recreational structures within Moapa Valley NWR to spring pools and channels	1, 2, 3, 4, and 5
High	Development of public use and education areas / trails within Moapa Valley NWR	non-habitat benefits, public outreach
High	Acquisition of water rights and / or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

7 - North-South Fork Confluence to North Fork Headwaters

Low	Invasive vegetation removal	1, 3, 4, 5, and 6

Medium	Conservation easements throughout riparian and wetland areas	1, 3, 4, 5, and 6
Medium	Conservation easements on private property within headwater area for Moapa dace habitat preservation	1, 3, 4, and 6
Medium	Coarse substrate augmentation within present channel	1
Medium	Construction/Enhancement of wetlands within desert riparian habitat where wet meadows exist	1, 2, 3, 4, 5, and 6
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6
8 - North-South Fork Confluence to South Fork Headwaters		
Low	Invasive vegetation removal	1, 3, 4, 5, and 6
Medium	Conservation easements throughout desert riparian habitat	1, 3, 4, 5, and 6
Medium	Construction/enhancement of wetlands within desert riparian habitat where wet meadows exist	3, 4, and 5
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6
9 - North Fork Headwaters to Arrow Canyon		
Low	Invasive vegetation removal	4 and 6
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6

* Individual conservation targets shown below
1 - Warm Spring/Stream Aquatic Assemblage
2 - Muddy River Aquatic Assemblage
3 - Riparian Woodland
4 - Riparian Shrubland
5 - Riparian Marsh
6 - Mesquite Bosque

5. Conclusions

The highest priority is the recovery of the Moapa dace and conservation of other endemic species because of their irreplaceability. Other conservation activities cannot preclude recovery of the Moapa dace or long term viability of endemic species.

Despite the ecological complexity of the upper Muddy River landscape, a few troubling facts stand out:

1. Spring discharge is decreasing steadily because of water withdrawals from the carbonate aquifer;
2. The floodplain has been disconnected from its river for at least a century due to deep entrenchment and straightening;

3. Non-native invasive plant and animal species occupy most ecological communities; and,
4. Riverine restoration options are greatly limited by land ownership patterns.

Some hopeful facts about the river's potential for recovery were noted:

1. A rich diversity of animal species of concern is still supported in primarily four areas retaining remnant plant communities upstream of Interstate 15;
2. The limited length of the upper watershed spatially bounds exotic species control within the realm of (long-term) feasibility;
3. Exotic species removal and land acquisition for conservation are on-going activities;
4. Many species of concern have common ecological requirements that could be met with generalized restoration and management approaches; and,
5. A core of local stakeholders have demonstrated success and interest in the conservation of the upper Muddy River.

This report has also identified issues where species of concern depend on human-caused habitat features that could be affected by riverine restoration:

1. Vermillion Flycatchers require open water and utilize the irrigation ditches adjacent to mesquite bosque, riparian shrublands, and open riparian forests;
2. Although tamarisk removal is desirable, its wholesale removal may result in the temporary loss of most habitat structure for bird species unless some thought is given to the rate and shape of removal (the current rate of removal is small) and native plant revegetation. Populations of bird species of concern, in particular, Vermilion Flycatcher, Yellow-billed Cuckoo, and the recently detected small breeding population of Southwestern Willow Flycatcher, could be affected by tamarisk removal in the short term and;
3. The only population of yellow bat in Nevada is found exclusively in fan palms of the upper Muddy River, including those of the Moapa Valley National Wildlife Refuge. While this bat species is relatively common in the southwest desert, the Moapa Valley individuals are significant in that they constitute a disjunct occurrence north of the previously known distribution in southern California and Arizona.

Facts discussed in this report are primarily of a technical and ecological nature, consequently, the preliminary restoration options presented herein are also technical and detached of their social context. This was intentional and temporary. During the second year of the Conservancy's contract, even more technical depth will be applied to restoration/management alternatives to delineate areas of feasibility and "ecological return on the investment" and weed out scientifically unproductive or impossible scenarios. After the technical material is sufficiently explored, it will be made available to stakeholders (many of whom are kept informed of this assessment's progress) and vetted out in a social forum (workshop). This contract's technical information will ultimately be used within the context of Clark County's MSHCP to develop a conservation management strategy to shape the decisions that will be required to fulfill vision for the upper Muddy River.

6. Acknowledgments

The Nature Conservancy is grateful to the Clark County's Desert Conservation Program and the U. S. Fish and Wildlife Service for funding, on-going advice, and logistic support. The Conservancy wishes to thank the following people for writing and reviewing the expert fact sheets of the 2002 workshop: Elisabeth Ammon, George Austin (author), David Charlet (author), Lisa "Cali" Crampton (author), David Bradford, Murrelet Halterman (author), David Herbst, Karin Hoff (author), Jeff Johnson (author), Jeri Krueger, Bruce Lund (author), Zane Marshall (author), Cynthia Martinez, David Merritt (tamarisk presentation), Kerstan Micone (author), Jan Nachlinger, Michael O'Farrell, Don Sada (author), Gary Scoppettone (author), Polly Sullivan (author), Cris Tomlinson, C. Richard Tracy, and Jason Williams (author). Janet Bair, Jeri Kreuger, Cynthia Martinez, Tim Mayer, Amy Sprunger-Allworth, Lewis Wallenmeyer, and Grant Webber reviewed and/or commented on a earlier draft. Ann Schreiber's advice and assistance and availability for field trips was greatly appreciated.

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8. Appendix I. Milestone #1 by Otis Bay, Inc—Scientific Literature Review

Upper Muddy River
Geomorphic Assessment

Scientific Literature Review

Prepared by
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Report for Deliverable 1
April 1 – June 30, 2003

Prepared for
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Table of Contents

Upper Muddy River Scientific Literature Summary

1.0 Introduction and Background

The geomorphic assessment of the Upper Muddy River (UMR) is being conducted for The Nature Conservancy (TNC) and its stakeholders, all of which have the common goal of preservation of important species and habitat along the UMR. According to the Clark County Multi-Species Habitat Conservation Plan (MSHCP), the Muddy River has been identified as one of the highest priority conservation areas in Clark County.

This study is being funded by the Clark County and involves a partnership between numerous groups. Federal groups involved in the study and/or management of the UMR include the United States Geological Survey (USGS), the United States Fish and Wildlife Service (FWS), Bureau of Land Management (BLM), and the Bureau of Reclamation (BOR). State agencies involved in the management of the UMR include the Nevada Department of Water Resources (NDWR), the office of the State Engineer, and the Nevada Division of Wildlife (NDOW). Municipalities associated with water resource management issues of the UMR include the Southern Nevada Water Authority (SNWA), the Las Vegas Valley Water District, and the Moapa Valley Water District. Corporations involved in the use of UMR water resources include the Nevada Power Company (NPC), Pacific Gas and Energy, and CALPINE. Local and community groups within the UMR include the Muddy River Regional Environmental Alleviation Impact Committee (MRREAIC) and the Moapa Band of Paiutes.

This report is the first in a series on the geomorphic assessment of the Upper Muddy River and presents a brief summary of scientific and historical literature regarding the Upper Muddy River. Topics discussed in this document include pre- and post-settlement history, hydrology, geology, geomorphology, hydrogeology, and ecology. The geomorphic assessment will be completed in stages beginning with the presentation of background information presented in this report and moving towards more detailed studies including characterization of the drainage basin and representative river segments, field surveys of the river channel, discharge frequency and duration analysis, and particle size distribution and sediment transport analysis. All of the above studies and reports will lead to a final report that will include recommendations for restoration along the Upper Muddy River.

2.0 Purpose

The UMR, here defined as the upper drainage basin of the Muddy River extending upstream from the Interstate 15 Bridge approximately 14 miles, is one of the most important stream corridors within the Mojave Desert. In addition to the presence of a unique Mojave Desert riparian vegetation community, this area contains habitat for 4 rare and endemic fish species and 7 species of rare invertebrates (TNC, 2000).

The primary objective of the geomorphic assessment is to investigate and define restoration options along the UMR in order to recover the species of concern. The purpose of this report is to present background information regarding the UMR within the overall context of habitat restoration. The production of this report will result in a gathering of important sources of information that will be necessary for more detailed studies and analyses to be presented in future reports. This initial report will serve as a foundation for the investigation and recommendation of habitat restoration alternatives.

3.0 Site Description

3.1 Mojave Desert

The Mojave Desert occupies approximately 48,000 square miles (125,000 km^2) in southern Nevada, western Arizona, southwestern Utah, and eastern California. Ecologically, the Mojave Desert is a transition between the Colorado Desert to the south, the Great Basin Desert to the north, and the Sonoran Desert to the east. Approximately 40% of the plants in this region are endemic, and some, such as the Joshua tree (*Yucca brevifolia*) well portray the uniqueness of this harsh, hot, dry-summer desert.

The Mojave Desert is the smallest of the four North American desert biomes, and is intermediate between the Great Basin desertscrub to the north and the Sonoran desertscrub to the south and southeast (Turner 1994). The dominant low elevation plant species of the Mojave Desert include creosotebush (*Larrea tridentata*), all-scale (*Atriplex polycarpa*), brittlebush (*Encelia farinosa*), desert holly (*Atriplex hymenelytra*), and white burrobrush (*Hymenoclea salsola*). Middle elevations in this desert biome support Joshua tree and blackbrush (*Coleogyne ramosissima*). Upper elevations support pinyon pine (*Pinus edulis* and *P. monophylla*), junipers (*Juniperus* spp.), and highest elevations support Ponderosa pine (*Pinus ponderosa*) and other typical Intermountain tree species. Isolated mountains in the Mojave Desert, such as Mt. Charleston, appear to support higher levels of endemism than do mountains nearer to the Rocky Mountains or the Sierra Nevada (Mozingo and Williams 1980). Although it contains a high proportion of endemic plant species, the designation of the Mojave Desert as a biome is rather loose, and some authors regard it as a subdivision of the Sonoran Desert (Turner 1994).

In addition to Joshua tree and blackbrush, the Mojave Desert supports numerous indicator plant species, including spiny menodora (*Menodora spinescens*), sages (*Salvia funerea, S. mohavensis*), desert senna (*Cassia armata*), Mojave dalea (*Psorothamnus arborescens*), Fremont dalea (*Dalea fremontii*), goldenhead (*Acamptopappus shockleyi*), scalebroom (*Lepidospartum latisquamum*), and *Ephedra funera* (Turner, 1994). Hot dry summers do not support a rich cactus flora, although several species of *Opuntia* and *Echinocereus* and other small, low-growing cacti exist there. However, the Mojave Desert is also renown for its winter or summer annual plant species, of which >80 species are endemic (Shreve and Wiggins 1964). Winter annual plants are triggered by heavy rains from late September through December, with a critical rainfall of >25 mm resulting from a single storm. Early autumn rains promote the germination of Polemoniaceae, Hydrophyllaceae, Polygonaceae, Fabaceae, and Onagraceae, while late autumn rains promote the germination of Cruciferae and Boraginaceae (Beatley 1974). Vasek and Barbour (1977) reported that the Mojave Desert consisted of 5 major vegetation series, including: creosotebush scrub, saltbush scrub, shadscale scrub, blackbrush scrub, and Joshua tree woodland. Of these, all but the latter exist in the Sonoran or Great Basin desert biomes, a further indication of the transitional nature of the Mojave Desert biome.

3.2 Mojave Desert Biogeography

A growing body of evidence indicates that the biogeographic relationships among springs invertebrates and fish species in the Southwest are the result of geologic history during three recent Cenozoic landscape transformations, and recent human impacts (Cross 1976; Deacon et al. 1964; Austin 1998; Hershler et al. 1999; Polhemus and Polhemus 2002). Associated with the Miocene-Pliocene development of the Basin and Range geologic province, springs aquatic snails and true bugs show affiliations with northern Mexico and the Rio Grande rift. Indeed, the snail genera of *Pyrgulopsis* and *Tryonia*, and the aquatic and semi-aquatic true bug faunae reach biodiversity maxima in the southern Great Basin. Integration of the Colorado River system in Pliocene-Pleistocene time has resulted in a fauna related to, and derived from that drainage basin, and extending into the Muddy River region. During late Pleistocene time, high surface levels of endorheic basin lakes in the Great Basin allowed interchange of aquatic and some terrestrial fauna (e.g., Hubbs and Miller 1948, Austin 1998). Most recently, human disruption of springs habitats and non-native plant and fish introductions have dramatically altered springs, stream, and riparian ecosystem development, with grave impacts on native endemic species (Cross 1976, Deacon et al. 1964).

3.3 Location

The Muddy River is located in Clark County, Nevada approximately 60 miles northeast of Las Vegas at the northern edge of the Mojave Desert (Figure 1). The final 7 miles of river length are submerged by Lake Mead. Prior to the construction of Hoover Dam, the river discharged to the Virgin River a short distance upstream of the confluence of the Virgin and Colorado Rivers. The Muddy River begins as a series of thermal springs and associated channels approximately 14 miles upstream from the town of Glendale and flows 26 miles to Lake Mead. Meadow Valley Wash is the only significant tributary to the Muddy River, and flows only during periods of intense runoff. Aerial photographs of the UMR are presented in Appendix A.

More than 20 springs surface in the upper Moapa Valley, within a radius of approximately 1.5 miles, and converge to form the Muddy River. For descriptive purposes, the headwaters are here defined as the point of convergence of the North and South forks. Three additional sources of discharge in the headwater area include the Muddy Spring and channel, Apcar Stream, and the Refuge Stream. The combined mean discharge of the numerous springs in the headwater area for 25 years from 1914 to 1962 was 46.5 cfs (approximately 34,000 afy) (Eakin, 1964). Current mean discharge at the Moapa gage is approximately 25,000 afy (SNWA, *unpublished data*).

3.4 Land Use

The majority of the land within the UMR is under Clark County jurisdiction. The towns of Moapa and Glendale have town advisory councils. Current zoning emphasizes the rural and agricultural lifestyle. According to the 1994 county land use plan, private land zoning is rural agricultural (over 1,300 acres), low density residential (under 100 acres), commercial-tourist (2.5 acres), industrial (40 acres), mineral use (46 acres) and public facilities (20 acres). The Moapa Indian Reservation encompasses more than 71,000 acres while public lands administered by the BLM surround the UMR. Approximately 7,700 acres of flood plain are present along the UMR. The floodplain intersects 219 parcels that are owned by 96 private entities (TNC, 2000).

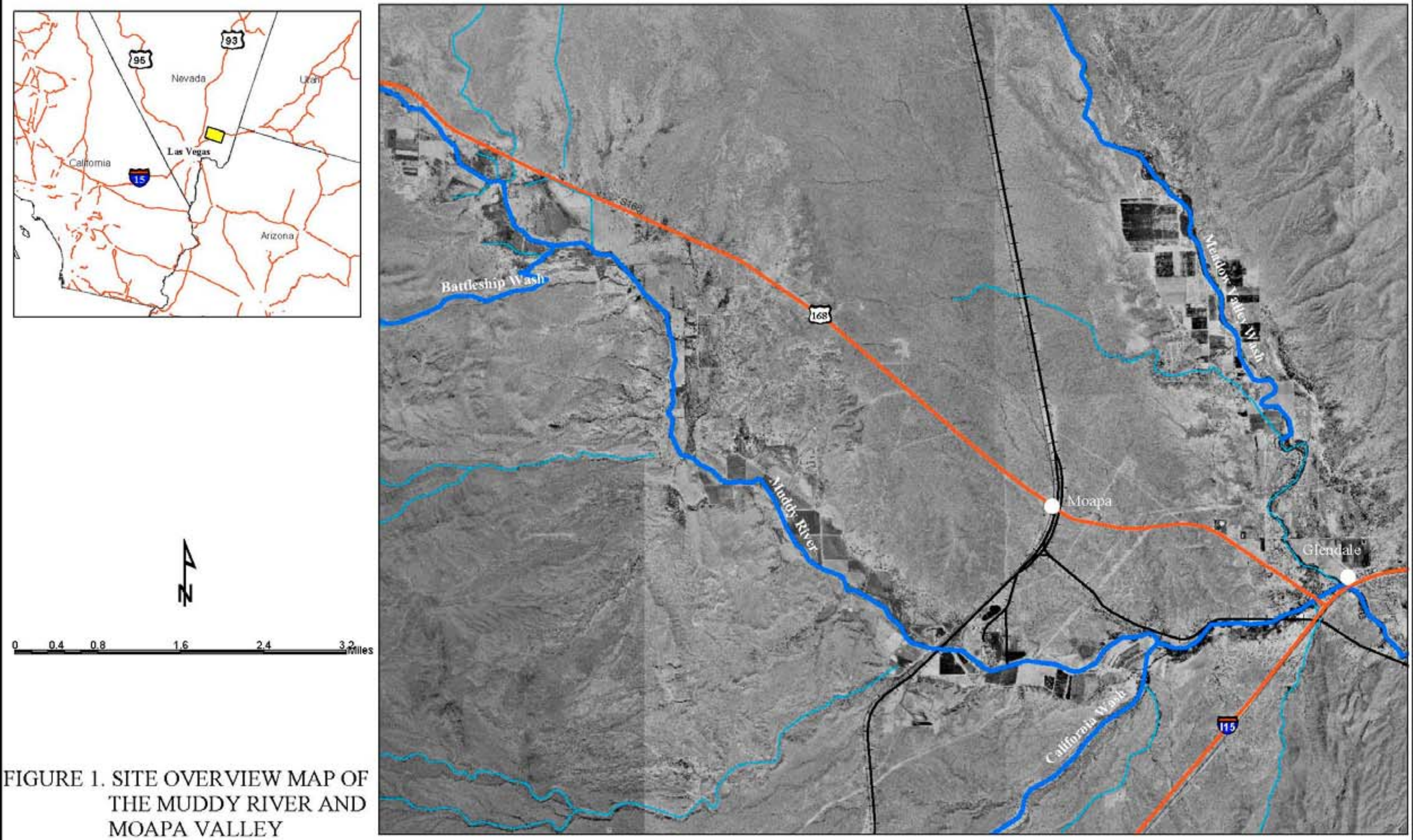

FIGURE 1. SITE OVERVIEW MAP OF THE MUDDY RIVER AND MOAPA VALLEY

3.5 Climate

Climate in the Moapa Valley is typical of the Mojave Desert with low humidity and high evaporation rates. Summers are long with temperatures in excess of 100° F and winters are short and mild (TNC, 2000). Precipitation patterns in the Great Basin are largely a function of topography and elevation and annual precipitation is greatest at the highest elevations. As shown in Figure 2, elevation within the White River and Muddy Springs drainage area ranges from less than 3,000 to more than 9,000 feet above sea level. However, elevation within the Moapa Valley ranges from approximately 1,200 to 1,800 feet above sea level. Both flashfloods and snowmelt contribute to runoff. In general, the valley floors receive 3 to 5 inches of precipitation per year while the highest mountain elevations receive an average annual precipitation of 12 inches or more. On the valley floors, little precipitation infiltrates to groundwater and events of intense precipitation result in sheet flow across the desert floor and flash flooding in washes that are normally dry.

The town of Moapa, situated in the northcentral portion of the Muddy River basin, lies at an elevation of approximately 1,280 feet at north latitude 36^{o} 33' and west longitude 114^{o} 27'. From 1951-2002 the mean annual temperature at Moapa was 18.9^{o}C (66.0^{o}F), varying from a mean minimum of 9.6^{o}C (49.2^{o}F) to a mean maximum of 28.9^{o}C (84.1^{o}F). Mean monthly minimum air temperature ranged from –1.1 to 21.3^{o}C (30.1-71.3^{o}F) and mean monthly maximum air temperature ranged from 15.3 to 42.5^{o}C (59.5-108.5^{o}F). This station receives an average of 8.8 inches of precipitation annually, with most precipitation occurring during the winter months. Moapa receives an average of 0.4 inches of snowfall/yr, with snow typically only occurring in January.

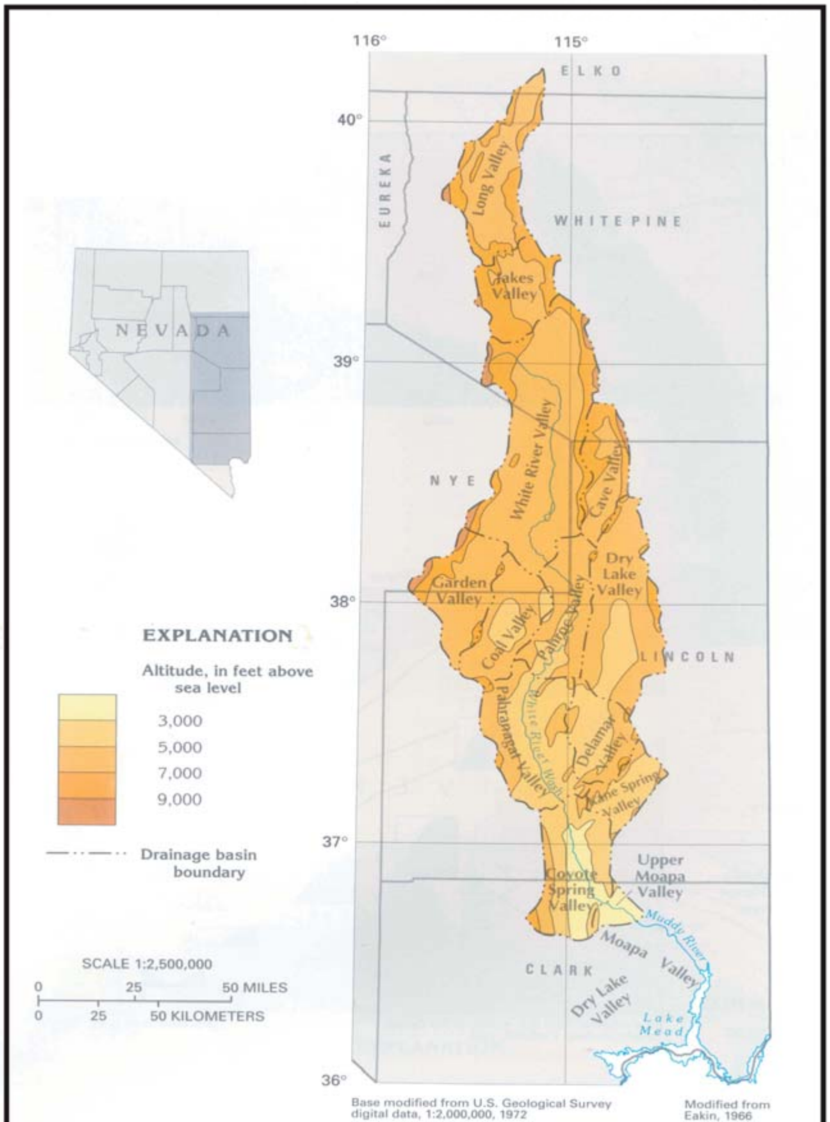

Figure 2. The White River/Muddy River Springs drainage area is located in southeastern Nevada. Altitudes within the area range from less than 3,000 to more than 9,000 feet.

Taken from the Groundwater Atlas of the United States (USGS, 1995).

4.0 Presettlement History

The archeological sequence and record of the Moapa Valley indicates a continuous occupation of the area from 300 B.C. to historic times and includes the Basketmaker, Pueblo, and Paiute cultures. However, the earliest evidence of human occupancy in the Moapa Valley was obtained from radiocarbon dates of 2,095 B.C. and 1,914 B.C. on ash deposits located at Stuart Rockshelter near Glendale (Shutler, 1961). The Basketmaker population was transitional from an Archaic hunting and gathering base and the agricultural economy of the Pueblo. Although early Paiute culture is typically defined as hunter-gatherer, deposits of several varieties of corn located stratigraphically between Pueblo artifacts below and historic deposits above at Paiute Cave indicate the importance of agriculture for the Paiute in the Moapa Valley (Clark, 1984).

The first archaeological excavations in the Muddy River Valley were completed by Mark Harrington in 1924 at the site know as the Lost City or "El Pueblo Grande de Nevada". Further excavations at the site from 1925-1926 yielded 46 prehistoric structures, the largest of which contained approximately 100 rooms. Although Harrington dated these structures at approximately 1,500 B.C, recent studies have shown the structures were occupied by Basketmaker culture between 300-500 B.C (Clark, 1984). Basketmakers practiced agriculture, wove baskets and cloth, but did not make pottery. Pueblo culture inhabited the region between 700 and 1,500 A.D. The Pueblo constructed stone and adobe dwellings and cultivated cotton that was woven into fine cloth. Early settlers of the valley recorded the presence of numerous irrigation ditches leading from the Muddy River to fields in the floodplain, indicating that the Pueblo had an extensive irrigation system. In addition, evidence for Paiute occupation concurrent with Pueblo occupation has been noted due to the discovery of Paiute pottery with Pueblo artifacts. Thus, Paiute occupation could have occurred as early as 700 A.D. (Clark, 1984).

Harrington returned to southern Nevada in 1929 to complete an archaeological survey of the entire Moapa Valley. This survey recorded 77 ruins within a 16-mile section of the Muddy River. Concurrently, an excavation of the site known as Mesa House was being completed by Irwin Hayden. Mesa House is a large pueblo structure arranged in courtyard fashion containing 84 rooms with single-family dwellings (Harrington, 1929). Harrington dated the Mesa House structure at 1,100 A.D.

Further work by Harrington at Gypsum Cave in the Frenchman Mountain Range east of Las Vegas, suggests that the Muddy River area could have been utilized by much earlier inhabitants. Harrington discovered atlatls, atlatl darts and points, and remains of cooking fires both above and below a deposit containing the remains of a large ground sloth. More recent radiometric testing dates the sloth remains at 9,700 to 6,500 B.C. and the human artifacts at 900 to 400 B.C (Clarke, 1984). However, debate still exists whether humans inhabited the region at the same time as the extinct sloth.

The earliest Europeans to visit the Muddy River area were Spanish explorers who traveled through the area in the 1770s. European settlement began in the in the mid 1860s and it was not until 1873, when the Moapa Indian Reservation was created, that the Paiute inhabitants of the Muddy River valley were provided with legal rights to the land. In 1875, the size of the reservation was reduced to approximately 1,000 acres, of which approximately 625 acres were irrigable (Shamberger, 1940).

5.0 Recent History

5.1 The Moapa Paiute

The Moapa Paiute Band occupies the Moapa Indian Reservation. The reservation is located approximately 8 miles west of Glendale, Nevada, near the junction of State Route 168 and Interstate 15, and approximately 55 miles northeast of Las Vegas, Nevada. The history of the reservation, briefly encapsulated, is as follows. On March 12, 1873 approximately 2 million acres of reservation were granted, by Executive Order, to the Moapa Paiute and an additional 1,000 acres were added on February 12, 1874. By the Authority of the Act of March 3, 1875, the reservation was reduced in size to 1,000 acres. It was not until December 3, 1980 that the Moapa Paiute were granted a portion of the original reservation to a total of 71,500 acres.

The Paiute were noted for their resourcefulness and the Bands were communally governed. They were a well adapted group that combined farming with hunting and gathering, and used the resources of the land with great ingenuity. Most of their domestic objects were various forms of intricately designed basketry, including water jars, winnowing and parching trays, cradle boards, cooking baskets, and seed beaters. They had great skill in the use of animal skins and plants. Cliffrose bark and Yucca as well as leather were used for clothing and shoes. Their knowledge of the nutritional and medicinal uses of plants was extensive. The Moapa Paiute were excellent hunters and fierce warriors. John Fremont records in 1844 an encounter in the Muddy Valley:

> *With each bow, each man carried a quiver of 30 to 40 arrows, partially drawn out. Besides these, each held in his hand two or three arrows for instant service. Their arrows are barbed with a very clear translucent stone, a species of opal nearly as hard as the diamond, and shot from their long bows, are almost as effective as gunshot.*

However, such skills were not enough to stop the intrusion of the European settlers into the Moapa Valley. Although the Moapa people have preserved a number of legends, songs, and dances, cultural disruption during the 1800's and early 1900's all but destroyed traditional life. Early Spanish and New Mexican Priests and traders provide a scanty written record of the Moapa Paiute Bands who lived and farmed in the Muddy Valley. The history of the Moapa following white contact (dating from the 1830 opening of the Old Spanish Trail) is a tragedy. Their land and water were seized and they were raided by slavers. They were often caught in conflicts among Mormon settlers, the New Mexicans, and the increasing numbers of emigrants. Their own numbers diminished rapidly as they contracted new diseases, especially tuberculosis and measles. Insurrection and raiding for survival were punished brutally by federal troops and white settlers. With their farming disrupted by unrestricted passage through the valley, the Paiute often had no choice but to live as low-paid laborers dependent on Mormon settlements.

John Wesley Powell was sent to investigate the condition of the Paiute Indians and recommended that the tribe be settled on a reservation to reverse the trend of poverty and cultural demise (Powell and Ingalls, 1874). In 1873, 39,000 square miles (two million acres) were set aside for tribal lands by the federal government. This area was increased somewhat to provide timber in 1874. In 1875 the area of the tribal lands was reduced to a meager reservation of 1,000 acres. The reduction of the homeland was followed by over 60 years of neglect and corrupt practices by white agents. Tuberculosis and whooping cough epidemics occurred periodically during the 1920's and 1930's, greatly adding to the distress of the Paiute.

In 1941, a Constitution and By-Laws were drawn up and the Tribal Business Council was established as the governing body. Because the individual allotments of the once communal land were too small to farm economically, the Tribe voted in 1941 to restore the plots to Tribal ownership, and to attempt to farm them cooperatively. However, because of water problems, a shortage of money, a lack of modern equipment, and the difficulties of managing a cooperative venture, the Tribe became discouraged and eventually agreed to lease the farmland to a dairy company - a demoralizing situation that was not to be undone until 1968.

In 1951, the Southern Paiute Tribes filed a suit with the Indian Claims Commission. In 1965, the Claims Commission granted a judgment to the Tribes, including the Moapa Paiutes, who used 60% of the monies awarded to establish a perpetual capital fund for improvements and economic development. This money amounted to $0.28 per acre compensation for Tribal Land confiscated in the 1860's. Then, in 1968, the Tribe refused to renew the 10-year lease on their arable land to non-members.

On December 3, 1980, the federal government allotted an additional 70,500 acres back to the tribe, making a total of approximately 71,500 acres of the once held two million acres. For the past three years the tribe has been negotiating with the State of Nevada for a settlement of much needed water rights of this land for economic development for future generations (Xeri.com Website, 2003).

5.2 Mormon Settlement

The Muddy River was a well know site along the Old Spanish Trail, known later as the Mormon Trail, as travelers made their way from Santa Fe, through Colorado, and across Utah to California. From Saint George, Utah, the route traveled south across the Beaver Dam Mountains and into the desert of Southern Nevada. There was no water along sixty-five mile long portion of the route between the Beaver Dam Mountains and the Muddy River. Thus, the Muddy River was a stopover point for all travelers along the route. Settlement of the Muddy River Valley began in 1864 with the establishment of a landing on the Colorado River, twenty miles below the confluence of the Virgin and Colorado Rivers, known as Call's Landing or Callville. The first colonists arrived at the first settlement in the Muddy River valley, which was to be named Saint Thomas, in January of 1865. The settlement of St. Joseph was established in June of 1865. In 1866, the town of Saint Joseph was moved three miles south to a settlement named Mill Point. Then in 1868, half of the individuals that had moved to Mill Point returned to re-establish the town at the original site of Saint Joseph while the other half established the town of Overton to the south of Mill Point.

At the time of first settlement, the Moapa Valley was located, according to the claims of three states, within Pah Ute County, Arizona, Rio Virgin County, Utah, and Lincoln County, Nevada. These counties were created prior to any official survey of the region could be completed. Congress placed the settlements of the Muddy River within the state of Nevada in 1866. The rate of taxation in Nevada by 1870 was approximately four times greater than that in Utah. For this reason the settlers returned to Utah. However, Mormon settlers returned in 1881 and re-established the towns of Saint Joseph, Overton, and Saint Thomas. The town of Saint Joseph was renamed Logandale and was located to the west, across the river from the original town site. The town of Saint Thomas was later inundated by the waters of Lake Mead following the construction of the Hoover Dam (Corbett, 1975).

5.3 Water Diversions and Appropriation

The Muddy River system has been significantly altered by human activity. Spring-fed tributaries have been excavated and earthen or concrete ditches have replaced natural channels. The development of water resources along the Muddy River for agricultural purposes began in the late 1800s. The first supply well in the Muddy Springs area was drilled in 1947. Established in 1920, the Muddy River Decree allocated the entire surface flow of the Muddy River and Springs.

Within the UMR valley, the Moapa Valley Water District (MVWD) diverts 3cfs from Baldwin and 1 cfs from Jones Springs for a total of 2,900 afy; the Nevada Power Company (NPC) diverts up to 3,000 afy during the winter from a point immediately upstream of the Moapa Gage; and the Paiutes divert water at the upstream end of the reservation for agricultural use. A 4.5 feet tall gabion dam was installed in 1988 to divert water from the Warm Springs Road crossing to Reid Gardner Station, a coal-fired power plant approximately 5 miles downstream. This dam was removed in 1995 and replaced with a no-head diversion system.

The Muddy Valley Irrigation Company (MVIC), incorporated in 1895, controls the irrigation water of the Lower Moapa Valley. Thus, downstream from Glendale, the entire Muddy River is diverted at “Wells” siding by MVIC. An agreement between SNWA and the MVWD was signed in 1996 that limited the amount of water that SNWA could transfer out of the Moapa Valley, until the year 2020, to 100 afy plus any unused water. After 2020, SNWA have the right to remove up to 5,000 afy, with the option for additional water in the event that MVWD acquires additional water resources other than Muddy River water.

In addition, numerous groundwater rights exist within the UMR. The NPC and the MVWD are the primary users of groundwater within the UMR valley. The NPC extracts groundwater from the alluvial aquifer at the Lewis well field, LDS wells, and Perkins and Behmer wells, primarily during summer months. The MWVD operates year round groundwater extraction from the carbonate aquifer at the Arrow Canyon and MX-6 wells

(SNWA, *unpublished data*). Several agencies are currently monitoring both surface and groundwater levels in order to monitor and minimize the potential effects to the groundwater system that may occur due to continued or increased withdrawals.

6.0 Geology

A brief discussion of the geologic history relative to the UMR should, at a minimum, extend as far into the past as the geology that has resulted in the presence of the springs discharging in the UMR. The generalized geology of the White River/Muddy Springs drainage area is presented in Figure 3 and consists of three primary lithologies within the basin; 1) Paleozoic carbonate rocks; 2) Tertiary volcanic rocks; and 3) Quaternary and Tertiary basin-fill deposits. The springs discharge groundwater primarily contained in the carbonate rocks and basin-fill deposits. The carbonate rocks formed from marine sediments that were deposited in an elongated trough extending north to south through western North America. The more recent basin-fill sediment was deposited by runoff from the adjacent mountains.

Approximately 40,000 feet of marine sediments were deposited in the structural trough from the Precambrian through the Paleozoic (prior to 544 million years ago to 248 million years ago). Both carbonate and non-carbonate rocks including sandstone, shale, siltstone, limestone, and dolomite were deposited. The earliest of Paleozoic rocks are primarily non-carbonate sandstone, shale, and siltstone, which form a zone of lower permeability below the more permeable carbonate rocks deposited later in the Paleozoic.

During the Mesozoic (248 to 65 million years ago), a period of volcanism and intercontinental marine sedimentation followed. Nevada, Utah, and Wyoming were inundated by a series of shallow marine invasions through the early Mesozoic until a narrow uplift in central Nevada blocked the transgression of these shallow seas. Following the uplift in central Nevada, a thick sequence of marine and continental sediments were deposited with interspersed volcanic rocks. During the middle to late Mesozoic, a mountain building event occurred resulting in the uplift, metamorphosis, faulting, and deformation of the rocks of the region.

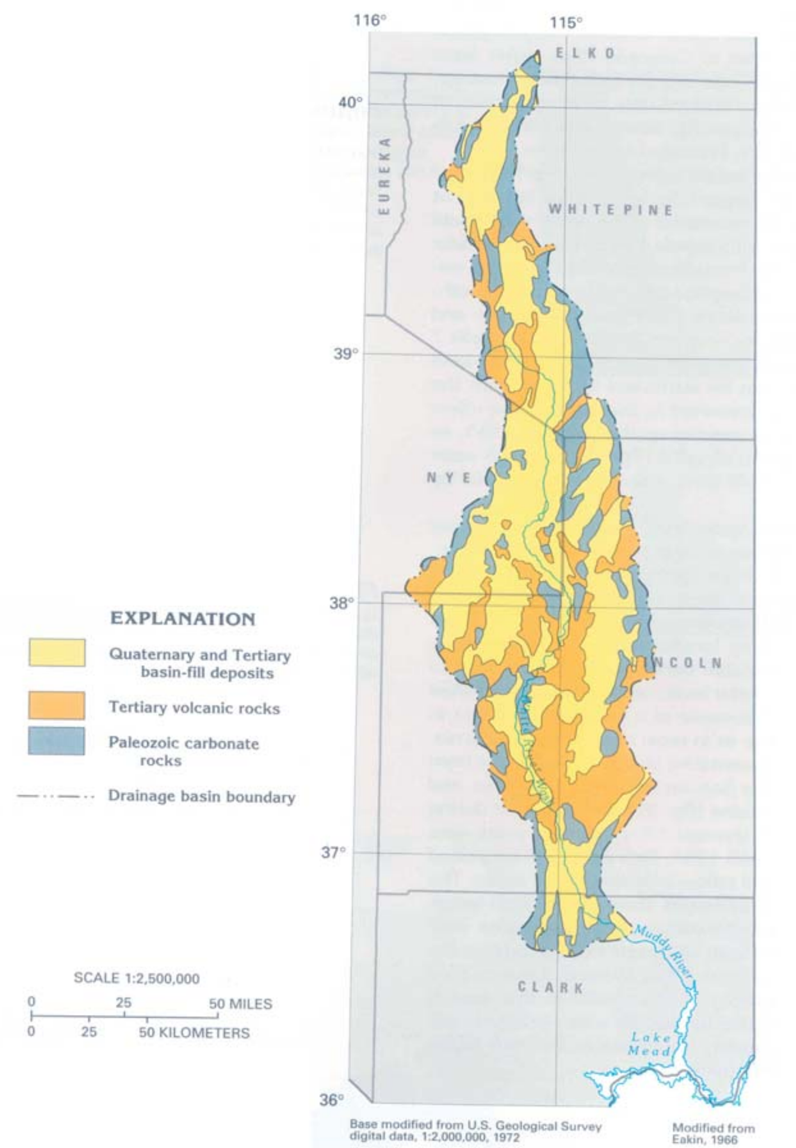

Figure 3. The geology of the White River/Muddy River Springs Basin can be generalized into three categories--basin-fill deposits, volcanic rocks, and carbonate rocks.

Taken from the Groundwater Atlas of the United States (USGS, 1995).

The Cenozoic(65 million years ago to present) was typified by the deposition of volcanic and sedimentary rocks up to 50,000 feet in thickness. In the early Cenozoic, the area known as the Basin and Range was an elevated area with external drainage. However, regional extension during the middle to late Cenozoic resulted in the formation of the present day structural setting of the Basin and Range which is typified by a region of alternating horsts (uplifted mountain blocks) and grabens (down-dropped blocks). During the late Cenozoic, the resulting basins were filled with continental sediments (basin-fill) to a thickness typically less than 2,000 feet, but locally as much as 50,000 feet (USGS, 1995).

Rocks consolidated from numerous layers of marine sediments underlie many of the basins and mountain ranges within a 50,000 square mile area of southern and eastern Nevada that is referred to as the carbonate-rock province. Similar sequences of carbonate rock extend into western Utah, southeastern Idaho, and eastern California. Numerous springs discharge from the carbonate terrane, some with discharges exceeding 1,000 gallons per minute. The great extent of the carbonate rocks, as well as the capacity to transmit significant quantities of water, indicates that the carbonate-rock province of Nevada contains regional aquifers of great significance.

7.0 Hydrogeology

There are approximately 260 basins, which form 39 groundwater flow systems, within the Great Basin region of Nevada, Utah, and adjacent states (Thomas et al, 1996). These flow systems are primarily in unconsolidated basin-fill deposits and in carbonate rock surrounding the basin-fill deposits in the eastern Great Basin. Where basin-fill aquifers are surrounded by low permeability rock, such as volcanic rock, groundwater flow is contained primarily within the basin-fill aquifer. However, where highly permeable carbonate rock surrounds the basin-fill aquifer, the degree of hydrologic connection is high, and deep (several thousand feet) and extensive (hundreds of square miles) flow systems are developed. These highly permeable carbonate-rock aquifers form regional groundwater systems in which groundwater is transmitted beneath topographic boundaries. These regional flow systems are located in the eastern part of the Great

Basin where sequences of carbonate rock exceed 20,000 ft in thickness (Plume and Carlton, 1988).

The groundwater flow systems throughout southern Nevada have been delineated using water levels obtained from wells completed in both carbonate-rock and basin-fill aquifers (Winograd and Thordarson, 1975; Thomas et al, 1986). These water levels indicate that the Muddy River Springs discharge groundwater from the Pahranagat Valley as well as the southern end of the Meadow Valley Wash flow system. The topography of the drainage area controls the movement of ground water at a regional scale. Within the White River/Muddy Springs flow system, groundwater movement is in a southerly direction along the axis of the valley as shown Figure 4 and is generally within tens of feet of the land surface in the center of the valleys (USGS, 1995).

The Muddy River Springs are the terminal point of discharge for a regional groundwater flow system that extends more than 200 miles north toward Ely, Nevada and includes both the White River and Lower Meadow Valley Wash Flow Systems. In addition, a portion of the groundwater within this regional flow system is transmitted to Ash Meadows, as shown in Figure 5. This groundwater flow can be transmitted through both the basin-fill and carbonate-rock aquifers. Because of higher altitudes and lower temperatures in the northern one-half of the White River/Muddy River Springs drainage area, approximately 70 percent of the groundwater recharge is estimated to be in the northern one-half of the area. Based on measurements of spring discharge, approximately 62 percent of the groundwater discharge of the system has been determined to be in the Pahranagat and the upper Moapa Valleys in the southern one-half of the area (USGS, 1995). In addition, the location of faults throughout the groundwater basin indicates that the majority of the water discharged at the Muddy River Springs is recharged in the Sheep Range while carbon-14 dating indicates that the average age of groundwater discharging at the Muddy River Springs is 6,100 years (Thomas et al, 1996).

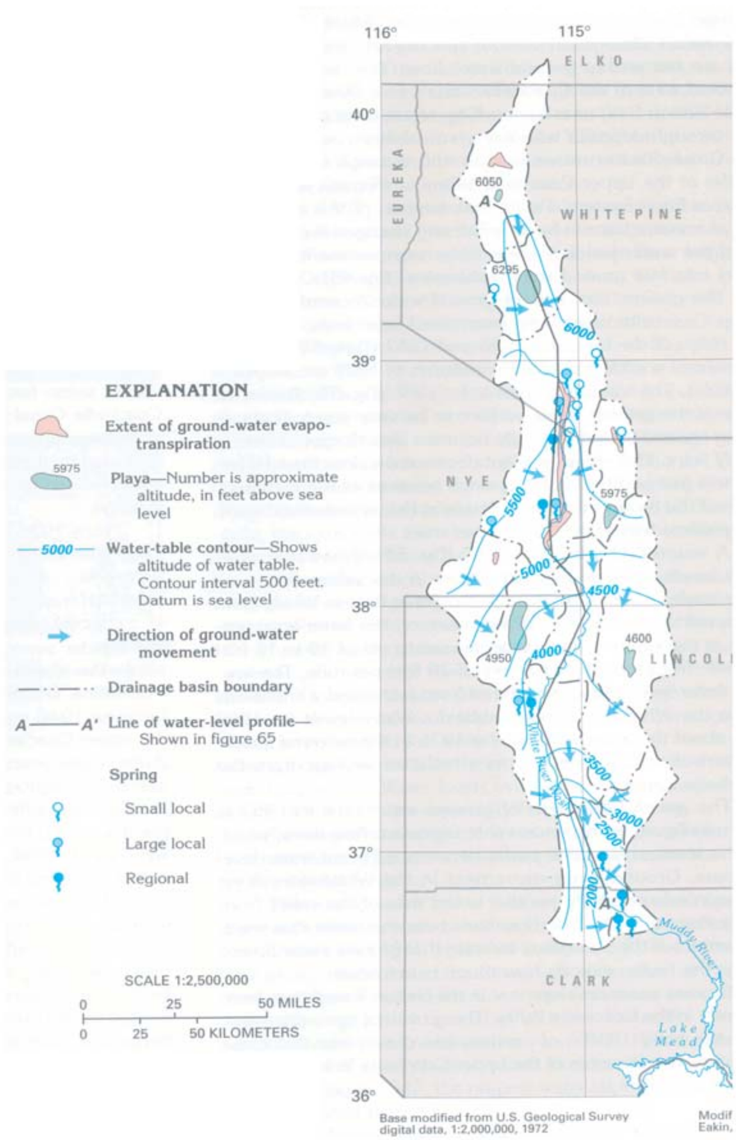

Figure 4. Groundwater movement in the White River/Muddy River Springs is from north to south and follows the approximate axis of the White River drainageway.

Taken from the Groundwater Atlas of the United States (USGS, 1995).

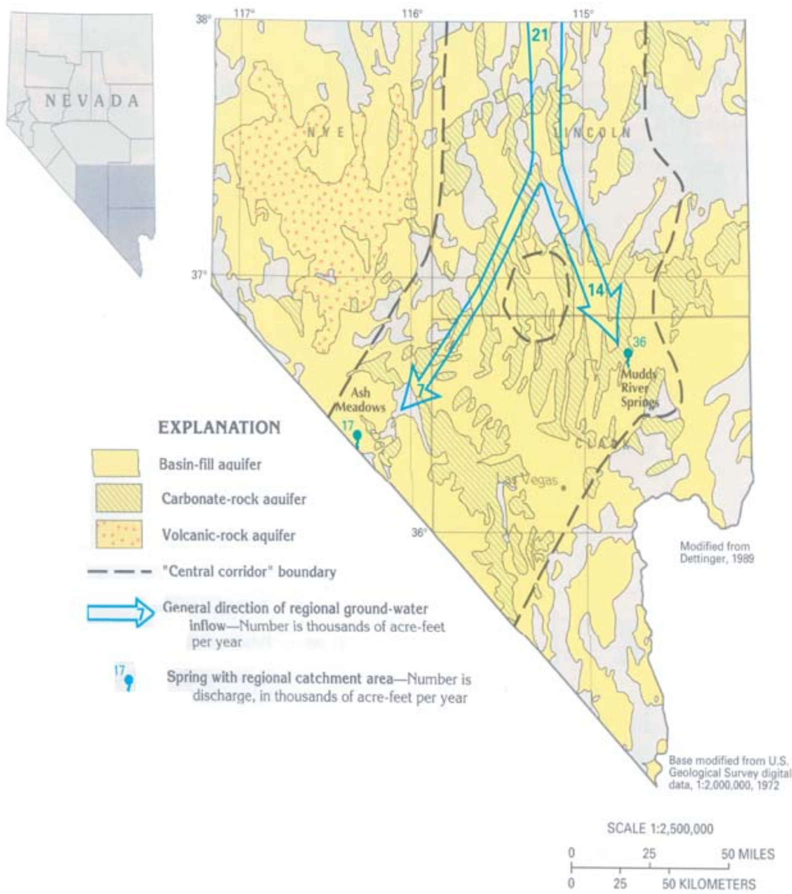

Figure 5. In eastern Nevada, a north-south-trending corridor of laterally continuous carbonate rocks is a conduit for groundwater flow. Flow in the southern part of the "central corridor" is discharged at two localities--approximately two-thirds of the regional inflow is discharged to Muddy River Springs, and one-third to springs in the Ash Meadows area.

Taken from the Groundwater Atlas of the United States (USGS, 1995).

Based on estimates of groundwater recharge and discharge within individual groundwater basins, an estimated 37,000 afy (spring discharge) to 74,000 afy (spring discharge plus underflow) has been suggested to discharge throughout the White River and Lower Meadow Valley Wash Flow systems. At least 13 basins within the White River Flow System contribute to the Muddy River Springs. The fact that discharge at the springs exceeds recharge in the UMR valley and adjacent basins is evidence that the springs discharge groundwater from several groundwater basins (interbasin flow) (Eakin, 1966). According to the SNWA, seasonal fluctuation in water levels within the basin fill aquifers and carbonate aquifers can be as great as 30 and 0.75 ft, respectively. In addition, SNWA has shown a decline in water level of approximately 2 ft since 1998 in carbonate aquifer monitoring wells adjacent to the UMR Springs and in the adjacent Coyote Spring Valley (SNWA, *unpublished data*).

Based on USGS gage records at the Moapa gage, discharge from springs in the UMR is approximately 36,000 to 37,000 acre-feet per year (afy) (Eakin, 1964). This value was based on a 25-year average flow between 1941 and 1962 of 34,000 afy (47 cfs). Eakin estimated losses to evapotranspiration to be approximately 2,000 to 3,000 afy resulting in a spring discharge of 36,000 to 37,000 afy. However, according to the SNWA, flow at the Moapa gage has decreased from 34,000 afy in the 1950s to 25,000 afy at present primarily due to surface water diversions.

Future development of the carbonate aquifer that discharges at the Muddy Springs is presently a significant issue and promises to become an even greater topic of debate in the future. Future and potential groundwater withdrawals include the potential development of a 42,000 acre planned development within Coyote Springs Valley, diversion of groundwater to supply potable water to Las Vegas, and the construction of two electrical generation plants (TNC, 2000). The effect upon the aquifer and springs due to the potential developments remains uncertain. More information about the aquifer system, particularly data pertaining to aquifer boundaries, is needed in order to accurately determine the potential effects of development (USGS, 1995).

8.0 Geomorphology

8.1 Paleoclimate

A rather complete paleoclimatic record is established on the basis of pollen spectra for southern Nevada and indicates no significant changes have occurred between 7,000 years ago and the present (Mehringer, 1963). Analysis of fossil seed and vegetal litter recovered from pack rat middens, located in the Sheep Mountains southwest of the Moapa Valley, indicates only minor variation in the long range and seasonal precipitation amounts between 7,000 years ago and the present (Van Devender and Spaulding, 1979).

Further studies of pollen and pack rat middens, in combination with dendrochronology, provide a paleoecological history of the southern Great Basin for the past 18,000 years. These combined studies indicate a 5° to 10° increase in temperature and a 40% decline in precipitation below the 7,000 feet elevation. This gradual warming and drying trend raised the pinyon-juniper desert scrub zones to the approximate elevation of 2,500 feet (Fritts, 1971). Cyclical drought conditions, as evidenced by the sediment and pollen record in Sierra Nevada lake bogs as well as the dendrochronological record from the Colorado Plateau, have occurred during the past 2,000 years (Weide, 1981). Although similar drought cycles have not been established for the southern Great Basin, it is possible that the southern Great Basin would have been exposed to the same cyclical drought conditions.

8.2 Landscape Development

The Muddy River drainage is a remnant of the pluvial White River system, developed during the Pleistocene (1.8 million years ago to 8,000 years ago), that originally extended approximately 200 miles from the Colorado River to east-central Nevada. Once continuous, the White River drainage consists of approximately 40 miles of restricted surface flow that begins within the upper drainage near Preston and Lund, Nevada followed by a dry channel to the vicinity of Pahranagat where springs appear at the surface. The drainage below Pahranagat consists of an additional 35 miles of dry channel through the Coyote Springs Valley, down Pahranagat Wash, and through Arrow Canyon near the headwaters of the Muddy River. Surface flow resumes at Warm Springs in the UMR valley.

Folded and faulted mountain ranges, valley floors, and slopes intermediate between the valley floors and mountain ranges are the three primary geomorphic units in the Muddy River drainage. The intermediate slopes include both alluvial fans and pediments. Pediments appear similar to alluvial fans but are an erosional surface mantled with a thin veneer of alluvium. In contrast, alluvial fans are composed of thick deposits of alluvium deposited by runoff from the mountains.

The formation of pediment surfaces and terraces has progressed since the Muddy River became a tributary to the Colorado River in the late Tertiary or early Pleistocene (approximately 10 million years ago). Three major episodes of pediment and terrace formation are recognized. The highest and oldest pediments and terraces, referred to as the Mormon episode surfaces, are located between approximately 600 to 700 feet above the valley floor. Mormon Mesa, located on the east side of the valley, is the most prominent remnant of this episode. Overton Mesa, located on the west side of the valley and approximately 200 feet above the valley floor, represents the second oldest erosional episode. The Lost City Surface, located along the east side of the lower Moapa Valley and between 60 and 80 feet above the valley floor is the youngest of all erosional surfaces Clark, 1984).

8.3 Moapa Valley Soils

There are two primary soil groups within the UMR; 1) soils occurring on flood plains, low alluvial fans, and low terraces and 2) soils occurring on higher alluvial fans, dissected terraces, slope breaks, and low hills. Soils of the first group occur primarily along the Muddy River at an approximate elevation of 1,300 feet where the mean annual temperature is 66.5 °F. The first group of soils exhibits a wide range of drainage capacities from excessively drained, well drained, and poorly to very poorly drained and are formed in sandy loam, silt, and clay alluvium derived from a variety of rock types. Soils of the second group are located at a slightly higher elevation than the first group with a similar mean annual temperature. These soils are well to excessively drained, are derived from limestone and sandstone, and occur in sandy or loamy valley fill. Both wind and water deposition of soil parent material is present in each of the two soil groups (USDA, 1980).

8.4 Alteration of the Muddy River Channel

Recent alteration of the Muddy River system in the headwater area includes the excavation of spring heads and replacement of natural spring channels with concrete or earthen ditches. Numerous springs have been capped for pumping purposes while others have been diverted for agricultural use. Much of the river between the White Narrows and Glendale has been channelized and straightened. The effects on the lower Muddy River channel due to repeated and destructive flooding of the Meadow Valley Wash has been recognized since at least 1923 (Youngs and Carpenter, 1923). In addition, according to early settlers, most of the deep incision, which occurs along the length of the river, has taken place since 1880 due to a period of unusual flooding (Longwell, 1928; Gardner, 1968).

In 1928, Longwell presented the degree of bank steepness as well as the absence of or limited lateral incision as evidence for recent vertical incision. The soils map created for the 1923 survey (Youngs and Carpenter, 1923), illustrates channelization and straightening of the Muddy River prior to urbanization. However, uncertainty remains regarding the earliest human impacts to channel morphology. Because the UMR had agricultural and irrigation activities for corn, beans, and gourds as early as 500 AD (Fowler and Madsen, 1986), it is possible that some alteration occurred prior to European settlement. Regardless, the scale and rate of channel modification would most likely have increased greatly following European settlement.

9.0 Hydrology

In general, approximately 30-40% of the total Muddy River flow is derived from the numerous springs in the headwater area while 60-70% is derived from groundwater (SNWA, *unpublished data*). Spring discharge is gaged by the USGS at three locations; 1) the Muddy Springs located on LDS property; 2) Warm Springs West; and 3) Pederson Spring. Flow at the springs varies daily, seasonally, and annually. Monthly average flows at the Muddy Springs, Warm Springs West, and Pederson Spring are less then 1 cfs, 3 to 4 cfs, and approximately 7-8 cfs, respectively.

Three USGS gages are present along the Muddy River; 1) the Moapa gage near the Warm Springs Road crossing; 2) the Glendale gage approximately 2 miles downstream from the town of Glendale; and 3) The Overton gage approximately 1.5 miles upstream of Lake Mead. Since the 1950's, flow at the Moapa gage has declined from approximately 34,000 afy to approximately 25,000 afy at present. Similarly, flows at the Glendale gage have declined and are approximately equal to that observed at the Moapa gage, suggesting that the amount groundwater inflow between the two gages approximates the amount of water lost to evapotranspiration. The SNWA estimates the evapotranspiration to be approximately 9,000 afy (SNWA, *unpublished data*)

10.0 Flora and Fauna of the Upper Muddy River

The Muddy River basin exists near the northeastern corner of the Mojave Desert, and therefore has elements of the Great Basin to the north, and the nearby Colorado Plateau. Beatley (1976) described the bajadas of southern Nevada as being dominated by creosotebush, while upland limestone-dominated lands were dominated by shadscale (*Atriplex confertifolia*). In the northeastern portion of the Mojave Desert in which the Muddy River basin is located, typical Mojave desertscrub vegetation gives way to Great Basin Desert vegetation at elevations above approximately 3,000 feet (900-1050 m), where creosotebush (*Larrea tridentata*) declines and sagebrush (*Artemesia* spp.) advance.

The wetland and riparian vegetation in the Muddy River basin similarly reflects the proximity of other deserts and the Rocky Mountain biome. The wetlands and riparian vegetation of Muddy River basin include elements of both the Warm-Temperate and Tropical-Subtropical Wetland series of Minckley and Brown (1994), and can generally be described as Sonoran riparian scrublands, deciduous woodlands and forests. Vegetation in the vicinity of springs is loosely described as Sonoran oasis forest and woodlands (Minckley and Brown 1994).

Descriptions of the terrestrial vegetation along the UMR by Carpenter in 1915 included greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), creosote bush (*Larrea tridentata*), and mesquite (*Prosopis* spp.). Streamside habitats were naturally dominated by Fremont cottonwood (*Populus fremontii*) and willows (*Salix* spp.), including Goodding's willow (*S. gooddingii*), coyote willow (*S. exigua*), as well as mesquites (*Prosopis* spp.), acacias (*Acacia* spp.), velvet ash (*Fraxinus velutina*), and arrow weed (*Pluchea sericea*) with various understory species.

Non-native phreatophytes have largely overtaken these habitats throughout the region, particularly saltcedar (*Tamarix pentandra*), anthel (*Tamarix aphylla*). Fan palms (*Washingtonia filifera*) dominate the springs in the UMR and are generally considered to be non-native, although debate continues and their eradication is unlikely due to various issues including consideration of the preferences of valley inhabitants, use of the palms as roosting areas by the only yellow bat population in Nevada, and the documentation of birds feeding on fan palm fruit. Other important non-native plant species in the Muddy River basin include brome grasses (*Bromus* spp.), Bermuda grass (*Cynodon dactylon*), Ravenna grass (*Saccharum ravennae*), and numerous mustards (e.g., *Brassica* spp.) and other taxa.

The Muddy River is included in the Vegas-Virgin Freshwater Ecoregion of the Colorado Complex (Abel, 2000). This freshwater ecoregion is distinguished by having 50-64% of its fish species listed as imperiled, 100% of its endemic fish species imperiled, 25-36% of its herpetofaunal species imperiled, and 100% of its endemic herpetofaunal species imperiled. These issues and the fact that this is one of the fastest developing areas in the United States creates great concern amongst conservation organizations over the continued ecological health of the Virgin-Muddy River system (Grand Canyon Trust, 1997).

10.1 Upper Muddy River Vegetative Communities and Conservation Targets

Six primary vegetative communities, roughly overlapping the conservation targets, were identified during the Upper Muddy River Integrated Science Workshop (TNC, 2002). In addition, six conservation targets along the UMR have been identified by TNC. These targets were determined based on 1) viable, vulnerable, rare, and endangered plant and animal species; 2) species of concern due to population decline, disjunct distribution, or regional endemism; 3) viable ecological communities; and 4) distinct ecological communities and species or systems (TNC, 2000). A description of the six primary vegetative communities and conservation targets are presented below.

Creosote Bush Shrubland

Although the largest area containing this community is outside of the area mapped by TNC for conservation targets, limited areas of the creosote bush shrubland are present within the area mapped as the 100 Year Floodplain. This community contains a diverse group of shrubs including *Larrea tridentata*, *Ambrosia dumosa*, *Krameria erecta*, and *Atriplex confertifolia* that grow on xeric soils occasionally dissected by dry washes. The presence of dry washes allows additional species that require more frequent water, such as *Acacia gregii*, to survive within this vegetative community. The creosote bush shrubland community is the most abundant vegetative community in Clark County as well as the Mojave Desert and is less than 50 miles from its northern limit. This community is most affected by housing development. Species of concern within this vegetative community include the Desert Tortoise, Phainopepla, and Loggerhead Shrike.

Saltbush Shrubland

This vegetative community is limited in extent to episodically flooded areas containing saline soils and is generally located within the 100 year floodplain. The presence of this community is severely limited due to human activities within the floodplain such as flood control, irrigation, and development. Further disturbance due to recreational vehicle use between shrubs adds to the degradation of this community. Additional plant species that occur include *Atriplex lentiformis* and *polycarpa, Suaeda moquinii*, *Allenrolfea occidentalis*, *Sporobulus airoides*, and *Distichlis spicata*.

Desert Riparian Forest

The desert riparian forest most closely corresponds to the warm springs and stream aquatic assemblage conservation target and includes cottonwood, velvet ash, numerous willow species, and fan palms with a diverse group of understory species. The spring heads and outflow channels comprise this community. In general, this community is confined to the headwaters of the river from the main springs to the Moapa gage at the Warm Springs Road crossing. However, this community also extends along agricultural ditches. The upper most 3.5 miles contains the Interior Woodland Riparian Woodland conservation target while the remaining portion of the river mainstem, extending downstream to the I-15 crossing, contains the Muddy River Aquatic Assemblage conservation target.

The importance of the desert riparian forest is emphasized by the fact that it contains the largest remaining area in Clark County with perennial streams supported by spring discharge. The Muddy River serves as a stopover for many migratory birds and provides biogeographic connection between the Mojave, Sonoran, and Great Basin Deserts. This vegetative community has been highly modified and is currently impacted by recreational use, channelization, diversions, and livestock grazing. Native fauna include the Moapa dace, White River springfish, Moapa pebble snail, grated tryonia, Warm Springs riffle beetle, and the Amargosa and Moapa naucorids.

Desert Riparian Shrubland

Similar to the desert riparian forest, described above, the desert riparian shrubland occurs along the spring channels, main stem of the river, and agricultural ditches. In addition, this community has been highly modified and is currently impacted by recreational use, channelization, diversions, and livestock grazing. This vegetative community most closely corresponds to the Interior Riparian Shrubland conservation target. Patches of *Baccharis emoryi*, *Pluchea sericea*, and *Distichlis spicata* occur within this vegetative community. In addition *Atriplex lentiformis* and numerous *Salix* spp. may be present. The southwestern willow flycatcher, Crissal thrasher, loggerhead shrike are among the priority bird species of this vegetative community.

Interior Wetlands Marsh and Seeps

The interior wetlands marsh and seeps community occurs within the desert riparian forest and shrubland communities and is equivalent to the Riparian Marsh conservation target. Remnants of this assemblage are present along the Apcar and Refuge streams and further downstream near Glendale. Plants of the riparian marsh include sedges, cattail, yerba mansa, and assorted grasses. Agricultural activities have exerted the greatest influence on riparian marshland, primarily due to drainage activities. The marshes serve as important habitat for the Virginia Rail, Sora, marsh wren, and assorted shorebirds, wading birds, and waterfowl.

Mesquite Bosque

The Mesquite bosque within the UMR valley occurs on floodplain terraces, stream banks, alkali sinks, and along ephemeral washes and is one of the northernmost occurrences of this vegetative community. *Prosopis glandulosa* and *Prosopis pubescens* dominate this assemblage while a sparse herbaceous layer is present in the understory. Phainopepla, Lucy's warbler, Loggerhead shrike, and verdin are among the important native birds that utilize the mesquite bosque.

10.2 Fish

The fish of the Muddy River have been studied and surveyed since the 1930s and 1940s (Cross, 1976; Deacon and Bradley, 1972; Hubbs and Miller, 1948; Miller and Hubbs, 1960; Scoppettone, 1993; Scoppettone et al., 1992; and Scoppettone et al., 1998). Thermal characteristics of the river headwaters, a downstream decrease in water temperature, and geographic isolation has resulted in the presence of endemic fish. Deacon et al. (1972) reported a total of 6 native fish species and 4 non-native fish species from the Muddy River. They segregated the headwater fish species into a single lentic species (*Crenichthys baileyi*) and one lotic species (*Moapa coriacea*). *Gila robusta* and

Rhinichthys osculus were abundant in the middle portion of the stream in deep, undisturbed riffle habitats. Deacon and Bradley (1972) considered *Plagopterus arentissimus* to be rare or accidental in the Muddy River. In their study, non-native fish included *Cyprinus carpio*, *Ictalurus melas*, *Gambusia affinis*, and *Poecilia mexicana*. Fish diversity decreased in the lower portion of the Muddy River in their study, a change that was related to increased turbidity in the lowermost river segment.

Although several species native to the Colorado River basin have been observed within the Muddy River basin, four species are considered to be native to the Muddy River while two of these species *Moapa coriacea* (Moapa dace) and *Crenichthys baileyi moapae* (White River springfish) are thermophilic and endemic to the headwater area know as the Warm Springs area. *Rhinichthys osculus moapae* (Moapa speckled dace) is a third endemic that occupies cooler water downstream from the Warm Springs area (Scoppettone et al., 1998). *Gila seminuda* (Moapa roundtail chub) is the only native fish that is not found exclusively in the Muddy River and occurs also in the Virgin River.

Thirteen non-native fish species have been observed in the Muddy River including *Poecilia mexicana* (shortfin molly), *Gambusia affinis* (mosquitofish), *Cyprinus carpio* (carp), *Notropis lutrensis* (red shiner), *Notemigonus crysoleucas* (golden shiner), *Ictalurus melas* (black bullhead), *Ictalurus punctatus*, *Pimephales promelas*, *Micropterus salmoides* (largemouth black bass), *Chaenobryttus cyanellus* (green sunfish), and *Salmo gairdneri* (rainbow trout), *Tilapia* sp., and *Oreochromis aurea* (Deacon and Bradley, 1972; Cross, 1976; Scoppettone et al., 1998).

Established in 1979, the Moapa National Wildlife Refuge was created in historic habitat at the southern edge of the Warm Springs area for the purpose of preserving the Moapa dace (Scoppettone et al., 1992). The approximate 1,500 feet long section of spring channel within the refuge has supported up to 500 Moapa dace and more than 10,000 White River springfish. Prior to the establishment of the refuge, the Moapa dace population had been precluded from the headwater springs due to habitat alteration and chlorination during the use of the property as a resort. The population was reestablished in 1984 with the introduction of 150 larvae and 40 adults (Scoppettone et al, 1998). The current Moapa dace population is approximately 1,000 due to predation by Tilapia. The native fish population within the refuge is currently separated from non-native fishes by a manmade barrier.

Both the Moapa dace and White River springfish inhabit waters ranging from 26 to 32 °C and reproduce in temperatures ranging from 30 to 32°C, typically within 500 hundred feet of the springs. Due to their thermophyllic nature, both species are restricted to the uppermost section of the river and smaller headwater tributaries. Peak reproductive activity occurs in spring and summer, but continues year round. The Moapa dace are reproductive within their first year and have a life span of approximately 6 years. Because body size is proportionate to water volume, smaller Moapa dace adults inhabit the spring channels while the largest adults inhabit the Muddy River. The Moapa dace are drift feeders and have been observed congregated in eddy areas where slower water persists while White River springfish are thought to be omnivorous (Williams and Williams, 1982; Scoppettone et al., 1992; and Scoppettone, 1993).

10.3 Aquatic Macroinvertebrates

The aquatic macroinvertebrate community is one of the few remaining terrestrial and aquatic communities in the UMR that is not currently dominated by introduced species. All aquatic habitat types within the UMR drainage are utilized by macroinvertebrates and the majority of the endemic macroinvertebrates do not prefer habitats occupied by endemic fishes. Over 100 macroinvertebrate species have been described from the thermal springs and headwaters of the Muddy River. Several species are globally rare (*Rhagovelia becki*, *Ambrysus mormon*, *Pelocoris biimpressus shoshone*, *Tryonia clatharta*) while five are endemic (*Pyrgulopsis avernalis, Pyrgulopsis clatharta*, *Stenelmis moapa*, *Limnocoris moapensis*, and *Microcylloepus moapus moapus*). These species are most abundant within the spring and spring channels and are scarce or absent further downstream where species better adapted to harsh environmental conditions comprise the macroinvertebrate community (Sada, 2000).

Sada and Herbst (1999) identified five key habitat types associated with and utilized by rare and endemic macroinvertebrate species. Fast moving and deep water with gravel and cobble substrate and sparse vegetation is inhabited by *Pyrgulopsis avernalis*, *Pyrgulopsis clatharta*, *Ambrysus mormon*, *Limnocoris moapensis*, *Microcylloepus moapus moapus*, and *Stenelmis moapa*. Slow and shallow backwater areas with sand substrate are inhabited by *Tryonia clatharta*. This habitat is also utilized by *Melanoides tuberculata*, an introduced mollusk; however, *M. tuberculata* prefers slightly slower water with a muddy substrate. Slow moving and deep backwater areas with emergent vegetation are primarily occupied by *Pelocoris biimpressus shoshone*. Swift moving and deep backwater areas with gravel substrate and a dense riparian cover is typically occupied by *Rhagovelia becki*, *Ambrysus mormon*, and *Limnocoris moapensis*. Mid-channel habitat composed of deep, slow moving water with a muddy substrate is primarily inhabited by the introduced mollusk *M. tuberculata*.

10.4 Insects

Mayflies
Polhemus and Polhemus (2002) noted that *Isonychia intermedia*, *Leptohyphes zalope*, and *Camelobaetidus musseri* occur as thermal disjuncts in the Muddy Springs complex.

Odonata (Dragonflies and Damselflies)
A total of 5 families, 11 genera, and 16 species of Odonata have been detected in Nye County, in which the Muddy River exists and are shown in Table 1 of Appendix B (Baumann and Huillet 2000, Polhemus and Polhemus 2002).

Aquatic Heteroptera
Polhemus and Polhemus (2002) documented the presence of *Limnocoris moapensis*, *Rhagovelia becki*, *Buenoa omani*, and *Nerthra martini* as thermal endemics and thermal disjuncts in the Muddy Springs complex.

Tiger Beetles
The tiger beetles (Cicindelideae) of Clark and Lincoln counties were summarized from range maps prepared by Pearson et al. (1997) and are presented in Table 2 of Appendix B. The fauna includes 17 species in 3 genera, with strong dominance by *Cicindela*.

These are primarily riparian and alkalai flats species, although *Amblycheila* is a primarily nocturnal species that exists on rocky desert slopes.

Aquatic Beetles
Polhemus and Polhemus (2002) documented the presence of *Neoclypeodytes discretus*, *Microcylloepus moapus moapus*, and *Stenelmis callida moapa* as thermal endemics and thermal disjuncts in the Muddy Springs complex.

Butterflies and Skippers
The butterflies and skippers (Lepidoptera) detected in Clark and Lincoln counties include 168 species in 77 genera among 7 families (Stanford and Opler, 1999). Lepidoptera species observed in Clark and Lincoln counties are shown in Table 3 of Appendix B. Not all of these species may occur in the Muddy River drainage, and Fleishman (personal communication) is currently developing a list of species actually detected in the basin in recent years. Austin (2002) documented the butterfly-host plant associations within the UMR as follows; *Hesperopsis gracielae-Atriplex lentiformis*; *Ochlodes yuma-Phragmites australis*; *Calephelis nemensis-Baccharis salicifolia*; *Apodemia palmerii-Prosopis* spp.; *Atlides halesus-Phoradendron califonicum*; *Ministrymon leda-Prosopis glandulosa*; *Lycaeides melissa-Medicago sativa*; and *Chlosyne lacinia-Helianthus annus*.

Mosquitoes
The mosquitoes (Diptera: Culicidae) of Clark and Lincoln counties have been documented by Darcie and Ward (1981) and Polhemus and Polhemus (2002). This fauna includes 25 species in 6 genera and is exhibited in Table 4 of Appendix B. Several of these species may carry West Nile virus, when it arrives in the region.

10.5 Herpetofauna
Historical amphibian species likely included populations of Relict Leopard Frog (*Rana onca*), the Pacific Tree Frog (*Hyla regilla*), the Red-Spotted Toad (*Bufo punctatus*), and the Southwestern Toad (*Bufo microscaphus microscaphus*). The present amphibian population is dominated by bullfrogs (*Rana catesbeiana*), Pacific Tree Frogs, and a hybrid toad complex (likely *Bufo woodhousii*, *B. m. microscaphus*) dominated by *Bufo woodhousii* (Hoff, *unpublished data*). Herpetofauna observed within the vicinity surrounding the Muddy River basin (Tanner, 1978) are shown in Table 5 of Appendix B.

Amphibian and reptile species recognized as species of concern are also shown in Table 6.

10.6 Birds

The UMR contains a bird community with one of the highest number of bird species within Clark County. Numerous surveys have been completed and reported. A total of 125 bird species were detected in 2001 in the Muddy River drainage, of which 76 were considered to be breeding species (Fleishman et al. 2003). Bird species richness was closely related to total vegetation volume, whereas bird species composition was related to floristics (plant species composition). Fleishman recommended that if non-native vegetation is to be removed for habitat restoration purposes, clear-cutting should be avoided, and selective removal of non-native trees may advantage established native tree species. Lund (2002) reported 230 bird species, of which 162 were categorized as regular species based on 1) year round residents, 2) species utilizing UMR habitat during migration, 3) seasonal nesters, and 4) winter residents. An additional 68 species were categorized as occasional species based on 1) a species with 5 or less observed occurrences within four years and 2) species recorded in habitats adjacent to the UMR.

Lund (*unpublished data*) categorized bird species observed according to the conservation targets presented by TNC (2000). Seventy nine species were observed in the Interior Riparian Shrubland including the Yellow-breasted chat, Blue Grosbeak, Indigo Bunting, Bullock’s Oriole, Loggerhead Shrike, and Crissal thrasher. Thirteen species were observed in the relatively small Interior Riparian Marsh including the Virginian rail, Sora, and Marsh wren. Sixty species were associated with the Mesquite Bosque and included the Phainopepla, Lucy’s Warbler, Verdin, and Vermillion Flycatcher. Numerous additional species were also observed in human made habitats such as open water ponds, sewage lagoons, flood irrigation waters/agricultural fields, and livestock pastures.

10.7 Mammals

A total of 5 orders, 15 families, 30 genera, 46 species, and 40 subspecies of mammals, as shown in Table 6 of Appendix B, have been detected in the Muddy River basin (Hall, 1995). This fauna is characteristic of desert basins in the northern portion of the lower Colorado River drainage. Additional species (particularly of bats) may be detected with further survey efforts. Of the 23 bat species documented in Nevada, 15 have been observed in the UMR valley. Bats have been observed in the Interior Riparian Woodland, Interior Riparian Shrubland, Mesquite Bosque, and Interior Riparian Marsh. The Spotted Bat (*Euderma maculatum*) is the only bat considered threatened in the state of Nevada (Williams, 2002).

11.0 Species of Concern

A total of 181 species, shown in Table 1 in Appendix C, are considered as sensitive in Clark County, Nevada (Nevada Natural Heritage Program 2002). The list of sensitive species is strongly dominated by endemic plants, particularly in the genus *Astragalus* (13 taxa). Some species on this list (i.e., those endemic on Mt. Charleston) are not likely to occur in the Muddy River, but are included because thorough surveys of distribution were not found. Additional information on these species can be found on the “NatureServe Explorer” website.

The Clark County Multiple Species Habitat Conservation Plan (2000) includes 103 species listed as Evaluation Species, 51 species as Watch List Species, and 79 species that are included as Covered Species (see Tables 2 and 3 in Appendix C). If the MSHCP is approved by the U.S. Fish and Wildlife Service, the USFWS would authorize incidental take of the listed species covered by the plan through the issuance of a Section 10(a)(1)(B) permit. In addition, the MSHCP would also be the basis for an incidental take permit and implementation agreement for additional species if these species become listed.

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Appendix A

Aerial Photographs of the Upper Muddy River

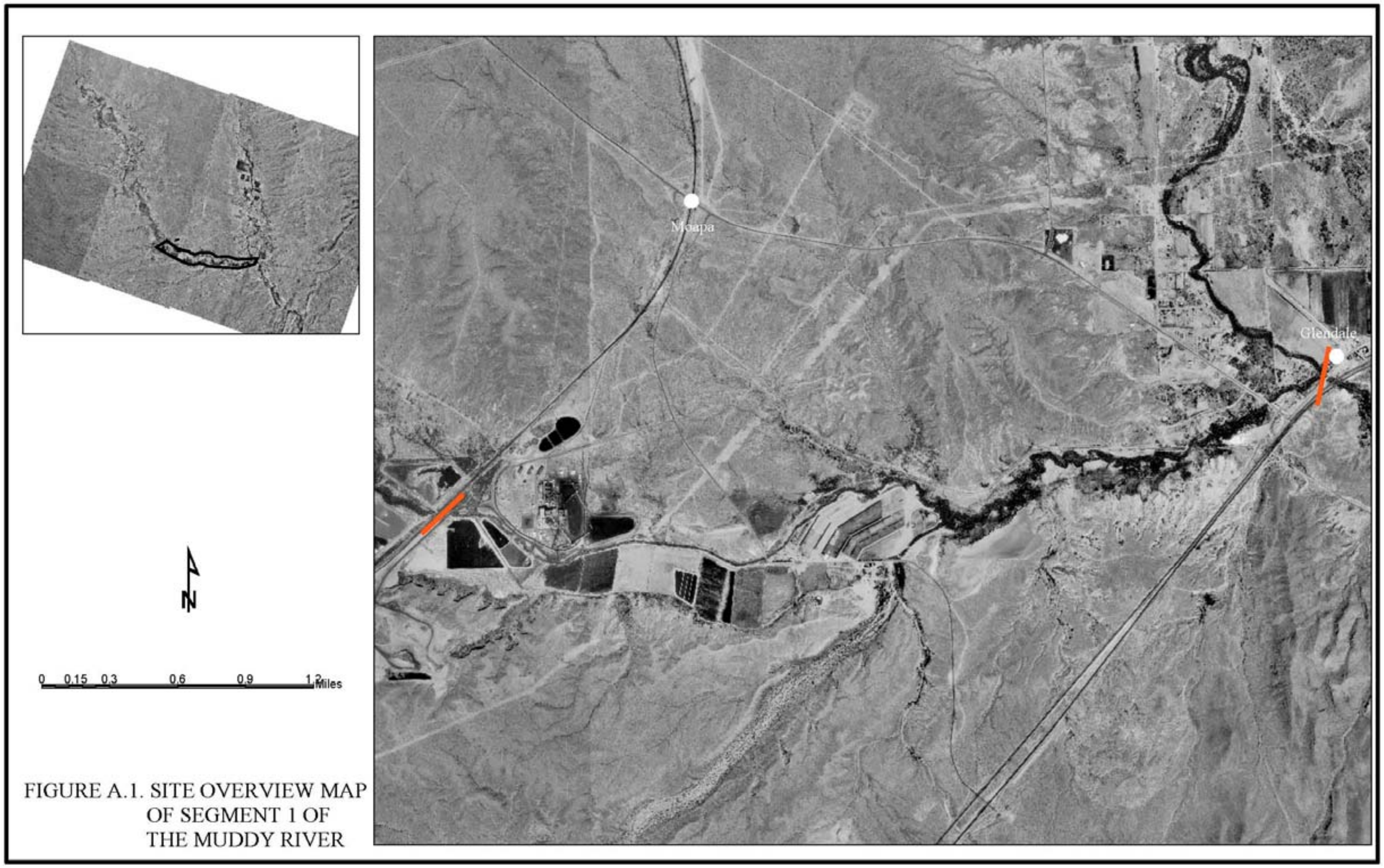

FIGURE A.1. SITE OVERVIEW MAP
OF SEGMENT 1 OF
THE MUDDY RIVER

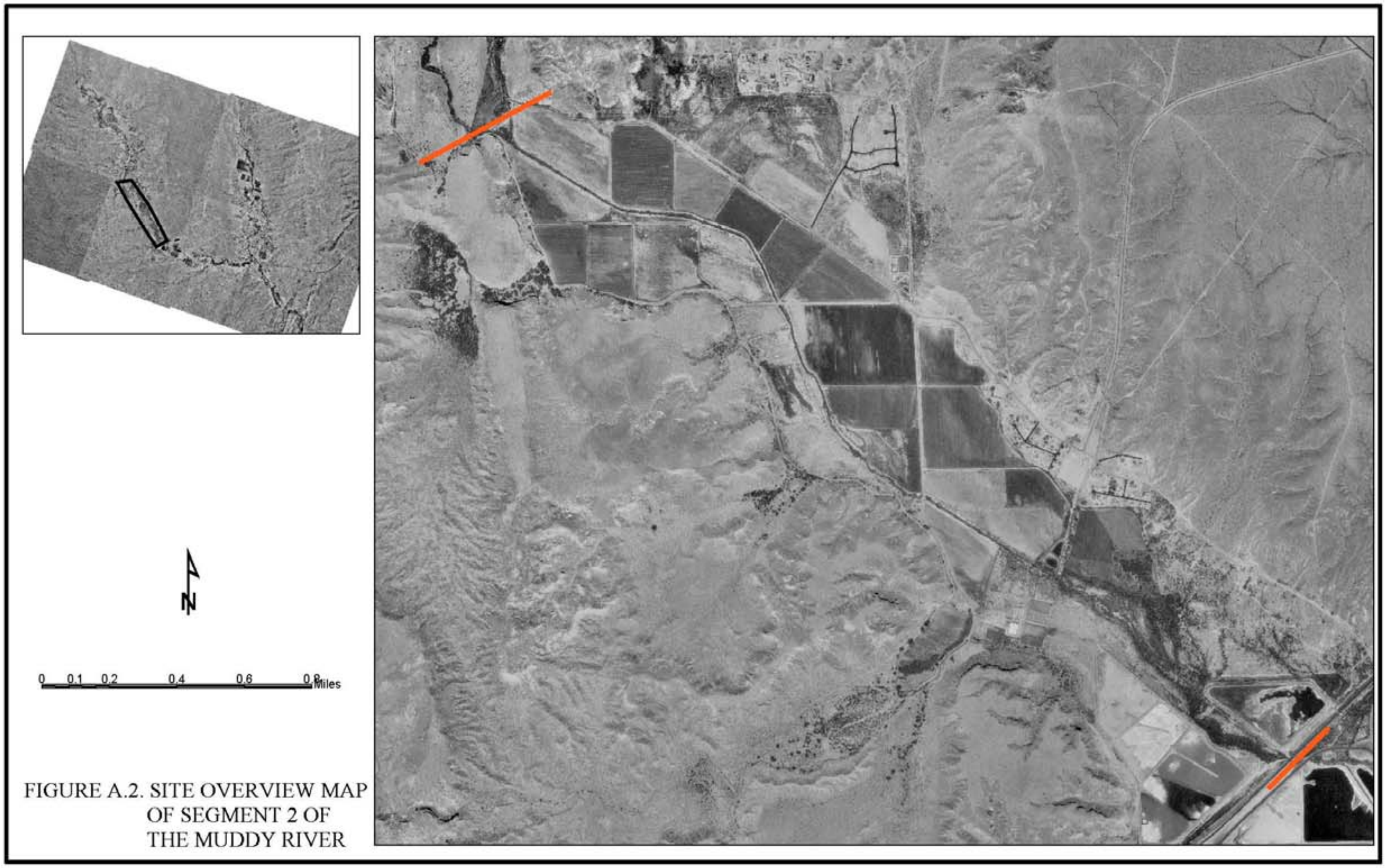

FIGURE A.2. SITE OVERVIEW MAP
OF SEGMENT 2 OF
THE MUDDY RIVER

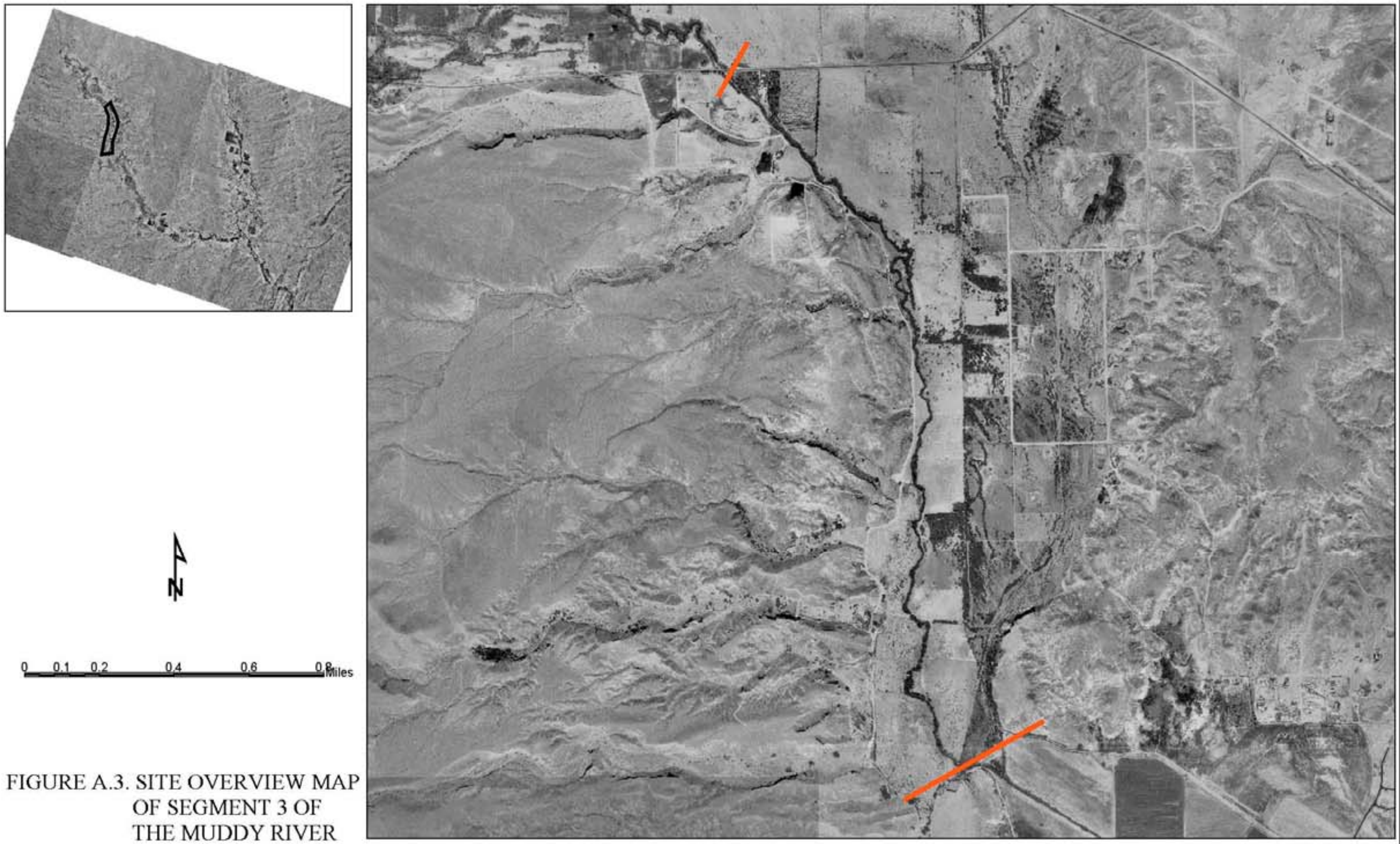

FIGURE A.3. SITE OVERVIEW MAP OF SEGMENT 3 OF THE MUDDY RIVER

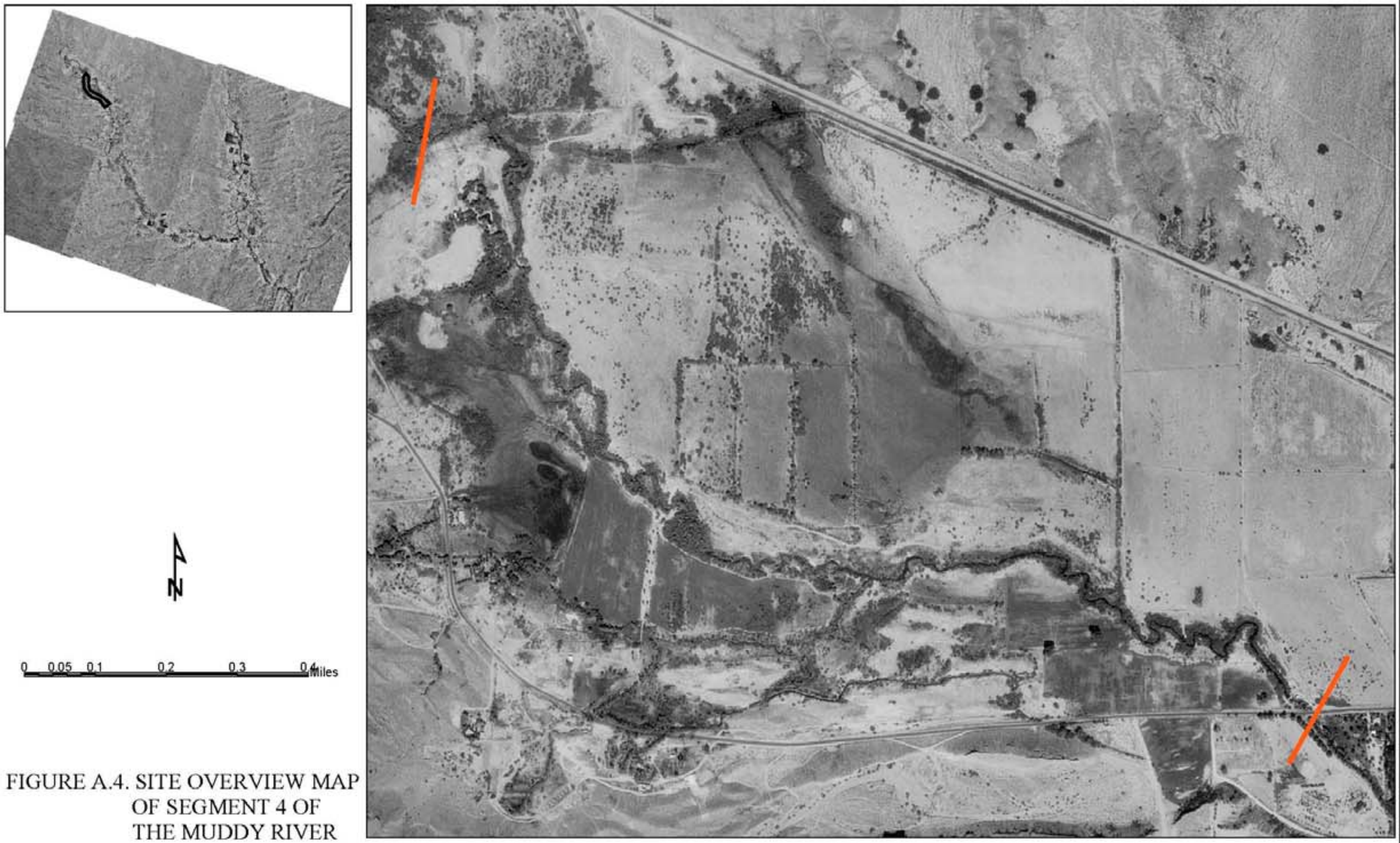

FIGURE A.4. SITE OVERVIEW MAP OF SEGMENT 4 OF THE MUDDY RIVER

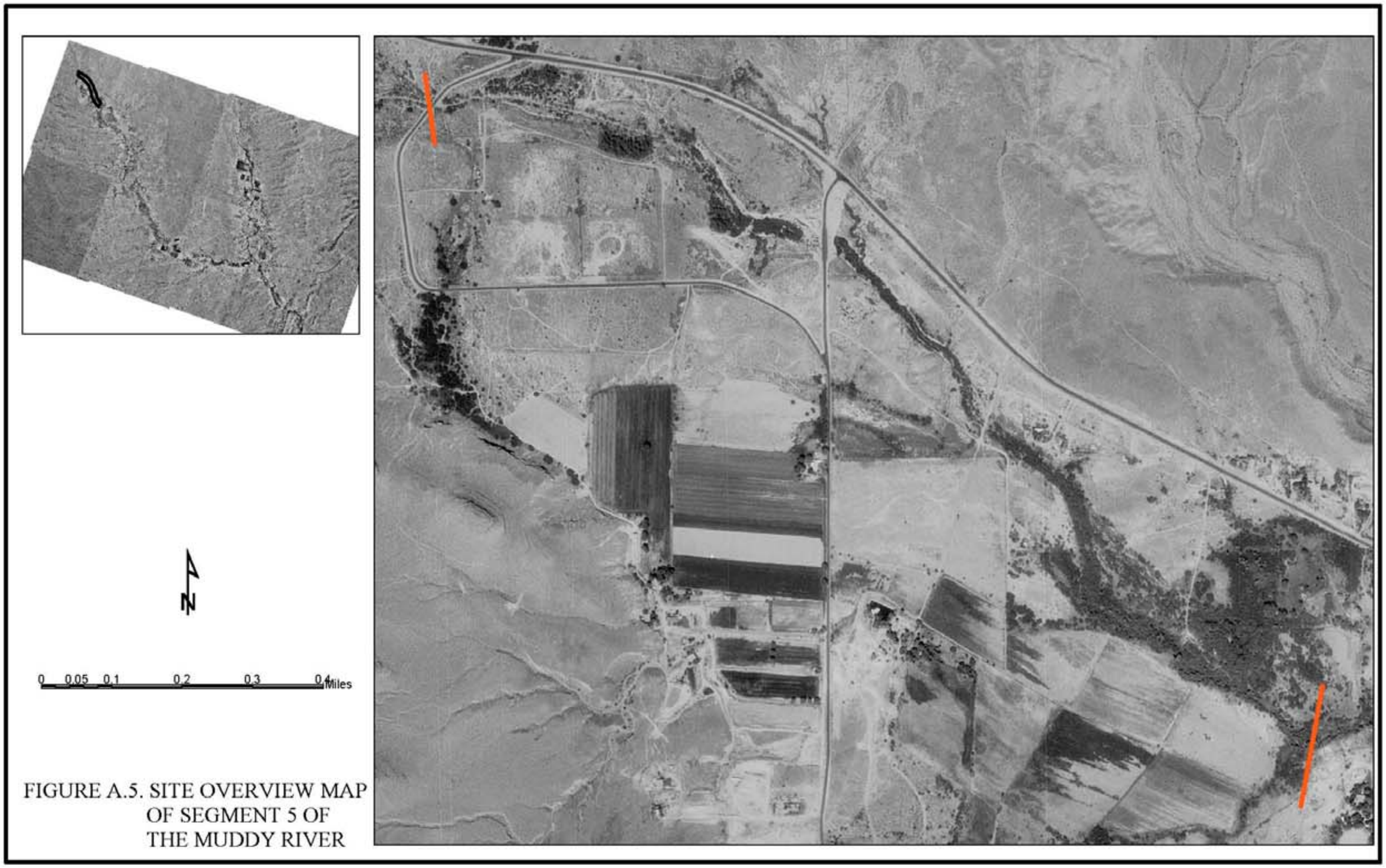

FIGURE A.5. SITE OVERVIEW MAP
OF SEGMENT 5 OF
THE MUDDY RIVER

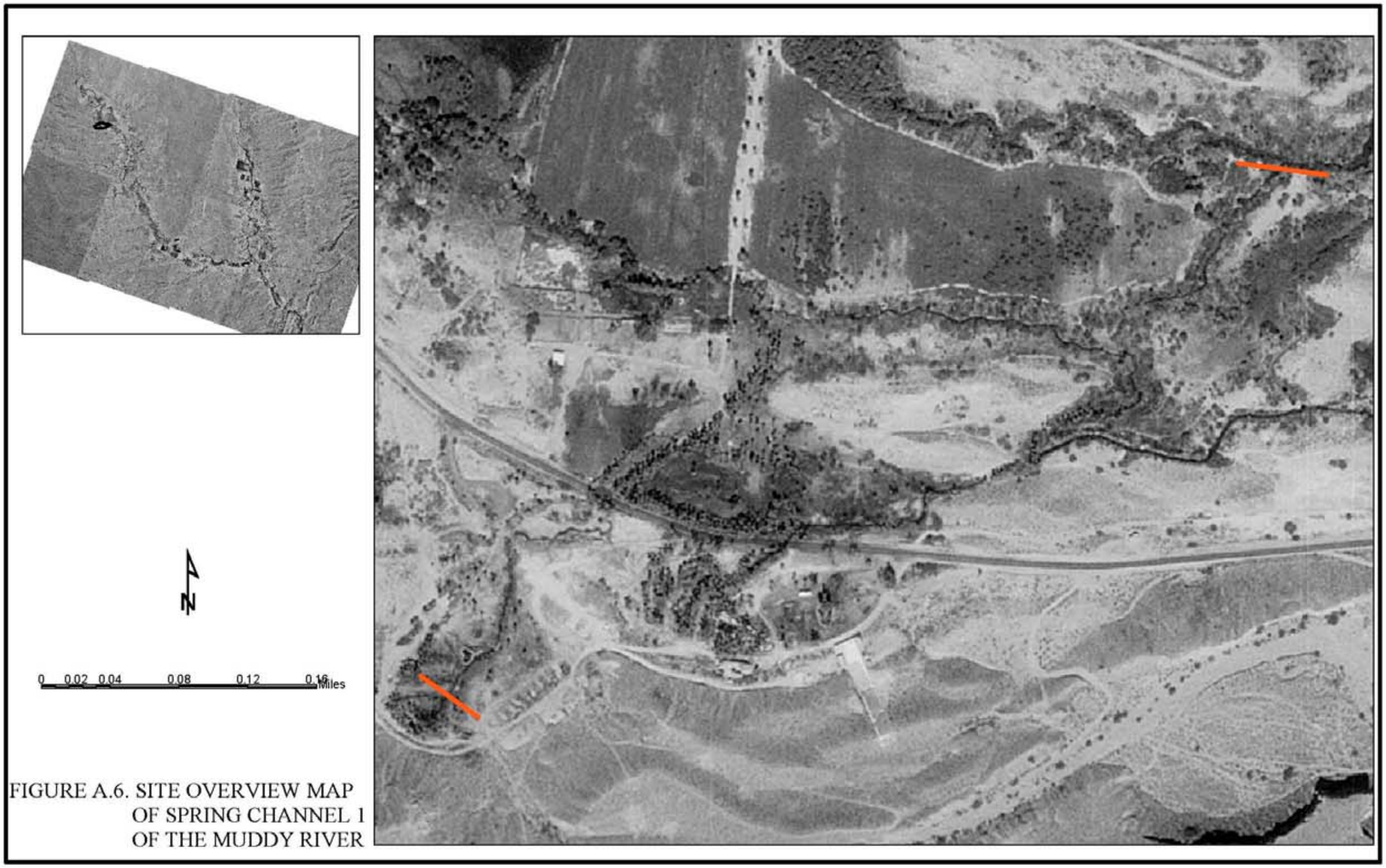

FIGURE A.6. SITE OVERVIEW MAP OF SPRING CHANNEL 1 OF THE MUDDY RIVER

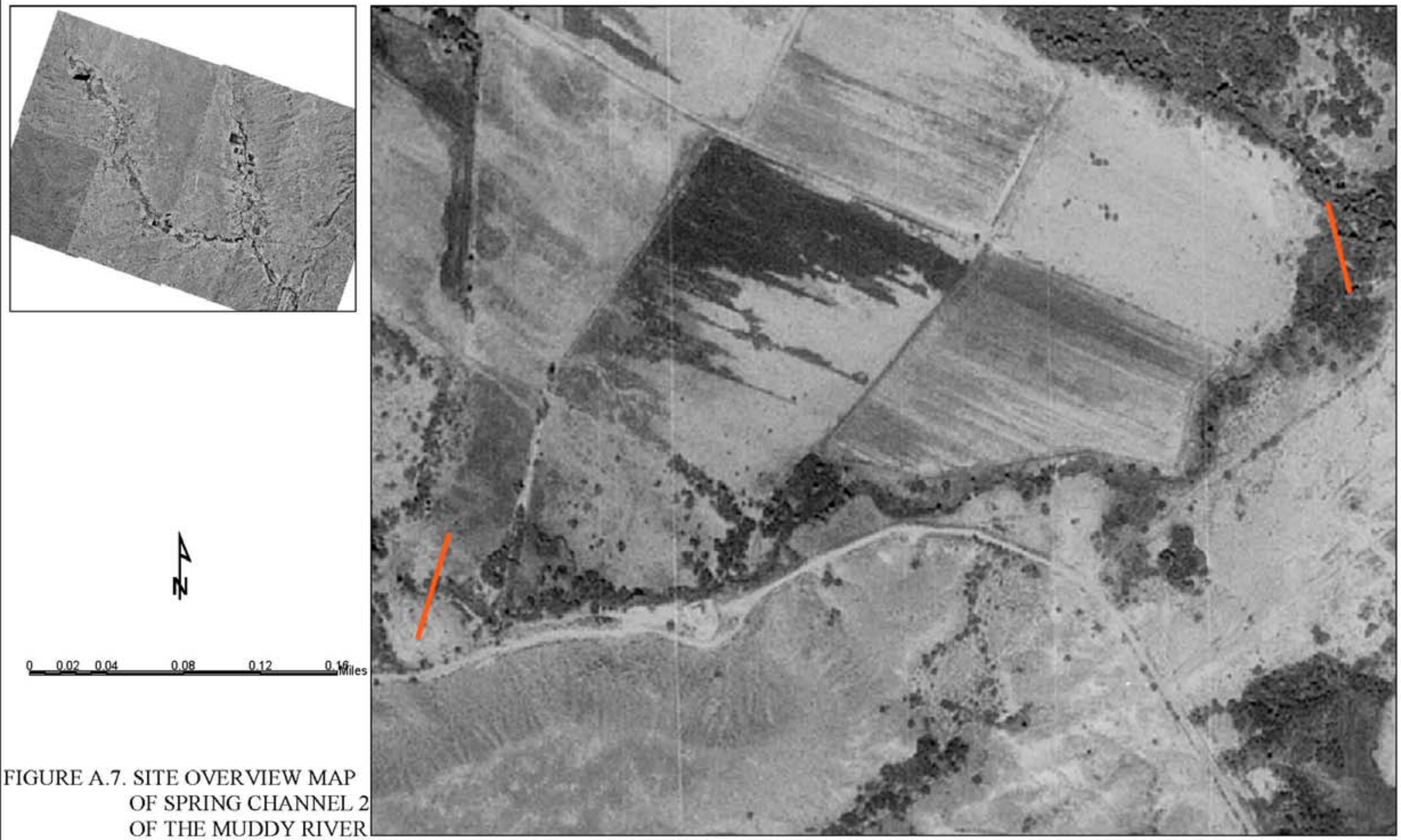

FIGURE A.7. SITE OVERVIEW MAP OF SPRING CHANNEL 2 OF THE MUDDY RIVER

Appendix B

Species Lists

Table 1. Odonata of Nye County, Nevada.

Family	Genus	Species	Common Name
Calopterygidae	*Hetaerina*	*americana*	American Rubyspot
Aeshnidae	*Aeshna*	*multicolor*	Blue-eyed Darner
Aeshnidae	*Anax*	*junius*	Common Green Darner
Gomphidae	*Erpetogomphus*	*compositus*	White-belted Ringtail
Gomphidae	*Erpetogomphus*	*designatus*	Eastern Ringtail
Corduliidae	*Macromia*	*magnifica*	Western River Cruiser
Libellulidae	*Brechmorhoga*	*mendax*	Pale-faced Clubskimmer
Libellulidae	*Erythemis*	*simplicicollis*	Eastern Pondhawk
Libellulidae	*Libellula*	*composita*	Bleached Skimmer
Libellulidae	*Libellula*	*forensis*	Eight-spotted Skimmer
Libellulidae	*Libellula*	*nodisticta*	Hoary Skimmer
Libellulidae	*Libellula*	*saturata*	Flame Skimmer
Libellulidae	*Libellula*	*subornata*	Desert Whitetail
Libellulidae	*Pachydiplax*	*longipennis*	Blue Dasher
Libellulidae	*Pantala*	*hymenaea*	Spot-winged Glider
Libellulidae	*Sympetrum*	*corruptum*	Variegated Meadowhawk
Libellulidae	*Tramea*	*lacerata*	Black Saddlebags

Table 2. Tiger beetles (Cicindelidae) of Clark and Lincoln counties, Nevada (Pearson et al. 1997).

Genus	Species	Clark	Lincoln
Amblycheila	*schwarzi*	*	
Cicindela	*amargosae*	*	
Cicindela	*cintipennis*	*	*
Cicindela	*haemorrhagica*	*	*
Cicindela	*hirticollis*	*	*
Cicindela	*lemniscata*	*	*
Cicindela	*longilabris*	*	*
Cicindela	*nebraskana*		*
Cicindela	*nevadica*	*	
Cicindela	*oregona*	*	*
Cicindela	*parowana*		*
Cicindela	*preatextata*	*	*
Cicindela	*punctulata*	*	*
Cicindela	*purpurea*	*	*
Cicindela	*tenuisignata*	*	*
Cicindela	*tranquebarica*	*	*
Tetracha	*carolina*	*	

Table 3. Butterflies and skippers reported from Clark and Lincoln counties, Nevada (Stanford and Opler 1999).

Family	Genus	Species	Clark	Lincoln
Hesperiidae	*Agathymus*	*alliae*	*	*
Hesperiidae	*Atalopedes*	*campestris*	*	*
Hesperiidae	*Atrytonopsis*	*python*	*	
Hesperiidae	*Calpodes*	*ethlius*	*	
Hesperiidae	*Chiomara*	*asychis*	*	
Hesperiidae	*Copaeodes*	*aurantiacus*	*	*
Hesperiidae	*Epargyreus*	*clarus (incl huachuca)*	*	
Hesperiidae	*Erynnis*	*brizo*	*	*
Hesperiidae	*Erynnis*	*funeralis*	*	*
Hesperiidae	*Erynnis*	*meridianus*	*	*
Hesperiidae	*Erynnis*	*telemachus*	*	*
Hesperiidae	*Heliopetes*	*domicella*	*	
Hesperiidae	*Heliopetes*	*ericetorum*	*	*
Hesperiidae	*Hesperia*	*comma COMPLEX*	*	*
Hesperiidae	*Hesperia*	*juba*	*	*
Hesperiidae	*Hesperia*	*nevada*	*	
Hesperiidae	*Hesperia*	*pahaska*	*	*
Hesperiidae	*Hesperia*	*uncas*		*
Hesperiidae	*Hesperopsis*	*alpheus*	*	*
Hesperiidae	*Hesperopsis*	*gracielae*	*	
Hesperiidae	*Hesperopsis*	*libya*	*	*
Hesperiidae	*Hylephila*	*phyleus*	*	*
Hesperiidae	*Lerodea*	*eufala*	*	*
Hesperiidae	*Megathymus*	*yuccae (incl coloradensis)*	*	*
Hesperiidae	*Nastra*	*julia*	*	
Hesperiidae	*Ochlodes*	*sylvanoides*		*
Hesperiidae	*Ochlodes*	*yuma*	*	*
Hesperiidae	*Pholisora*	*catullus*	*	*
Hesperiidae	*Polites*	*draco*	*	
Hesperiidae	*Polites*	*sabuleti*	*	*
Hesperiidae	*Polygonus*	*leo (=lividus)*	*	
Hesperiidae	*Pyrgus*	*albescens*	*	*
Hesperiidae	*Pyrgus*	*communis communis*	*	*
Hesperiidae	*Pyrgus*	*communis COMPLEX*	*	*
Hesperiidae	*Pyrgus*	*scriptura*	*	*
Hesperiidae	*Staphylus*	*ceos*	*	
Hesperiidae	*Systasea*	*zampa (=evansi)*	*	
Hesperiidae	*Thorybes*	*pylades*	*	*

Table 3 continued. Butterflies and skippers reported from Clark and Lincoln counties, Nevada (Stanford and Opler 1999).

Family	Genus	Species	Clark	Lincoln
Libytheidae	*Libytheana*	*carinenta COMPLEX (incl bachmanii)*	*	*
Lycaenidae	*Atlides*	*halesus (Sin & Dgo material probably represents several spp. incl. gaumeri, polybe, carpasia)*	*	*
Lycaenidae	*Brephidium*	*exile*	*	*
Lycaenidae	*Callophrys*	*affinis*		*
Lycaenidae	*Callophrys*	*comstocki (incl paradoxa)*	*	*
Lycaenidae	*Callophrys*	*dumetorum COMPLEX*		*
Lycaenidae	*Callophrys*	*sheridanii COMPLEX*	*	*
Lycaenidae	*Celastrina*	*argiolus (ladon) COMPLEX (incl echo, lucia)*	*	*
Lycaenidae	*Chlorostrymon*	*simaethis*	*	
Lycaenidae	*Euphilotes*	*battoides COMPLEX*	*	*
Lycaenidae	*Euphilotes*	*bernardino*	*	*
Lycaenidae	*Euphilotes*	*enoptes (fall-flying)*	*	*
Lycaenidae	*Euphilotes*	*mojave*	*	
Lycaenidae	*Euphilotes*	*rita (incl pallescens)*		*
Lycaenidae	*Euphilotes*	*spaldingi*		*
Lycaenidae	*Everes*	*amyntula (incl herii)*	*	*
Lycaenidae	*Glaucopsyche*	*lygdamus*	*	*
Lycaenidae	*Glaucopsyche*	*piasus*		*
Lycaenidae	*Hemiargus*	*ceraunus*	*	*
Lycaenidae	*Hemiargus*	*isola*	*	*
Lycaenidae	*Hypaurotis*	*crysalus*		*
Lycaenidae	*Incisalia*	*eryphon*	*	*
Lycaenidae	*Incisalia*	*fotis*	*	*
Lycaenidae	*Leptotes*	*marina*	*	*
Lycaenidae	*Lycaeides*	*melissa*	*	*
Lycaenidae	*Lycaena*	*helloides*	*	*
Lycaenidae	*Lycaena*	*heteronea*		*
Lycaenidae	*Lycaena*	*rubida (incl ferrisi)*		*
Lycaenidae	*Lycaena (Tharsala)*	*arota*		*
Lycaenidae	*Ministrymon*	*leda (incl ines)*	*	*
Lycaenidae	*Mitoura*	*siva*	*	*
Lycaenidae	*Mitoura*	*spinetorum (incl millerorum)*	*	*
Lycaenidae	*Philotiella*	*speciosa*	*	*
Lycaenidae	*Plebejus*	*saepiolus*		*
Lycaenidae	*Plebejus (Icaricia)*	*acmon*	*	*
Lycaenidae	*Plebejus (Icaricia)*	*icarioides*	*	*
Lycaenidae	*Plebejus (Icaricia)*	*lupini*	*	
Lycaenidae	*Plebejus (Icaricia)*	*shasta*	*	*

Table 3 continued. Butterflies and skippers reported from Clark and Lincoln counties, Nevada (Stanford and Opler 1999).

Family	Genus	Species	Clark	Lincoln
Lycaenidae	*Satyrium*	*behrii*	*	*
Lycaenidae	*Satyrium*	*californicum*		*
Lycaenidae	*Satyrium*	*saepium*		*
Lycaenidae	*Satyrium*	*sylvinum COMPLEX (incl dryope)*		*
Lycaenidae	*Satyrium*	*titus*		*
Lycaenidae	*Strymon*	*melinus*	*	*
Nymphalidae	*Adelpha*	*bredowii*	*	*
Nymphalidae	*Asterocampa*	*celtis COMPLEX*	*	*
Nymphalidae	*Basilarchia*	*archippus*	*	*
Nymphalidae	*Basilarchia*	*weidemeyerii*	*	*
Nymphalidae	*Cercyonis*	*oetus*		*
Nymphalidae	*Cercyonis*	*pegala*	*	*
Nymphalidae	*Cercyonis*	*sthenele (incl sylvestris)*	*	*
Nymphalidae	*Chlosyne*	*acastus COMPLEX (incl neumoegeni)*	*	*
Nymphalidae	*Chlosyne*	*californica*	*	*
Nymphalidae	*Chlosyne*	*lacinia*	*	*
Nymphalidae	*Chlosyne*	*palla (incl sterope)*	*	
Nymphalidae	*Coenonympha*	*california*	*	
Nymphalidae	*Coenonympha*	*ochracea*	*	*
Nymphalidae	*Coenonympha*	*tullia COMPLEX*	*	*
Nymphalidae	*Cyllopsis*	*pertepida*	*	*
Nymphalidae	*Danaus*	*gilippus*	*	*
Nymphalidae	*Danaus*	*plexippus*	*	*
Nymphalidae	*Dione (Agraulis)*	*vanillae*	*	
Nymphalidae	*Euphydras*	*anicia*	*	*
Nymphalidae	*Euphydras*	*chalcedona*	*	
Nymphalidae	*Euphydras*	*chalcedona/colon COMPLEX*	*	
Nymphalidae	*Euphydras*	*editha*		*
Nymphalidae	*Euptoieta*	*claudia*	*	*
Nymphalidae	*Junonia*	*coenia*	*	*
Nymphalidae	*Junonia*	*nigrosuffusa (species affiliation still uncertain)*	*	*
Nymphalidae	*Neominois*	*ridingsii*		*
Nymphalidae	*Nymphalis*	*antiopa*	*	*
Nymphalidae	*Nymphalis*	*californica*	*	*
Nymphalidae	*Nymphalis (Aglais)*	*milberti*	*	*
Nymphalidae	*Oeneis*	*chryxus COMPLEX (excl ivallda)*		*
Nymphalidae	*Phyciodes*	*campestris (= pratensis)*		*
Nymphalidae	*Phyciodes*	*mylitta*	*	
Nymphalidae	*Phyciodes*	*pallidus*	*	*

Table 3 continued. Butterflies and skippers reported from Clark and Lincoln counties, Nevada (Stanford and Opler 1999).

Family	Genus	Species	Clark	Lincoln
Nymphalidae	*Phyciodes*	*phaon*	*	
Nymphalidae	*Phyciodes*	*selenis (pascoensis, type B)*	*	
Nymphalidae	*Phyciodes*	*texana*	*	*
Nymphalidae	*Phyciodes*	*tharos (strict sense)*	*	
Nymphalidae	*Phyciodes*	*tharos COMPLEX*	*	
Nymphalidae	*Poladryas*	*arachne*	*	*
Nymphalidae	*Poladryas*	*minuta COMPLEX*	*	*
Nymphalidae	*Polygonia*	*gracilis (incl zephyrus)*	*	*
Nymphalidae	*Polygonia*	*satyrus*	*	*
Nymphalidae	*Speyeria*	*callippe (incl nevadensis)*		*
Nymphalidae	*Speyeria*	*nokomis*		*
Nymphalidae	*Speyeria*	*zerene*	*	*
Nymphalidae	*Thessalia*	*leanira (incl alma)*	*	*
Nymphalidae	*Vanessa*	*annabella*	*	*
Nymphalidae	*Vanessa*	*atalanta*	*	*
Nymphalidae	*Vanessa*	*cardui*	*	*
Nymphalidae	*Vanessa*	*virginiensis*	*	*
Papilionidae	*Battus*	*philenor*	*	*
Papilionidae	*Papilio*	*bairdii (all records)*	*	*
Papilionidae	*Papilio*	*bairdii, black form*		
Papilionidae	*Papilio*	*cresphontes*	*	
Papilionidae	*Papilio*	*indra*	*	*
Papilionidae	*Papilio*	*multicaudatus*	*	*
Papilionidae	*Papilio*	*polyxenes coloro (=rudkini), black form clarki*	*	
Papilionidae	*Papilio*	*polyxenes coloro (=rudkini), yellow & black forms*	*	*
Papilionidae	*Papilio*	*rutulus*	*	*
Papilionidae	*Papilio*	*zelicaon, yellow (incl gothica)*		*
Pieridae	*Anthocharis*	*cethura*	*	*
Pieridae	*Anthocharis*	*pima*	*	*
Pieridae	*Anthocharis*	*sara COMPLEX*	*	*
Pieridae	*Colias*	*alexandra, yellow morphs*	*	*
Pieridae	*Colias*	*eurytheme*	*	*
Pieridae	*Colias*	*philodice*	*	*
Pieridae	*Colias (Zerene)*	*cesonia*	*	*
Pieridae	*Euchloe*	*hyantis COMPLEX*	*	*
Pieridae	*Eurema*	*boisduvaliana*	*	
Pieridae	*Eurema*	*mexicana*	*	*
Pieridae	*Eurema*	*nicippe*	*	*
Pieridae	*Eurema*	*nise*	*	
Pieridae	*Nathalis*	*iole*	*	*

Table 3 continued. Butterflies and skippers reported from Clark and Lincoln counties, Nevada (Stanford and Opler 1999).

Family	Genus	Species	Clark	Lincoln
Pieridae	*Neophasia*	*menapia*	*	*
Pieridae	*Phoebis*	*agarithe*	*	
Pieridae	*Phoebis*	*philea*	*	
Pieridae	*Phoebis*	*sennae*	*	*
Pieridae	*Pieris*	*rapae*	*	*
Pieridae	*Pontia*	*beckerii*	*	*
Pieridae	*Pontia*	*occidentalis*		*
Pieridae	*Pontia*	*protodice*	*	*
Pieridae	*Pontia*	*sisymbrii*	*	*
Riodinidae	*Apodemia*	*mormo*	*	*
Riodinidae	*Apodemia*	*palmerii*	*	*
Riodinidae	*Calephelis*	*nemesis (incl guadeloupe)*	*	*
Riodinidae	*Calephelis*	*wrighti*	*	

Table 4. Mosquitoes of Clark and Lincoln counties, Nevada (Darcie and Ward 1981; Polhemus and Polhemus, 2002).

Genus	Species	Clark	Lincoln
Aedes	*campestris*		*
Aedes	*cataphylla*	*	*
Aedes	*cinereus*		*
Aedes	*dorsalis*	*	*
Aedes	*fitchii*	*	*
Aedes	*increpitus*		*
Aedes	*melanimon*	*	*
Aedes	*nigromaculis*	*	*
Aedes	*niphadopsis*		*
Aedes	*schizopinax*		*
Aedes	*vexans*	*	*
Anopheles	*franciscanus*	*	*
Anopheles	*freeborni*	*	*
Culex	*apicalis*		*
Culex	*erythrothorax*	*	*
Culex	*quinquefasciatus*	*	*
Culex	*tarsalis*	*	*
Culex	*thriambus*	*	*
Culiseta	*alaskensis*		*
Culiseta	*impatiens*		*
Culiseta	*incidens*	*	*
Culiseta	*inornata*	*	*
Psorophora	*columbiae*	*	
Psorophora	*signipennis*	*	*
Uranotaenia	*anhydor* Complex		*

Table 5. Regional herpetofauna observed within the vicinity of the Muddy River basin (Tanner, 1978) and amphibian and reptile species of concern according to the MSHCP (Clark County, 2000).

Regional Taxa	Clark County MSHCP Taxa
Ambystoma tigrinum	Relict leopard frog
Bufo microscaphus	Banded gecko
Bufo punctatus	California kingsnake
Bufo woodhousei	Desert iguana
Cnemidophorus tigris	Desert tortoise
Crotalus mitchellii	Glossy snake
Crotalus viridis abyssus	Great Basin collared lizard
Eumeces skittonianus	Large-spotted leopard lizard
Gopherus agassizi	Mojave green rattlesnake
Hyla arenicolor	Sonoran lyre snake
Hyla regilla	Speckled rattlesnake
Rana catesbiana	Western chuckwalla
Sauromalus obesus	Western leaf-nosed snake
Sceloporus magister	Western long-nosed snake
Sceloporus occidentalis	Western red-tailed skink
Sceloporus sp.	
Thamnophis elegans	
Uta stansburiana	
Xantusia vigilis	

Table 6. Mammals of the Muddy River basin (data from Hall, 1995 and Williams in TNC, 2002).

Order	Family	Genus	Species	Subspecies
Chiroptera	Molossidae	*Tadarida*	*mexicana*	
Chiroptera		*Euderma*	*maculatum*	
Chiroptera		*Lasiurus*	*blossevillii*	
Chiroptera		*Lasiurus*	*xanthinus*	
Chiroptera		*Lasiurus*	*cinereus*	
Chiroptera		*Macrotus*	*califonicus*	
Chiroptera		*Nyctinomops*	*macrotis*	
Chiroptera	Vespertilionidae	*Antrozous*	*pallidus*	*pallidus*
Chiroptera	Vespertilionidae	*Corynorhinus*	*rafinesquii*	*palescens*
Chiroptera	Vespertilionidae	*Eptesicus*	*fuscus*	*pallidus*
Chiroptera	Vespertilionidae	*Lasionycteris*	*noctivagans*	
Chiroptera	Vespertilionidae	*Myotis*	*californicus*	*pallidus*
Chiroptera	Vespertilionidae	*Myotis*	*yumanensis*	*yumanensis*
Chiroptera	Vespertilionidae	*Myotis*	*thysanodes*	
Chiroptera	Vespertilionidae	*Pipistrellus*	*hesperus*	*hesperus*
Carnivora	Bassariscidae	*Bassariscus*	*astutus*	*nevadensis*
Carnivora	Canidae	*Canis*	*latrans*	*estor*
Carnivora	Canidae	*Urocyon*	*cinereoargenteus*	
Carnivora	Canidae	*Vulpes*	*macrotis*	*arsipus*
Carnivora	Felidae	*Lynx*	*rufus*	*baileyi*
Carnivora	Mustellidae	*Mephitis*	*mephitis*	*estor*
Carnivora	Mustellidae	*Mustella*	*frenata*	*nevadensis*
Carnivora	Mustellidae	*Spilogale*	*gracilis*	*gracilis*
Carnivora	Mustellidae	*Taxidea*	*taxus*	*berlandieri*
Carnivora	Procyonidae	*Procyon*	*lotor*	*pallidus*
Rodentia	Castoridae	*Castor*	*canadensis*	*repentinus*
Rodentia	Cricetidae	*Neotoma*	*cinera*	*acraia*
Rodentia	Cricetidae	*Neotoma*	*ledpida*	*ledpida*
Rodentia	Cricetidae	*Onychomys*	*torridus*	*longicaudus*
Rodentia	Cricetidae	*Peromyscus*	*boylii*	*rowleyi*
Rodentia	Cricetidae	*Peromyscus*	*crinitus*	*stephensi*
Rodentia	Cricetidae	*Peromyscus*	*eremicus*	*eremicus*
Rodentia	Cricetidae	*Peromyscus*	*maniculatus*	*sonoriensis*
Rodentia	Cricetidae	*Peromyscus*	*truei*	*truei*
Rodentia	Cricetidae	*Reithrodontomys*	*megalotis*	*megalotis*
Rodentia	Erithizontidae	*Erethizon*	*dorsatum*	*couesi*
Rodentia	Erithizontidae	*Erethizon*	*dorsatum*	*epixanthum*
Rodentia	Heteromyidae	*Dipodomys*	*deserti*	*deserti*
Rodentia	Heteromyidae	***Dipodomys***	*merriami*	*merriami*
Rodentia	Heteromyidae	***Perognathus***	*formosus*	*mohavensis*

Table 6 continued. Mammals of the Muddy River basin (data from Hall, 1995 and Williams in TNC, 2002).

Order	Family	Genus	Species	Subspecies
Rodentia	Heteromyidae	*Perognathus*	*longimembris*	*virginis*
Rodentia	Geomyidae	*Thomomys*	*bottae*	*centralis*
Rodentia	Sciuridae	*Ammospermophilus (Citellus)*	*leucurus*	*leucurus*
Rodentia	Sciuridae	*Ammospermophilus (Citellus)*	*variegatus*	*grammurus*
Lagomorpha	Leporidae	*Lepus*	*californicus*	*deserticola*
Lagomorpha	Leporidae	*Sylvilagus*	*audubonii*	*arizonae*
Artiodactyla	Bovidae	*Ovis*	*canadensis*	*nelsoni*

Appendix C

Species of Concern

Table 1. Sensitive species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
e G2 S2	**Bryophytes**	*Crossidium seriatum*	W	seriate crossidium
e G2G3 S1 n		*Didymodon nevadensis*	W	
e G1 S1		*Grimmia americana*	W	American grimmia
e G2? S1		*Trichostomum sweetii*	W	Sweet trichostomum
e G2G3 xC2 sc	**Pteridophytes**	*Botrychium ascendens*	W W	upswept moonwort
G3 xC2 n si S1?		*Botrychium crenulatum*	W W	dainty moonwort
e G2G3 SH		*Selaginella utahensis*	W	Utah spikemoss
E G2 xC2 n s S2	**Flowering Dicots**	*Angelica scabrida*	T W Y	rough angelica
E G1G2 xC2 s S1S2		*Antennaria soliceps*	W Y	Charleston pussytoes
e G3 xC2 s S3		*Arctomecon californica*	CE T	Las Vegas bearpoppy
G3 xC2 n s S3		*Arctomecon merriamii*	W	white bearpoppy
T2? G5 S2?		*Arenaria congesta var. charlestonensis*	W	Mount Charleston sandwort
E T2G4 xC2 s S2		*Arenaria kingii ssp. rosea*	W Y	rosy King sandwort
G2 S2		*Arenaria stenomeres*	W Y	Meadow Valley sandwort
G2 S2		*Astragalus ackermanii*	W Y	Ackerman milkvetch
E G2 xC2 n s S2		*Astragalus aequalis*	W Y	Clokey milkvetch
T2G5 xC2 n S2		*Astragalus amphioxys var. musimonum*	W	Sheep Range milkvetch
T2Q G5 S2		*Astragalus calycosus var. monophyllidius*	W	one-leaflet Torrey milkvetch
G2 xC2 n s S2		*Astragalus funereus*	W	black woollypod
T2T3G4? xC2 s S2S3		*Astragalus geyeri var. triquetrus*	CE T S	threecorner milkvetch
e T3?G5 I S1		*Astragalus lentiginosus var. kernensis*	W	Kern Plateau milkvetch
T2T3G5 S1S2		*Astragalus lentiginosus var. stramineus*	W s	straw milkvetch
T2T3G3 xC2 s s S2S3		*Astragalus mohavensis var. hemigyrus*	CE E Y	halfring milkvetch
e G2G3Q n S1S21		*Astragalus mokiacensis*	W	Mokiak milkvetch
G3 S3		*Astragalus nyensis*	D	Nye milkvetch
T2G4 RA s s S2		*Astragalus oophorus var. clokeyanus*	W Y	Clokey eggvetch
E G2 xC2 n s S2		*Astragalus remotus*	W Y	Spring Mountains milkvetch

Table 1 continued. Sensitive species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
G1 xC2 n S1	**Flowering Dicots contd.**	*Chrysothamnus eremobius*	W Y	remote rabbitbrush
E G2G3 S2S3		*Cirsium clokeyi*	D Y	Clokey thistle
e G2 xC2 S1		*Cirsium virginense*	W W	Virgin River thistle
E GHQ xC2* s SH		*Cryptantha insolita*	CE PE Y	Las Vegas catseye
e G1G2 S1		*Draba brachystylis*	W w	Wasatch draba
E G2 xC2 s S2		*Draba jaegeri*	W Y	Jaeger whitlowcress
E G1G2 xC2 s S1S2		*Draba paucifructa*	W w Y	Charleston draba
e G2G3 n S1?		*Enceliopsis argophylla*	W	silverleaf sunray
G2 xC2 n s S2		*Epilobium nevadense*	W	Nevada willowherb
G3? S1		*Ericameria cervina*	W	Antelope Canyon goldenbush
E G2? s S2?		*Ericameria compacta*	W Y	Charleston goldenbush
G2 xC2 n S2		*Erigeron ovinus*	W Y	sheep fleabane
G2 xC2 n S2		*Eriogonum bifurcatum*	T	Pahrump Valley buckwheat
T2G5 n s S2		*Eriogonum heermannii var. clokeyi*	W Y	Clokey buckwheat
G2 xC2 s S2		*Eriogonum viscidulum*	CE T S	sticky buckwheat
E G2 xC2 s S2		*Glossopetalon clokeyi*	W Y	Clokey greasebush
e T1QG2G3 xC2 n s S1		*Glossopetalon pungens var. glabrum*	W	smooth dwarf greasebush
T2QG2G3 n S2		*Glossopetalon pungens var. pungens*	W Y	rough dwarf greasebush
G2G3Q S2		*Helianthus deserticola*	W S	dune sunflower
E G1 n S1		*Ionactis caelestis*	W Y	Red Rock Canyon aster
E G2 xC2 s S2		*Ivesia cryptocaulis*	W Y	hidden ivesia
e G2G3 xC2 n s S2S3		*Ivesia jaegeri*	W	Jaeger ivesia
e T1G4? c S1?		*Lotus argyraeus var. multicaulis*	W	scrub lotus
E T1QG4? RI s S1		*Opuntia whipplei var. multigeniculata*	CE T Y CY	Blue Diamond cholla
e G3 xC2 S3		*Pediomelum castoreum*	W	Beaver Dam breadroot
G2 xC2 n S2		*Penstemon albomarginatus*	T S	white-margined beardtongue
E T2QG3 xC2 n s S2		*Penstemon bicolor ssp. bicolor*	W Y	yellow twotone beardtongue
T3QG3 xC2 s S3		*Penstemon bicolor ssp. roseus*	W	rosy twotone beardtongue

Table 1 continued. Sensitive species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
? T3G4 xC2 n s S2		*Penstemon fruticiformis ssp. amargosae*	T	Death Valley beardtongue
E T2G3 S2		*Penstemon leiophyllus var. keckii*	W Y	Charleston beardtongue
E T2G4 S2		*Penstemon thompsoniae ssp. jaegeri*	W Y	Jaeger beardtongue
G2 S2		*Phacelia filiae*	W Y	Clarke phacelia
G2G3 xC2 n S2S3		*Phacelia parishii*	W W	Parish phacelia
G2 xC2 n S2		*Porophyllum pygmaeum*	W Y	pygmy poreleaf
E T3G5 xC2 n s S3		*Salvia dorrii var. clokeyi*	W Y	Clokey mountain sage
E G2 xC2 s S2		*Silene clokeyi*	W Y	Clokey catchfly
E G2 S2 s		*Sphaeromeria compacta*	W Y	Charleston tansy
E G2G3 s S2S3		*Synthyris ranunculina*	W W Y	Charleston kittentails
T3G4 xC2 n s S3		*Townsendia jonesii var. tumulosa*	W Y	Charleston grounddaisy
e G3Q S2S3		*Viola charlestonensis*	W W	Charleston violet
G2 xC2 nc c S1	**Flowering Monocots**	*Calochortus striatus*	W	alkali mariposa lily
E G1G2 xC2 S1S2	**Mollusks**	*Pyrgulopsis avernalis*	W Y	Moapa pebblesnail
E G1 S1		*Pyrgulopsis carinifera*	W Y	Moapa Valley springsnail
E GH SH		*Pyrgulopsis coloradensis*	W Y	Blue Point springsnail
G1 S1		*Pyrgulopsis deaconi*	W Y	Spring Mountains springsnail
E G1 S1		*Pyrgulopsis fausta*	W Y	Corn Creek springsnail
G3 xC2 n S2		*Pyrgulopsis micrococcus*	W	Oasis Valley springsnail
G2 S2		*Pyrgulopsis turbatrix*	W	southeast Nevada springsnail
G2 xC2 n S2		*Tryonia clathrata*	W Y	grated tryonia
E G1? S1	**Insects**	*Aegialia knighti*	S Y	aegialian scarab beetle
T1G4G5 n S1		*Chlosyne acastus robusta*	Y	Spring Mountains acastus checkerspot
T2G5 n S1S2		*Euphilotes ancilla purpura*	Y	Spring Mountains dark blue
T3G3G4 S2		*Euphilotes bernardino inyomontana*		Bret's blue (Spring Mtns phenotype)
E T2G5 xC2 S2		*Euphydryas anicia morandi*	Y	Morand's checkerspot

Table 1 continued. Sensitive species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
T3G5 xC2 n S3		*Hesperia colorado mojavensis*	Y	Spring Mountains comma skipper
e G2G3 xC2 n S1		*Hesperopsis gracielae*		MacNeill's sooty wing
E T2G5 xC2 n S2		*Icaricia icarioides austinorum*	Y	Spring Mountains icarioides blue
E T2G5 xC2 S2		*Icaricia shasta charlestonensis*	Y	Spring Mountains blue
E G1? S1		*Lasius nevadensis*	Y	endemic ant
T2T3G5 xC2 n S2S3		*Limenitis weidemeyerii nevadae*	Y	Nevada admiral
E G1 S1		*Limnocoris moapensis*	W Y	Warm Springs naucorid
T1G1G3 n S1		*Pelocoris shoshone shoshone*	Y	Pahranagat naucorid bug
E G2G3 xC2 S2S3		*Speyeria carolae*	Y	Carole's silverspot
G1 xC2 n S1		*Stenelmis moapa*	W Y	Moapa Warm Spring riffle beetle
e G3G4 xC2 n S1	**Fish**	*Catostomus latipinnis*	W	flannelmouth sucker
E T2G2 xC2 S2		*Crenichthys baileyi moapae*	yes W Y	Moapa White River springfish
G1 LE s S1		*Cyprinodon diabolis*	yes W Y	Devils Hole pupfish
T1G1 LEPT s S1		*Empetrichthys latos latos*	yes W Y	Pahrump poolfish
G1 LE s e S1		*Gila elegans*	yes W	bonytail chub
e G1 LE s S1		*Gila seminuda*	yes W	Virgin River chub
E T1QG1 LE p S1		*Gila seminuda pop*	yes W Y	Virgin River chub
e T1G1 n S1		*Lepidomeda mollispinis mollispinis*	yes W	Virgin River spinedace
G1 LE s S1		*Moapa coriacea*	yes W Y	Moapa dace
e G1 LEXN s S1		*Plagopterus argentissimus*	yes W	woundfin
E T1G5 xC2 p S1		*Rhinichthys osculus moapae*	yes W Y	Moapa speckled dace
e G1 LE s e S1		*Xyrauchen texanus*	yes W	razorback sucker
G3G4 n S1S2	**Amphibians**	*Bufo microscaphus*	W	southwestern toad
e G1 C S1		*Rana onca*	yes W	relict leopard frog
G4 LTNL s t S4	**Reptiles**	*Gopherus agassizii*	yes	desert tortoise
T4G4 xC2N s S2 L		*Heloderma suspectum cinctum*	yes	banded Gila monster

Table 1 continued. Sensitive species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
G4 n siS3B	**Mammals**	*Corynorhinus townsendii*		Townsend's big-eared bat
G4 xC2 s s S1S2		*Euderma maculatum*	yes	spotted bat
e T4G5 xC2 n S1		*Eumops perotis californicus*		greater western mastiff bat
e G3G4 xC2 n S1		*Idionycteris phyllotis*		Allen's big-eared bat
e G5 S1		*Lasiurus xanthinus*		western yellow bat
e T1G5 SH		*Lutra canadensis sonora*	yes W	southwestern otter
e G4 xC2 n cS2		*Macrotus californicus*		California leaf-nosed bat
G5 S3B		*Myotis californicus*		California myotis
G5 xC2 n S3B		*Myotis ciliolabrum*		western small-footed myotis
T3T4G5 xC2 S1		*Myotis lucifugus occultus*		occult myotis
G4G5 xC2 n S2B		*Myotis thysanodes*		fringed myotis
e G5 xC2 n S1		*Myotis velifer*		cave myotis
e G5 xC2 n S1N		*Nyctinomops macrotis*		big free-tailed bat
E G2 xC2 S2		*Tamias palmeri*	Y	Palmer's chipmunk
E THG5 xC2 SH		*Tamias umbrinus nevadensis*	Y	Hidden Forest Uinta chipmunk
TUG4 xC2 p S3B	**Birds**	*Athene cunicularia hypugaea*	yes	Western Burrowing Owl
G4 xC2 p S3		*Buteo regalis*	yes	Ferruginous Hawk
T3G5 C s I S1B		*Coccyzus americanus occidentalis*	yes W	Western Yellow-billed Cuckoo
e T1T2G5 LE s e S1B		*Empidonax traillii extimus*	yes W	Southwestern Willow Flycatcher
G4 LENL s e S2		*Falco peregrinus*	yes	Peregrine Falcon
T2T3G5 xC2 S2N		*Ixobrychus exilis hesperis*	yes W	Western Least Bittern
G4 p s S4?B		*Otus flammeolus*	yes	Flammulated Owl
G5 n S2B		*Phainopepla nitens*	yes	Phainopepla
T?G5 LE S1		*Rallus longirostris yumanensis*	yes W	Yuma Clapper Rail

Table 2. Watch List species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

WATCH-LIST TAXA

Status	Order	Scientific Name		Common Name
? G1 C c SP	**Plants - Pteridophytes (fern allies)**	*Botrychium lineare*	W W	slender moonwort
G3 S2	**Plants - Gymnosperms (conifers)**	*Ephedra funerea*	D	Death Valley Mormon tea
T3T4G4 i S1?	**Plants - Flowering Dicots**	*Abronia nana ssp. covillei*		Coville abronia
G3 ci S3		*Arabis shockleyi*	D	Shockley rockcress
T3?G3 S2S3		*Astragalus mohavensis var. mohavensis*		Mojave milkvetch
e T2T3G4 S1S2		*Astragalus preussii var. laxiflorus*	s	Lancaster milkvetch
T3QG3Q S3		*Castilleja martinii var. clokeyi*	D	Clokey paintbrush
G4? s S2		*Cryptantha tumulosa*	W	New York Mountains catseye
G4G5T4T5 S3		*Dudleya pulverulenta ssp. arizonica*		chalk liveforever
T3?G3G4 S3?		*Erigeron uncialis var. conjugans*	D Y	Charleston fleabane
G2? S1		*Eriogonum contiguum*	D	Amargosa buckwheat
e T3?QG5 n S1S2		*Eriogonum corymbosum var. glutinosum*	W	Las Vegas buckwheat
e G4G5 S1		*Eustoma exaltatum*	M W	catchfly gentian
T4?G5 s S4		*Ferocactus cylindraceus var. lecontei*	CY	Mojave barrel cactus
G3 S3		*Gilia ripleyi*	D	Ripley gilia
G3 S3		*Lesquerella hitchcockii*	D Y	Hitchcock bladderpod
G3? S3		*Linanthus arenicola*	D S	dune linanthus
e T3?G4 n S2S3		*Lomatium graveolens var. alpinum*	D	Alpine stinking lomatium
T3T4G5 S3		*Machaeranthera grindelioides var. depressa*	D	rayless tansy aster
G3 S3		*Mirabilis pudica*	D Y	bashful four-o'clock
E T3QG4 xC2 S3		*Pedicularis semibarbata var. charlestonensis*	D Y	Charleston pinewood lousewort
G3Q S3		*Perityle intricata*	D P	desert rockdaisy

Table 2 continued. Watch List species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
G2G3 S1S2	**Plants - Flowering Dicots**	*Phacelia anelsonii*	D	Aven Nelson phacelia
T3T4G5 S3S4		*Phacelia hastata var. charlestonensis*	Y	Spring Mountains phacelia
G3G4 S2		*Phacelia petrosa*	W	rock phacelia
T3QG4 S3	**Plants - Flowering Monocots**	*Agave utahensis var. eborispina*	D	ivory-spined agave
T3QG4 S3		*Agave utahensis var. nevadensis*	D	Clark Mountain agave
e G? S?	**Insects**	*Haliplus eremicus*	W	Warm Springs crawling water beetle
G4 S1S2		*Stenelmis occidentalis*	W	riffle beetle
G5 xC2 n S3S4	**Reptiles**	*Sauromalus obesus*		common chuckwalla
G5 i S3B	**Mammals**	*Antrozous pallidus*		pallid bat
G5 S2		*Chaetodipus penicillatus*		desert pocket mouse
e G5 S3		*Chaetodipus spinatus*		spiny pocket mouse
e G4 xC2 SA		*Choeronycteris mexicana*		Mexican long-tongued bat
G5 S3N		*Lasionycteris noctivagans*		silver-haired bat
G5 i S?		*Lasiurus blossevillii*		western red bat
G5 S3?		*Lasiurus cinereus*		hoary bat
G5 xC2 n S4B		*Myotis evotis*		long-eared myotis
G5 xC2 n S4B		*Myotis volans*		long-legged myotis
G5 xC2 n S4B		*Myotis yumanensis*		Yuma myotis
G3G4 S2		*Sorex tenellus*		Inyo shrew
G5 S4B		*Tadarida brasiliensis*		Brazilian free-tailed bat
G5 p S4	**Birds**	*Aquila chrysaetos*	yes	Golden Eagle
G2 PT s SZN		*Charadrius montanus*	yes	Mountain Plover

Table 2 continued. Watch List species of Clark County, Nevada (data from Nevada Natural Heritage Program 2002). See Appendix D for abbreviations used for status designations and standard global (G-ranking) and state (S-ranking) criteria.

Status	Order	Scientific Name		Common Name
G5 p S3B	**Birds**	*Dendroica petechia*	yes W	Yellow Warbler
G5 p S3B		*Geothlypis trichas*	yes W	Common Yellowthroat
G5 p S3B		*Icteria virens*	yes	Yellow-breasted Chat
G4 LENL s SAN		*Mycteria americana*	yes W	Wood Stork
e G4 LENL s SAN		*Sterna antillarum*	yes W	Least Tern
G4 p S3S4B		*Vireo vicinior*	yes	Gray Vireo

Table 3. Clark County Multiple Species Conservation Plan (2000) covered species.

Covered Species
Alkali mariposa lily
Anacolia menziesii
Blue Diamond cholla
Charleston beardtongue
Charleston draba
Charleston grounddaisy
Charleston kittentails
Charleston pinewood lousewort
Charleston pussytoes
Charleston tansy
Claopodium whippleanum
Clokey catchfly
Clokey eggvetch
Clokey greasebush
Clokey milkvetch
Clokey mountain sage
Clokey paintbrush
Dicranoweisia crispula
Forked (Pahrump Valley) buckwheat
Hidden ivesia
Hitchcock bladderpod
Inch high fleabane
Jaeger beardtongue
Jaeger ivesia
Jaeger whitlowgrass
Las Vegas bearpoppy
Limestone violet
Parish's phacelia
Pungent dwarf greasebush
Red Rock Canyon aster
Rosy king sandwort
Rough angelica
Sidewinder Clokey thistle
Smooth pungent (dwarf) greasebush
Spring Mountains milkvetch
Sticky buckwheat
Sticky ringstem
Syntrichia princeps
Threecorner milkvetch
White bearpoppy
White-margined beardtongue

Table 3. Clark County Multiple Species Conservation Plan (2000) covered species.

Covered Species
Carole's silverspot butterfly
Dark blue butterfly
Morand's checkerspot butterfly
Mt. Charleston blue butterfly
Nevada admiral
Southeast Nevada springsnail
Spring Mountains acastus checkerspot
Spring Mountains comma skipper
Spring Mountains icarioides blue
Spring Mountains springsnail
Relict leopard frog
Banded gecko
California kingsnake
Desert iguana
Desert tortoise
Glossy snake
Great Basin collared lizard
Large-spotted leopard lizard
Mojave green rattlesnake
Sonoran lyre snake
Speckled rattlesnake
Western chuckwalla
Western leaf-nosed snake
Western long-nosed snake
Western red-tailed skink
American peregrine falcon
Arizona bell's vireo
Blue grosbeak
Phainopepla
Southwestern willow flycatcher
Summer tanager
Vermilion flycatcher
Yellow-billed cuckoo
Long-eared myotis
Long-legged myotis
Palmer's chipmunk
Silver-haired bat

Appendix D

Key to Listing Status for Species of Concern

SYMBOL AND DATA DEFINITIONS

U. S. Fish and Wildlife Service (USFWS) Categories for Listing under the Endangered Species Act (ESA) (USESA) (see also the USFWS http://endangered.fws.gov/Endangered Species Program web site):

LE	Listed Endangered - in danger of extinction in all or a significant portion of its range
LT	Listed Threatened - likely to be classified as Endangered in the foreseeable future if present trends continue
PE	Proposed Endangered
PT	Proposed Threatened
(PS)	Partial Status: a subspecies or a portion of a taxon's range has listed or candidate status, but not in Nevada.
C	Candidate for listing as threatened or endangered, sufficient data on vulnerability or threats on file
XE	Essential experimental population
XN	Nonessential experimental population
_NL	Not Listed (no status) in a portion of the species' range
RA	Former Candidate or Proposed species; current information does not support proposal to list because species has proven more abundant or widespread, or to lack identifiable threats; still a "species of concern"
RI	Former Candidate or Proposed species; current information does not support proposal to list because species lacks sufficient evidence of vulnerability and threats; still a "species of concern"
xC1	Former Category-1 Candidate, now "species of concern"
xC2	Former Category-2 Candidate, now "species of concern"
_SA	Similarity of appearance species

Bureau of Land Management (BLM) Species Classification:

S	Nevada Special Status Species - USFWS listed, proposed or candidate for listing, or protected by Nevada state law
N	Nevada Special Status Species - designated Sensitive by State Office
P	Proposed Nevada Special Status Species - designated proposed Sensitive by State Office
C	California Special Status Species (see definitions S and N)

United States Forest Service (Usfs) Species Classification:

S	Region 4 (Humboldt-Toiyabe NF) sensitive species
I	Region 5 (Inyo NF) sensitive species
W	Region 5 (Inyo NF) watch species
P	Region 5 (Inyo NF) proposed watch or sensitive species
L	Region 5 (Lake Tahoe Basin Management Unit) sensitive species
C	Region 5 sensitive species, not yet known from Inyo NF or Lake Tahoe Basin Management Unit
E	Region 4 and/or Region 5 Endangered species
T	Region 4 and/or Region 5 Threatened species

Nevada Natural Heritage Program Global (Grank) and State (Srank) Ranks for Threats and/or Vulnerability:

G	Global rank indicator, based on worldwide distribution at the species level
T	Global trinomial rank indicator, based on worldwide distribution at the infraspecific level
S	State rank indicator, based on distribution within the state at the lowest taxonomic level
SE	State Exotic rank indicator, for taxa with only exotic occurrences within the state

_l	Critically imperiled due to extreme rarity, imminent threats, or and/or biological factors
_2	Imperiled due to rarity and/or other demonstrable factors
_3	Rare and local throughout its range, or with very restricted range, or otherwise vulnerable to extinction
_4	Apparently secure, though frequently quite rare in parts of its range, especially at its periphery
_5	Demonstrably secure, though frequently quite rare in parts of its range, especially at its periphery
_#_#	Range of uncertainty in a numeric rank (for example, G2G4 or S1S2)
_A	Accidental (casual or stray) within the state, usually far outside its normal range, seen infrequently and irregularly
_H	Historical occurrence(s) only, presumed still extant and could be rediscovered

Nevada Natural Heritage Program Global (Grank) and State (Srank) Ranks for Threats and/or Vulnerability (continued):

_P Potential in the state, but not yet reported or documented
_R Reported from the state, awaiting firm documentation
_U Unrankable; present and possibly in peril, but not enough data yet to estimate rank
_X Extirpated from the state (SX) or extinct (GX or TX)
_Z Zero definable occurrences in the state, and therefore not of practical conservation concern, although native and regularly found there (usually long-distance migrants without regular and repeating breeding sites)
_? Not yet ranked at the scale indicated (G, T, or S)
- __B Breeding status within the state; rank for breeding occurrences only
- __C Only in Captivity or Cultivation within the state
- __N Non-breeding status within the state; rank for non-breeding occurrences only
- __Q Taxonomic status Questionable or uncertain
- __? Assigned rank inexact or uncertain

Trend (Trnd) (Tr) of historic Nevada population (blank if not possible to estimate):
\\ Declining rapidly
\ Declining
= Stable
+ Increasing
__? Trend estimated or inferred

Nevada (NV) state protected (State) Species Classification:
Fauna:
YES Species protected under NRS 501.
Flora:
CE Critically endangered - species threatened with extinction, whose survival requires assistance because of overexploitation, disease or other factors or because their habitat is threatened with destruction, drastic modification or severe curtailment (N.R.S. 527.260-.300)
CE# Recommended for listing as critically endangered
CY Protected as a cactus, yucca, or Christmas tree (N.R.S. 527.060-.120)

Endemic (End) status (see separate list of endemic species):
Y Found naturally only in the State of Nevada
P Probable endemic of Nevada

Occurrence Status (Occ) status:
(blank) known or presumed to be present currently and historically in a county or state
- Absent, not known to be present currently or historically in a county or state
? Possible or predicted to occur in a county or state, but not yet verified
e Endemic within a state, known statewide currently and historically only from this county
E Endemic, known worldwide currently and historically only from this county or state
I Introduced or re-introduced, no natural populations currently known from a county or state
X Extirpated, no populations remain in a county or state

Nevada Native Plant Society (NNNPS) (2N) (3NPS) (3N) Status:
A Absent currently and historically from Nevada, previously with another status but not now of concern
D Delisted, dropped from consideration, no longer of concern to NNNPS
E Endangered, believed to meet the ESA definition of endangered
M Marginal/Disjunct, rare and/or possibly distinct, and potentially vulnerable, in the Nevada portion of its range, but much more widespread and secure outside Nevada.
PE Possibly Extirpated, historically native to Nevada, but may no longer survive in the wild
T Threatened, believed to meet the ESA definition of threatened
W Watch-list species, potentially vulnerable to becoming Threatened or Endangered

Precision (Prec), or confidence level, of the mapped coordinates of a species-location record:

S	Seconds - within 3 seconds of latitude and longitude, or about 0.06 mile (0.1 km), of the true location
M	Minute - within 1 minute of latitude and longitude, or about 1 mile (1.6 km), of the true location
G	General - within about 5 miles (8 km) of the true location, or to map quadrangle, township, or place-name precision only
U	Unmappable - insufficient information for even General-level precision

Element (sensitive taxon) Occurrence Records (EORs) mapped and computerized in Nevada; additional records may be currently unprocessed or may exist for adjacent states:

Ext	Computerized EORs assumed extant (or Extnt), generally separated by at least 0.16 km
Extir	Computerized EORs known extirpated (or Extrp), generally separated by at least 0.16 km
1km-#	Computerized EORs assumed extant and separated by at least 1.0 km

Site Biodiversity Significance (B) Rank: (see also definitions of G, T, and S ranks)

1	Outstanding significance (only known or highest quality population of a G1 or T1 taxon; concentration of higher quality G1/T1, G2/T2, or declining taxa).
2	Very high significance (lower quality G1/T1; higher quality G2/T2 or G3/T3; concentration of moderate quality G2/T2, G3/T3, or declining taxa).
3	High significance (lower quality G2/T2; higher quality G3/T3; concentration of high quality S1 taxa).
4	Moderate significance (lower quality G3/T3; higher quality or only S1 population; highest quality S2; concentration of higher quality S2 or S3s).
5	Of general biodiversity interest or open space.

Site Protection Urgency (P) Rank:

1	Good chance of being immediately threatened (within 1 year of rank date) by severely destructive forces.
2	Threat expected within 5 years.
3	Definable threat, but not in next 5 years.
4	No threat known for foreseeable future.
5	Land protection complete or adequate reasons exist not to protect the site.

Site Management Urgency (M) Rank:

1	Loss or irretrievable degradation of populations could occur within 1 year without immediate new, or ongoing annual, management.
2	Loss of populations could occur within 5 years without new or ongoing management action.
3	Quality of populations could degrade within 5 years without new or ongoing management action.
4	Although not currently threatened, management may be needed in the future to maintain current quality of populations.
5	No serious management needs known or anticipated at site.

Site Code: Nevada Natural Heritage Program internal code for a site.
Elevation (Elev): range in feet for all extant Nevada occurrences of the element or site.
Habitat Codes (Hab): dependence of a taxon on aquatic/wetland and/or deep-sand habitats in Nevada:

S	Taxon is dependent upon sand dunes or strongly associated with sand dunes (i.e. found on dune skirts or extensive deep-sand deposits).
s	Taxon is possibly dependent upon sand dunes or deep-sand deposits.
W	Taxon requires aquatic or wetland habitats (open water, or hydric vegetation and at least seasonally saturated soil) for its survival, either always or at one or more critical life stages.
w	Taxon is usually or always found around the margins of wetland habitats but does not directly use such habitats.

Maximum distance (Maxkm, in kilometers) (Max. Dist.): the greatest distance, in kilometers or miles, between any two extant Nevada occurrences of a taxon or site (to indicate the approximate size of the taxon range or site), excluding the most disjunct taxon occurrence when there are 4 or more occurrences.

Population Count (Popcount) (Census): The estimated total number of extant individuals (genets) or above-ground stems (ramets) recorded and computerized for a taxon in Nevada. The number usually reflects genets. Warning: census data are very incomplete, and/or very roughly estimated, for most taxa, and generally reflect major underestimates.

Area (Hectrs, in hectares): The total of the recorded and computerized land-area estimates, in acres or hectares, for the extant Nevada occurrences of a taxon. Warning: land-area data are very incomplete, and/or very roughly estimated, for most taxa.

Land Ownership Symbols (Owners) (Mgmt):
These symbolize the major land-management categories in which extant occurrences of a site or taxon are recorded in Nevada, roughly in descending order of dominance for the site or taxon. These cannot be guaranteed to be either complete or entirely accurate, and are intended only for general information purposes. Owners known are those for which we have documentation, and possible (or separated from known owners with +__?) are uncertain and/or nearby.

b	Bureau of Land Management (US Department of the Interior), Nevada resource areas.
c	County land or right-of-way.
d	US Department of Defense (Fallon, Hawthorne, Nellis, or Wendover).
e	US Department of Energy (primarily Nevada Test Site).
f	Forest Service (US Department of Agriculture), Humboldt-Toiyabe National Forest (Region 4).
i	Indian reservations and colonies.
k	National Park Service (US Department of the Interior; Death Valley, Great Basin, Lake Mead).
l	Wilderness areas (all agencies).
m	Municipal land or right-of-way.
n	State of Nevada (parks, transportation corridors, university, waters, wildlife management areas).
p	Private.
r	Bureau of Reclamation (US Department of the Interior).
s	Bureau of Land Management (US Department of the Interior), California resource areas (former Susanville District).
t	Forest Service (US Department of Agriculture), Lake Tahoe Basin Management Unit (Region 5).
w	Fish and Wildlife Service (US Department of the Interior; wildlife ranges and refuges).
y	Forest Service (US Department of Agriculture), Inyo National Forest (Region 5).

Years observed or surveyed (Year):
for taxa: most recent year of any Nevada survey record in database (above), followed by the average year of all Nevada survey records in database (below)
for sites: most recent year taxon was observed at site (above), followed by most recent year taxon was surveyed at site (below, or omitted if same as year observed)

Family: name of taxonomic family, abbreviated if necessary, including major group designations (where applicable) for pteridophytes (fern), bryophytes (moss), fungi (fungus), lichens (lichen), and algae (alga).

Months (Mnths): numeric range of up to the four most frequent months in the database in which a taxon has been observed, surveyed, or collected. Does not necessarily reflect particular life-cycle stage(s).

Distribution: Historic range of taxon. Nevada county and municipality symbols (below) are in upper/lower-case, other states and provinces are in bold upper-case following a forward slash (/) and using standard postal codes.

Cc	Carson City (former Ormsby County)
Ch	Churchill County
Cl	Clark County
Do	Douglas County
El	Elko County
Es	Esmeralda County
Eu	Eureka County
Hu	Humboldt County
La	Lander County
Li	Lincoln County
Ly	Lyon County
Mi	Mineral County
Ny	Nye County
Pe	Pershing County
St	Storey County
Wa	Washoe County
Wp	White Pine County
_?	Possible or probable occurrence(s) only
_!	Introduced occurrence(s) only
_#	Extirpated occurrence(s) only

Tracked (Track) by the Nevada Natural Heritage Program:

N	Not tracked as either a sensitive or watch-list species
W	Tracked as a watch-list species, data passively accumulated
Y	Tracked as a sensitive animal or plant, actively inventoried

9. Appendix II. Milestones #2 & 3 by Otis Bay, Inc—History of Water Developments and Basin and Sub-basin Characterization

Upper Muddy River
Geomorphic Assessment

History of Water Development and Channel Modification

Characterization of the Upper Muddy River

Prepared by
Otis Bay Inc
1049 South 475 West
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Report for Deliverables 2 and 3
June 30, 2003 – September 30, 2003

Prepared for
The Nature Conservancy
One East First Street
Reno, NV 89501

Table of Contents

Upper Muddy River Geomorphic Assessment

1.0 Introduction

This report is the second in a series on the geomorphic assessment of the Upper Muddy River (UMR). A brief history of water development and channel modification is provided in sections two and three, respectively. Preliminary geomorphic and biologic characterization of individual river segments within the UMR valley is presented in the fourth and fifth sections, respectively. The purpose of this report is to provide a brief history and a qualitative description of the UMR valley relative to the current form of the Muddy River channel. Information gathered during field characterization of the channel, such as relative entrenchment, bank stability, channel bed material, land use, and features of human influence adjacent to or within the channel will be used in the future to provide recommendations for restoration within the UMR valley.

2.0 History of Water Development

The Office of the State Engineer in the Nevada Division of Water Resources was created in 1903 to quantify and manage the groundwater resources of Nevada. Two laws, the General Water Law Act of 1913 and the 1939 Underground Water Act granted the State Engineer complete jurisdiction over all groundwater within the State of Nevada (SNWA, 2002). The Muddy River is located within the Colorado River Hydrographic Basin and contains two subareas; 1) Muddy River Springs Area and 2) Lower Moapa Valley. The Muddy River Springs Area and Lower Moapa Valley areas contain 58,240 (91 square miles) and 161,280 (252 square miles) acres, respectively. Both of these subareas are defined by the Nevada Division of Water Resources as Designated Groundwater Basins, a definition which indicates that the permitted groundwater rights within the subarea approach or exceed the annual recharge and that the resource is being depleted or requires additional administration (NDWR, 2003).

Groundwater discharging from the regional carbonate aquifer of the White River and Lower Meadow Valley Wash flow systems creates the springs within the UMR valley. A decline in Muddy River streamflow since the 1950s has been shown to be correlated with groundwater extraction and surface water diversion. Since 1998, a two feet decline in water surface elevation within the carbonate aquifer underlying the UMR as well as Coyote Spring Valley has been observed. Beginning in 2002, the Nevada State Engineer issued a five year abeyance on the granting of additional groundwater rights for the carbonate aquifer while additional groundwater studies and aquifer tests are completed (SNWA, 2002).

The development of water resources for agricultural purposes within the Muddy River basin began in the late 1800's. Established in 1920, the Muddy River Decree allocated the entire surface flow of the Muddy River and associated springs. The first supply well in the Muddy Springs area was drilled in 1947. The Muddy Valley Irrigation Company (MVIC), incorporated in 1895, controls the irrigation water of the Lower Moapa Valley. Numerous groundwater and surface water rights exist within the UMR. The primary users and points of diversion of the greatest quantity are shown on Figure 1. The NPC and MVWD are the primary users of both groundwater and surface water within the UMR valley. The NPC extracts groundwater from the alluvial aquifer (approximate depth of 100 ft) at the Lewis well field, LDS wells, and Perkins and Behmer wells. The MVWD operates year round groundwater extraction from the carbonate aquifer at the Arrow Canyon and MX-6 wells (SNWA, 2000).

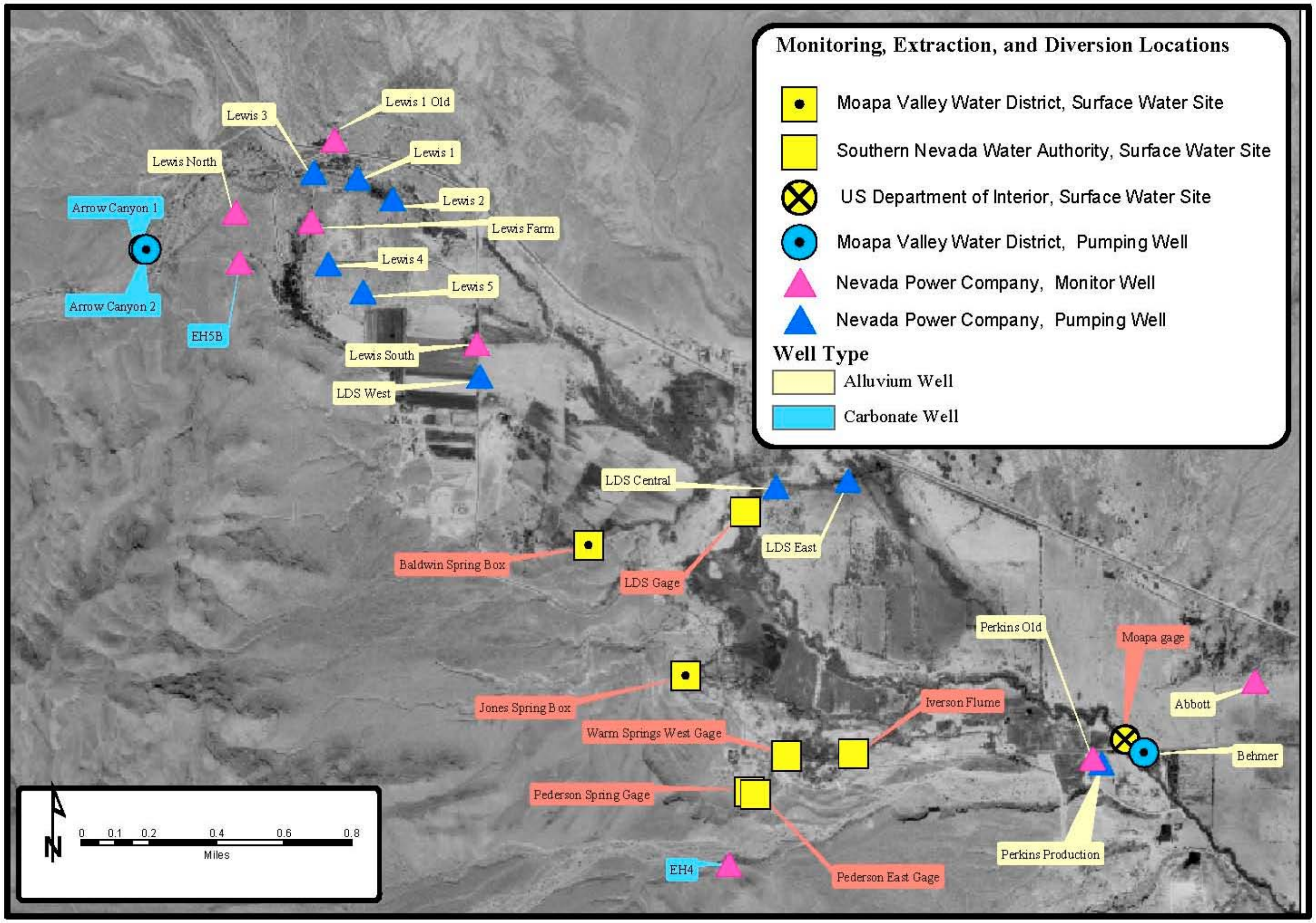

Figure 1. Groundwater and surface water monitoring, extraction, and diversion locations.

Modified from SNWA (2000)

The NPC diverts up to 3,000 afy during the winter from the Reid Gardner diversion located at the Warm Springs Road crossing. The MVWD diverts 3 cfs and 1 cfs from the Baldwin and Jones Springs, respectively, for a total of 2,900 afy. The Moapa Band of Paiutes diverts water at the upstream end of the reservation for agricultural use. Downstream from Glendale, the entire Muddy River is diverted by MVIC at Wells Siding. The SNWA currently holds approximately 5,600 afy in water rights from the Muddy River. An agreement between SNWA and MVWD was signed in 1996 that limited the amount of water that SNWA could transfer out of the Moapa Valley, until the year 2020, to 100 afy plus any unused water. After 2020, SNWA has the right to remove up to 5,000 afy, with the option for additional water in the event that MVWD acquires additional water resources other than Muddy River water. Several agencies are currently monitoring both surface and groundwater levels in order to monitor and minimize the potential effects to the groundwater system that may occur due to continued or increased withdrawals.

3.0 History of Channel Modification

A report on the Muddy River, produced in 1940, by the State Engineer provides an indirect account of historical channel alteration. Following Mormon settlement of the Moapa Valley in 1865, the population within the valley increased to approximately 600 people. Following their arrival, the Mormons began tilling the land and digging canals to divert Muddy River water for irrigation. Following the creation of the Moapa Indian Reservation in 1873, approximately 130 acres were under irrigation, primarily planted in barley, wheat, corn, beans, and melons. The following year, 1874, approximately 370 acres of reservation lands were being cultivated. The development of new agricultural lands by tilling and leveling and the construction of irrigation canals and ditches continued into the early 1900's.

Agricultural development continued with little concern for water availability until 1906, when a request was made for the State Engineer to settle discrepancies in water rights and usage. Following a hydrographic survey of the Muddy River, the State Engineer issued 121 certificates defining the appropriators, the priority number, the number of acres for which the water was appropriated, and a description of the land to which the water was to be applied. The issuance of these certificates adjudicated water to approximately 2,800 acres of land within the Muddy River valley (Shamberger, 1940).

Agricultural records from 1938 indicate that approximately 2,126 acres were in summer cultivation by the Muddy Valley Irrigation Company, producing 4,014 tons of alfalfa, 2,437 crates of asparagus, 411 tons of barley, 148,308 pounds of beet seed, 20,216 crates of cantaloupes, 883 tons of corn, 1,687 crates of green onions, 675 crates of lettuce, 90 tons of milo, 31,255 dozen radishes, 124 tons of wheat, and 9,038,700 tomato plants (Shamberger, 1940).

Annual peak and annual mean discharge at the Muddy River gage 09416000 (located at the Warm Springs Road Crossing) for the years 1913 through 1917 and 1945 through 2000 is shown in Figure 2. Annual peak and mean discharge was not reported for the years 1918 through 1944. As shown, events of peak discharge exceeding 1,000 cfs occurred in 1945, 1960, 1967, 1976, 1979, 1984, 1990, and 1993. Flood events exceeding 100 cfs occur during most years and commonly occur more than once each year. A gradual decline in annual mean discharge beginning in the 1950's, which has been attributed to groundwater extraction and surface water diversion in the UMR valley, is shown in Figure 2.

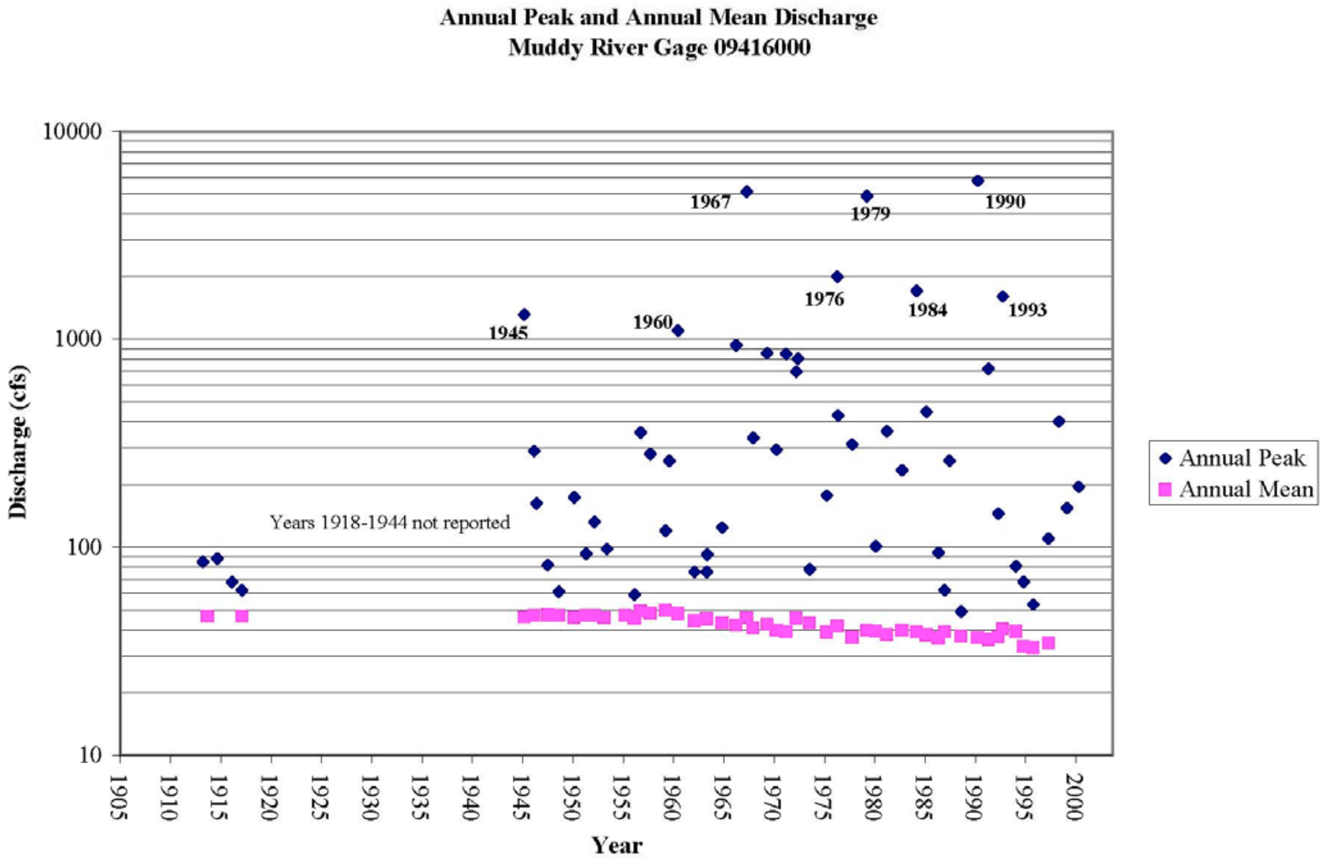

Figure 2. Annual peak and annual mean discharge at Muddy River Gage 09416000.

Floods between 1905 and 1940, reported in the State Engineers Report on the Muddy River (Schamberger, 1940), are based primarily on historical accounts and personal interviews during the production of the report. Severe flooding was noted in the years 1905, 1909, 1910, 1913, 1922, 1925, 1937, and 1938. The majority of destructive flooding occurred in the lower Moapa Valley, below Glendale, with the primary contribution to flooding being received from Meadow Valley Wash. For example, the Soil Conservation Service measured the flood of 1938 on Meadow Valley Wash at approximately 20,000 cfs. This flood resulted in the inundation of 1,612 acres of agricultural land and 928 acres of undeveloped floodplain below the Wells Siding diversion. Floods occurring in 1925 and 1938 were the only floods measured within the UMR valley between 1905 and 1940. During the 1925 flood, it was estimated that discharge from Arrow Canyon reached 1,485 cfs while the 1938 flood was estimated to have peaked between 1,400 and 1,800 cfs (Shamberger, 1940). It is unlikely that these two events were the only floods to occur in this period.

The record of agricultural land development, associated utilization of irrigation water, and the documentation of intense flooding provide a timeline for major channel modifications. As new lands were cleared for agriculture and diversion structures placed within the channel, beginning in 1865, a great degree of impact upon the channel would have occurred. In addition, the channel would have been straightened and moved to the margin of newly cleared agricultural fields to maximize the irrigable acres thus increasing the slope and stream power leading to channel incision and the upstream migration of headcuts. This process would have began in the late 1800's following settlement, and continued through the 1900's as larger scale channelization, drainage, and land development activities progressed. Channel incision was evident by 1923 based on general descriptions during the 1923 soil survey (Youngs and Carpenter, 1923). Historic accounts of flooding by early settlers indicate that much of the channel incision observed today has occurred since 1880 following a period of unusual and intense flooding (Longwell, 1928; Gardner, 1968). Channel incision and impacts to streamside habitat would have been exacerbated by the occurrence of intense flooding following significant changes in surrounding land use and straightening of the channel.

4.0 Preliminary Upper Muddy River Geomorphic Characterization

4.1 Introduction

The UMR has been divided into distinct geomorphic segments for the purpose of assessing the geomorphic condition of the channel. This characterization will form the foundation of our understanding of the factors that influence the channel. A complete description of these characteristics, processes, and influences is necessary in order to formulate habitat restoration recommendations. Aerial photographs of the individual segments are included in Appendix A. Photographs from most of the segments are presented in Appendix B in order to exhibit geomorphic, land use, and vegetative characteristics of each segment. Additional geomorphic characterization and analysis will be completed following channel cross section survey activities and hydrologic analysis.

4.2 Methods

Field investigations were completed in order to characterize individual segments of the UMR. Initial segment delineation was completed using aerial photographs and topographic maps. Segment delineation was further refined during field characterization activities following the observation of channel and valley characteristics or the presence of natural or human induced constrictions to flow. Channel and valley characteristics used to delineate the individual segments include channel pattern, valley confinement, and sinuosity. Natural constrictions to flow include features such as the White Narrows while human induced constrictions to flow include road and railroad crossings. The segments increase in numerical order from downstream to upstream along the UMR. The start and end points of each segment are shown in Table 1. Each segment was assessed for geomorphic characteristics, land use, and human influences. Qualitative features of channel morphology such as relative entrenchment, bank stability, channel bed material, and general geomorphologic characteristics were described. Land use and features of human influence were described including encroachments into the floodplain, encroachment into the channel, bridges, roads, irrigation ditches, water diversions, channelization activities, and impacts to stream habitat. Quantitative geomorphic features obtained from channel cross section surveys, HEC-RAS modeling, and sediment transport analysis will be described in future reports.

Table 1. Upper Muddy River segments.

Segment	Start Point Feature	Endpoint Feature
1	I-15 Bridge	Power Station RR Bridge
2	Power Station RR Bridge	White Narrows
3	White Narrows	Warm Springs Road
4	Warm Springs Road	Warm Springs-Muddy Confluence
5	Warm Springs-Muddy Confluence	North-South Fork Confluence
6	Warm Springs-Muddy Confluence	Warm Springs
7	North-South Fork Confluence	North Fork Headwaters
8	North-South Fork Confluence	South Fork Headwaters
9	North Fork Headwaters	Arrow Canyon

4.3 Characterization of Individual River Segments

Segment 1

As shown on Figure A.1, segment 1 begins at the I-15 Bridge and continues upstream to the railroad bridge at Reid Gardner Station. Compared to most upstream segments, segment 1 is relatively confined between canyon walls. The channel is entrenched approximately ten feet throughout the length of this segment and the channel bed is composed of fine to medium sand and silt. Although entrenched by as much as 10 feet, the lower half of segment 1 exhibits a sinuosity possibly approximating that of pre-disturbance conditions. Flood deposits were observed on the floodplain within the lower half of this segment, as shown in Figure B.1.4. California Wash enters the UMR valley in the vicinity of the Hidden Valley Dairy and likely plays a significant role in flooding within the lower half of segment 1. The upper half, extending from the Hidden Valley Dairy to Reid Gardner Station has been straightened and dredged. Dredge piles are present in the vicinity of the dairy.

Aside from the presence of a railroad on the north side of the channel, the floodplain within the lower half of segment 1 is relatively free of obstructions. However, the more channelized upper half is confined by the dairy, agricultural fields, and power station settling and cooling ponds. With the exception of several small parcels at the furthest most downstream portion of the segment and Nevada Power Company property on the upstream end, land ownership adjacent to the river in segment 1 is almost exclusively held by Hidden Valley Dairy.

The Highway 168 Bridge and a railroad crossing are present in the downstream half of segment 1 while the Hidden Valley Road and railroad cross the river within the upstream half of segment 1. As shown in Figure B.1.6, a recently installed Kern River pipeline crossing is present directly downstream from Reid Gardner Station. The railroad bridge at Reid Gardner Station impedes flow between segments 1 and 2. Fine sediment deposited on the floodplain and evidence of ponding directly upstream from the railroad crossing was observed during characterization activities and indicates that the railroad bridge impedes flow between segments 1 and 2.

The Muddy River Regional Environmental Impact Alleviation Committee (MRREIAC) has completed tamarisk and other non-native removal activities, including goat grazing, throughout segment 1. As shown in Figures B.1 through B.3, tamarisk has been replaced with native vegetation. A spring-fed, constructed pond surrounded by spring-fed wetlands is the most important feature, relative to riparian vegetation, within segment 1. As shown in Figure B.1.5 the pond is surrounded by numerous native wetland species and likely hosts wetland plants and animals that formerly had a much wider distribution within the UMR valley.

Segment 2

Segment 2 extends upstream from the railroad crossing at Reid Gardner Station, through the Moapa River Indian Reservation, to the White Narrows (see Figure A.2). Land within segment 2 is owned primarily by the Moapa Band of Paiutes, with the exception of limited private and Nevada Power Company ownership at the downstream end. Land use is primarily agricultural and limited residential property exists within the 100 year floodplain. Within this segment, the channel flows across a broad floodplain. Channel scars revealed in aerial photographs indicate the presence of a sinuous channel prior to channel straightening, as shown in Figure 3. The channel has been extensively straightened, channelized, and moved to the south side of the valley for agricultural purposes. Aside from steep, straight, and entrenched channel banks, the channel is relatively free from obstructions to flow and flows along the margins of agricultural fields. Two minor roads cross the river within the segment. As mentioned above, the railroad bridge at the downstream end of segment 2 impedes flow between segments 1 and 2 and results in a damming effect behind the railroad bridge.

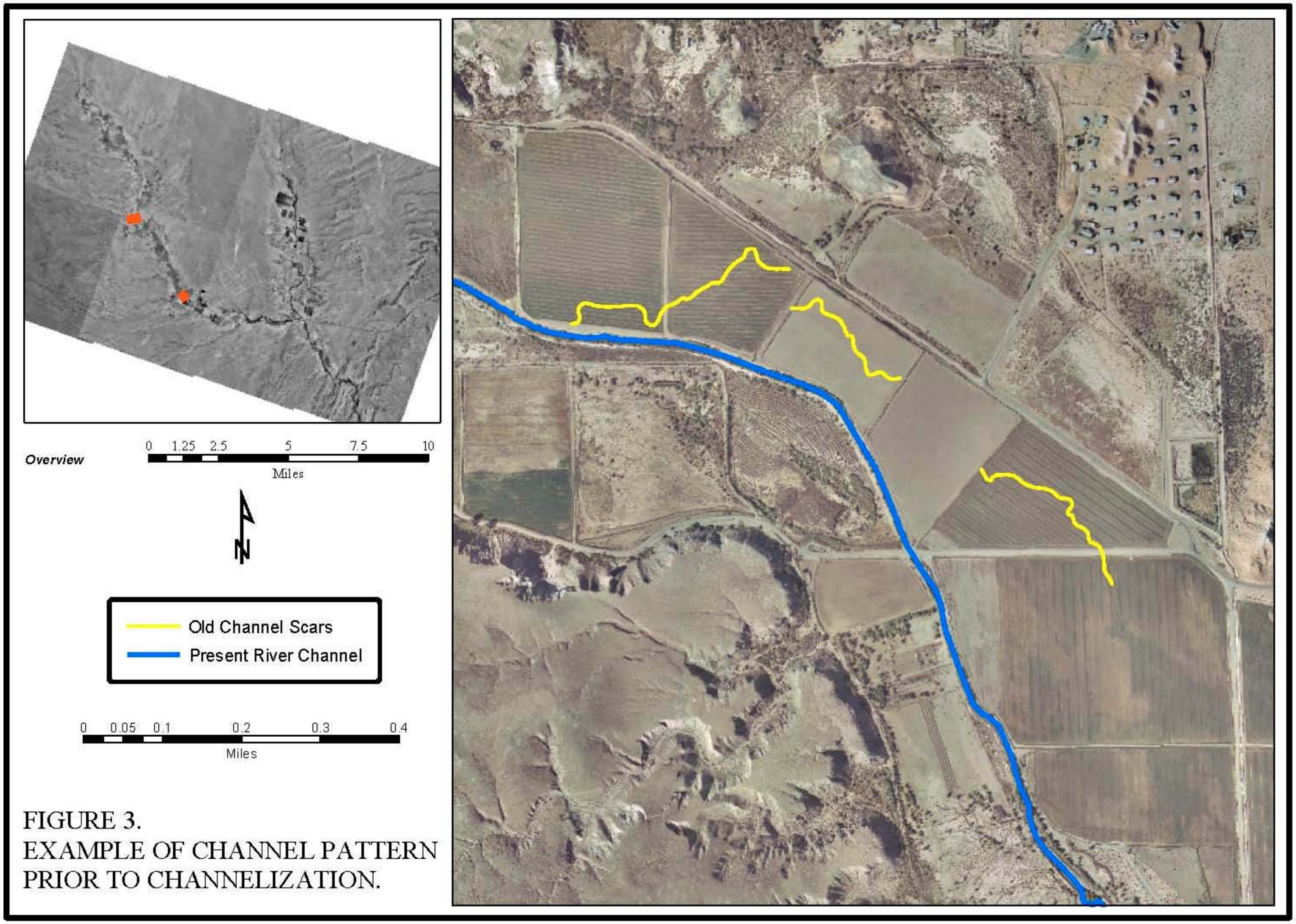

FIGURE 3.
EXAMPLE OF CHANNEL PATTERN
PRIOR TO CHANNELIZATION.

Segment 3

Segment 3 begins at the White Narrows and extends upstream to the river crossing at Warm Springs Road (see Figure A.3). Although a limited amount of sinuosity exists in the upper half of this segment, the channel is straight and entrenched approximately ten feet. The channel bed material is composed of a mixture of sand and silt with local accumulation of gravel. Calcium carbonate cementation of channel bed material occurs where the channel has incised into coarse material, and where tributary washes supply a source of coarse material. Cliffs formed by a large paleospring deposit are present along the west side of the channel at the upstream end of segment 3, in the vicinity of the Perkins Ranch, and the channel has incised into cemented gravels at the base of the cliffs. A series of step pools in the vicinity of these erosion resistant deposits likely function as grade control. A constructed, spring-fed pond is also located in the upstream end of this segment.

Most of the land within segment 3 has recently been purchased by the Bureau of Land Management (BLM) and, with the exception of the Warm Springs Road at the upper end and two minor road crossings at the downstream end of the segment, very few obstructions exist within the floodplain. Aside from several homes near the eastern edge of the 100 year floodplain at the in the approximate middle of segment 3, large areas of open land are present along the channel. As shown in Figures A.3, B.3.2, and B.3.3, mesquite is beginning to replace former agricultural fields.

Segment 4

As shown in Figure A.4, segment 4 extends from the Warm Springs Road crossing upstream to the confluence of the Warm Springs channel and the mainstem of the Muddy River. The channel has been straightened both above and below the Warm Springs Road crossing, while a more sinuous channel exists throughout the remainder of the segment. The channel bed is composed of fine to medium sand and silt and is entrenched approximately ten to fifteen feet. Meander bends within the channel contain pools up to six feet deep. Although large cut banks are present throughout the segment, thick vegetation covers even the steepest of banks, as shown in Figure B.4.1.

The Reid Gardner diversion and the Warm Springs Road crossing are the primary impedances to flow within the segment. Land ownership within this segment is currently held by the South 15 investment group. Currently inactive agricultural fields and horse pasture border the channel.

Segment 5

Segment 5 extends from the confluence of the Warm Springs channel and the mainstem of the Muddy River upstream to the confluence of the North and South Forks of the Muddy River (see Figure A.5). Although entrenchment is significant, both segments 4 and 5 exhibit sinuosity that likely approximates that present prior to channelization activities throughout the remainder of the UMR valley. Entrenchment is approximately 10 to 15 feet deep and steep cut banks border the channel. Thick vegetation covers the banks. The channel bed material consists of fine to medium sand and silt. Muddy Spring, located on the LDS Recreation Center property, enters the main stem of the river at the approximate midpoint of segment 5.

A river crossing is present on the former Warm Springs Ranch and cobble material has been placed within the channel. This crossing appears to have been abandoned, but the channel remains wider and shallower in the vicinity of the crossing as shown in Figure B.5.1. Similar to segment 4, all of the land bordering the river is currently owned by the South 15 investment group. The patchwork of former agricultural lands with limited grazing and horse pasture is shown in Figure B.5.2.

Segment 6

Segment 6 includes the warm springs channels associated with the Plummer, Pederson, and Apcar warm springs which are located on the Moapa National Wildlife Refuge. These springs issue from the base of low hills on the south edge of valley and the channels represent crucial habitat for thermal endemic species. These channels are currently free of tilapia and a gabion barrier is located directly downstream from the confluence of the Apcar and Plummer/Pederson channels.

Segment 7

Segment 7, shown in Figure A.7, extends from the confluence of the North and South Forks of the Muddy River upstream to the headwaters of the North Fork. The channel bed material is composed of coarser grained sand and gravel and entrenchment is approximately five to eight feet. During characterization activities, the headwaters of the North Fork consisted of a series of springs within and adjacent to the channel and were located on private land. The channel area had been recently (Summer 2003) burned in a wildfire, as shown in Figures B.7.1 through B.7.4. The approximate location of the headwaters of the North Fork is shown on Figure A.7.

A five to six feet tall headcut, shown in Figure B.7.3, is present approximately 1,500 feet upstream from the uppermost headwater spring. The presence of this headcut upstream from any perennial flowing stream indicates either that perennial flow above the headcut has ceased, or that flood flows from Arrow Canyon provide the erosive force necessary to create the headcut. Both scenarios are possible, however, channel scouring into calcified soil, as shown in Figure B.7.4, suggests that floodwaters created, or at least continue to propagate, the headcut. Several smaller, dry channels were observed upstream from the headcut suggesting that a series of springs once issued from the ground surface and into the main channel and that these dry channels occasionally transport floodwaters that spread out from Arrow Canyon and onto the relatively low gradient slope upstream from the present headwaters. A flood event occurred approximately two to three days prior to characterization activities. Evidence of flooding, in the form of wet, fine grained material deposition upstream from the headcut and the removal of ash within the flood zone (see Figure B.7.1) dowsnstream from the headcut, was observed.

A single, unpaved river crossing is located in the vicinity of the headwater springs. Houses and structures, including the LDS Recreation Area and Cardy Lamb pool, built within the 100 year floodplain represent the primary encroachment to the floodplain within this segment. The majority of the floodplain is primarily unused agricultural fields and horse pasture.

Segment 8

As shown in Figure A.8, segment 8 consists of the South Fork of the Muddy River. The headwaters of the South Fork are located directly upstream from the Baldwin Spring Box where several springs emerge. As shown in Figure B.8.1, a marshy area is present above the spring box. Vegetation patterns shown in Figure B.8.1 appear to provide evidence of a more extensive wetland area extending from the current location of the spring box to the Cardy Lamb pool. However, the majority of the flow within segment 8 is discharged from the Baldwin Spring Box and flows into a narrow and channelized stream that borders agricultural fields as shown in Figure B.8.2. The channel is essentially a narrow ditch that dissipates into marshes and occasionally reforms until discharging into the mainstem of the river.

Segment 9

Segment 9 includes the ephemeral channel upstream from the North Fork headwater springs and extends into Arrow Canyon. The channel is composed of cobble sized material near the mouth of Arrow Canyon and a combination of gravel, sand, and silt further downstream toward the North Fork headwater springs. As shown in Figures B.9.1 and B.9.2, a high degree of entrenchment has occurred. The collapsing banks are composed of fine grained alluvium. Warm Springs Road joins Highway 168 at two locations within this segment and the two road crossings, shown in Figure A.9, impede flows from Arrow Canyon. The easternmost road crossing is undersized and evidence of damming during a recent flood event was observed directly upstream from the crossing. This road crossing likely dampens the flood effect and also prevents coarser grained material from entering the mainstem of the Muddy River. Arrow Canyon Dam, at the head of Arrow Canyon, also serves to dampen the effects of flooding within the UMR. Several homes are located throughout the 100 year floodplain within this segment.

5.0 Preliminary Upper Muddy River Biologic Characterization

5.1 Introduction

A preliminary biologic characterization of the UMR has been completed. Plant species, plant canopy architecture, native status, and vegetation distribution among the riparian zones were noted. Plant canopy strata have been divided into the following four categories: GC – ground cover (annual or biennial, deciduous, non-woody plant cover; "GC-a" indicates aquatic cover and "GC-w" indicates wetland ground cover), SC – shrub cover (0-4 m tall, perennial, woody plants), MC – mid-canopy cover (4-10 m tall, perennial, woody cover), and TC – tree cover (>10 m tall, perennial, woody cover). Three stage zones were distinguished: HRZ – aquatic and wetland zone (permanently inundated), LRZ – lower riparian zone (1-10 yr flood return frequency stage zone), and URZ – upper riparian zone (10-1000 yr flood terrace). All species of invertebrates and vertebrates observed during the preliminary characterization activities (Tables 3 and 4) were recorded. A more detailed biologic characterization will follow in future reports.

5.2 Vegetation

Preliminary site visits revealed at least 38 common stream-riparian vascular plant species, including 1 aquatic, 5 wetland, and 32 riparian phreatophyte species (Table 2). Of these species, at least 5 non-native species are common, and some such as saltcedar and spotted knapweed, strongly dominate habitat and ecological processes in the study area. Several patterns of vegetation are apparent within the project area. (1) Strong zonation of vegetation exists. The only aquatic plant detected was *Vallisneria americana*, which occurred throughout the slow-flowing segments. Wetland plant species included native cattail (*Typha domingensis*), common reed (*Phragmites australis*), baltic rush (*Juncus balticus), Carex* nr *hystricina*, and yerba-mansa (*Anemopsis californica*), and non-native *Polypogon monspeliensis*). Lower riparian zone plant species included non-native saltcedar (*Tamarix ramosissima*), and native Emory and willow-leaf seepwillow (*Baccharis emoryi* and *B. salicifolia*, respectively) and arrowweed (*Pluchea sericea*).
(2) Non-native saltcedar strongly dominated the entire drainage, and (presumably) non-native fan palm (*Washingtonia filifera*) was strongly dominant in the headwaters reaches.

(3) Entrenchment is sufficiently severe that little normal riparian plant recruitment is taking place in the lower riparian zone. In addition, (4) native tree populations (i.e., ash, cottonwood, and Goodding willow) are declining, with little recruitment in most reaches.

Table 2. Aquatic, wetland, and riparian plant species detected in various segments of the Muddy River in May and August 2003. Cover strata include: GC – ground cover (annual or perennial deciduous, non-woody), GC-a – aquatic, GC-w – wetland, SC – shrub cover (0—4 m woody perennial), MC – mid-canopy (4-10 m woody perennial), TC – tree canopy (>10 m woody perennial). Native status: native (N) or non-native (NN) species. Zonation is indicated in each segment column with three presence-absence numbers (0 – absent, 1 – present). The first number is presence-absence in the hydroriparian zone (HRZ; aquatic or wetland), the second number is for the lower riparian zone (LRZ; 1-10 yr flood terrace), and the third number is for the upper riparian zone (URZ; 10-1000 yr flood terrace).

			Segment								
	Cover	**Native or**	**1A**	**1B**	**1C**	**1D**	**3, Wrm Sp**	**7,Woods**		**8,SC2**	**2, Up fr/**
Plant Species	**Stratum**	**Non-native**	**Tara Remvl**	**Chnlzd**	**HV Rnch**	**ds fr/ Dairy**	**Artfcl Pondr**	**Ranch**	**5**	**Pump**	**Pwrplnt**
Acacia constricta	SC,MC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,1	0,0,1
Acacia greggii	SC,MC,TC	N	0,0,0	0,0,0	0,0,1	0,0,0	0,0,0	0,0,1*	0,0,0	0,0,0	0,0,0
Anemopsis californicus	GC	N	0,0,0	0,0,0	1,0,0	0,0,0	1,1,0	0,0,0	1,1,0	1,1,0	0,0,0
Atriplex canescens	SC	N	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Atriplex lentiformis	SC	N	0,0,0	0,0,1	0,0,1	0,1,1	0,0,0	0,0,1	0,0,1	0,0,1	0,0,0
Baccharis emoryi	SC	N	0,0,0	0,0,0	0,1,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Baccharis salicifolia	SC	N	0,1,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Carex hystricina?	GC-w	N	0,0,0	0,0,0	1,0,0	1,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Centaurea sp.	GC	NN	0,0,0	0,0,0	0,1,1	0,0,0	0,0,0	0,0,0	0,0,1	0,0,0	0,0,0
Cirsium sp.	GC	NN?	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,1,0	0,0,0
Distichlis spicata	GC	N	0,1,1	0,1,1	0,1,1	0,0,0	0,0,0	0,0,1	0,0,0	0,0,1	0,0,0
Festuca octoflora	GC	N	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Fraxinus pennsylvanicus	SC,MC,TC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,1,1	0,0,0	0,1,0	0,0,0	0,0,0
Helianthus annuis	GC	N	0,0,0	0,0,0	0,1,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Heliotropium	GC	N	0,0,0	0,0,0	0,0,0	0,1,0	0,0,0	0,0,1	0,0,0	0,0,0	0,0,0
Isocoma acredenius	SC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,1	0,0,1	0,0,0
Juncus balticus	GC-w	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0
Larrea tridentata	SC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Lepidium (annual) sp.	GC	N	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Lycium sp.	SC	N	0,0,0	0,0,0	0,0,1	0,1,0	0,0,0	0,0,0	0,0,0	0,0,1	0,0,0
Mentha sp.	GC-w	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Phoradendron californica	SC	N	0,0,1	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Phragmites australis	GC-w	N	0,0,0	0,0,0	1,1,0	1,1,1	1,1,0	0,0,0	1,1,0	0,0,0	1,1,1
Pluchea sericea	SC	N	0,0,1	0,0,0	0,0,0	0,0,0	1,1,0	0,0,1	0,1,0	0,0,1	0,0,0
Polypogon monspeliensis	GC	NN	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Populus fremontii	MC,TC	N	0,0,0	0,0,0	0,0,1	0,0,0	0,0,0	0,0,0	0,0,1	0,0,0	0,0,0

Prosopis glandulosa	SC, MC	N	0,0,1	0,0,1	0,0,1	0,0,1	0,0,0	0,0,0	0,0,0	0,0,1	0,0,1
Prosopis pubescens	SC,MC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,1*,1*	0,0,1	0,0,0	0,0,1
Salicornia sp.	SC	N	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Salix exigua	SC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1,1,0	0,0,0
Salix gooddingii	SC,MC,TC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,1*,1*	0,0,0	0,0,0	0,0,0
Salsola iberica	GC	N	0,0,1	0,0,0	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Suaeda torreyana	SC	N	0,0,1	0,0,0	0,0,1	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Tamarix ramosissima	SC, MC,TC	NN	0,1,1	0,1,1	0,1,1	0,1,1	0,1,1	0,1*,1*	0,1,1	0,0,1	0,1,1
Typha domingensis	GC-w	N	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0	1,0,0,0	0,0,0	1,0,0	1,0,0
Vallesenaria sp.	GC-a	N	0,0,0	0,0,0	1,0,0	1,0,0	1,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Vitis arizonicus	SC,MC	N	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,1	0,0,0
Washingtonia filifera	SC,MC,TC	NN	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1*,1*,1*	0,0,0	1,1,0	0,0,0

** heavily burned recently*

5.3 Fauna

Our preliminary site visits provided us with some observational data on invertebrate and vertebrate distribution (Tables 3 and 4, respectively). We observed a wide array of aquatic invertebrates, including several Anisoptera (3 families) and Zygoptera (three families). Aquatic snails and beetles were observed in the headwaters reaches. Numerous terrestrial invertebrates were observed, including several Hesperiidae skippers (with at least one *Hesperopsis* species).

Vertebrate observations of note included the following. *Tilapia* were observed on private land at the north headwaters. Bullfrogs (*Rana catesbiana*) were heard at artificial ponds just downstream from the headwaters springs. Avifaunal activity in the spring-fed headwaters reaches was high, and previously compiled data on avifaunal diversity there indicates a good potential for avifaunal habitat and species conservation.

Table 3. Invertebrates observed during Upper Muddy River site visits in 2003.

				Segment								
Invertebrate Order	**Family**	**Scientific Name**	**Native or Non-native**	**1A Tara Remvl**	**1B Chnlzd**	**1C HV Rnch**	**1D ds fr/ Dairy**	**3, /Wrm Sp Artfcl Pondr**	**7,Woods Rnach***	**5**	**8,SC2 Pump**	**2, Up fr/ Pwrplnt**
Coleoptera	Elmidae		N						X			
Hemiptera	Naucoridae		N						X			
Hymehoptera	Sphecidae	*Sceliphron caementarium*	N				X					
Lepidoptera	Hesperiidae	*Copaeodes aurantiaca*	N	X								
Lepidoptera	Hesperiidae	*Ochlodes yuma*	N	X								

Lepidoptera	Hesperiidae	*Spp.*	N	X								
Mollusca	Aquatic		N									
Neuroptera	Corydalidae	*Corydalus sp.*	N					X				
Odonata	Aeshnidae	*Aeshna multicolor*	N						X			
Odonata	Aeshnidae	*Anax junius*	N					X				
Odonata	Calyopterigidae	*Hetaerina americana*	N			X	X	X				
Odonata	Coenagrionidae	*Argia sp.*	N				X					
Odonata	Coenagrionidae	*spp*	N	X		X	X	X	X			
Odonata	Gomphidae	*Erpetogomphus*	N				X					
Odonata	Lestidae	*Archilestes sp.*	N			X						
Odonata	Libellulidae	*Libellula saturata*	N	X					X			
Odonata	Libellulidae	*Sympetrum sp.*	N						X			
Odonata	Libellulidae	*Tramea lanceolata*	N	X		X			X			
Trichoptera	Helicopsychidae	*Helicopsyche mexicana?*	N					X	X			
Trichoptera	Limnephilidae		N					X				

Table 4. Vertebrates observed during Upper Muddy River site visits in 2003.

			Segment								
Vertebrate Class	**Scientific Name**	**Native or Non-native**	**1A Tara Remvl**	**1B Chnlzd**	**1C HV Rnch**	**1D ds fr/ Dairy**	**3, /Wrm Sp Artfcl Pondr**	**7,Woods Rnach***	**5**	**8,SC2 Pump**	**2, Up fr/ Pwrplnt**
Fish	Tilapia *sp.*	N						X			
Amphibian	*Rana catesbiana*	NN					X				
Reptile	*Masticophis flagellum*	N								X	
Bird	*Amphispiza bilineata*	N	X								
Bird	*Ardea herodias*	N						X			
Bird	*Calllipepla gambelii*	N								X	
Bird	*Carpodacus mexicanus*	N						X			
Bird	*Carthartes aura*	N						X			
Bird	*Anas cyanoptera*	N					X				
Bird	*Empidonax sp.*	N								X	
Bird	*Fulica americana*	N					X				
Bird	*Mimus polyglottos*	N								X	
Bird	*Myiarchus cinerascens*	N									
Bird	*Passerina* sp.	N	X								
Bird	*Polioptila caerulea*	N				X					
Bird	*Stelgidopteryx serripenis*	N					X				
Bird	*Thryomanes bewickii*	N	X			X					
Bird	*Auriparus flaviceps*	N				X					
Bird	*Zenaida macroura*	N									

6.0 References

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Appendix A

Aerial Photographs of the Upper Muddy River

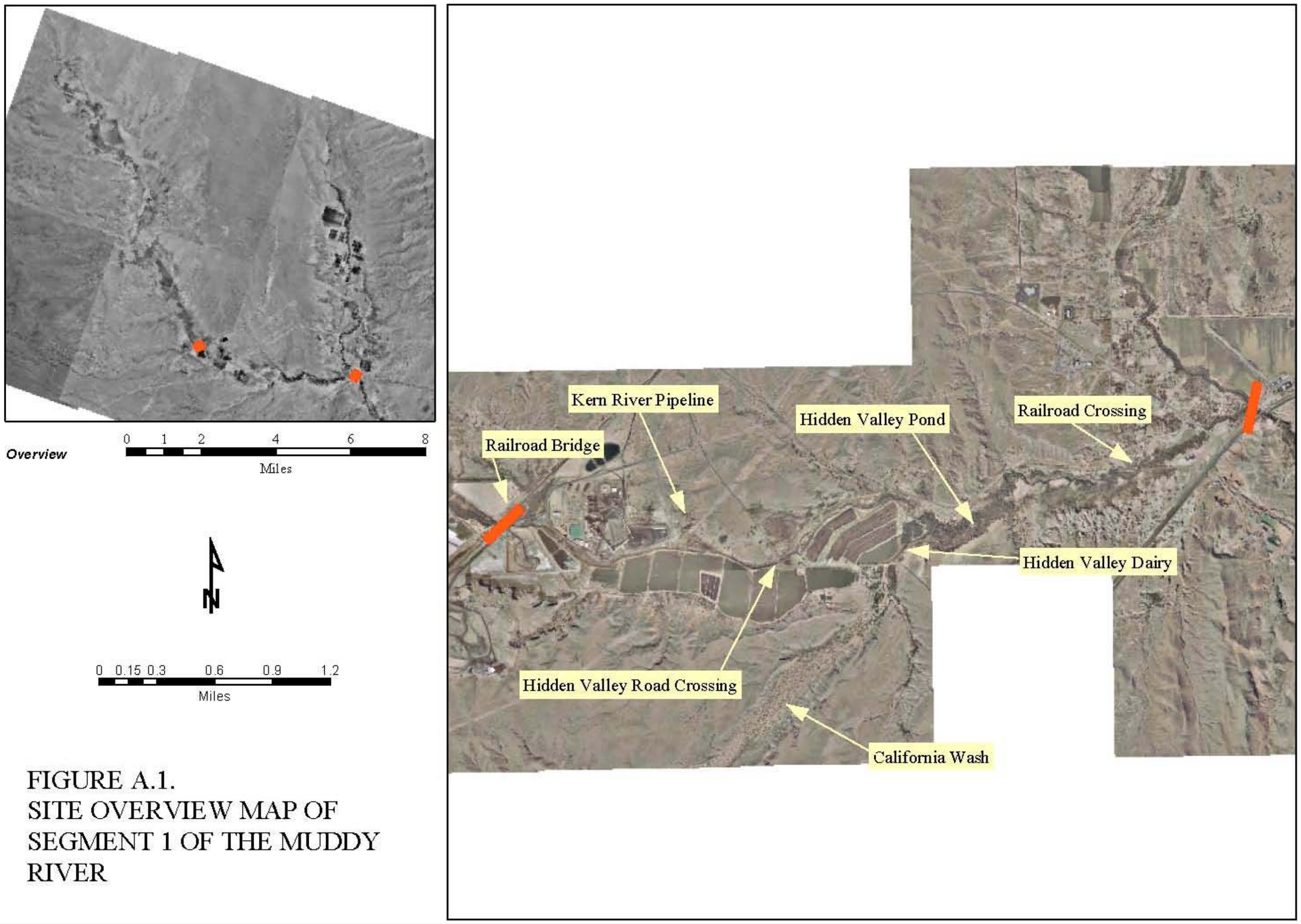


FIGURE A.1.
SITE OVERVIEW MAP OF SEGMENT 1 OF THE MUDDY RIVER

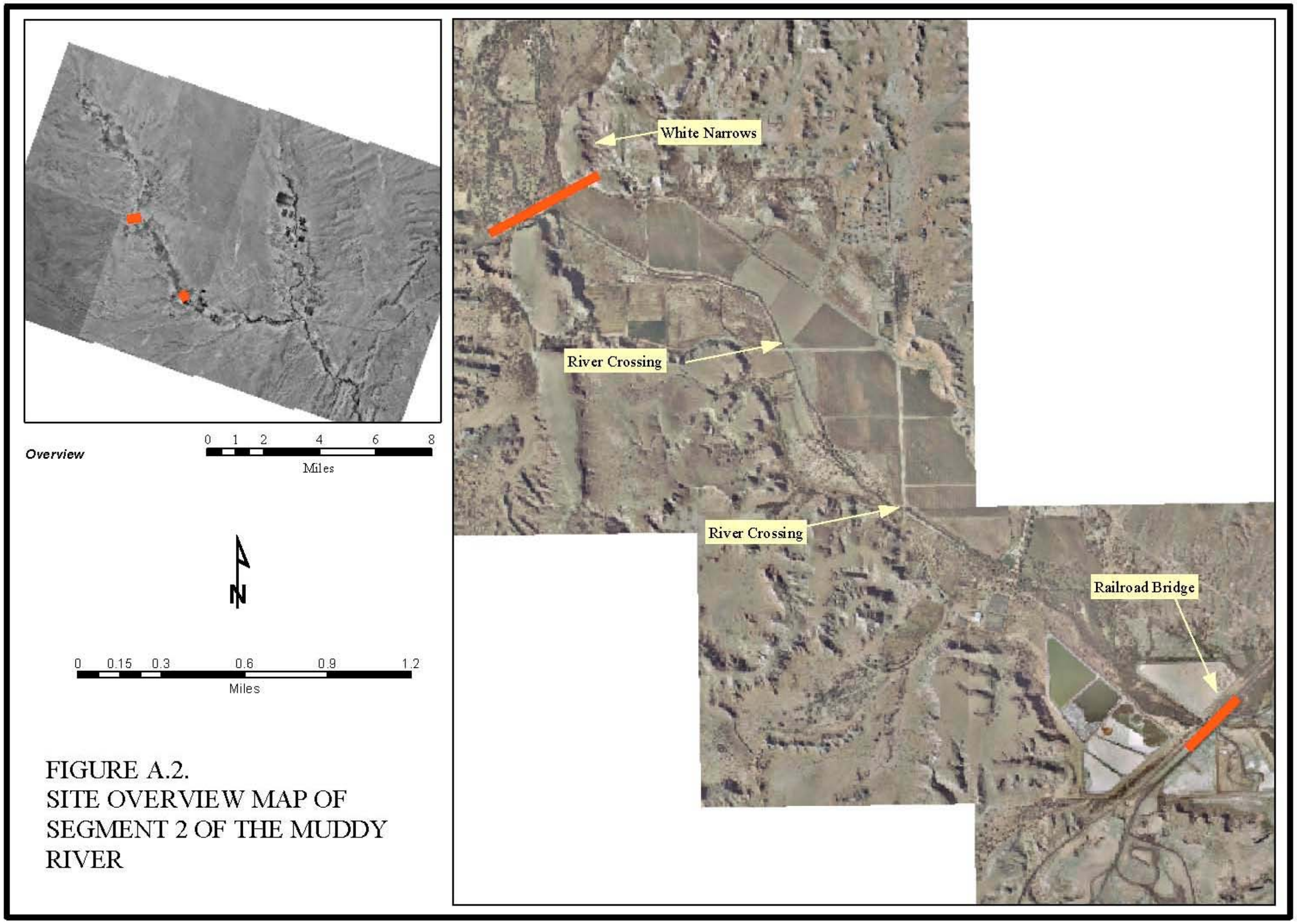


FIGURE A.2.
SITE OVERVIEW MAP OF SEGMENT 2 OF THE MUDDY RIVER

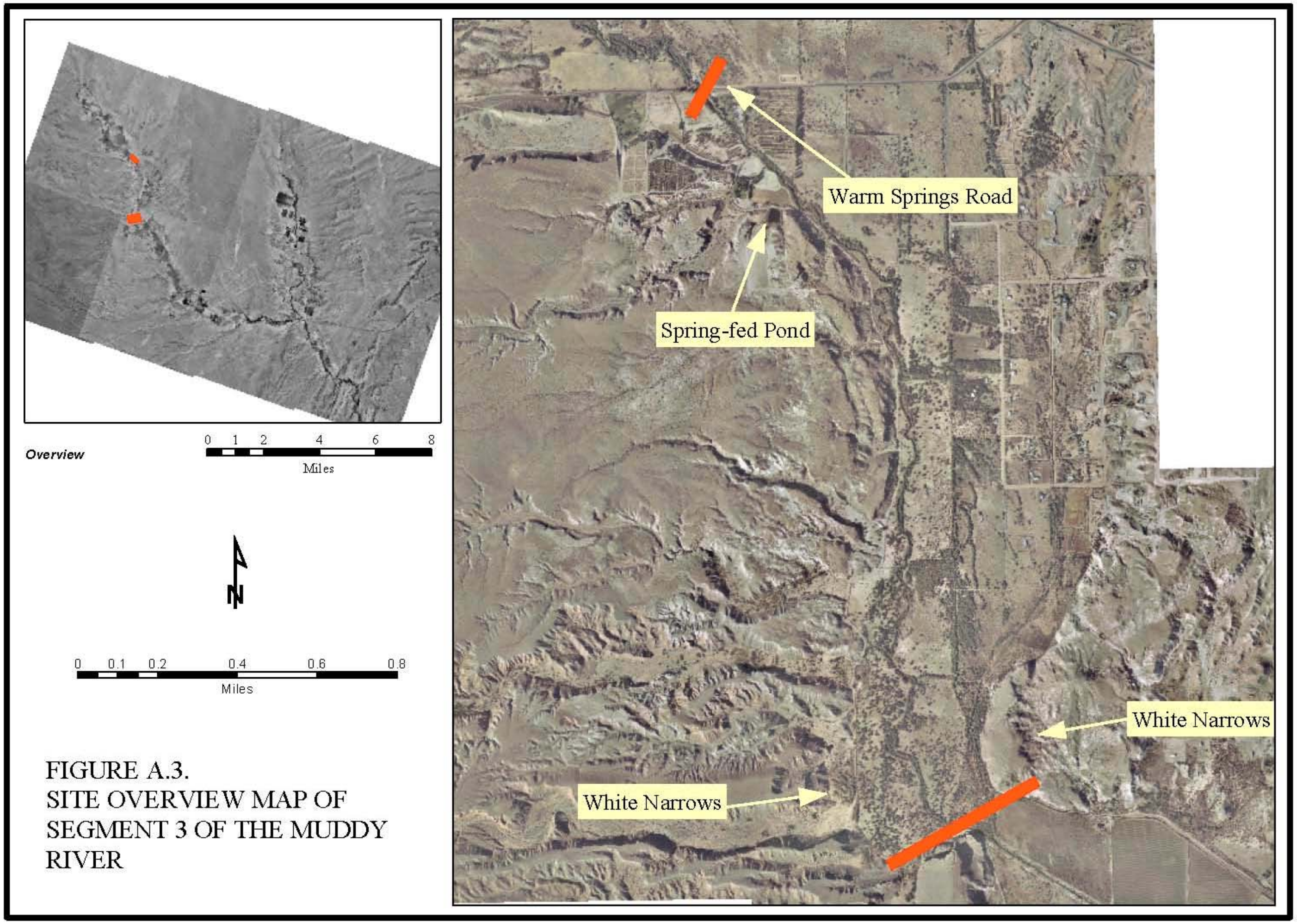


FIGURE A.3.
SITE OVERVIEW MAP OF SEGMENT 3 OF THE MUDDY RIVER

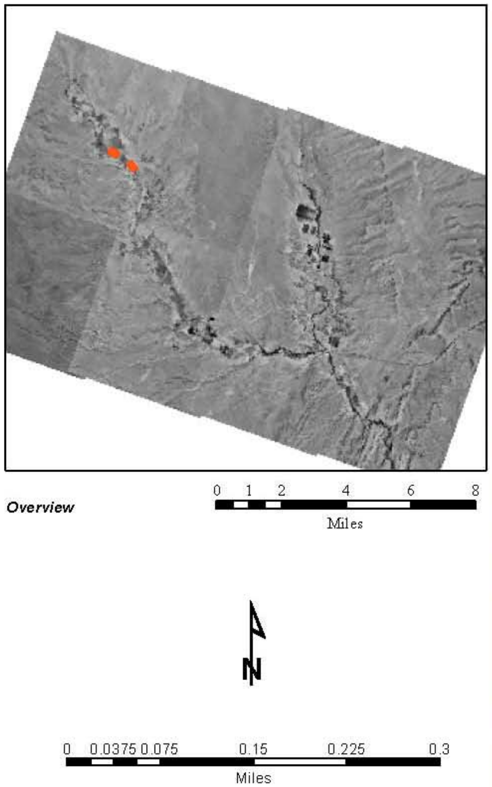
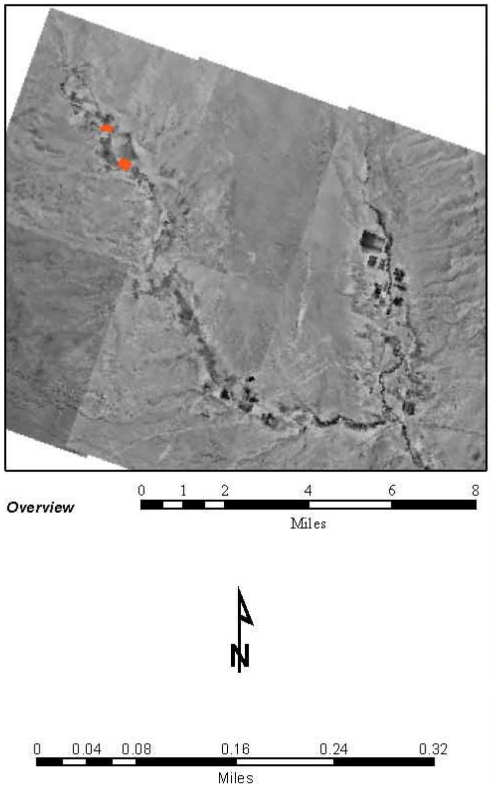


FIGURE A.4.
SITE OVERVIEW MAP OF SEGMENT 4 OF THE MUDDY RIVER



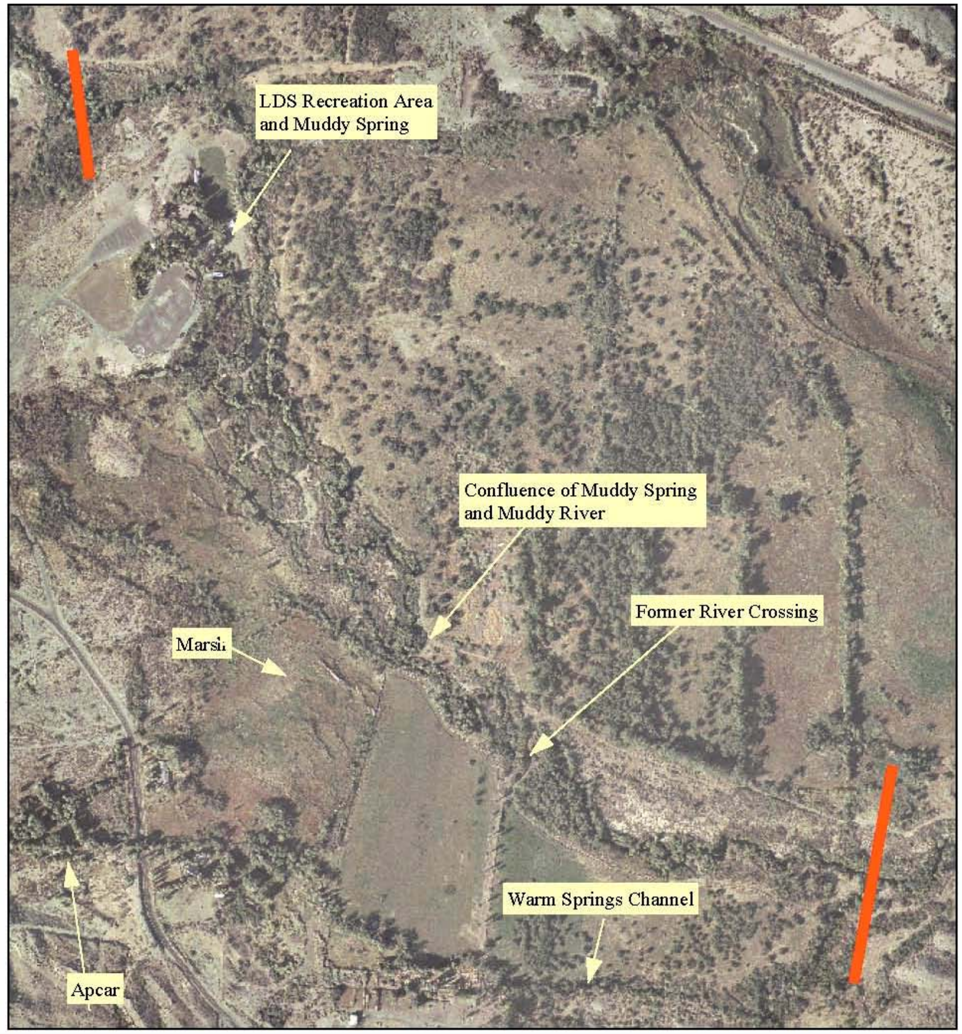


FIGURE A.5.
SITE OVERVIEW MAP OF
SEGMENT 5 OF THE MUDDY
RIVER

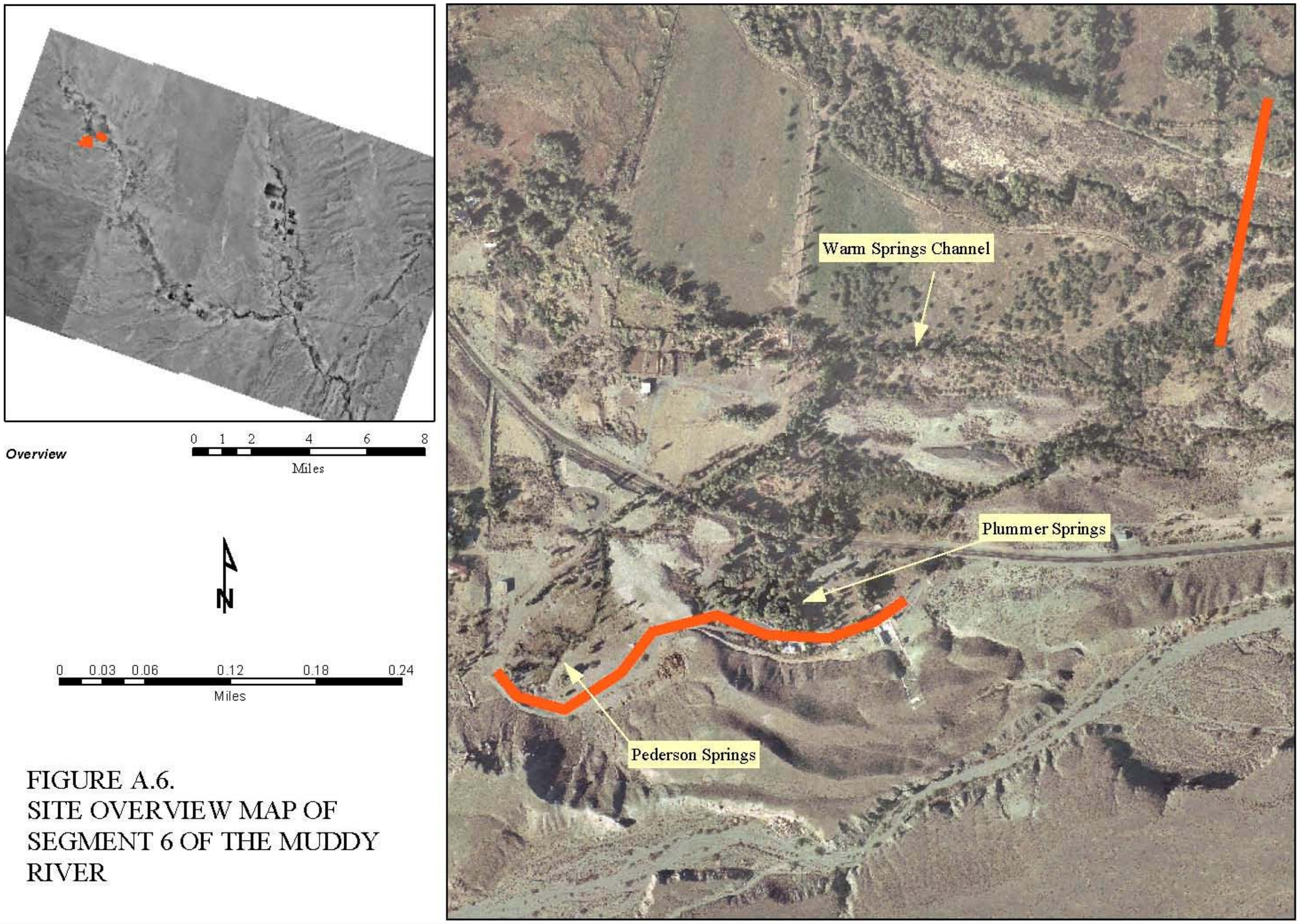


FIGURE A.6.
SITE OVERVIEW MAP OF SEGMENT 6 OF THE MUDDY RIVER

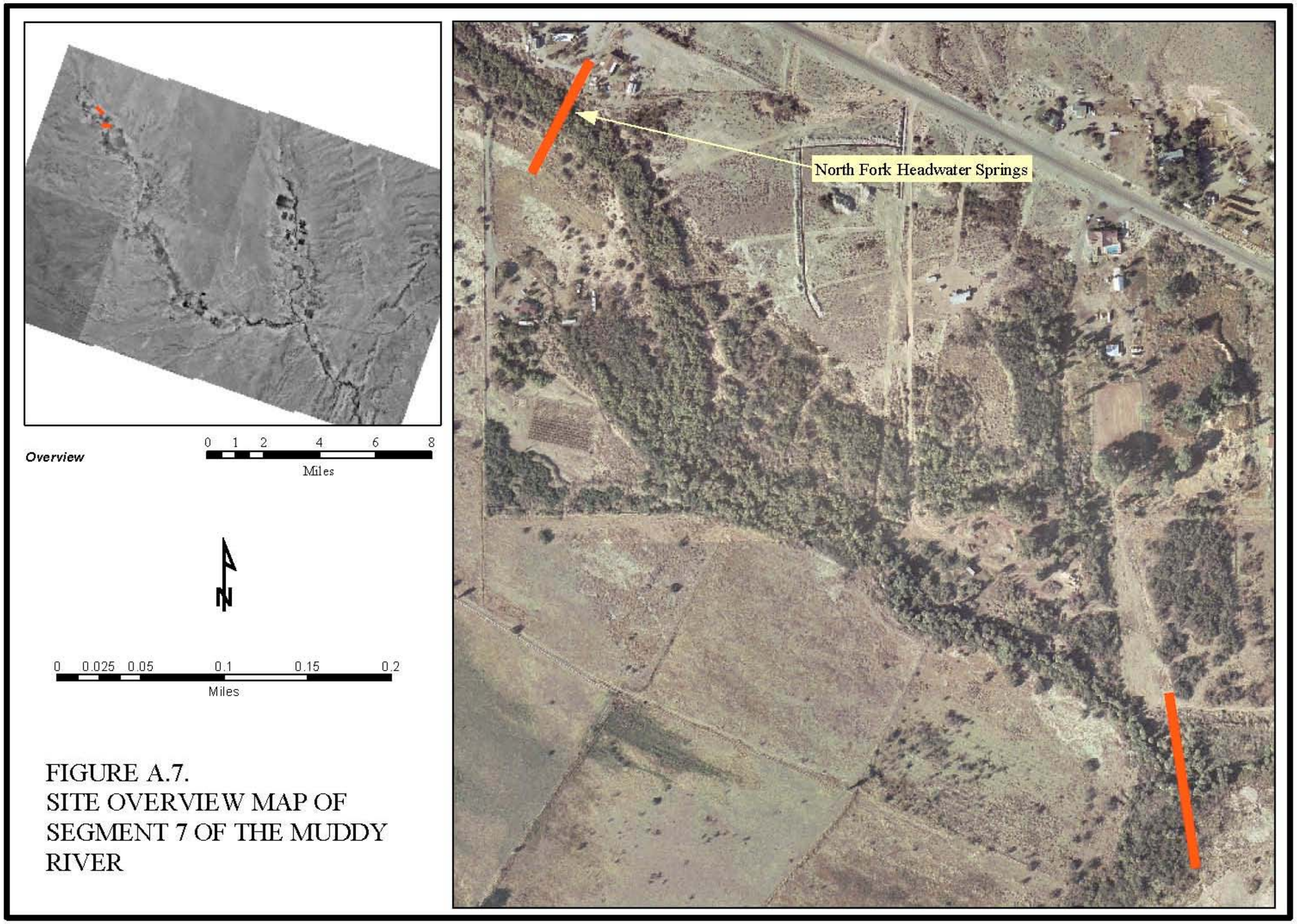


FIGURE A.7.
SITE OVERVIEW MAP OF SEGMENT 7 OF THE MUDDY RIVER

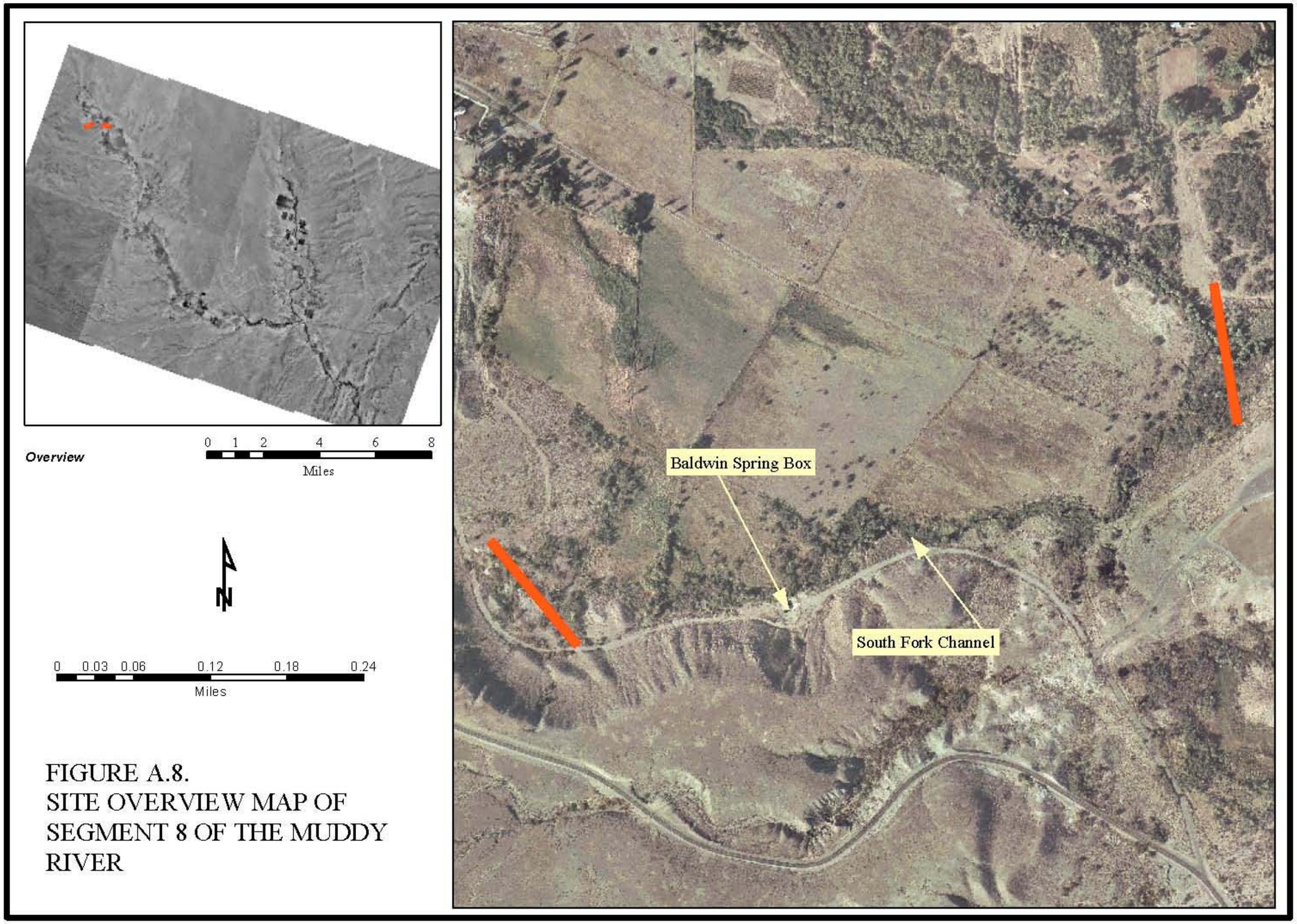


FIGURE A.8.
SITE OVERVIEW MAP OF SEGMENT 8 OF THE MUDDY RIVER

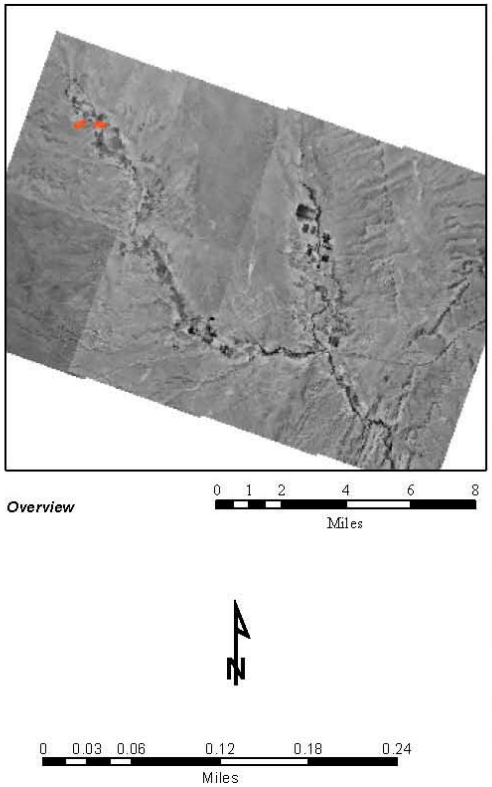


FIGURE A.8.
SITE OVERVIEW MAP OF SEGMENT 8 OF THE MUDDY RIVER

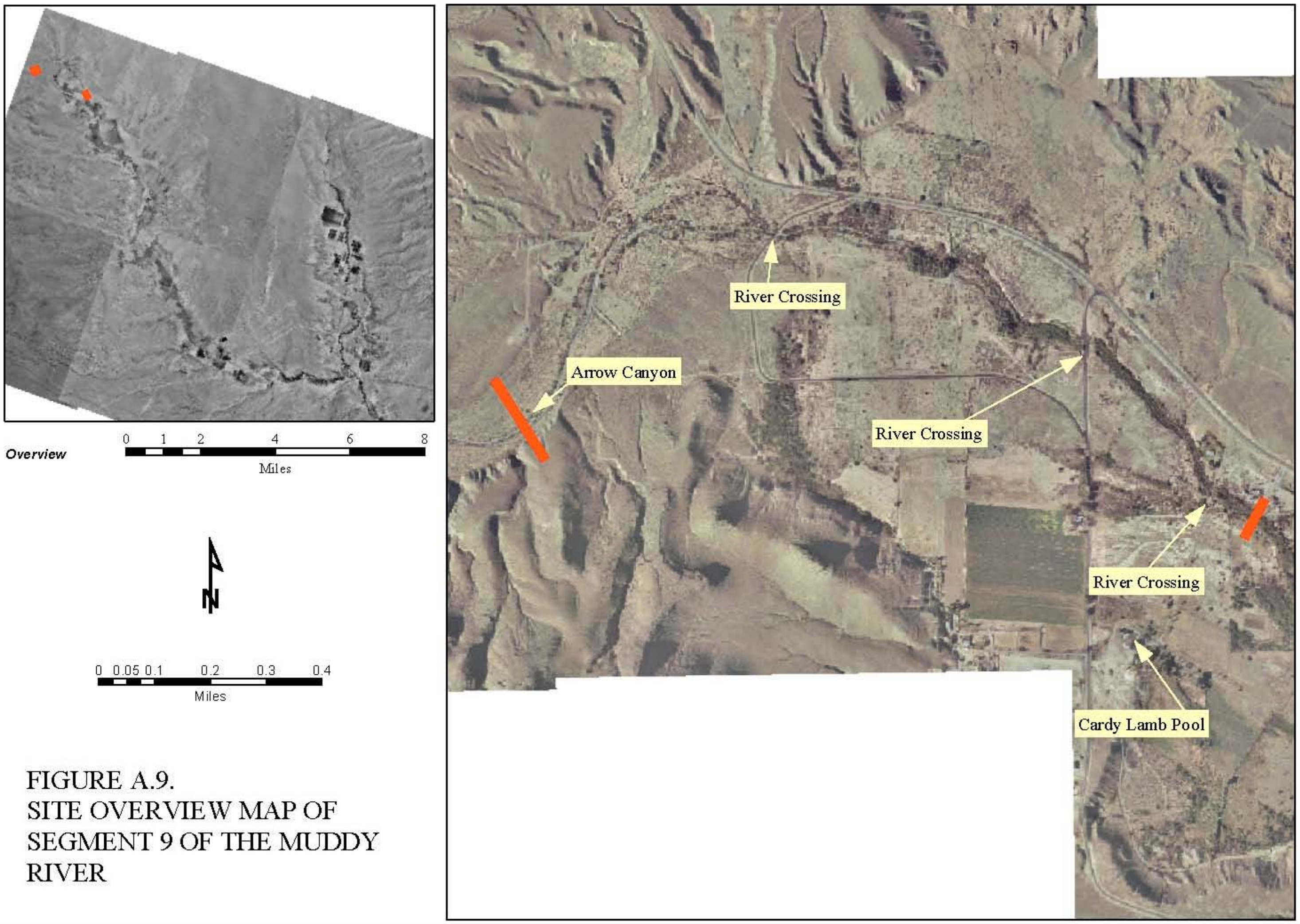


FIGURE A.9.
SITE OVERVIEW MAP OF
SEGMENT 9 OF THE MUDDY
RIVER

Appendix B

Characterization Photos

Figure B.1.1. Downstream view showing area of tamarisk removal at river crossing downstream from Reid Gardner Station.

Figure B.1.2. Upstream view showing area of tamarisk removal at river crossing downstream from Reid Gardner Station.

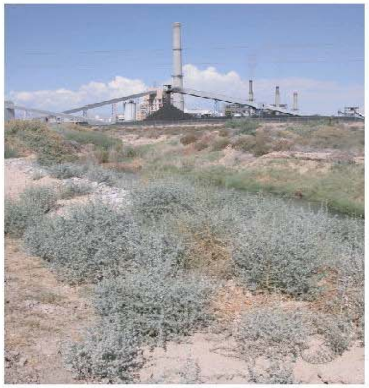


Figure B.1.3. Area of tamarisk removal downstream from Reid Gardner Station.

Figure B.1. 4. Flood debris downstream from Hidden Valley Dairy.

Figure B.1.5. Spring-fed, constructed pond and wetland on Hidden Valley Dairy property.

Figure B.1.6. Kern River pipeline crossing downstream from Reid Gardner Station.

Appendix B. Segment 1

Figure B.3.1. Possible former channel or spring channel scar in field on Perkins Ranch.

Figure B.3.2. Cleared field in former Mesquite bosque and basin-wide view from Perkins Ranch.

Figure B.3.3. Cleared field in former Mesquite bosque and basin-wide view from Perkins Ranch.

Appendix B. Segment 3

Figure B.4.1. Thick vegetation at channel margin, typical of most river segments. Entrenched channel is approximately 15 feet below floodplain/terrace from which photo was taken.

Figure B.4.2. View to north, across Moapa Valley, from above Battleship Wash. Most of segment 4 is visible in this photo.

Appendix B. Segment 4

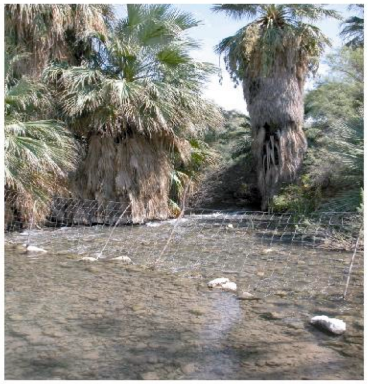


Figure B.5.1. Downstream view of channel within segment 5. Channel has been widened and coarse material placed for a vehicle and water pipeline crossing at this location. Channel is much narrower and contains fine grained material both above and below photo location.

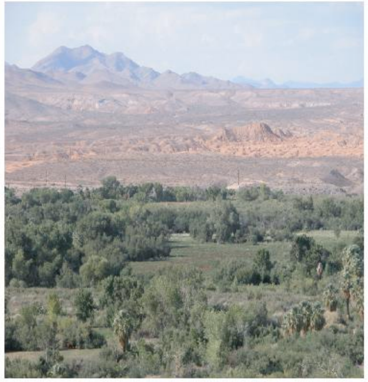


Figure B.5.2. View to the north across Moapa Valley in vicinity of segment 5 showing patchwork of abandoned agricultural fields. Photo taken from above Battleship Wash.

Appendix B. Segment 5

Figure B.7.1. Downstream view of channel within headwater area (North Fork). Note depth of channel below floodplain in upper portion of photo and the removal of ash within the flood zone of a recent flood event one to two feet above the current water level.

Figure B.7.2. Upper most spring and source of flow for the North Fork.

Figure B.7.3. Five to six feet tall headcut approximately 1,500 feet upstream from upper most spring on the North Fork.

Figure B.7.4. Dry channel directly upstream from headcut at top of North Fork. Flood waters from the Arrow Canyon drainage have scoured the channel into resistant calcium carbonate cemented soil and provide the erosive force creating the headcut.

Appendix B. Segment 7

Figure B.8.1. Area of diffuse groundwater discharge directly above Baldwin Spring Box. Area appears to have included a more extensive wetland extending from marshy area in foreground to grove of cottonwood and palm trees in upper one-third of photo (Cardy-Lamb pool).

Figure B.8.2. View of South Fork from above Baldwin Spring Box where the primary flow within the South Fork emerges.

Figure B.8.3. Alluvial fan surface above segment 8. A wash draining from the fan surface, under Warm Springs Road, and into the headwater area of the South Fork provides a connection between the upland fan surface and the spring discharge area.

Appendix B. Segment 8

Figure B.9.1. Collapsing channel banks in ephemeral channel approximately one half mile above headwaters of the North Fork and downstream from Arrow Canyon.

Figure B.9.2. Scale of entrenchment in ephemeral channel above headwaters of the North Fork and downstream from Arrow Canyon.

Figure B.9.3. View into upper Moapa Valley from above Arrow Canyon channel.

Figure B.9.4. View of Arrow Canyon channel at mouth of Arrow Canyon.

Figure B.9.5. Upstream view immediately downstream from where the Arrow Canyon channel exits the slot canyon.

Appendix B. Segment 9

10. Appendix III. Attendees of the upper Muddy River Integrated Science Plan workshop, 17-19 July 2002, Las Vegas, NV. Listed by alphabetic order. Some attendees may have not signed the attendance sheet.

Steve	Acheampong	Zane	Marshall
Elisabeth	Ammon	Cynthia	Martinez
Jennifer	Back	Tim	Mayer
Lynn	Bowdidge	Rebecca	McArther
Dave	Bradford	David	Merritt
Michael	Cameron	Christo	Morris
David	Charlet	Dennis	Murphy
Lisa "Cali"	Crampton	Heather	Powell
Jim	Deacon	Louis	Provencher
Curt	Deuser	Maria	Ryan
Dave	Donovan	Don	Sada
Chad	Gourley	Rob	Scanland
Jim	Heinrich	Ann	Schreiber
Hermi	Hiatt	Gary	Scoppettone
Karin	Hoff	Amy	Sprunger-Allworth
Jeff	Johnson	Cris	Tomlinson
Jeri	Krueger	Vicki	Tripoli
Bruce	Lund	Jason	Williams

11. Appendix IV. Expert fact sheets from the upper Muddy River Integrated Science Plan workshop, 17-19 July 2002, Las Vegas, NV.

A. Muddy River Springs Area by Jeff Johnson;
B. Wetland marsh and seep by David Charlet;
C. Desert riparian forest by David Charlet;
D. Desert riparian shrubland by David Charlet;
E. Mesquite bosque by David Charlet;
F. Saltbush shrubland matrix by David Charlet;
G. Creosote-mixed scrub matrix by David Charlet;
H. Moapa dace by Gary Scoppettone;
I. Amphibian species assemblage by Karin Hoff;
J. Upper Muddy River bird community by Bruce Lund;
K. Yellow-billed Cuckoo by Murrelet Halterman;
L. Phainopepla by Cali Crampton;
M. Vermilion Flycatcher by Polly Sullivan;
N. Southwestern Willow Flycatcher by Louis Provencher (with information from Cris Tomlinson and NatureServe©);
O. Bat species assemblage by Jason Williams;
P. Desert pocket mouse by Zane Marshall and Kerstan Micone.
Q. Aquatic macroinvertebrate community by Donald Sada; and
R. Butterfly species assemblage by George Austin.

Appendix IV–A. Muddy River Springs Area

Muddy River Springs Area

Overview

The Muddy River Springs Area is comprised of numerous spring orifices and seeps concentrated in a two square mile area in Upper Moapa Valley. Spring flow is derived from the regional carbonate-rock aquifer of the White River and Lower Meadow Valley Wash ground-water flow systems, extending hundreds of miles north (Figure 1). Geologic faulting and increasing thickness of Tertiary sediments govern the location of the springs, which form the headwaters of the Muddy River that flows into Lake Mead 25 miles downstream.

Water resources development along the lower Muddy River began in the late 1800s for agriculture, and the first well in the Muddy Springs Area was drilled in 1947. Today, the entire surface water flow is apportioned under the 1920 Muddy River Decree and numerous certificated ground-water rights exist in the Upper Moapa Valley ground-water basin. Monitoring of both surface water flows and ground-water levels is being conducted by multiple agencies to ensure potential effects to the natural system are minimized.

Key Points

- ❖ Muddy River Springs are fed by the regional carbonate aquifer of the White River and Lower Meadow Valley Wash Flow Systems
- ❖ Muddy River flows have declined since the 1950s and correlate to ground-water pumpage and surface water diversions
- ❖ Spring discharge recorded since 1986 at three USGS gages show variable flows that are being examined closely
- ❖ A water level decline in the carbonate aquifer adjacent to the Muddy Springs and in Coyote Spring Valley of approximately 2 feet has been observed since 1998
- ❖ Coordinated monitoring of spring flow and ground-water levels is increasing through collaborative efforts by water right holders and federal entities
- ❖ Issuance of additional ground-water rights from the regional carbonate aquifer in the southern portion of the White River Flow System are being held in abeyance for 5-years (2002 – 2007) while aquifer studies are conducted

Regional Carbonate Aquifer

- **Spring Discharge:** Eakin (1964) estimated the Muddy River Spring discharge to be 36,000 to 37,000 acre-feet per year (afy) based upon USGS gage records and ET losses. USGS gaging station *Muddy River near Moapa, NV* (Moapa gage) measures the coalesced base flow of the spring, less surface water diversions and evapotranspiration (ET) that occurs between the springs and the gage (Figure 1). The 25-year average flow at the Moapa gage between 1914 and 1962, with flood flows removed, was 34,000 afy (47 cubic feet per second (cfs)). Adding the estimated ET losses between the springs and the gage of 2,000 to 3,000 afy yields the Spring discharge of 36,000 to 37,000 afy.

- **Interbasin Flow:** Spring discharge exceeds natural recharge of Upper Moapa Valley and nearby basins; therefore, the springs receive ground water from several ground-water basins through interbasin flow. Interbasin flow in the fractured Paleozoic carbonate terrain of eastern Nevada has been documented since 1949 and occurs when recharge to a basin exceeds its discharge, forming regional ground-water flow systems.

- **Flow System Supporting Muddy River Springs:** Muddy River Springs, because of its large stable flow, is a regional spring. Eakin (1966) defined 13 basins within the White River Flow System that contribute to the Muddy River Springs. However, when examining regional carbonate flow to the Muddy River Springs, researchers consider both the White River and Lower Meadow Valley Wash Flow Systems to be tributary to the Muddy River (Figure 2).

- **Estimating and Routing Flow:** Routing of water based on individual basin estimates of recharge and discharge, throughout the White River and Lower Meadow Valley Wash Flow Systems, has resulted in regional carbonate outflow estimates ranging from 37,000 afy (discharge at the springs) to 74,000 afy (spring discharge + underflow). Water budgets in the Great Basin have been estimated using the Maxey-Eakin technique since 1949. This technique incorporates both a basin ET (discharge) and the percent of precipitation that infiltrates into the ground-water system based on elevation (recharge). This methodology and modified versions have been utilized to estimate and route flow in the White River and Meadow Valley Wash Flow Systems.

Gaged Spring Flow

- **USGS Gages:** Spring flow occurs through both discrete orifices and seepage to stream channels. Three USGS gaging stations measure individual spring and tributary flows in the Springs Area: (1) Muddy Springs at LDS Farm near Moapa, NV; (2) Pederson Spring near Moapa, NV; and (3) Warm Springs West near Moapa, NV (Figure 1).

- **Water Temperature:** Water temperature of the spring discharge at the Pederson gage averages 89° F (31.5° C) (Figure 3).

- **Historical Flows:** Flows at the three gages from 1986 to present (the full period of record) fluctuate daily, seasonally, and over periods of years (Figure 4 and 5). This variation is no doubt the result of wet and dry cycles, the influence of ground-water pumpage, and perhaps barometric pressure fluctuations. Causal relationships to fluctuations are not fully understood. Hydrologists continue to examine 1) variability of flow, 2) water surface elevations at orifices, and 3) ground-water level fluctuations.

Water Quality

- **Carbonate ground-water:** The total dissolved solids of spring discharge is approximately 550 mg/L. The discharge is a sodium calcium magnesium bicarbonate water. Representative concentrations of major ions are listed below in mg/L:

Sodium	Potassium	Calcium	Magnesium	Iron	Sulfate	Alkalinity (total)	Chloride
92	11	60	26	<.1	150	215	55

Surface and Ground Water – Developing the Resources

- **Surface Water Diversions:** The Muddy River Decree of 1920 allocated the entire surface flow of the Muddy River and Springs. Surface water uses from upstream to downstream include the following (Figure 6):
  - Moapa Valley Water District (MVWD) has permits to divert 3 cfs from Baldwin and 1 cfs from Jones Springs via spring boxes and pumps (2,900 afy);
  - Nevada Power Company (NPC) diverts up to 3,000 afy immediately upstream of the Moapa gage in the winter;

- Paiutes divert water at the upstream end of the reservation for agriculture; and
- Muddy Valley Irrigation Company (MVIC) diverts the entire Muddy River at "Wells" siding downstream of the Glendale gage.

- **Ground-water Diversions:** All ground-water in Nevada is permitted by the Nevada State Engineer's Office. Ground-water development for agriculture in the Muddy Springs Area began in 1947 when the first well was drilled. Today, NPC and MVWD are the primary ground-water users in the Muddy River Springs Area, although several domestic wells are also present.
  - NPC operates the Lewis well field, LDS wells, and Perkins and Behmer wells. Pumping is from the alluvial aquifer with well depths of about 100 ft and operation of the wells is primarily during the summer months.
  - MVWD operates the Arrow Canyon and MX-6 wells. Pumping is from the carbonate aquifer, and operation of the wells is year round.

  Figure 7 shows the historical pumpage and surface water diversions by NPC and MVWD (as compiled by SNWA).

<u>**Muddy River Flow**</u>

- **Moapa Gage:** Flow at the Moapa gage has declined from 34,000 afy in the 1950s to 25,000 afy in 2000. The decline correlates to the ground-water pumpage and surface water diversions that occur above the Moapa gage as interpreted by SNWA (Figures 7 through 9).

- **Glendale Gage:** The USGS Glendale gage (*Muddy River near Glendale, NV*), located in Lower Moapa Valley, measures a depleted base flow of the Muddy River downstream of the Moapa Gage, plus periodic flood flows from the Muddy River, California Wash, and Lower Meadow Valley Wash. Flows at the Glendale Gage have declined coincident with the Moapa Gage and flows at both gages are relatively equal (Figure 10). Interpreted by SNWA this implies that ground-water inflows between the gages occur at a rate equal to ET losses between the gages. The ET between the gage is estimated by SNWA at approximately 9,000 afy (1,800 acres at 5 afy per acre).

- **Overton Gage:** The USGS gaging station *Muddy River at Lewis Avenue at Overton, NV* is located about 1.5 miles upstream of Lake Mead and measures agricultural returns and flood flows. This gage is operated and maintained by SNWA, with records reviewed and published by USGS.

<u>**Ground Water Fluctuations**</u>

- **Carbonate water level fluctuations:** Water levels in the carbonate aquifer adjacent to the Muddy Springs Area fluctuate due to barometric pressure, ground-water pumpage, and wet/dry cycles. Figure 11 shows carbonate water levels fluctuate seasonally by up to 0.75 ft and shows a general water level decline of approximately 2 feet since 1998 in carbonate monitoring wells adjacent to the Springs and in Coyote Spring Valley. This decline is no doubt due to either ground-water pumpage or drought conditions (and is probably a combination of both).

- **Alluvial water level fluctuations:** Water levels in the alluvial aquifer of the Muddy Springs Area fluctuate due to barometric pressure, ground-water pumpage, and wet/dry cycles. Figure 12 shows alluvial water level fluctuations in monitor wells adjacent to pumping wells. Water levels can fluctuate as much at 30 ft seasonally.

Surface and Ground Water Monitoring

- **Participating Agencies:** Monitoring is being conducted by SNWA, MVWD, NPC, USGS, and USFWS in accordance with water right requirements, and in an attempt to better understand effects of ground-water and surface water diversions, and natural changes in the flow system.

- **Annual Reports:** NPC, MVWD, and SNWA submit annual monitoring reports to the State Engineer's office.

- **Monitoring Questions:** Figures 5 through 7 demonstrate flow over time at the three gages measuring spring flow and the Moapa Gage. Key questions to be answered by monitoring are: **(1)** Is spring flow declining relative to declining river flow? **(2)** Is there a difference in effects from alluvial pumpage verses carbonate pumpage? **(3)** What are the effects of local and regional wet and dry periods? **(4)** Is there additional unappropriated ground-water that can be permitted?

Development of the Carbonate Aquifer & Integrated Monitoring

- **Water Right Hearings:** In the summer of 2001, the Nevada State Engineer held water right hearings on ground-water applications in Coyote Spring Valley filed by the Las Vegas Valley Water District (LVVWD) and Coyote Spring Investments, Inc. LVVWD, prior to the hearing, entered into a stipulation with Department of Interior Bureaus, USFWS, NPS, and BLM, regarding development of ground-water rights in Coyote Spring Valley. The goal of the stipulation "is to manage the development of the carbonate aquifer as a water resource without resulting in unreasonable adverse impacts to state and federal water rights and water resources of the Federal Bureaus."

- **Technical Review Panel (TRP):** This stipulation, besides establishing monitoring requirements in Coyote Spring Valley and the Muddy Springs Area, forms a Technical Review Panel with membership including LVVWD, SNWA, MVWD, USFWS, NPS, and BLM. The purpose of the Technical Review Panel is to:
  - Ensure data dissemination;
  - Identify needs for additional data collection and scientific investigations; and
  - Provide a forum for discussion to help develop agreement for prescribed courses of action on technical issues.

- **Ruling and 5-Year Test:** The State Engineer's ruling on the hearings, issued March 8, 2002, holds all ground-water applications in the carbonate rock aquifer in Coyote Spring Valley (and in Kane Springs Valley, Garnet Valley, Hidden Valley, California Wash, Upper Moapa Valley, and Lower Moapa Valley) in abeyance for a five year testing period while a minimum of 50% of existing rights in Coyote Spring Valley (8,000 afy) are pumped for two consecutive years.

- **Cooperation Among Agencies***:* Testing parameters and timelines associated with the aquifer test are in conceptual form and will be developed through the Technical Review Panel over the next 6 months to 1-year. In the interim SNWA in consultation with FWS, NPS, and BLM is preparing to drill up to 6 monitoring wells in Coyote Spring Valley and Upper Moapa Valley at a cost of approximately $1.4 million dollars. Two new surface water gages have also been recently installed in the Muddy Springs Area by SNWA in cooperation with USGS. SNWA is also conducting a detailed elevation survey of wells and springs in the southern portion of the White River Flow System. In addition, SNWA, FWS, and NPS are cooperatively funding a geologic mapping project of the carbonate aquifer terrain in southern Nevada.

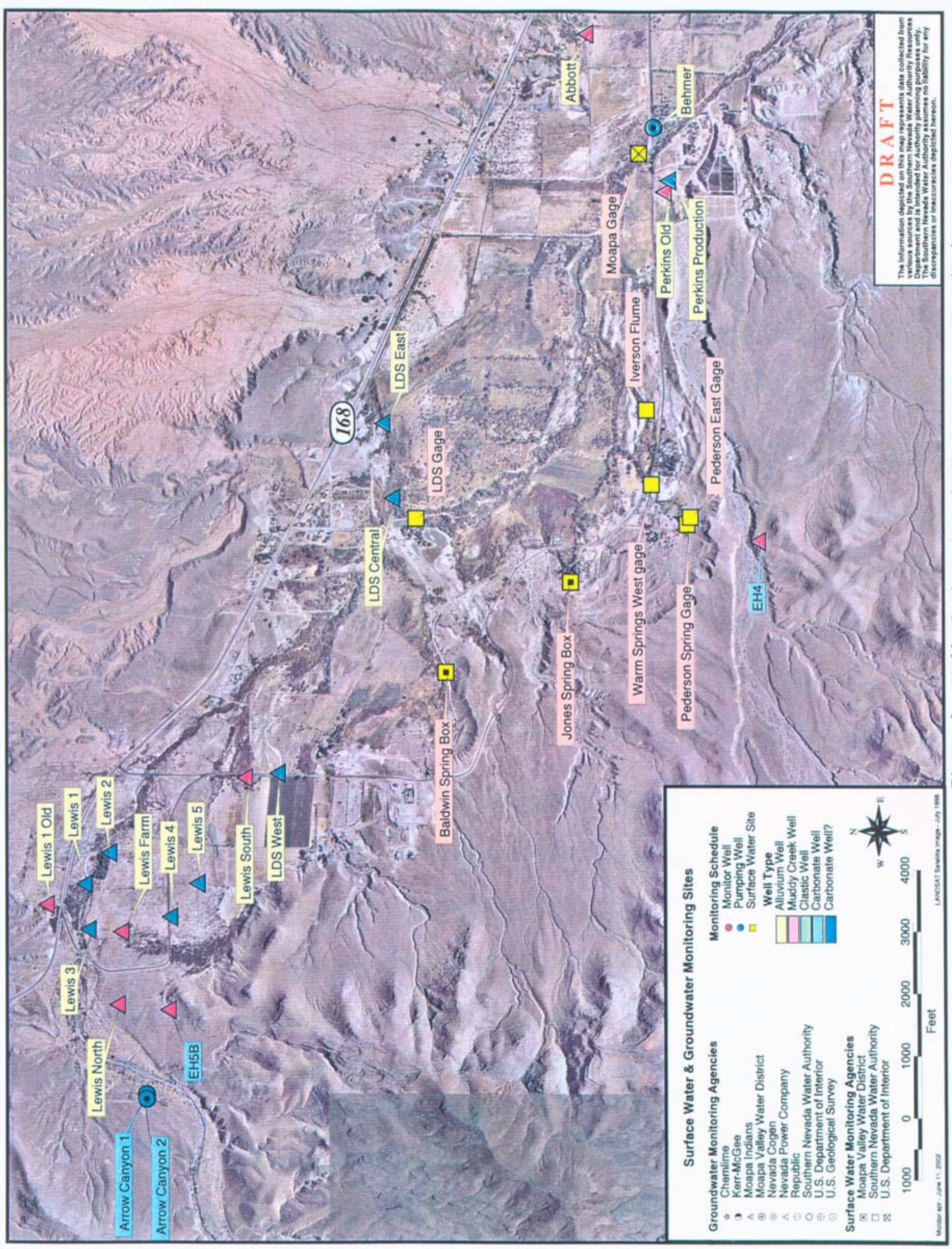


Figure 1. Muddy Springs Area in Upper Moapa Valley (11/01 aerial photo)

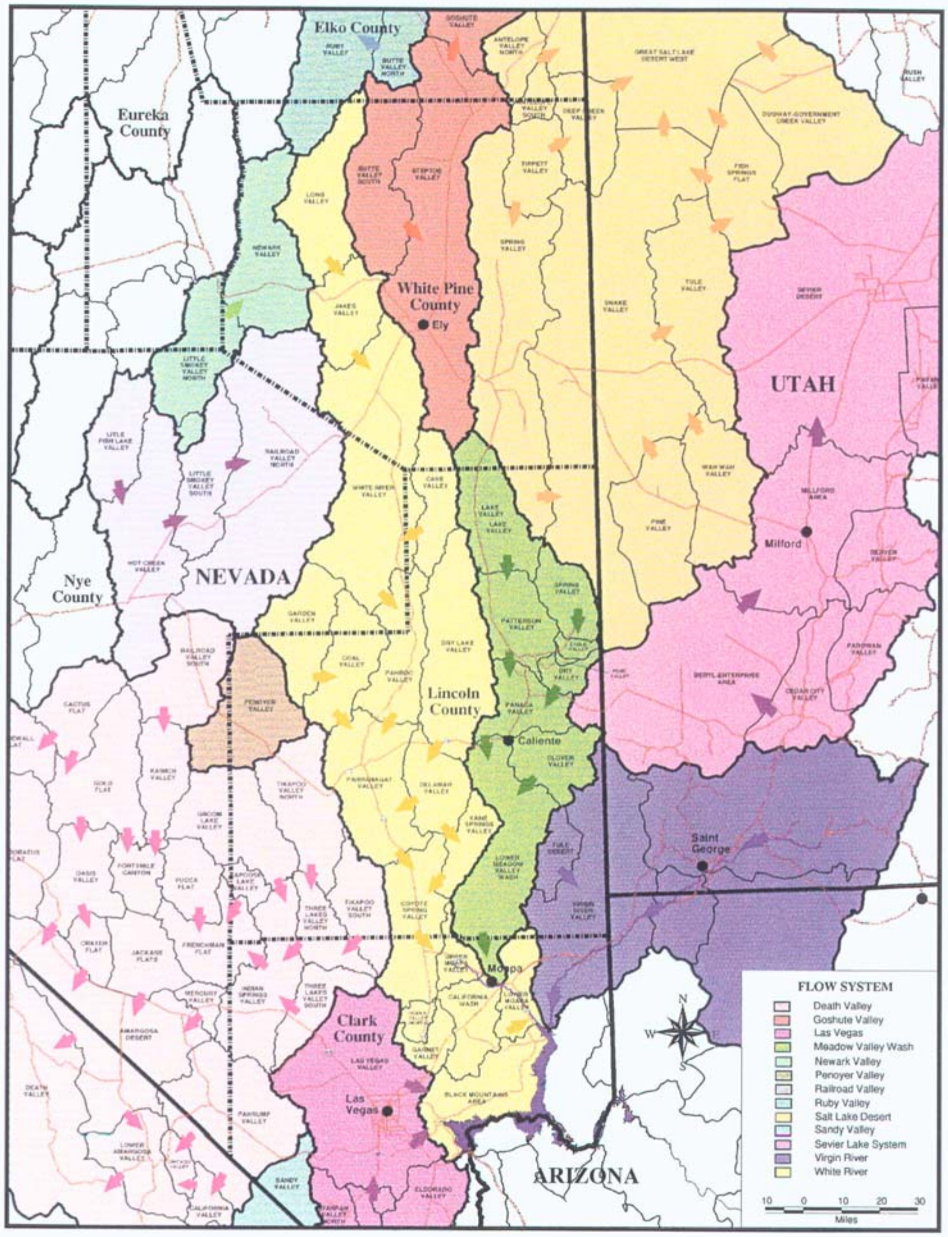


Figure 2. Regional Carbonate Aquifer Flow Systems. Based on Harrill and Prudic, 1998 (USGS Professional Paper 1409 A)

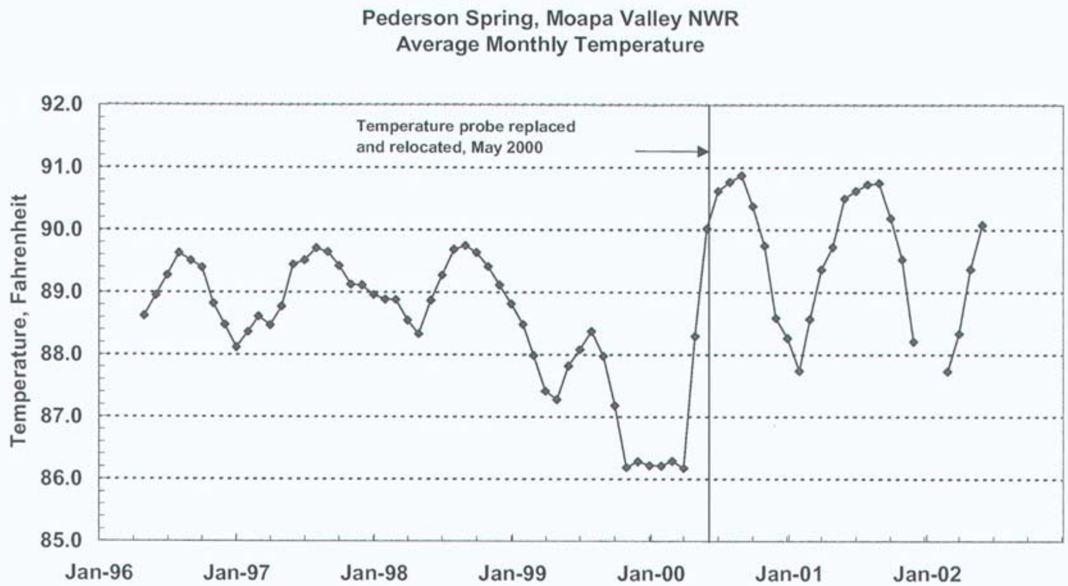


Figure 3. Average monthly temperature at Pederson Spring April 1996 to May 2002

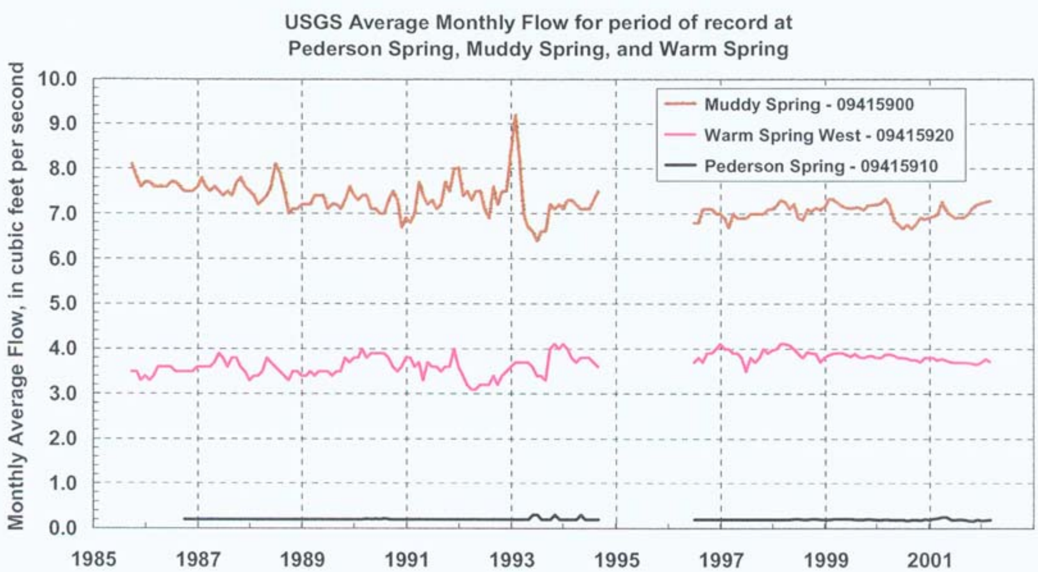


Figure 4. Monthly average flow at the three USGS gaging stations measuring tributary flow to the Muddy River (gages cooperatively funded by SWNA and USGS)

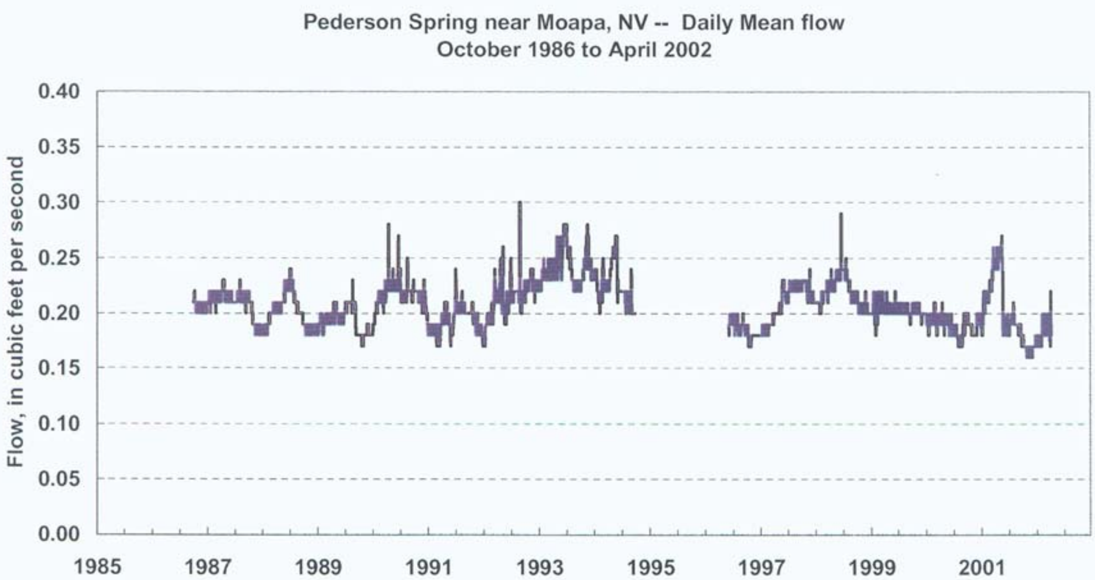


Figure 5. Daily average flow in cfs at Pederson Spring for period of record.

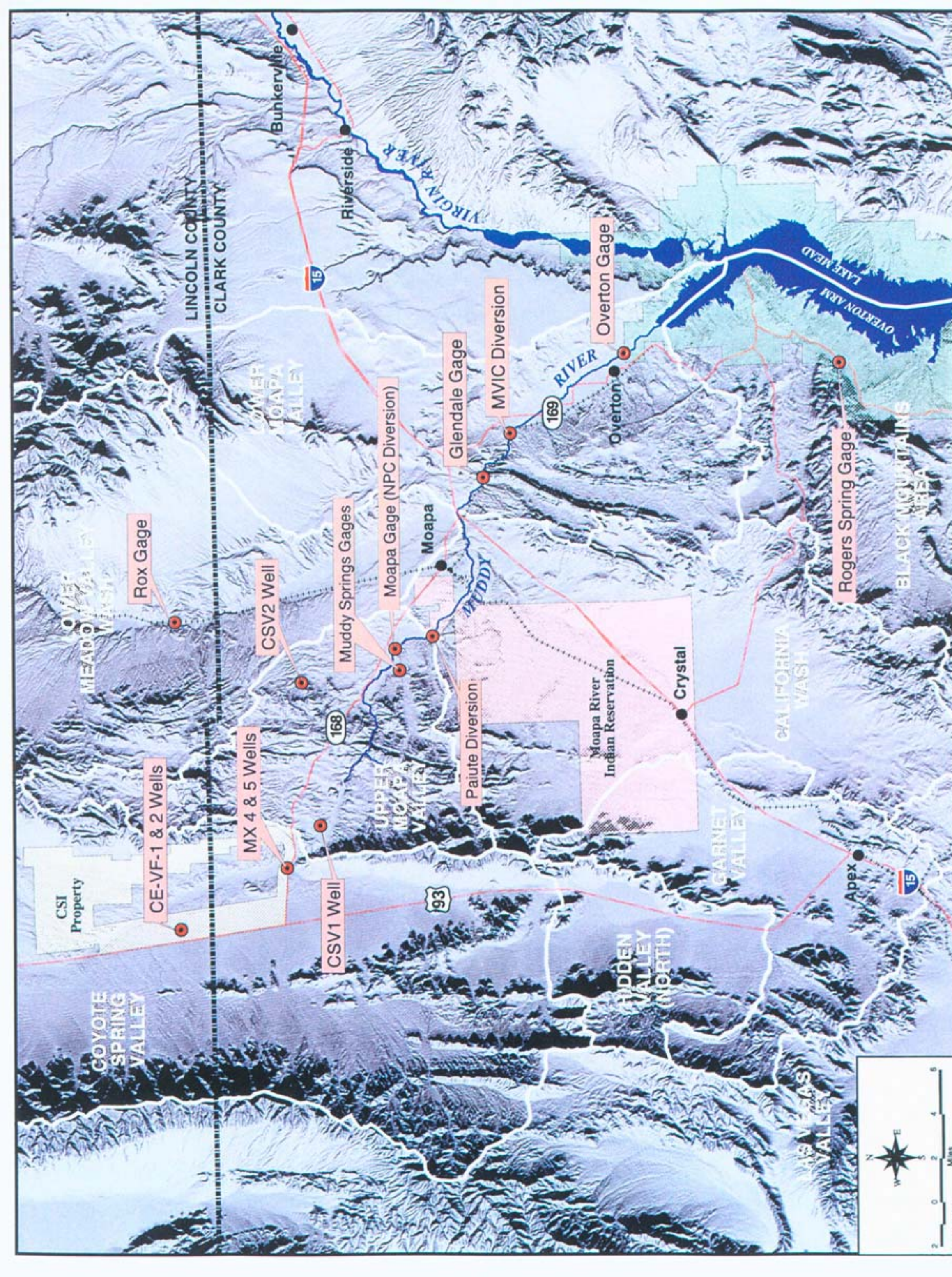


Figure 6. Location of diversions and surface gages on the Muddy River.

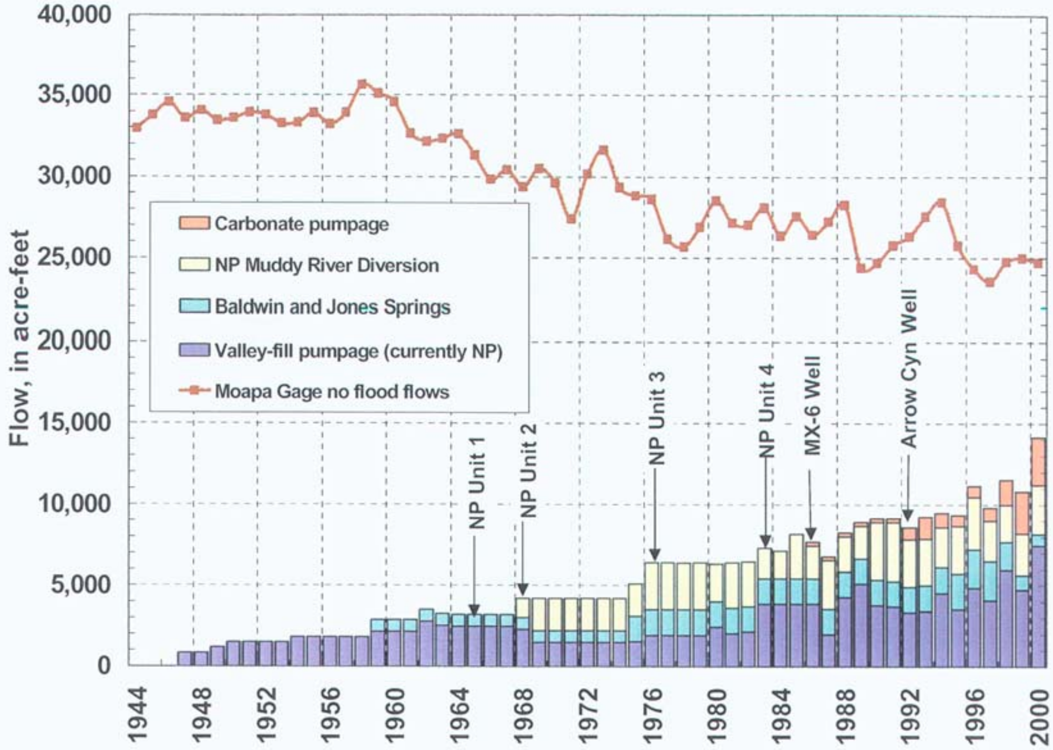


Figure 7. Annual flow without flood flows at USGS gaging station *09416000 Muddy River near Moapa, NV,* compared to ground-water pumpage and surface-water diversions. Also indicated are the years production wells became operational as well as each generating unit at Nevada Power Company's Reid Gardner power generation.

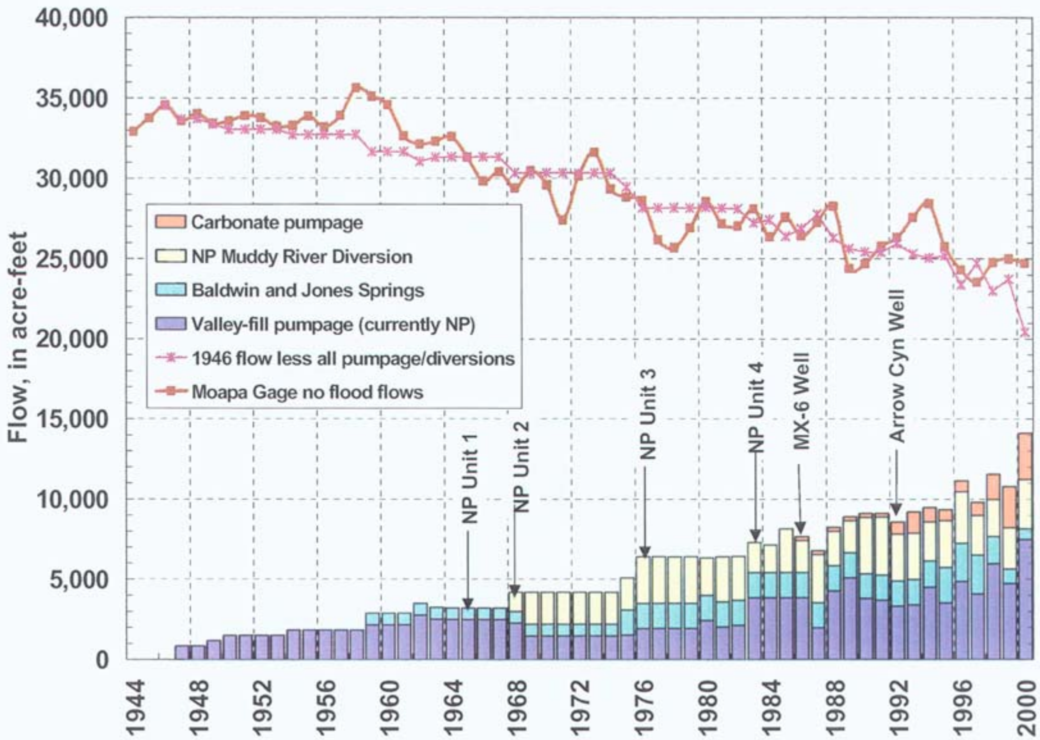


Figure 8. A correlation exists between the ground-water pumpage in the Muddy Springs area of Upper Moapa Valley and the decline in stream flow at the Moapa gage. The measured flow at the Moapa gage without flood flows and the corresponding volume of ground-water pumpage and surface-water diversion is depicted above. Subtracting ground-water pumpage and surface-water diversions from the pre-development stream flow of water year 1946 for each water year from 1947 to 2000 equals a theoretical flow that closely approximates the actual measured flow **(Figure 5-10)**. This suggests the decline in gage flow at the Moapa gage is directly related to ground-water pumpage and surface-water diversions.

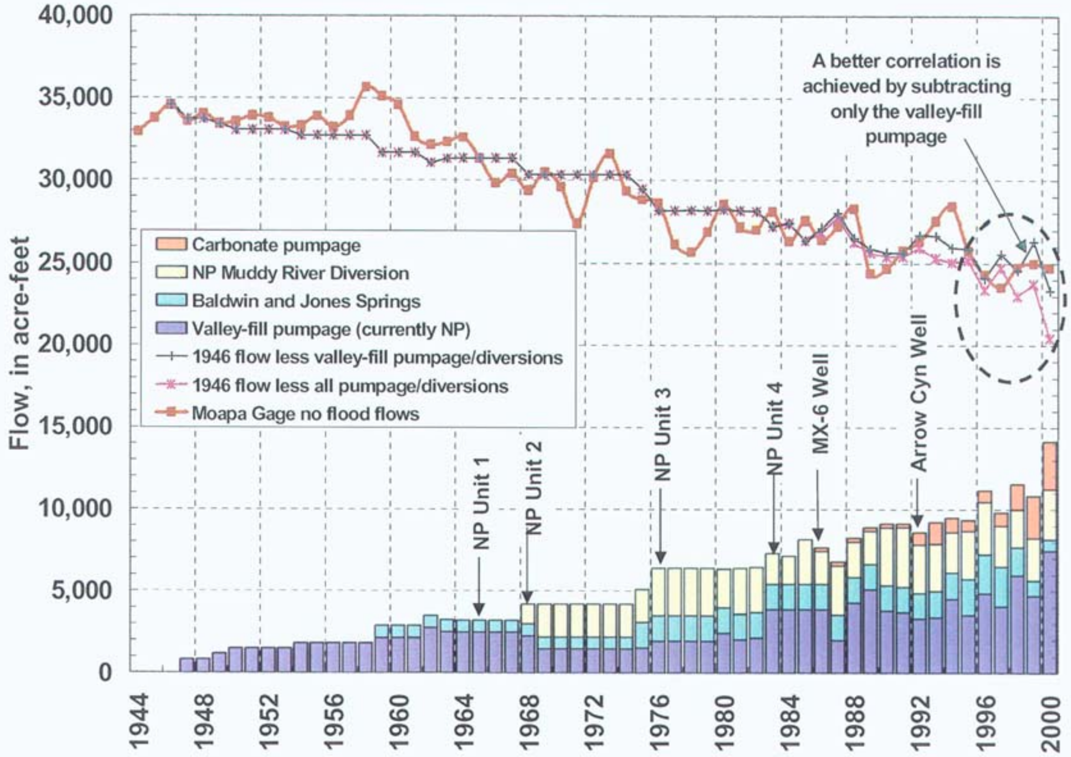


Figure 9. The exception to the discussion in figure 8 is water years 1998 to 2000. To correct for this, only the valley-fill ground-water pumpage and surface-water diversions are subtracted from the pre-development stream flow of water year 1946 (carbonate ground-water pumpage is excluded), and a better comparison is achieved for water years 1998 to 2000 **(Figure 5-11)**. Inclusion of the carbonate pumpage yields a difference from the gage flow, while the exclusion of the carbonate pumpage yields a closer comparison to the gage record. This suggests that ground-water pumpage from the carbonate aquifer may not be having an effect on the flows at the Moapa gage. Future observations of stream flow and ground-water pumpage will need to be collected to further corroborate this hypothesis.

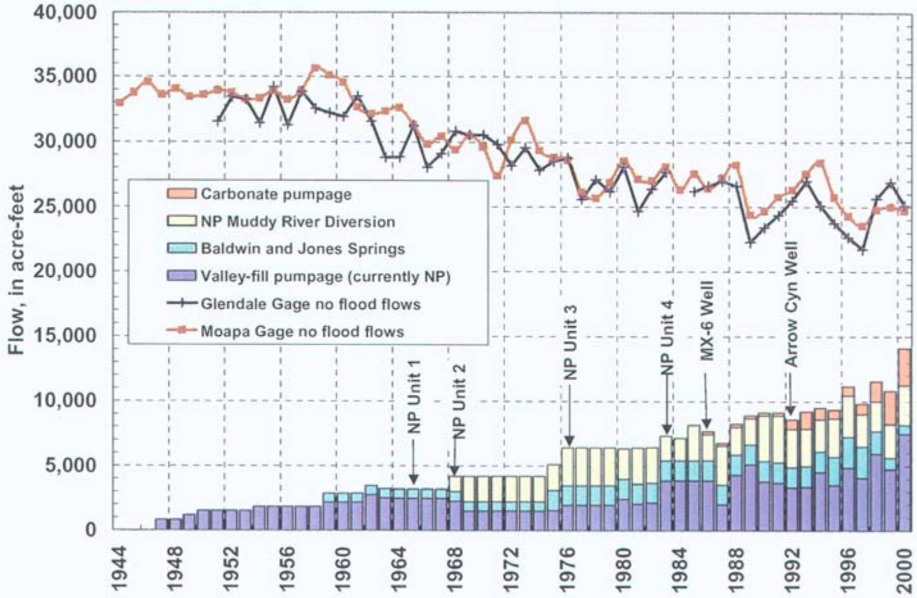


Figure 10. Comparison between the measured flow at the Moapa and Glendale gages without flood flows.

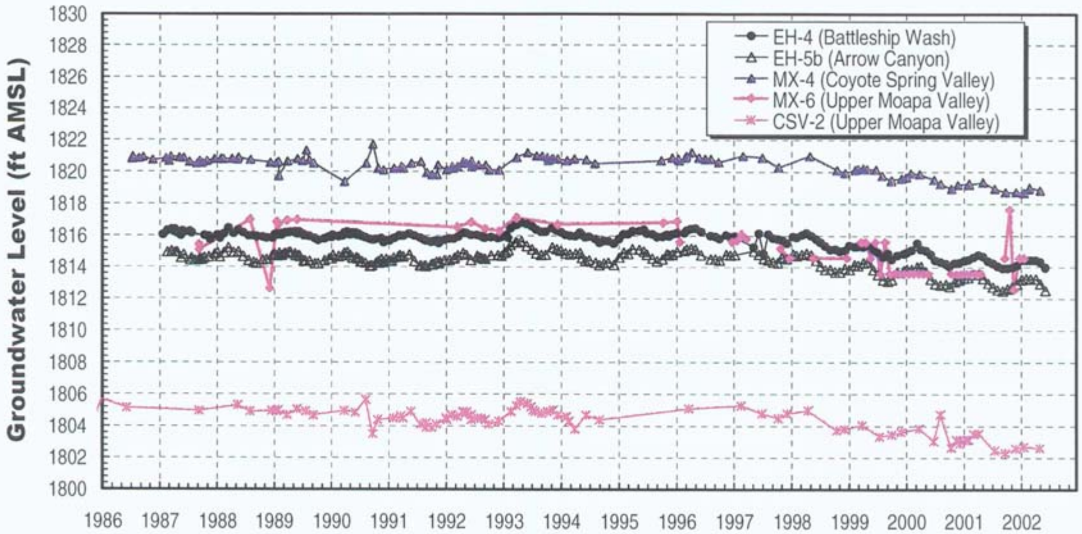


Figure C-2

Figure 11. Ground-water levels in the carbonate aquifer within 20 miles of the Muddy River Springs.

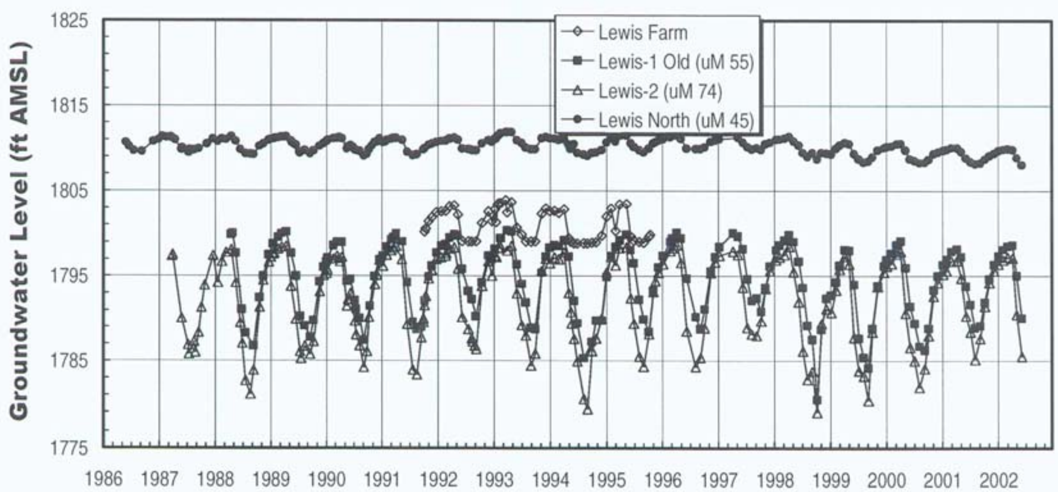


Figure C-1

Figure 12. Ground-water levels in the alluvial aquifer in the Muddy Spring Area.

Appendix IV–B. Interior Wetland Marsh and Seep Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
<u>Condition</u> Unknown **<u>Spatial</u>** Expansion of current area by 25%. **<u>Management Actions</u>** Increase water supplies	**<u>Condition</u>** Unknown **<u>Spatial</u>** Expansion of current area by 50%. **<u>Management Actions</u>** Dramatically increase water supplies	**<u>Condition</u>** Unknown **<u>Spatial</u>** Graminoid-dominated communities, from tall (ca. 4m) to short (0.2m), controlled by a gradient of water availability. *Scirpus* and *Eleocharis* at the core of a complex of permanently wet areas. *Phragmites* dominates drier peripheries, often grading into *Juncus* communities and/or *Distichlis* grasslands. *Distichlis* grades into either the Saltbush Shrubland Matrix or the Desert Riparian Shrubland Matrix. Ambitious methods may be able to expand the habitat by 100% or more, with no appreciable change in species composition. **<u>Management Actions</u>** Restore all water supplies to pre-agricultural levels to support the wild ecosystems
Total Acreage: 293 acres (118 ha)	**Total Acreage:** unknown	**Total Acreage:** historic map of wetlands unknown
Other Focal Targets Captured: amphibians, nesting birds, butterflies, fish, desert riparian mammals	**Other Focal Targets Captured:** amphibians, nesting birds, butterflies, fish, desert riparian mammals	**Other Focal Targets Captured:** amphibians, nesting birds, butterflies, fish, desert riparian mammals

Preferred DFC: Alternative 2

Interior Wetlands Marsh and Seeps

Natural history description of community: The Interior Wetlands Marsh and Seeps community in the upper Muddy River are located in areas of permanent or semi-permanent water. They are interfingered with the Riparian Shrublands Matrix and the Desert Riparian Forest Matrix, centered on a constant and relatively high water table. The communities are comprised of seasonal and perennial graminoids. The distribution of this community matrix roughly corresponds to the "Riparian Marsh" category in the TNC Conservation Targets map for the Muddy River. The community matrix is expanded artificially between agricultural ditches in the Mormon Ranch vicinity. Such redistribution of surface waters here almost certainly curtails the development of the community matrix in the "Mesquite Bosque" and "100 year Floodplain" categories, and further downstream.

Biogeographic Context: This is an unexceptional assemblage of mostly widespread wetland species in an exceptional location. The most notable species about which I am aware to occur here in this matrix is *Typha domingensis*. The nearest wetland complex of equivalent size is in the Virgin River, 40 km to the West. Pahranagat Valley, 60 km away, has the closest wetlands to the North. Big Springs in Las Vegas Valley is essentially gone, leaving Corn Creek as the nearest spring system of comparable size to the east, some 60 km to the southeast. Given the area's connection to the north-central Great Basin via the White River and the Sonoran Desert via the Virgin and Colorado Rivers, the wetlands are at a critically located for migrating birds and other wildlife.

Key ecological process: hydrology, river connected to floodplain

Embedded communities

TNC: *Typha* spp. Semi-permanently Flooded Herbaceous Alliance. Perennial, tall graminoid wetland community. A 1m to 3m tall graminoid wetland, depending on the species.
Grank: G5. Ecoregion Distribution: W.

TNC: *Pragmites australis* Semi-permanently Flooded Herbaceous Alliance. Seasonally green, tall perennial grassland with 100% cover. Locally dominant in prominent patches.
Grank: G5. Ecoregion Distribution: W.

TNC: *Juncus balticus* Seasonally Flooded Herbaceous Alliance. Perennial, short graminoid wetland with fairly high diversity, dominated by *Juncus balticus*. Up to 100% cover.
Grank: G5. Ecoregion Distribution: W

Yerba Mansa (*Anemopsis californica*) Meadow [not in TNC list of Mojave communities]. Meadows dominated by the perennial herb, *Anemopsis californica*, with up to 100% herbaceous cover. Here, sometimes heavily infected by *Xanthium*.
Grank: undescribed and unranked. Ecoregion Distribution: undescribed and unclassified.

TNC: *Distichlis spicata* Intermittently Flooded Herbaceous Alliance (Saltgrass Grassland). Simple, short, perennial grassland with a few species; from 60-100% cover. Fairly low productivity, on intermittently flooded saline soils. Ecotonal to Saltbrush Shrubland Matrix and Desert Riparian Shrublands Matrix.
Grank: G5. Ecoregion Distribution: W.

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
25%	25%	25%	25%

Desired structure, composition, and landscape context and configuration

I. Structure

- <u>Dominant native canopy species density</u>
  High-quality condition:
  100% cover of natives, mainly of whichever native species is dominant.
  Degraded condition:
  Most degradation is simply habitat destruction and decline due to redistribution of water.
- <u>Dominant native canopy species distribution</u>
  Apparently even-aged stands.
- <u>Dominant canopy species seedling mortality</u>
  I do not know anything about any seedling mortality in any of these species in any condition.
- <u>Dominant non-native canopy species or co-dominant canopy species that indicates problem</u>
  There is no problem with non-native canopy species.

II. Species composition

- Vegetation
  100% cover of natives, mainly of whichever native species is dominant.
- Graminoids
  100% cover, often emergent in all communities except for *Anemopsis*. In these communities, there may be up to 20% graminoid cover and 80% herbaceous cover.
- Indicators of degradation–high quality for process hydrology
  Uncertain, but it seems that increase of *Eleocharis* and *Scirpus* indicates improved condition, increase of *Distichlis* and *Juncus* indicates degradation.
- Specific information of taxa responses
  Not know.
- T & E species (see Table)

III. Landscape context and configuration

- A semi-continuous distribution of different wetland communities, from the source to The Narrows. Interfingers with Desert Riparian Forest and Desert Riparian Shrublands.

Challenges to reaching and maintaining sustainable population

- Threats

1) Groundwater pumping
   Lowering of water table by pumping within the White River/Meadow Valley Wash drainages. Of particular concern is the recent assignment of water rights to a private landowner in Coyote Springs Valley. Additional consumptive uses of water are planned within the drainage

system for new power plants proposed in the valley.

- Management constraints:

1) Culture of "right of prior appropriation."
2) Water rights are very expensive.
3) Water is wanted by Clark County.

Potential management options to reach DFC (with Pros + and Cons -)

- Increase Water Supply
  + Increase of habitat area and quality
  + Connect currently isolated habitat patches
  – water rights are very expensive

Ecological and Management Uncertainties

- Research uncertainties
  I have not seen most of these wetland types except from afar and from aerial photographs.
- Management uncertainties
  I am not very learned about wetlands.

Information Source(s) and Reviewers

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, P.K. Holmgren. Intermountain flora. Volume VI: The monocotyledons. New York Botanical Garden, New York.

Hickman, J.C. (editor). 1993. The Jepson manual: Higher plants of California. University of California Press, Berkeley. 1400 pp.

- Author: David A. Charlet (david_charlet@ccsn.nevada.edu)
- Reviewers: Jan Nachlinger (partial review; jnachlinger@tnc.org)

TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ NV STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Interior Wetland Marsh and Seep Matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	***Typha* spp. Semi-permanently Flooded Herbaceous Alliance**		**G5**	
	***Pragmites australis* Semi-permanently Flooded Herbaceous Alliance**		**G5**	
	***Juncus balticus* Seasonally Flooded Herbaceous Alliance**		**G5**	
	Yerba Mansa (*Anemopsis californica*) Meadow			
	***Distichlis spicata* Intermittently Flooded Herbaceous Alliance** (ecotonal community)		**G5**	
	***Fraxinus velutina – Prosopis glandulosa* Woodland Alliance** (ecotonal community)		**G1?**	

Appendix IV–C. Desert Riparian Forest
Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
<u>Condition</u> Overstory codominated by *Salix gooddingii* and *Fraxinus velutina*, with *Salix* dominating the core and *Fraxinus* at the periphery. *Populus fremontii* also abundant. *Washingtonia filifera* community retained at Warm Springs. **<u>Spatial</u>** Community Matrix fading into Mesquite Bosque away from the perennial streams, and near the confluence of dry washes. Small, linear habitat. **<u>Management Actions</u>** 1) Remove *Tamarix ramosissima* to a low level (no more than 10%) of any stand. 2) Remove the following species: *Phoenix canariensis*, *Elaeagnus angustifolia* 3) Promote the following species: *Salix goodingii, Fraxinus velutina*, *Populus fremontii.* 4) Tolerate the following species: Washingtonia filifera, Tamarix aphylla	**<u>Condition</u>** **<u>Spatial</u>**	**<u>Condition</u>** Overstory codominated by *Salix goodingii* and *Fraxinus velutina*, with *Salix* dominating the core and *Fraxinus* at the periphery. *Populus fremontii* also abundant. **<u>Spatial</u>** Community Matrix fading into Mesquite Bosque away from the perennial streams, and near the confluence of dry washes. Community mainly developed near the source of the Muddy River, but patches developing discontinuously downstream. Narrow community. **<u>Management Actions</u>** 1) Remove all *Tamarix ramosissima, T. aphylla, Washingtonia filifera, Phoenix canariensis, Elaeagnus angustifolia*. 2) Increase water supplies 3) Geomorphic restoration
Total Acreage: 612 acres (248 ha) shared with desert riparian shrublands (50 m river buffer)	**Total Acreage:** unknown	**Total Acreage:** unknown, but potentially larger than 612 acres (248 ha) if wider than DFC
Other Focal Targets Captured: breeding birds, amphibians, butterflies, reptiles, gray fox, aquatic invertebrates, butterflies, small	**Other Focal Targets Captured:** breeding birds, amphibians, butterflies, reptiles, gray fox, aquatic invertebrates, butterflies, small	**Other Focal Targets Captured:** breeding birds, amphibians, butterflies, reptiles, gray fox, aquatic invertebrates, butterflies, small

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
mammals	mammals	mammals

Preferred DFC: Minimum DFC, but requires evaluation.

Desert Riparian Forest

Natural history description of community: The Desert Riparian Forest in the upper Muddy River is a community of arboreal phreatophytic communities centered upon a constant and abundant surface water flow. The distribution of this community matrix roughly corresponds to the "Warm Springs Aquatic Assemblages" category in the TNC Conservation Targets map for the Muddy River. The communities are comprised of mainly broadleaved trees, although microphyllous species are present and sometimes dominant. Most of the species are seasonally deciduous, the exceptions to this are *Washingtonia filifera*, *Phoenix canariensis*, and *Tamarix aphylla*, all of which are almost certainly not native to the site. The community matrix is expanded artificially along the agricultural ditches in the Mormon Ranch area. Such redistribution of surface waters here almost certainly curtails the development of the community matrix further downstream.

To gain insight as to the Muddy River's character at contact time, the words of early explorers may prove insightful. Once known as Rio Atascoso, one early explorer observed, "Rio Atascoso is a narrow stream, but in many places quite deep; its water is clear and it derives its name form the slimy and miry nature of its banks and bed" (Heap in Hafen and Hafen 1957, cited in Carlson 1974:174). This seems to indicate that the deep channel of the river may have been present at contact time. This area is by far the oldest in Nevada to have agricultural activities, with irrigation provided to corn, beans, and cucurbits since about 500 AD (Fowler and Madsen 1986), with new practices and crops introduced to the area between 1855 (Fowler and Madsen 1986) and 1865 (Carlson 1974) by Mormon settlers.

Biogeographic Context: This community matrix has significant biogeographic importance in the region, as it represents the largest remaining area in Clark County with perennial streams from spring discharge. In southern Nevada, only Ash Meadows has more water discharged into surface streams on a perennial basis. Elsewhere in Clark County, only the Virgin River has more perennial surface flow supporting riparian forests. As such, the Muddy River is unique, is vitally important as a refugium for many species, and is an important stopover for migratory birds. In addition, its connection to the Colorado River drainage allows biogeographic communication between the Mojave Desert and the Sonoran Desert to the southeast. The Meadow Valley Wash creek has a confluence with the Muddy River in the upper Moapa Valley connects the Mojave Desert and the Great Basin. Similarly, the White River drainage is continuous with the Muddy River drainage, facilitating migration between the Central Great Basin and the Mojave Desert. Thus, the Muddy River is a nexus between three of the four major deserts of North America.
Key ecological process(es): spring discharge, flash floods, fire
Federal and State Listing Status, if known: animals only

Embedded communities

TNC: Mixed Cottonwood-Willow Riparian Woodland. I would call what occurs in the Muddy River as Cottonwood – Velvet Ash – Black Willow Riparian Forest. This is a

broadleaf, deciduous, phreatophytic, temperate riparian forest, with fairly high diversity of tree and shrub species. Several canopy layers contribute to a complex vertical structure.
Grank: G2. Ecoregion distribution: L.

TNC: California Fan Palm Oasis. This is a broadleaf, evergreen, phreatophytic, subtropical riparian forest. The community is entrenched and flourishing at springs, especially at Warm Springs in the Pederson Unit. It is possible, however unlikely, that the stand is native. The main native distribution of the species is in the southwestern Mojave Desert. The strong lowland connection the Muddy River has via the Colorado River as well as the warm springs may have allowed them to persist throughout the Pleistocene. However, if native, the more likely explanation for their occurrence here is Holocene migration to the site via an avian vector and persistence due to the constant water supply.
Grank: G2G3. Ecoregion distribution: P

TNC: *Fraxinus velutina – Prosopis glandulosa* Woodland Alliance. (Velvet Ash – Honey Mesquite Woodland). Ecotonal to Desert Riparian Forest Matrix.
Grank: G1? Ecoregion distribution: E.

Fremont Cottonwood - Velvet Ash Woodland. Association Summary: This is a lowland forested riparian association known from central and southeastern Arizona, southwestern New Mexico and southwestern Utah. Elevations range from 1200-1550 m . Sites are typically rocky or sandy banks of moderate-gradient streams (1.5%) that are frequently flooded (two-year recurrence interval). Soils have been reported as coarse-loamy over fragmental Typic Torrifluvents, and as cobbly riverwash, reflecting the coarse substrates of sites. *Populus fremontii* and *Fraxinus velutina* codominate young, moderate to dense canopies (>50% cover). *Acer negundo, Salix gooddingii, Juglans major, Alnus oblongifolia,* and *Celtis laevigata var. reticulata* are occasional canopy or subcanopy associates. Undergrowth is moderately diverse, but cover is low. In the shrub layer there are usually scattered individuals of *Baccharis salicifolia* and *Amorpha fruticosa*. The herbaceous layer has sparse to moderate cover. Common associates may include *Juncus saximontanus, Sphenopholis obtusata, Sporobolus cryptandrus, Muhlenbergia wrightii,* and *Datura wrightii*. Disturbed stands often have high cover of the introduced *Bromus diandrus, Bromus tectorum,* or some other exotics.
Global Heritage Status Rank Reasons: G2G3. This lowland riparian association is limited to scattered stands in Arizona, New Mexico, and southwestern Utah where plants, particularly trees and shrubs, have access to an active groundwater table. High-quality occurrences are not likely to exceed 100 in number. As with many riparian zone communities in the Southwest, impacts over the past 150 years from livestock use, agricultural conversion, urbanization, recreational use, and the alteration of hydrological regimes have led to extensive fragmentation and loss of this community. Viable occurrences are mostly found along unregulated rivers where periodic flooding and sustained maintenance flows lead to successful reproduction and establishment of native riparian species. In the Southwest, such unregulated rivers are few, hence the community has become globally rare, still is threatened, and declines continue today. The rank was changed from G3 to G2G3 to reflect these trends.

Global Range Comments: This association occurs in lowlands of southwestern New Mexico, southern Arizona, southwestern Utah, and may occur in western Texas.
Environmental Summary: This is a lowland forested riparian association known from central and southeastern Arizona, southwestern New Mexico and southwestern Utah. Elevations range from 1200-1550 m . Sites are typically rocky or sandy banks of moderate-gradient streams (1.5%) that are frequently flooded (two-year recurrence interval). However, stands are also reported from higher elevations in cool drainages or ravines. Soils have been reported as coarse-loamy over fragmental Typic Torrifluvents, and as cobbly riverwash, reflecting the coarse substrates of sites.
Vegetation Summary: This riparian association is characterized by an open to moderately dense canopy (20-60% cover) that is codominated by large *Populus fremontii* and *Fraxinus velutina* trees. *Acer negundo, Salix gooddingii, Juglans major, Alnus oblongifolia, Celtis laevigata var. reticulata,* and *Populus angustifolia* (at higher elevations) are occasional canopy associates, but may be more common in the subcanopy (if present). Undergrowth is moderately diverse, but cover is low. In the shrub layer there are usually scattered individuals of *Amorpha fruticosa, Baccharis salicifolia,* and several other shrubs including *Baccharis emoryi, Brickellia californica,* and *Ericameria nauseosa*. The herbaceous layer has sparse to moderate cover. Common associates may include *Juncus saximontanus, Sphenopholis obtusata, Sporobolus cryptandrus, Muhlenbergia wrightii,* and *Datura wrightii*. Disturbed stands often have high cover of the introduced *Bromus diandrus, Bromus tectorum,* or some other exotics.

Populus fremontii - Salix gooddingii Woodland. Association Summary: This community occurs as small isolated stands or as linear bands that parallel stream channels. This deciduous woodland typically towers above the surrounding vegetation. *Populus fremontii* and *Salix gooddingii* may be nearly equal in abundance, or either may dominate. Individuals of *Populus fremontii* are scattered or occur in groves, and may reach 30 m in height and 2 m in diameter. Other species that may occur in the canopy/subcanopy include *Populus deltoides ssp. wislizeni, Salix lasiolepis, Salix exigua, Salix amygdaloides, Fraxinus berlandieriana, Celtis laevigata var. reticulata, Juglans microcarpa, Prosopis pubescens, Prosopis glandulosa,* and *Prosopis velutina*. The understory of most examples have been considerably altered by grazing and other factors, thus the composition and cover of the native understory is difficult to ascertain, but frequently consists of shrubs and small trees (1-5 m tall). The herbaceous stratum varies in composition and coverage, but is characterized by mixed annuals and short-lived perennials.
Global Heritage Status Rank Reasons: G2. Few intact examples of this association remain in the southwestern United States. The association continues to be in decline, primarily as a function of major hydrological alterations (dams and diversions), grazing, off-road vehicles and agricultural conversion. The remaining functional stands are restricted to wild rivers such as the Gila and San Francisco rivers, and possibly along the Mimbres River in New Mexico, or the San Pedro River in Arizona. A few remnant stands are also known from the middle Rio Grande and a few locations in western Texas. This is a very significant association with respect to biodiversity and was once one of the major riparian communities of the Southwest. Stands that have not been invaded by exotic trees,

shrubs and herbs are also very rare. Even protected examples are threatened by continued declines in upland watershed conditions and hydrological modification.

Global Range Comments: This community is found in the Trans-Pecos region of western Texas, in southwestern New Mexico, and southeastern Arizona, south into northern Mexico. This community type is known to occur along the southern middle Rio Grande, along smaller montane tributary basins that drain the eastern side of the Black Range, along the Gila, the San Francisco and in Pecos basin in southern New Mexico along three tributaries (Rio Ruidoso, Rio Hondo and Black River).

Environmental Summary: This deciduous woodland is best developed along alluvial floodplains of large, low-gradient, perennial streams that flow through wide, unconstrained valleys. The vegetation is dependent upon a subsurface water supply and varies considerably with the height of the water table. Major flood events and consequent flood scour, overbank deposition of water and sediments, and stream meandering are important factors that shape this community. Soils are typically stratified sands, loams, and gravels classified as Torrifluvents or Ustifluvents, with Haplustolls on more stable sites. These coarse-textured, alluvial sediments have a low water-holding capacity and low nutrient availability.

Vegetation Summary: This community occurs as small isolated stands or as linear bands that parallel the stream channel. This deciduous woodland typically towers above the surrounding vegetation with *Populus fremontii* and *Salix gooddingii* as the dominant species. These species may be nearly equal in abundance, or either may dominate. Individuals of *Populus fremontii* are scattered or occur in groves, and may reach 30 m in height and 2 m in diameter. Other species that may occur in the canopy/subcanopy include *Populus deltoides ssp. wislizeni*, *Salix lasiolepis*, *Salix exigua*, *Salix amygdaloides*, *Fraxinus berlandieriana*, *Celtis laevigata var. reticulata*, *Juglans microcarpa*, *Prosopis pubescens*, *Prosopis glandulosa*, and *Prosopis velutina*. The understory of most examples has been considerably altered by grazing and other factors, thus the composition and cover of the native understory is difficult to ascertain. The understory can be dense to open and frequently consists of shrubs and small trees 1-5 m tall, including *Prosopis* spp., *Baccharis salicifolia*, *Sambucus mexicana*, *Rhamnus* spp., *Morus microphylla*, and *Amorpha fruticosa*. The woody exotics *Elaeagnus angustifolia* and various species of *Tamarix* now dominate the understory of most examples. The herbaceous stratum varies in composition and coverage, but is characterized by mixed annuals and short-lived perennials. While most examples now have a herbaceous flora dominated by exotic species, in particular *Cynodon dactylon*, native species reported from this community include *Amaranthus palmeri*, *Amsinckia* spp., *Anemopsis californica*, *Boerhavia coccinea*, *Bowlesia incana*, *Carex* spp., *Chloracantha spinosa*, *Conyza canadensis var. canadensis*, *Cucurbita* spp., *Datura wrightii*, *Distichlis spicata*, *Gutierrezia sarothrae*, *Juncus balticus*, *Lemna* spp., *Oenothera* spp., *Sorghum halepense*, *Sporobolus wrightii*, and *Trifolium longipes* ssp. *shastense*.

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
0	10%	15%	75%

Desired structure, composition, and landscape context and configuration

III. Structure

- Dominant native canopy species density
  High-quality condition:
  100% cover in curvilinear strips along the perennial surface waterways. My guess is that there would be hundreds of native reproductive tree stems per acre, of many different ages and sizes; i.e., high diversity and complexity of vertical structure.
  Degraded condition:
  100% cover, thousands of stems / acre in an impenetrable thicket, and they are all *Tamarix ramosissima*. Alternatively, if *Tamarix aphylla* is the dominant, there are probably only 100 reproductive stems / acre, complete cover, and it is possible for large animals to move through the stands. In either case, vascular plant species richness is extremely low, with very few species, if any, in the understory. Presumably, *Washingtonia filifera* is not native to the site, and thus its dominance indicates a degraded condition. However, at present it maintains high vertical structural diversity and roosting habitat for turkey vultures and probably other bird species. *Phoenix canariensis* is also present in the matrix, but is not nearly as aggressive or abundant as *Washingtonia*.
- Dominant native canopy species distribution
  Populus fremontii tend to be in cohorts, as most recruitment follows flood events and the subsequent redistribution of soils along flood watercourses. When mature, *P. fremontii* trees are 30m tall, canopy can be wide (ca. 20m) or narrow (ca. 5m) depending upon the density of the trees, and no more than 75 yr. old. *Fraxinus velutina* individuals do not tend to occur in cohorts, and so perhaps are not as dependent upon flood disturbance for recruitment. This may be the native dominant or codominant tree at climax in the system. I suspect that this species would not be dominant in the core, but rather at the periphery, as it does not seem to depend on a constant surface water supply, and occurs in transitional communities in the ecotone between Desert Riparian Forest and the Mesquite Bosque.

  Salix gooddingii also appear to be of many different ages, not occurring in cohorts. This may also be a dominant or codominant in the core of the Desert Riparian Forest system.

  Washingtonia filifera is well established and aggressive in the current core areas, especially at the spring sites. The species has tremendous fire tolerance, as evidenced by its recovery following the fire at the Pederson Unit in 1994. None of the dicotyledenous tree species are its equal in fire tolerance. Hence, if fire is, or becomes, an important ecological process here, *W. filifera* will easily overcome all the other arboreal species at sites of permanent surface water flow; i.e., at the core of the Desert Riparian Forest.
- Dominant native canopy species basal area
  I do not know what the dominant native canopy species basal area is under any condition.
- Dominant native canopy species diameter (DBH)

I do not know the native canopy species DBH in either high-quality or degraded condition.

- Dominant canopy species seedling mortality
  I do not know anything about any seedling mortality in any of these species in any condition.

  Notes: Since I do not know which tree species are native to the site, I cannot speculate as to the DBH or seedling mortality of the species in the canopy while in a high-quality condition. I do not know what the *high-quality condition* for this community is.
- Dominant non-native canopy species or co-dominant canopy species that indicates problem
  High-quality condition:
  Any *Tamarix ramosissima* individual in the system indicates a problem. This is not the case with *Tamarix aphylla*. *Tamarix aphylla* has the potential to be a problem in areas that flood regularly, as it has been observed to reproduce sexually at Lake Mead National Recreation Area (Libby Powell, personal communication), and has been observed reproducing and aggressively invading riparian communities in Australia (Lawrence Walker, personal communication). As currently managed, I do not think that this species will escape and become a large problem in this system. There is one large stand along a wash entering the main river channel from the South, in the Moapa Indian Reservation.
  Degraded condition:
  100% cover, thousands of stems /acre, and it is all *Tamarix ramosissima*
- Dominant non-native canopy species or co-dominant canopy species DBH distribution
  High-quality condition:
  I do not know.
  Degraded condition:
  I do not know.

IV. Species composition

- Vegetation
  High-quality condition:
  I do not know.
  Degraded condition:
  Tamarix ramosissima up to 100% cover or *Washingtonia filifera* up to about 50% cover.
- Graminoids
  High-quality condition:
  I do not know, but probably not abundant.
  Degraded condition:
  None occur in degraded *Tamarix* woodlands.
- Forbs
  High-quality condition:
  I do not know, although it seems that there should be somewhere around 8-15% cover contributed by forbs.
  Degraded condition:
  Virtually no native forbs occur in degraded condition.
- Woody species
  High-quality condition:
  I do not know.
  Degraded condition:
  I do not know
- Indicators of degradation–high quality for process hydrology
  Uncertain

- Specific information of taxa responses
  I do not know
- T & E species (see Table)
  No plant species with special status remain in the system. If any did occur

here, they are now extirpated or have yet to be found.

III. Landscape context and configuration

- A configuration of management units that facilitates flash flood management. Large enough to absorb disturbances of both flood and fire.
  The bigger the area, the better. Ideally, the entire flood plain and riparian strips should be included all the way to Lake Mead.
- This community has significant biogeographic importance in the region, as it represents the largest remaining area in Clark County with perennial streams from spring discharge. In southern Nevada, only Ash Meadows has more water discharged into surface streams on a perennial basis. Elsewhere in Clark County, only the Virgin River has more perennial surface flow supporting riparian forests.

Challenges to reaching and maintaining sustainable population

Threats

1) **Groundwater pumping.** Lowering of water table by pumping within the White River/Meadow Valley Wash drainages. Of particular concern is the recent assignment of water rights to a private landowner in Coyote Springs Valley. Additional consumptive uses of water are planned within the drainage system for new power plants proposed in the valley.
2) **Species not native to site** (descending order of threat):
   Tamarix ramosissima
   Tamarix aphylla
   Elaeagnus angustifolia
   Washingtonia filifera
   Phoenix canariensis
   Acroptilon repens

   Both *Tamarix* species significantly alter the biogeochemical processes in the system, severely interfering with the reproductive success of understory species. Both are rich in nectar and have long flowering seasons. The evergreen lifestyle of *Tamarix aphylla*, *Washingtonia* and *Phoenix* significantly lowers the solar radiation incident on the understory during the winter. Very few *Elaeagnus* individuals occur in the area. However, it can spread and be aggressive and may do so here if it is released from competition with *Tamarix ramosissima*.
3) **Agriculture.** Continued agricultural activities such as water management, pesticide use, continued periodic disturbance regime, constantly creating habitat for invasive species. The dairy dumps manure in the drainage very close to the river. A large dumping ground for manure occurs on a flat above the West side of the River, North of the road on the way to the Post Office. This area is a large N source, and is incised by several washes that pass through the area before reaching the river.
4) **Fire.** The non-native *Tamarix ramosissima* responds positively to fire. Given the proximity to human settlements, fire risk is higher than under natural conditions.

Management constraints:

1) **Culture**. The locals like the palms. There is a lot of private property in the area with a long history. The locals like where they live and are unlikely to give up their ranches. Ranches are probably very expensive, and prices are increasing due to Clark County growth. If we determine that there are no native tree

species at the site other than *Prosopis*, and we decide to restore the site to a non-arboreal state, this will be met with great resistance by the local residents.

2) **Human Development and Water Resources.** Southern Nevada Water Authority is aggressively pursuing water sources to sustain current levels of growth in the Las Vegas Valley and environs. They would like to use Muddy River water to supply continued growth, and wanted to increase surface water flows to Lake Mead. My imperfect understanding and recollection is that they wanted these increased flows to count toward their withdrawals from Lake Mead. Recently they were informed that these flows could not be counted. Since they cannot use increased water flows from the Muddy River to add to the allowable withdrawal from Lake Mead, then it seems that planners think it is in their best interest to exhaust the upstream sources before they reach the Lake. The Clark County Planning Commission continues to approve new power plants in the valley with applications for consumptive water use. Upstream, developments have been approved and water rights appropriated in Coyote Springs Valley.

   Alternatively, perhaps they can be persuaded to see that adhering to their MSHCP is in their best interest. And to sweeten the pot, I think they would be delighted to buy the water rights if the flows could be counted toward their withdrawal. Then it would be in their best interest to not allocate groundwater upstream in the drainage system.

3) **Attempts to Save Money**. The Nevada Division of Forestry has conducted mechanical *Tamarix* removal operations with prison crews in the area. This saves money, but these workers sometimes destroy native trees, especially in heavily infected areas (e.g., California Wash). Saving money is good, but without good supervision of these crews, their activities may not achieve the desired result. I am anxious to see what kind of succession will occur in these treated areas.

4) **Reluctance to Develop and Adopt Biological Control of *Tamarix***. The US Fish and Wildlife Service is not willing to allow tamarisk beetles to be released as a biological control, due to concerns regarding other potential impacts this release may have. If approval cannot be gained, then we are resigned to mechanical and chemical treatments. I have seen several areas where managers attempted to control *Tamarix* with fire treatments following mechanical removal, and have not seen a single success. What I have seen is major weed recruitment and *Tamarix* regeneration, resulting in communities even less diverse than what they were before treatment. Examples include south end of Pahranagat NWR and an area in the western side of Ash Meadows. The Ash Meadows fire got out of control, destroying a local resident's home. I talked to this man, and he was extremely upset. Current large scale *Tamarix* removal operations involving fire are underway in the Nevada portion of the Virgin River, but it is too early to see how the community will respond. Treatments I have seen that seem to be successful are at Ash Meadows, near Point of Rocks Spring and southwest of Kings Pool. My understanding of these successful treatments is that they were very labor intensive. They included mechanical removal and chemical treatment, followed by additional mechanical removal.

Potential management options to reach DFC (with Pros + and Cons -)

- *Tamarix ramosissima* mechanical and chemical removal.
  - + stabilization of natural competition
  - + evapotranspiration reduction, leading to increased water supplies
  - – the disturbances necessary to remove *Tamarix* and create conditions conducive to colonize by noxious weeds, several species of which are poised to dominate newly disturbed ground. Most notably, Russian knapweed (Ac*optilon repens* , synonym = *Centaurea repens*). Given the abundance of Russian knapweed in the vicinity, if these stands are simply cut and not replaced with something, there will be considerable opportunities for its colonization and spread.
  - – expensive

- *Tamarix ramosissima* biological control through tamarisk beetle.
  - + no mechanical disturbance to site
  - + no release of dangerous chemicals into the system
  - + minimal threat posed by invasives
  - + inexpensive
  - + no mechanical or chemical damage to native woody species present at site, providing seed and vegetative sources for native species recovery without reintroduction of material from other gene pools.
  - – permit for the application may be impossible to obtain due to US F&WS policy
  - – tiny chance that the biological control organisms will consume native plants

- *Tamarix ramosissima* removal by fire.
  - + immediate removal of *Tamarix* and *Acroptilon* overstories
  - – risk of fire getting out of control and destroying private property
  - – not effective in long-term

- *Washingtonia* removal
  - + increase productivity of aquatic ecosystem
  - + decrease competition for arboreal species native to site
  - – initial decline in vertical structure in the community, causing a decline in cover and nesting habitat.
  - – destruction of rare habitat, while probably not native to site, is native to region

- Geomorphic Restoration
  - + perhaps significant increases in biodiversity
  - – initial decline in vertical structure in the community, causing a decline in cover and nesting habitat.
  - – extremely difficult to remove *Tamarix ramosissima*. The most successful methods include significant disturbance of ground, application of chemicals.

Ecological and Management Uncertainties

- Research uncertainties

1) Who are the dominants native to site? It is unknown which of the dominant trees are native to the site. It appears as though *Salix gooddingii* is a native dominant. Early journals report that Mormon settlers planted cottonwoods. Moapa Indians claim the *Washingtonia* have been there since the beginning of time. While *Washingtonia* is native to the Mojave Desert and is doing well at this time here, it is highly improbable that they are native to site. It is also

unclear whether *Fraxinus velutina* is native to site. Tree species that definitely are native to the site are *Prosopis glandulosa* and *P. pubescens*.

2) Who are the missing species? Almost certainly some of the overstory and some of the understory species formerly present in the area are now extirpated. Who these are and what their functional roles in the community matrix is unknown.
3) What is the successional sequence of seres following disturbance by fire?
4) What is the successional sequence of seres following disturbance by flood?
5) What is the climax state of this community?
6) What is the natural fire frequency in this community?
7) What is the human use history of the area as it impacted the structure and diversity of native vegetation?
8) Unclear what the geomorphology was at contact time.
9) Floristic composition and distribution is poorly known.

- List all management uncertainties

1) Removal of *Tamarix ramosissima* can be very dangerous to the system, requiring intensive mechanical and chemical treatments over several years. This causes considerable disturbance to the system, and may not be successful.
2) Uncertain what the effect of releasing tamarisk beetles would be, either positive or negative.

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TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ NV STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Desert Riparian Forest Matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	MIXED COTTONWOOD-WILLOW RIPARIAN WOODLAND		**G2**	
	ecotonal community: **Velvet Ash – Mesquite**		**E**	
	California Fan Palm Oasis		**G2G3**	
	Aquatic Stream Community		**?**	
	FISHES			
	latin name	common name	rank	listing
	Moapa coriacea	**Moapa dace**		
		White River Springfish		

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ FNAI STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Desert Riparian Forest Matrix	BIRDS			
	latin name	common name	rank	listing
	Phainopepla nitens	**Phainopepla**		

Appendix IV–D. Desert Riparian Shrubland
Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Not known **Spatial** Curvilinear arrangement of communities that provide an interface between the Desert Riparian Forest, Mesquite Bosque, and the Interior Wetland, Marsh, and Seep matrices. Descending downstream discontinuously from the source of the river to The Narrows. No control of *Tamarix* attempted. **Management Actions** 1) Increase water supply	**Condition** Not known **Spatial** Curvilinear arrangement of communities that provide an interface between the Desert Riparian Forest, Mesquite Bosque, and the Interior Wetland, Marsh, and Seep matrices. Descending downstream discontinuously from the source of the river to The Narrows. *Tamarix* presence accepted, but no new spreading of the species allowed. **Management Actions** 1) Increase water supply. 2) Control *Tamarix* spread	**Condition** Not known **Spatial** Curvilinear arrangement of communities that provide an interface between the Desert Riparian Forest, Mesquite Bosque, and the Interior Wetland, Marsh, and Seep matrices. Descending downstream nearly continuously from the source of the river to The Narrows. Eradication, or nearly so, of *Tamarix ramosissima* and *Acroptilon repens*. **Management Actions** 1) Increase water supply 2) Geomorphic restoration 3) *Tamarix* eradication 4) *Acroptilon* eradication
Total Acreage: 612 acres (248 ha) shared with desert riparian shrubland matrix	**Total Acreage:** unknown	**Total Acreage:** unknown, but larger than 612 acres (248 ha) given 50 m buffer
Other Focal Targets Captured: Moapa dace, aquatic invertebrates, nesting birds, amphibians, butterflies	**Other Focal Targets Captured:** Moapa dace, aquatic invertebrates, nesting birds, amphibians, butterflies	**Other Focal Targets Captured:** Moapa dace, aquatic invertebrates, nesting birds, amphibians, butterflies

Preferred DFC: Alternative 2

Desert Riparian Shrubland

Natural history description of community: The Desert Riparian Shrubland community in the upper Muddy River is a diverse mix of shrubby phreatophytic communities centered upon a constant and abundant surface water flow. The communities are comprised of both evergreen and deciduous, armed and unarmed, microphyllous and broadleaved shrubs. The distribution of this community matrix roughly corresponds to the boundary between the "Warm Springs Aquatic Assemblages" and the "100 Year Floodplain" categories in the TNC Conservation Targets map for the Muddy River. The community matrix is expanded artificially along the agricultural ditches in the Warm Springs Ranch and Mormon Ranch vicinity. Such redistribution of surface waters here almost certainly curtails the development of the community matrix further downstream.

Key ecological process: flood, fire, hydrology

Embedded communities

TNC: *Pluchea sericea* Seasonally Flooded Shrubland Alliance. This is a tall, evergreen, microphyllous, phreatophytic shrubland, up to 2.5m tall and 100% cover in the shrubby overstory. Patches of overstory are sometimes dominated by *Baccharis emoryi*. Very few herbs in the understory. When an understory is present, it is often dominated by *Distichlis spicata*.
Grank: G3? Ecoregion Distribution: L.

TNC: *Distichlis spicata* Intermittently Flooded Herbaceous Alliance. Simple, short, perennial grassland with a few species; from 60-100% cover. Fairly low productivity, on intermittently flooded saline soils. Ecotonal to Saltbush Shrubland Matrix and Interior Wetland Marsh and Seep Matrix.
Grank: G5. Ecoregion Distribution: W.

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
20%	20%	20%	40%

Desired structure, composition, and landscape context and configuration

V. Structure

- Dominant native canopy species density
  High-quality condition:
  Pluchea sericea and *Baccharis emoryi* combine to form a canopy of nearly 100% cover and up to 2.5m tall. *Lycium torreyi* present in varying degrees.
  Degraded condition:
  Tamarix ramosissima indicates degradation
- Dominant native canopy species distribution
  Tends to be even-sized stand of *Pluchea sericea*, about 2-3m tall.

- Dominant canopy species seedling mortality
  I do not know anything about any seedling mortality in any of these species in any condition.
- Dominant non-native canopy species or co-dominant canopy species that indicates problem
  High-quality condition:
    trace of *Tamarix ramosissima* or *Acroptilon repens*
  Degraded condition:
    community can be dominated by *T. ramosissima* or *Acroptilon repens*; up to 100% cover of either.

VI. Species composition

- Vegetation
  High-quality condition:
    Shrubby mosaic dominated by either *Pluchea sericea* or *Baccharis emoryi*, usually with *Lycium torreyi* on the drier peripheries.
  Degraded condition:
    Tamarix ramosissima indicates degradation
- Graminoids
  High-quality condition:
    not certain what high quality condition is
  Degraded condition:
    none
- Forbs
  High-quality condition:
    not certain
  Degraded condition:
    not certain
- Indicators of degradation–high quality for process hydrology
  Tamarix indicates decline of process; unsure what indicates improvement.
- Specific information of taxa responses not certain
- T & E species (see Table): no plants

III. Landscape context and configuration

- Curvilinear arrangement of communities, interfacing between the Desert Riparian Forest, Mesquite Bosque, and the Interior Wetland, Marsh, and Seep matrices. Descending downstream discontinuously from the source of the river to The Narrows.

Challenges to reaching and maintaining sustainable population

Threats

1) **Groundwater pumping**
   Lowering of water table by pumping within the White River/Meadow Valley Wash drainages. Of particular concern is the recent assignment of water rights to a private landowner in Coyote Springs Valley. Additional consumptive uses of water are planned within the drainage system for new power plants proposed in the valley.
2) **Species not native to site** (descending order of threat):
   Tamarix ramosissima
   Tamarix aphylla
   Elaeagnus angustifolia
   Acroptilon repens

   Both *Tamarix* species significantly alter the biogeochemical processes in the system, severely interfering with the reproductive success of understory species. Both are rich in nectar and have long flowering seasons. The evergreen lifestyle of *Tamarix aphylla* significantly lowers the solar radiation incident on the understory during the winter. Very few *Elaeagnus* individuals occur in the area. However, it can spread and be aggressive and may do so here if it is released from competition with *Tamarix ramosissima*.
3) **Agriculture**
   Continued agricultural activities such as water management, pesticide use,

continued periodic disturbance regime, constantly creating habitat for invasive species. The dairy dumps manure in the drainage very close to the river. A large dumping ground for manure occurs on a flat above the West side of the River, North of the road on the way to the Post Office. This area is a large N source, and is incised by several washes that pass through the area before reaching the river.

4) **Fire**
The non-native *Tamarix ramosissima* responds positively to fire. Given the proximity to human settlements, fire risk is higher than under natural conditions.

Management constraints:

1) Culture of "right of prior appropriation."
2) Clark County leadership divided on need to adhere to MSHCP and desire to sustain continued growth through augmentation of water supply.
3) Desire of public to recreate in the beautiful areas of their area.

Potential management options to reach DFC (with Pros + and Cons -)

- *Tamarix ramosissima* and *Acroptilon repens* mechanical and chemical removal.
  - + stabilization of natural competition
  - + evapotranspiration reduction, leading to increased water supplies for natives
  - – considerable disturbance involved in removal of these species, creating new openings for invasive species
  - – expensive
- *Tamarix ramosissima* and *Acroptilon repens* biological control through tamarisk beetle and knapweed nematode.
  - + no mechanical disturbance to site
  - + no release of chemicals into the system
  - + minor threat posed by invasives
  - + inexpensive
  - + no mechanical or chemical damage to native species present at site, providing seed and vegetative sources for native species recovery without reintroduction of material from other gene pools.
  - – permit for the application may be impossible to obtain due to US F&WS policy
  - – beetle may not be adapted to the hot climate of the Mojave desert
  - – tiny chance that the biological control organisms will consume native plants
- *Tamarix ramosissima* and *Acroptilon repens* removal by fire.
  - + immediate removal of *Tamarix* and *Acroptilon* overstories
  - – not effective in long-term
  - – risk of fire getting out of control and destroying private property
  - – air quality
- *Geomorphic restoration*
  - + treatment tackles the source of many problems
  - – initial declines in the community are inevitable
  - – moving water to new areas will allow the most aggressive colonists (i.e., *Tamarix ramosissima* and *Acroptilon repens*) to invade these sites first. Diligence will be required to prevent such invasions

Ecological and Management Uncertainties

- Research uncertainties

1) Where is *Salix exigua* and why is it not here? I met one ornithologist last year who thought she saw some, but I was unable to locate any. It may be here, but it certainly if of little consequence. Why?

2) Floristic composition and distribution of the community throughout the system.
- Management uncertainties
1) Can *Tamarix* be controlled with tamarisk beetles?

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TARGET	LISTED, TRACKED AND RARE SPECIES		GLOBAL RANK/ NV STATE RANK	FEDERAL/ STATE STATUS
	SCIENTIFIC NAME	COMMON NAME		
Desert Riparian Shrubland Matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	***Pluchea sericea* Seasonally Flooded Shrubland Alliance**		**G3**	
	***Distichlis spicata* Intermittently Flooded Herbaceous Alliance** (ecotonal community)		**G5**	
	PLANTS			
	latin name	common name	rank	listing
	None known			
	FISHES			
	latin name	common name	rank	listing
	Moapa coriacea	**Moapa Dace**		

Appendix IV–E. Mesquite Bosque
Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Small stands, many recovering from past agriculture, and intermixed with tamarisk **Spatial** Main population at Warm Springs ranch with small disconnect patches throughout UMR **Management Actions** 1) Hydrologic augmentation	**Condition** Patches in various recovery phases (from agriculture) supporting existing and future mistletoe populations **Spatial** Increasingly connected patches of mesquite bosque parallel to river. **Management Actions** 1) Hydrologic augmentation 2) *Tamarix* control and passive and artificial mesquite regeneration	**Condition** Dense stands, heavily infested with mistletoe. Different phases of succession. **Spatial** A curvilinear shape, much longer than wide, extending nearly continuously along the course of the river from the source to The Narrows. Slender arms of the shape reach up into larger tributaries of the system. Great diversity in structure throughout the system, from dense, short woodlands to open woodlands with abundant understory, to open forests of moderate height and medium to high understory density of shrubs, forbs, and graminoids. **Management Actions** 1) Hydrologic restoration 2) Geomorphic restoration 3) *Tamarix* eradication and replanting
Total Acreage: 242 acres (97.8 ha)	**Total Acreage:** unknown, dependent on available land	**Total Acreage:** 2639 acres max. (1068 ha)
Other Focal Targets Captured: Phainopepla, Loggerhead Shrike, butterflies	**Other Focal Targets Captured:** Phainopepla, Loggerhead Shrike, butterflies	**Other Focal Targets Captured:** Phainopepla, Loggerhead Shrike, butterflies

Preferred DFC: Alternative 2

Mesquite Bosque

Natural history description of community: The Mesquite Bosque community in the upper Muddy River is a woodland of shrubs, arborescent shrubs, and shrubby trees centered on a constant and relatively high water table. The communities are comprised of deciduous, armed, microphyllous trees and evergreen and deciduous, armed and unarmed, microphyllous shrubs. The distribution of this community matrix roughly corresponds to the "Mesquite Bosque" category in the TNC Conservation Targets map for the Muddy River. The community matrix is expanded artificially between agricultural ditches in the Mormon Ranch vicinity. Such redistribution of surface waters here almost certainly curtails the development of the community matrix further downstream. This may artificially widen and shorten the community matrix. Such a development concentrates the resources in a particular area of the drainage, rather than distributing them more evenly throughout the otherwise xeric and demanding landscape, the Creosote Bush Shrubland Matrix.

Biogeographic Context: The upper Muddy River is one of the most northern occurrences of the Mesquite Bosque Matrix. The *Prosopis pubescens* woodlands are particularly uncommon, not only here at the northern boundary of the species' range, but throughout the range of the species. Although the species occurs from Texas to California, its distribution within the region is much less common than that of P. glandulosa. In southern Nevada *P. pubescens* is much more arboreal than *P. glandulosa*, adding height and vertical complexity to the canopy. In southern Nevada, *P. pubescens* has a patchy and widespread distribution. However, I am aware of *P. pubescens* woodlands only in the upper Muddy River and Ash Meadows.

Key ecological process: flood, fire, hydrology
Embedded communities:

> **TNC: *Prosopis glandulosa – Prosopis velutina* Woodland Alliance** (Honey Mesquite Woodland). *Prosopis velutina* is not known to occur in Nevada. Here in the Muddy River, it is "replaced" by *P. pubescens*.
> Grank: G3? Ecoregion Distribution: L
>
> ***Prosopis pubescens* Woodland (Screwbean Mesquite Woodland)** (not in TNC list of Mojave communities). Understory often completely covered in herbs and graminoids, dominated by up to 80% *Lotus tenuis*.
> Grank: undescribed and unranked. Ecoregion Distribution: unclassified. .

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
10%	20%	40%	30%

Desired structure, composition, and landscape context and configuration

VII. Structure

- <u>Dominant native canopy species density</u>

Condition not dependent on stems per acre. Good condition can range from about 20%-80% cover.

- <u>Dominant native canopy species distribution</u>
  do not know shape of size and/or age distribution
- <u>Dominant native canopy species basal area</u>
  not certain what constitutes good condition since such a wide range. Condition not as important as what species has the most basal area.
- <u>Dominant native canopy species diameter (DBH)</u>
  High-quality condition:
  diameters can be as high as 1m in high quality, and ca. 0.1m in low quality.
- <u>Dominant canopy species seedling mortality</u>
  I do not know anything about any seedling mortality in any of these species in any condition.
- <u>Dominant non-native canopy species or co-dominant canopy species that indicates problem</u>
  High-quality condition:
  A trace to no *Tamarix* present.
  Degraded condition:
  100% Tamarix
- <u>Dominant non-native canopy species or co-dominant canopy species DBH distribution</u>
  Not certain, but these seem to be mostly even-aged stands.

VIII. Species composition

- Vegetation
  High-quality condition:
  Ranging from pure stands of Prosopis pubescens to pure stands of P. glandulosa, with various mixtures of each. Salix goodingii and/or Fraxinus velutina sometimes present.
  Degraded condition:
  From 10-100% *Tamarix ramosissima*.
- Graminoids – cover ranges
  High-quality condition:
  uncertain but probably at least 30-50% in *Prosopis pubescens* woodlands, and perhaps no more than 10% in *P. glandulosa* woodlands.
  Degraded condition:
  no graminoids in the understory of *P. glandulosa*, and probably few in *P. pubescens* understory.
- Forbs
  High-quality condition:
  up to 80% under *Prosopis pubescens*, as low as <1% under *Prosopis glandulosa*.
  Degraded condition:
  There are really two types of degradation in *P. pubescens* woodlands. Either they are occupied with up to 90% + cover of *Tamarix*, hence with no forbs, or they are dominated by *Lotus tenuis* and other herbs and grasses. While this is not a natural community, considerable N fixation occurs, productivity is high, and the forage value is good. Some remarkable communities of this type are in Mormon Ranch, immediately North of the river. The condition of these communities is degraded if degradation is defined to be loss of native communities. Condition is high if quality is based on productivity and other ecosystem properties. I am very interested to learn what is the natural state of these woodland's understories.

  Degradation can also be of two types in *P. glandulosa* woodlands. The forb cover can be as low as 0% under *P. glandulosa* when either overgrown or when dominated by

Tamarix. Alternatively, the forb cover can be 100% and dominated by *Acroptilon repens*.

- Woody species
  High-quality condition:
  Up to 100% cover by native woody species in *Prosopis glandulosa* woodlands, and up to 75% cover in *P. pubescens* woodlands.
  Degraded condition:
  Community health not necessarily dependent on amount of woody overstory in this system. In these communities, it is mainly which woody species are present that indicates degradation.
- Indicators of degradation–hydrology
  - *Tamarix* spp. have very high transpiration rates, indicating detriment to process.
  - While Prosopis also has high transpiration rates, they are considerably lower than *Tamarix* and they have much higher wildlife value.
- Indicators of degradation–high quality for process fire
- *Tamarix* spp. aggressively recolonize following fire
- *Atriplex lentiformis* seems to be the early successional shrub following fire in natural series.
- Specific information of taxa responses
  I do not know.
- T & E species (see Table)

III. Landscape context and configuration

- A curvilinear shape, much longer than wide, extending nearly continuously along the course of the river from the source to The Narrows.
- The upper Muddy River is one of the most northern occurrences of the Mesquite Bosque Matrix. The *Prosopis pubescens* woodlands are particularly uncommon, not only here at the northern boundary of the species' range, but throughout the range of the species. Although the species occurs from Texas to California, its distribution within the region is much less common than that of P. glandulosa. In southern Nevada, *P. pubescens* has a patchy and widespread distribution. However, I am aware of *P. pubescens* woodlands only in the upper Muddy River and Ash Meadows.

Challenges to reaching and maintaining sustainable population

- Threats

1) **Groundwater pumping**
Lowering of water table by pumping within the White River/Meadow Valley Wash drainages. Of particular concern is the recent assignment of water rights to a private landowner in Coyote Springs Valley. Additional consumptive uses of water are planned within the drainage system for new power plants proposed in the valley.

Species not native to site (descending order of threat):

Tamarix ramosissima
Tamarix aphylla
Elaeagnus angustifolia
Acroptilon repens
Centaurea melitensis

Both *Tamarix* species significantly alter the biogeochemical processes in the system, severely interfering with the reproductive success of understory species. Both are rich in nectar and have long flowering seasons. Very few *Elaeagnus* individuals occur in the area. However, the species can spread and be aggressive and may do so here if it is released from competition with *Tamarix ramosissima*. *Acroptilon* is present from

Mormon Ranch to the Lewis Ranch, and appears to be actively spreading. I have seen *Centaurea* only at Mormon Ranch, but it is likely to spread throughout the system also.

2) **Agriculture**
Continued agricultural activities such as water management, pesticide use, continued periodic disturbance regime, constantly creating habitat for invasive species. The dairy dumps manure in the drainage very close to the river. A large dumping ground for manure occurs on a flat above the West side of the River, North of the road on the way to the Post Office. This area is a large N source, and is incised by several washes that pass through the area before reaching the river.
3) **Fire**
The non-native *Tamarix ramosissima* responds positively to fire. Given the proximity to human settlements, fire risk is higher than under natural conditions.
4) **Non-native invasive herbs** that will increase following disturbances related to *Tamarix* removal.

- Management constraints:

1) Culture of "Right of Prior Appropriation"
2) Perceived need by Clark County for more water.

Potential management options to reach DFC (with Pros + and Cons -)

- Hydrological and Geomorphic restoration
  - \+ eventually will stabilize the system by returning to naturally occurring drainage patterns, thus requiring lower maintenance
  - \+ increased water flows will increase total habitat area
  - – expensive and labor intensive if technically possible
  - – will cause large initial declines in Mesquite Bosque, away from areas that are currently in good condition in irrigated fields.

- *Tamarix ramosissima* mechanical and chemical removal.
  - \+ stabilization of natural competition
  - \+ evapotranspiration reduction, leading to increased water supplies
  - – the disturbances necessary to remove *Tamarix* and create conditions conducive to colonize by noxious weeds, several species of which are poised to dominate newly disturbed ground. Most notably, Russian knapweed (Ac*optilon repens* , synonym = *Centaurea repens*). Given the abundance of Russian knapweed in the vicinity, if these stands are simply cut and not replaced with something, there will be considerable opportunities for its colonization and spread.
  - – expensive

- *Tamarix ramosissima* biological control through tamarisk beetle.
  - \+ no mechanical disturbance to site
  - \+ no release of dangerous chemicals into the system
  - \+ minimal threat posed by invasives
  - \+ inexpensive
  - \+ no mechanical or chemical damage to native woody species present at site, providing seed and vegetative sources for native species recovery without reintroduction of material from other gene pools.
  - – permit for the application may be impossible to obtain due to US F&WS policy

- tiny chance that the biological control organisms will consume native plants

- *Tamarix ramosissima* removal by fire.
  - \+ immediate removal of *Tamarix* and *Acroptilon* overstories
  - – not effective in long-term
  - – risk of fire getting out of control and destroying private property

Ecological and Management Uncertainties

- Research uncertainties
  1) What is the successional sequence of seres following disturbance by fire?
  2) What is the successional sequence of seres following disturbance by flood?
  3) What is the climax state of this community?
  4) What is the natural fire frequency in this community?
  5) What is the human use history of the area as it impacted the structure and diversity of native vegetation?
  6) Flora of the community, and the details of its distribution. What species are present? Which species appear to be missing, and why?
- Management uncertainties
  1) What is the best way to remove the *Tamarix*?

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- Author: David A. Charlet (david_charlet@ccsn.nevada.edu)
- Reviewers: Jan Nachlinger (partial review; jnachlinger@tnc.org)

TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	LISTED, TRACKED AND RARE SPECIES		GLOBAL RANK/ FNAI STATE RANK	FEDERAL/ STATE STATUS
	SCIENTIFIC NAME	COMMON NAME		
Mesquite Bosque Community Matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	***Prosopis glandulosa – Prosopis velutina* Woodland**		**G3?**	
	***Prosopis pubescens* Woodland (Screwbean Mesquite Woodland)**		**N/A**	
	PLANTS			
	latin name	common name	rank	listing
	None known			
	BIRDS			
	latin name	common name	rank	listing
	Phainopepla nitens	**Phainopepla**		
	Lanius ludocianus	**Loggerhead Shrike**		

Appendix IV–F. Saltbush Shrubland Matrix
Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Unknown **Spatial** This community type has been severely degraded and much has been lost in the past 100 years. Any amount of the habitat that can be gained or protected from further degradation will be beneficial. **Management Actions** Protect high quality examples of the habitat as possible.	**Condition** Unknown **Spatial** unknown **Management Actions**	**Condition** Unknown **Spatial** Dominant over large tracts of the 100 year floodplain, in areas that are occasionally flooded. Forms a nearly continuous, curvilinear community with several phases. Community phases distributed along water availability and salinity gradients. Spatially distributed outside the Desert Riparian Forest and Desert Riparian Shrubland matrices. *Atriplex lentiformis* are tall shrubland communities on soils with more gravels and more regular disturbance by flood or fire, sometimes an early successional shrub in Mesquite Bosque following fire. *Atriplex polycarpa* communities appear to be slower growing and are more stable. *Suaeda moquinii* communities are mainly only a possibility at present, but some could form with a redistribution of waters, leading to some areas with longer flooding periods. *Distichlis spicata* and *Sporobolus airoides* communities provide valuable contrast and forage, and serve as ecotonal communities to Desert Riparian Shrubland and Interior Wetland, Marsh, and Seep matrices. **Management Actions** Purchase and protect all occurrences of community type along the river.
Total Acreage: unknown, but assumed small	**Total Acreage:**	**Total Acreage:** unknown, but assumed small
Other Focal Targets Captured: Ground-nesting birds, reptiles, butterflies, desert pocket mouse	**Other Focal Targets Captured:** Ground-nesting birds, reptiles, butterflies, desert pocket mouse	**Other Focal Targets Captured:** Ground-nesting birds, reptiles, butterflies, desert pocket mouse

Preferred DFC: Alternative 2

Saltbush Shrubland Matrix

Natural history description of community: The Saltbush Shrubland matrix in the upper Muddy River is a diverse mix of halophytic shrublands centered on episodically flooded areas with saline soils. The communities are comprised of evergreen, microphyllous, armed, and unarmed shrubs. The distribution of this community matrix roughly corresponds to the “”100 Year Floodplain” category in the TNC Conservation Targets map for the Muddy River. A few perennial herbs, such as *Stanleya pinnata* and *Sphaeralcea ambigua*, are common, and there should be a high diversity of annual herbs, although I have not seen them.

The community matrix has been seriously and negatively impacted by human development in the area. Impacts include flood control and irrigation, which reduce the water available to the community. Serious disturbance to soils between shrubs from recreational activities and infestation of non-native noxious weeds (e.g., *Salsola paulsenii* and *Acroptilon repens*) further degrade the community. The main human impact on the community has been reduction in total area by direct habitat destruction through development. Throughout Clark County, a large proportion of *Atriplex lentiformis* shrubland has been lost and little remains.

Key ecological process: flood, fire

Embedded communities

***Atriplex lentiformis* Shrubland Alliance.** This is a tall (to 4m+), microphyllous, unarmed, evergreen shrubland. *Acacia greggii* is sometimes emergent. The quailbush (*Atriplex lentiformis*) phase of the community matrix has especially high wildlife value, providing nesting habitat for ground-nesting birds such as Gambel’s Quail and Roadrunner, and for rabbits and hares. In certain circumstances, this community is an early successional stage to Mesquite Bosque, following disturbance by either fire or flood.
Grank: G4. Ecoregion Distribution: L.

TNC: *Atriplex polycarpa* Shrubland Alliance. This is a microphyllous, unarmed, evergreen shrubland. It is of medium height and varying degrees of cover. I think that its distribution is rather limited in the system.
Grank: G5. Ecoregion Distribution: L.

TNC: *Suaeda moquinii* Intermittently Flooded Shrubland Alliance. The presence of *Suaeda moquinii* and *Allenrolfea occidentalis* patches indicates the potential for communities of *Suaeda* to be present in sufficient numbers and coverage to constitute communities, but I have not seen them in the area. Instead, I have observed these species in low-density patches, often with *Sporobolus airoides*, in openings in *Atriplex lentiformis* communities. I include the *Suaeda moquinii* Alliance as an embedded community in that it may attain sufficient size to be called a community if the hydrology of the area is restored to pre-agricultural conditions.
Grank: G5. Ecoregion Distribution: L

TNC: *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance. A shrubland-steppe dominated by perennial bunchgrasses of low-moderate forage value. Limited distribution in the area.
Grank: G3G5. Ecoregion Distribution: W.

TNC: *Distichlis spicata* Intermittently Flooded Herbaceous Alliance. Simple, short, perennial grassland with a few species; from 60-100% cover. Fairly low productivity, on intermittently flooded saline soils. Ecotonal to Interior Wetland, Marsh and Seep Matrix, and to Desert Riparian Shrubland Matrix.
Grank: G5. Ecoregion Distribution: W.

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
<5%	<10%	30%	>55%

Desired structure, composition, and landscape context and configuration

IX. Structure

- <u>Dominant native canopy species density</u>
  High-quality condition:
    widely variable, depending on which Alliance. Can range from 15% to nearly 100% cover, and from 0.5m to 4m tall. Probably with high diversity of annuals and some perennial herbs.
  Degraded condition:
    The communities can be degraded without any appreciable change in native overstory canopy species density.
- <u>Dominant native canopy species distribution</u>
  They seem to be even-aged stands.
- <u>Dominant canopy species seedling mortality</u>
  I do not know anything about any seedling mortality in any of these species in any condition.
- <u>Dominant non-native canopy species or co-dominant canopy species that indicates problem</u>
  There is no particular problem with non-native canopy species. However, on the edges of *Atriplex lentiformis* communities as they fade into Mesquite Bosque, *Tamarix ramosissima* is often present and appears to interfere with the normal successional sequence leading to Mesquite Bosque.

X. Species composition

- Vegetation
  The species composition and the structure of the vegetation depends on the Alliance. Can tend to be nearly pure stands of whichever species is dominant in the community, often with others as well as *Atriplex canescens* and/or *Atriplex confertifolia*.
- Graminoids – cover ranges from 0-5%;
  High-quality condition:
    not much
  Degraded condition:
    still not much
- Indicators for processes uncertain what the increasers or decreasers are
- Specific information of taxa responses
  Nesting bird reproductive success crashes when their shrubs get bulldozed.
- T & E species (see Table)

III. Landscape context and configuration

- Dominant over large tracts of the 100 year floodplain, in areas that are occasionally flooded. Forming a nearly continuous, curvilinear community with several phases. Community phases distributed along water availability and salinity gradients. Spatially distributed outside the Desert Riparian Forest and Desert Riparian Shrubland matrices. *Atriplex lentiformis* communities on soils with more gravels and more regular disturbance by either flood or fire, sometimes an early successional shrub in Mesquite Bosque following fire.
- Throughout Clark County, a large proportion of *Atriplex lentiformis* shrubland has been lost and little remains.

Challenges to reaching and maintaining sustainable population

Threats

1) Habitat destruction from development
2) Habitat disturbance from off-road vehicle use
3) Continued diversion of waters and flood control
4) Invasive herbs, especially *Acroptilon, Centaurea,* and *Salsola*.

Management constraints:

1) Culture and ignorance are the main constraints.
2) People think these shrublands are ugly.

Potential management options to reach DFC (with Pros + and Cons -)

- Buy remaining habitat, close to vehicular travel, buy water rights, restore hydrology
  + reduce disturbances
  + increase water supplies
  – expensive to buy land and water rights
  – curtails development options for community

Ecological and Management Uncertainties

Research uncertainties

1) Floristic composition and distribution, particularly of herbs
2) Climax state of *Atriplex lentiformis* community.
3) Whether or not there will be a place for *Suaeda* communities in a restored system.

Management uncertainties

1) our ignorance of the successional sequence in these communities

Information Source(s) and Reviewers

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Kartesz, J. T. 1987. A flora of Nevada. Unpublished Ph.D. dissertation, Department of Biology, University of Nevada, Reno. 1729 pp.

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TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ NV STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Saltbush Shrubland Matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	***Atriplex lentiformis* Shrubland Alliance**		**G4**	
	***Atriplex polycarpa* Shrubland Alliance**		**G5**	
	***Suaeda moquinii* Intermittently Flooded Shrubland Alliance**		**G5**	
	***Sporobolus airoides* Intermittently Flooded Herbaceous Alliance**		**G3G5**	
	***Distichlis spicata* Intermittently Flooded Herbaceous Alliance**		**G5**	
	PLANTS			
	latin name	common name	rank	listing
	None known			

Appendix IV–G. Creosote - Mixed Scrub Matrix Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Unknown **Spatial** Imperceptible change from present spatial distribution. **Management Actions** 1) Complete removal of *Centaurea melitensis*. 2) Prevent expansion of *Schismus barbatus* and *Bromus madritensis.* 3) Prevent further degradation of cryptogammic crust.	**Condition** Unknown **Spatial** Imperceptible change from present spatial distribution. **Management Actions** 1) Complete removal of *Centaurea melitensis*. 2) Prevent expansion of *Schismus barbatus* and *Bromus madritensis.* 3) Prevent further degradation of cryptogammic crust.	**Condition** Unknown **Spatial** Dominated by *Larrea tridentata* distributed semi-regularly in tall overstory, from 1-3m tall, covering about 20% of the ground. Understory dominated by *Ambrosia dumosa* with about 10% cover, and 0.25-0.5m tall. Overstory in dry washes dominated by *Acacia greggii*, with richly diverse understory. **Management Actions** 1) Complete removal of *Centaurea melitensis*, *Schismus barbatus,* and *Bromus madritensis*. 2) Reestablishment of cryptogammic crust. I 3) Increase shrub species richness.
Total Acreage: habitat extends into desert; covers ~3000 acres of UMR land ownership	**Total Acreage:** habitat extends into desert; covers ~3000 acres of UMR land ownership	**Total Acreage:** habitat extends into desert; covers ~3000 acres of UMR land ownership
Other Focal Targets Captured: Phainopepla, Loggerhead Shrike, Desert tortoise	**Other Focal Targets Captured:** Phainopepla, Loggerhead Shrike, Desert tortoise	**Other Focal Targets Captured:** Phainopepla, Loggerhead Shrike, Desert tortoise

Preferred DFC: Alternative 2

Creosote – Mixed Scrub Matrix

Natural history description of community: The Creosote Bush Shrubland Matrix in the upper Muddy River is a diverse mix of shrub species with much vertical complexity centered on xeric soils. The communities are comprised of evergreen and deciduous, microphyllous, armed and unarmed shrubs. The homogeneous community matrix is dissected by dry washes that host additional species that require the additional water that the washes occasionally provide, such as *Acacia greggii*. The distribution of this community matrix roughly corresponds to the areas outside the area mapped as TNC Conservation Targets map for the Muddy River. Where it does occur within these targets, it is within the "100 Year Floodplain" category. Human development in the area has negatively impacted the community matrix. Degradation of the community matrix is caused due to its popularity for off-road vehicle use and the introduction of the non-native grasses, *Schismus barbatus* and *Bromus madritensis* ssp. *rubens*. The non-native weed *Centaurea melitensis* has recently arrived to this area, and could potentially become a major problem in the washes. Outright destruction of this habitat is caused by building houses and other developments.

Biogeographic Context: This is the most abundant community matrix in Clark County and the Mojave Desert region in Nevada. In the upper Moapa Valley, it is about 50-75 km from its northern limit. In this area, it is naturally depauperate in species.

Key ecological process: flood, fire. Rare episodes of heavy precipitation and floods are important to sustain the larger shrub species in the system. Fire was rare in the system, but with the introduction of *Schismus barbatus* and *Bromus madritensis* ssp. *rubens* (synonym = *Bromus rubens*), fire frequency has been increasing in this system throughout the region. This results in a simplification of the community, and its conversion from a multi-layered shrubland to an annual grassland maintained by frequent fire. To date, I am unaware of recent wildfires in this community matrix in the Moapa Valley, but the potential is present.

Federal and State Listing Status, if known: not known. Ecoregion Distribution = L

Embedded communities

> **TNC: *Larrea tridentata – Ambrosia dumosa* Shrubland.** *Larrea tridentata* dominant in the overstory of a multi-layered shrubland canopy. Shrub species in the understory are dominated by *Ambrosia dumosa*, with *Krameria erecta*, *Opuntia basilaris*, and many other shrub species in low abundance. The soils retain a large seedbank of ephemeral annuals that appear after occasional wet winters. Grank: G5. Ecoregion Distribution: L.
>
> **TNC: *Larrea tridentata – Atriplex confertifolia* Shrubland.** I am uncertain of the distribution of this evergreen, microphyllous, multi-layered canopy shrubland in the area. It is not nearly as common as the former community, and usually at higher elevations. The shrub and annual species diversity is typically not as high as the former community. Grank: G5. Ecoregion Distribution: L.
>
> **TNC: Badlands/Mudhills.** Badlands are locally common along the river, especially to the North. I know nothing about them except that I find aesthetic value in them. Elsewhere, this community supports rare species. Grank: G?. Ecoregion Distribution: L.

TNC: *Acacia greggii* Shrubland Alliance. Larger washes that dissect the bajadas and plains of the Moapa Valley are dominated by the arborescent shrub, *Acacia greggii*. Shrub species commonly associated with these tall shrublands include *Salazaria mexicana*, *Krameria erecta*, *Larrea tridentata*, and *Hymenoclea salsola*. The *Acacia* often is infected with *Phoradendron californica*. When the Acacia has sufficient density (ca. 5% cover), is infected by the *Phoradendron*, then this community becomes nesting habitat for *Phainopepla*, very near the northern boundary of the range of all three species. Grank: G4G5. Ecoregion Distribution: L.

Current Status			
High quality	**Hi-Medium quality**	**Medium-Low quality**	**Low quality**
20%	30%	30%	20%

Desired structure, composition, and landscape context and configuration

I. Structure

- <u>Dominant native canopy species density</u>
  High-quality condition:
  Larrea – 1-3m tall, 10-20% cover. *Ambrosia dumosa* – 0.3-0.5m tall, 10-15% cover. *Krameria erecta* – 0.2-0.4m tall, <5% cover. Other shrub species, <1% cover. Cryptogammic crust present throughout.
  Degraded condition:
  Shrubs the same as above, but with lower covers and less diversity. Cryptogammic crust discontinuous or absent. Non-native grasses present or dominant in the understory.
- <u>Dominant native canopy species distribution</u>
  Mainly reproductively mature individuals with some recruitment. Age of most shrubs is very old.
- <u>Dominant canopy species seedling mortality</u>
  High-quality condition:
  I do not know.
  Degraded condition:
  I do not know. Crust may suppress germination.
- <u>Dominant non-native canopy species or co-dominant canopy species that indicates problem</u>
  High-quality condition:
  No non-native grasses.
  Degraded condition:
  Non-native grasses present.

II. Species composition

- Vegetation
  High-quality condition:
  see above
  Degraded condition:
  see above
- Graminoids –
  High-quality condition:
  cover ranges from 0-5%
  Degraded condition:
  from 10-50% cover
- Forbs
  High-quality condition:
  nearly absent in dry years, 20-30% cover in wet years
  Degraded condition:
  not certain, but certainly less than above
- Woody species
  High-quality condition:
  see above

Degraded condition:
see above

- Indicators of degradation for process flood
  I do not know who the increasers or decreasers for this process are in this system. *Acacia greggii* will benefit from episodic floods due to groundwater replenishment
- Indicators of degradation for process fire

  increasers of degradation: *Schismus barbatus, Bromus madritensis*
- Specific information of taxa responses
  Nothing I know except that Phainopepla thrives by and induces decline of *Acacia* via *Phoradendron californicum* infection.
- T & E species (see Table)

III. Landscape context and configuration

- A configuration of management units that facilitates elimination of off-road vehicle use and weed control.
- Large enough to absorb disturbances ...
- In the upper Moapa Valley, it is about 50-75 km from its northern limit. In this area, it is naturally depauperate in species.

Challenges to reaching and maintaining sustainable population

- Threats

1) off-road vehicle use
2) grazing
3) fire
4) development
5) invasive weeds

- Management constraints:

  The locals live in the desert because they like to recreate in it and/or because they earn money doing things in the desert. Any restrictions on their activities will be met with resistance. The locals and visitors from urban areas do not understand how their activities damage the ecosystem in which they live. Communication between federal agencies, local government, and residents needs to be improved.

Potential management options to reach DFC (with Pros + and Cons -)

- Curtail off-road vehicle use and grazing
  - \+ remove source of disturbance
  - – expensive, because unless there is a major change of attitude, land and/or grazing rights will need to be purchased
- Remove all non-native grasses and herbs
  - \+ restore prehistoric fire regime
  - – expensive and labor intensive if technically possible
  - – continued disturbance delays reestablishment of cryptogammic crust

Ecological and Management Uncertainties

- floristic composition and distribution, particularly of annuals not known
- how to remove non-native grasses while minimizing disturbance to cryptogammic crust

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TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	LISTED, TRACKED AND RARE SPECIES		GLOBAL RANK/ NV STATE RANK	FEDERAL/ STATE STATUS
	SCIENTIFIC NAME	COMMON NAME		
Creosote Bush Shrubland	NATURAL COMMUNITIES/ASSOCIATIONS			
	***Larrea tridentata – Ambrosia dumosa* Shrubland**		**G5**	
	***Larrea tridentata – Atriplex confertifolia* Shrubland**		**G5**	
	Badlands/Mudhills		**G?**	
	***Acacia greggii* Shrubland Alliance**		**G4G5**	
	PLANTS			
	latin name	common name	rank	listing
	None known			
	FISHES			
	latin name	common name	rank	listing
	None known			
	INVERTEBRATES			
	latin name	common name	rank	listing
	None known			
	AMPHIBIANS			
	latin name	common name	rank	listing
	???			

TARGET	LISTED, TRACKED AND RARE SPECIES		GLOBAL RANK/ NV STATE RANK	FEDERAL/ STATE STATUS
	SCIENTIFIC NAME	COMMON NAME		
Creosote Bush Shrubland	REPTILES			
	latin name	common name	rank	listing
	Gopherus agassizii	**Desert Tortoise**		
	BIRDS			
	latin name	common name	rank	listing
	Phainopepla nitens	**Phainopepla**		
	Lanius ludocianus	**Loggerhead Shrike**		

Appendix IV–H. Moapa Dace
Desired Future Condition Summary

Minimum DFC (~current)	Alternative 1	Alternative 2 (ambitious)
Abundance 1000 adults **Spatial** Maintain occupied spring systems (e.g., Moapa Refuge is one spring system*) and streams. **Management Actions** Remove tilapia from occupied spring systems and tributaries. Restore stream from Patterson Unit of Moapa Refuge to Apcar stream to reestablish thermal loads. Partial removal of fan palms near waterways and springs.	**Abundance** 4500 adults, 3 or more age classes (minimum acceptable population size) **Spatial** Three connect spring systems **Management Actions** Remove tilapia from next reach and tributaries of river. Partial geomorphic restoration of upper Muddy River. Reconnect many spring systems. Remove fan palms near waterways and springs.	**Abundance** 6000 adults, 3 or more age classes **Spatial** Five connected spring systems **Management Actions** Complete removal of tilapia from Moapa dace habitat and UMR. Full geomorphic restoration of upper Muddy River. Reconnect all spring systems. Remove majority of fan palms near waterways and springs. Uncap springs, especially on Warm Springs Ranch.
Total Acreage: Apcar Unit (1.08 km, 0.67 mi), Moapa Refuge (1.39 km, 0.86 mi)	**Total Acreage:** 3 spring sytems; Apcar Unit (1.08 km, 0.67 mi), Moapa Refuge (1.39 km, 0.86 mi), Cardy Lambs (0.8 km, 0.5 mi)	**Total Acreage:** 75% of historical habitat. 5 spring systems; including those of Alternative 1 and River; Baldwin (1.02 km, 0.63 mi), Muddy Springs (0.86 km, 0.5 mi), Upper Muddy River (north & south fork confluence to warm spring bridge, 3.33 km, 2.07 mi)
Other Focal Conservation Targets Captured: desert riparian vegetation	**Other Focal Conservation Targets Captured:** desert riparian vegetation, desert fishes, riparian woodland birds, aquatic invertebrates, etc	**Other Focal Conservation Targets Captured:** desert riparian vegetation, desert fishes, riparian woodland birds, aquatic invertebrates, etc

Preferred DFC: Alternative 2

***** Spring systems defined in Moapa Dace recovery plan, USFWS, 1996

Moapa Dace

General Natural history: Moapa dace is endemic to the warm springs area of the Muddy River, where it persist in water temperature ranging from 27 to 32^{o} C. Reproduction is only known in temperatures ranging from 30 to 32^{o} C, and occurs year round with peaks in spring and summer. Moapa dace become reproductive in their first year at about 45 mm Fork Length, and they live until at least 6 years. Body size is scaled to water volume, with the largest (125 mm FL) and most fecund fish inhabiting the Muddy River, while smaller adults generally inhabit the spring-fed tributaries. The species congregates at specific hydraulic conditions (drift stations); slow water adjacent to chutes and back eddy areas where it is presumably most energetically efficient at feeding upon drift.
Key Ecological Processes: Warm and constant temperature environment: Flash flood.
Federal and State Listing status: Moapa dace is federally listed as an endangered species and because it is a mono-specific genus it has been given high priority for recovery (rank: G1, N1, S1).

Associated community

Aquatic Stream Community. This is the habitat for the Moapa dace. There are few, if any, native vascular plants in these streams. *Vallisneria americana* has invaded some areas of the streams, and where it does, it dominates.
Grank: G1

Desired abundance, population structure, habitat requirements, and landscape context and configuration

I. Abundance and population structure

- Population has declined from 4,000 in 1995 to 1,000 in 2002 after tilapia invasion.
- Minimum acceptable population size is 4,000 – 4,500 adults
- Productivity: is a function of fish size, largest and most fecund dace occurred in main stem Muddy River.
- Growth rate (addition of new clusters): Population growth rate has stagnated because blue tilapia have replaced Moapa dace in most of its former habitat

  Goal: Population growth rate should exceed 50% for several years post tilapia removal
- Limiting factors: Population seriously limited by blue tilapia invasion, elimination of spawning habitat, and foraging habitat.
- Adult sex ratio: Sex ratio is currently unknown but among cyprinids, females generally outnumber males.
- Average group size: Adult Moapa dace congregate in areas where there is a high rate of drifting invertebrate capture with little energy expenditure, these areas are referred to as drift stations. Prior to tilapia invasion there were 30 to 60 adult Moapa dace per drift station on the main stem Muddy River.
- Group composition: Drift station groups on the main stem Muddy River were comprised of fish 40 to 120 mm in Fork Length.

II. Habitat requirements

- Vegetation structure: Dead falls are important for shelter and they enhance turbulent flow, an important component of drift stations.

- Vegetation composition and age/size vegetation requirements: Trees serving as dead falls range in size.
- Home range size for successful reproduction: Moapa dace reproduce in spring outflow channels in water temperatures ranging from 30 to 32^{o} C.
- Food resources: Feed on drifting invertebrates, but also consume filamentous algae by pecking at substrate.

III. Landscape context and configuration

- Proximity to other individuals or groups: There is only modest aggressive behavior among individuals. Drift station separations are dictated by stream hydraulics.
- Landscape configuration of critical habitat : There needs to be complete connectivity between spring-fed outflows and the Upper Muddy River. Flash floods are important to drift station maintenance and dynamics.
- Landscape configuration should minimize the negative effects of fire and flood.
- Spatial configuration of population should maximize the number of drift stations.

Challenges to reaching and maintaining sustainable population

List all threats:

- blue tilapia invasions;
- flash fire associated with fan palms;
- loss of spring-flow due to pumping of ground water.

List all management constraints:

- Most habitat is on private land;
- Springs may have a delayed discharge response to current and future ground water pumping, but there is insufficient information or power to stop this activity;
- The local human population has embraced the nonnative fan palm as a native species;
- As a flood control measure flash flood peak and duration have been reduced.

Potential management options to reach sustainable population (with Pros + and Cons -)

- Management method #1: Chemically treat to eradicate blue tilapia
  - \+ Moapa dace and cohabiting thermo-endemics will increase in number and expand their range
  - – Chemical treatments usually do not work
  - – Negatively impact endemic invertebrate population
  - – Potential public relation problem
- Management method #2: Control or eradicate blue tilapia through habitat manipulation and restoration
  - \+ Enhance habitat for all thermo-endemic species.
  - \+ Eliminate tilapia without negatively impacting invertebrates.
  - – May not get permission to make stream alterations needed
- Management method #3: Restore tributary from Patterson Unit of Refuge to Apcar Stream
  - \+ Restore thermal load in Apcar stream
  - – Land ownership not public
- Management method #4: Restore hydrology of Refuge (uncap springs, return streams to original bedstreams)
  - \+ Improve dace habitat
  - – Expensive but CCMSHCP funds available
- Management method #5: Sequentially restore segments of the system using removable/replaceable barriers to protect the rehabilitated segments as expansion of the protected system permits

connection of segments, or to isolate the segments that become contaminated by exotics.
  - + Permits adaptive management
  - + Creates a long-term vision for the community
  - – Requires building consensus within the local community
  - – Potentially very expensive
- Management method #6: Full fluvial geomorphic restoration of UMR
  - + Reconnect spring systems and dace subpopulations
  - + Beneficial to all UMR conservation targets, except maybe yellow bats
  - – Land ownership not public
  - – Social resistance
  - – Expensive
- Management method #7: Implement a land acquisition plan designed to expand the refuge when opportunities arise.
  - + Protects existing habitat
  - + Increases management/restoration flexibility
  - – Expensive
  - – Key conservation buyers limited by fair market value policy
  - – May meet social resistance

Ecological and Management Uncertainties

List all research uncertainties
- What are the reproductive habitat requirements of blue tilapia?
- Will future pumping diminish spring-outflow?

List all management uncertainties
- May not be able to acquire permission to manipulate habitat.
- May not acquire permission to restore habitat on private land

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Appendix IV–I. Amphibian Species Assemblage: Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition ▪ Mixed, relatively open riparian woodland; mostly willow with some ash. River with natural meanders and open, terraced banks. Rocky/gravelly/sandy river bottom; mostly shallow. ▪ Some deeper pools with overhanging vegetation. ▪ Patches of riparian marsh and mixed riparian shrubland. ▪ Shallow areas with relatively sparse vegetation due to recent disturbance. **Spatial** Warm Springs area downstream to SR168. Exact configuration and amounts of different habitat types unknown. **Management Actions** ▪ Partial hydro-geomorphic restoration upstream of SR168. ▪ Protection of existing habitat. ▪ Piecemeal restoration of desert riparian vegetation. ▪ Occasional artificial disturbance of small areas simulating effects of natural flooding.	**Condition** ▪ Mixed, relatively open riparian woodland; mostly willow with some ash. River with natural meanders and open, terraced banks. Rocky/gravelly/sandy river bottom; mostly shallow. ▪ Some deeper pools with overhanging vegetation. ▪ Patches of riparian marsh and mixed riparian shrubland. **Spatial** Warm Springs area to confluence with Meadow Valley Wash. Exact configuration and amounts of different habitat types unknown. **Management Actions** ▪ Hydro-geomorphic restoration upstream of I-15. ▪ Protection of existing habitat. ▪ Restoration of desert riparian vegetation, especially wetlands. ▪ Occasional artificial disturbance of small areas simulating effects of natural flooding.	**Condition** ▪ Mixed, relatively open riparian woodland; mostly willow with some ash. River with natural meanders and open, terraced banks. Rocky/gravelly/sandy river bottom; mostly shallow. ▪ Some deeper pools with overhanging vegetation. ▪ Patches of riparian marsh and mixed riparian shrubland. **Spatial** Warm Springs area to confluence with Virgin River. Exact configuration and amounts of different habitat types unknown. **Management Actions** ▪ Landscape scale, long term political action to promotethe restoration and conservation of critical habitats of the Muddy River. ▪ Landscape scale hydro-geomorphic restoration of Muddy River. ▪ Restoration of desert riparian vegetation, especially wetlands.
Total Acreage: <300 acres (121 ha)	**Total Acreage:** 3509 acres (1420 ha) 100-yr floodplain	**Total Acreage:** Unknown
Other Focal Targets Captured: Desert riparian vegetation, Native Fishes	**Other Focal Targets Captured:** Desert riparian vegetation, Native Fishes	**Other Focal Targets Captured:** Desert riparian vegetation, Native Fishes

Preferred DFC: Alternative 1

Amphibian Species Assemblage

Natural history description of community:
Species considered: The historical amphibian community, prior to the extensive development of the water resources of the Colorado River that followed the building of Hoover Dam and the creation of Lake Mead, probably consisted of four anuran species. These were: the Relict Leopard Frog, *Rana onca*; the Pacific Tree Frog, *Hyla regilla*; the Red-spotted Toad, *Bufo punctatus*; and the Southwestern (Arizona) Toad, *Bufo microscaphus microscaphus*.

Currently, the amphibian community consists of introduced Bullfrogs, *Rana catesbeiana*; Pacific Tree Frogs, *Hyla regilla*; and a hybrid toad complex (probably *Bufo woodhousii*, *B. m. microscaphus*) dominated by *Bufo woodhousii*. In addition, the Great Plains toads (*Bufo cognatus*) are occasionally found in the Las Vegas area and along the Virgin River and may hybridize with *B. woodhousii*. This species, also, may be, or could become, part of the hybrid toad complex. *Rana onca* has been extirpated from the Muddy River drainage. Reestablishment of the pre-modern water development (pre-1920) amphibian community would require extensive restoration of habitat, reintroduction of species and intensive management.

Bufo punctatus and *Hyla regilla* are widely distributed in the Southwestern United States and are common in many places. *Bufo woodhousii* and *Bufo cognatus* also have very wide distributions and have, in some places extended their ranges coincident with human development of water resources, especially agriculture, and sometimes at the expense of other native species. *Bufo microscaphus microscaphus* and *Rana onca* are narrowly distributed and rare. (I think Sullivan would dispute this statement for B. micro) The considerations below focus on the last two species, but will also capture *B. punctatus* and *H. regilla*. *Rana catesbeiana* is introduced and predaceous on the other amphibian species, thus habitat descriptions and recommendations will consider that species only as an obstacle to the desired future condition.

General habitat considerations: Amphibians use both terrestrial and aquatic habitats for different life stages. In the Muddy River drainage amphibians use both temporary and permanent water for breeding and larval life. The larvae are herbivores. Riparian woodland, riparian shrubland, mesquite bosque, oxbows, and riparian marsh are used by adults for foraging (terrestrial and flying insects) and sheltering (rocky crevices and cracks, burrows dug by themselves or other animals). Some species also venture many hundreds of meters into desert upland adjacent to riparian areas. Amphibians are year-round residents and, depending on temperature, may be active in every month of the year.

Key ecological processes: flooding, meandering river, river connected to floodplain

Federal and State Listing Status: *Rana onca* is currently under petition for Federal Listing.

Embedded communities: Conservation management strategies for amphibians in the Muddy River drainage will very likely complement strategies for the native fishes and a wide variety of riparian marsh and riparian woodland bird species. The use of existing habitat by amphibians for breeding, larval life and adult foraging in the upper Muddy River area was mapped over the last 2 years. Additional habitat preference data was inferred from published descriptions of occupied habitat outside of the Upper Muddy River area.

Desert Springs: The relict leopard frog, *Rana onca* has been extirpated from most of its range, including the Muddy River. The remaining populations of relict leopard frogs are restricted to perennial desert springs along the Virgin and Colorado River drainages. Water sources for all six of the sites where frogs remain are geothermally influenced, with relatively constant water temperatures between 16° and 55° C. Currently occupied habitats seem to reflect a preference for minimally disturbed spring or spring-fed habitats that may be critical for one or more life history stages. While naturalists have collected other species of leopard frogs in the southwest in modified habitats, even in canals and roadside ditches, relict leopard frogs have not been collected in such habitats in the past century. Potential *R. onca* habitat includes permanent small streams, springs, and spring-fed wetlands. Juvenile *R. onca* have been observed in the same areas as adults and their habitat requirements are presumed to be similar.

Red-spotted toads, *Bufo punctatus*, are desert spring specialists. They are most often found in open rocky areas and do well at permanent springs where at least some banks are sparsely vegetated as well as in flood-scoured washes where there is little permanent water. Breeding occurs in spring time and after rain in temporary pools with little vegetation in washes, at springs and along intermittent flow, or shifting, river drainages (such as the Virgin River). They breed more consistently in spring than they do after rain in these parts because sufficient summer rain is rare.

Riparian marsh: *Hyla regilla* breed in shallow quiet pools in streams or in open areas adjacent to marshes. In the Warm Springs area they are found in temporarily flooded fields. Adults are found most often in association with marshland vegetation including rushes, sedges and cattails wherever that vegetation occurs, including along the banks of the Upper Muddy River.

Relict leopard frogs also use marshy habitat including submerged, emergent, and perimeter vegetation. Emergent or submergent vegetation such as bulrushes, cattails, spikerushes (*Eleocharis* sp.), or small tules (*Scirpus* sp.) is probably needed for cover and as substrate for oviposition.

River: Throughout most of it's described range, *Bufo microscaphus microscaphus* (Southwestern toad) breeds in continuously flowing gravelly streams and is not dependent on rain for reproduction. Breeding in agricultural ditches and ponds has also been described. The nearest non-hybridized populations of *B. m. microscaphus* occur in Lincoln Co. Nevada in Meadow Valley Wash, and in the upper Virgin River drainage in Utah. Genetic remnants of *B. m. microscaphus* (hybridized with and genetically closer to *B. woodhousii*) occur in the upper Muddy River, in the washes in Las Vegas, along the banks of Lake Mead and in the Virgin River drainage.

Riparian woodland: *B. m. microscaphus* adults forage along the banks of streams without dense vegetation and burrow in loose soils. They have been found in a variety of native woodlands from lowland areas to elevations above 6000 feet. In the Meadow Valley Wash they have been found in relatively open stands of Willow. In the Upper Muddy River drainage, *B. m. microscaphus* hybrids with the strongest *B. m. microscaphus* characteristics (determined by morphology only) have been found in stands of Ash with little vegetation in the understory.

Mesquite bosque: Used as foraging habitat by toad species.

Riparian shrubland: Used as foraging habitat by toad species

Desired structure, composition, and landscape context and configuration

I. Habitat requirements

- The amphibian community in the upper Muddy River area has been dramatically altered by river channelization, agricultural practices and both animal and plant invader species.
- The habitat most conducive to recovering the amphibian community is probably a natural desert river system with permanent flow from springs and periodic violent scouring by floodwater. The river channel would meander, creating oxbows, and the distribution of shallow and deep areas would shift, as would the riparian marsh and shrub land. Ponds would be short-lived.
- Soils would be relatively loose and low in organic content. Riverbanks would be gradually sloping and also possibly terraced.
- Riparian woodland would be relatively open with trees not close together and relatively little vegetation in the understory.
- Some areas would have sparse vegetation (both banks and open shallow water) resulting from disturbance events.
- The exact composition is unknown, but general goals could include. Reestablish a natural river channel.
    - Remove and/or control exotic plants and animals
    - Reestablish desert riparian plant community
    - Reestablish/reintroduce desired amphibian species
    - Ensure flooding disturbance is allowed both from main channel upstream as well as small lateral drainages.

LANDSCAPE CONTEXT AND CONFIGURATION

- The Muddy River connects to the Meadow Valley Wash (MVW) drainage at I-15. There are currently *Bufo microscaphus microscaphus* in Meadow Valley Wash in Lincoln County well North of the Lincoln/Clark Co. border, but there has been no water flowing in that wash into the Muddy River for at least the last six years. Restoration of the *Bufo microscaphus microscaphus* in the Muddy River and it's connection to the MVW population will require restoration of riverine and riparian habitat down to I-15 as well as riparian restoration of MVW including reestablishment of at least periodic surface flow connection.
- The Muddy River flows into Lake Mead and thus retains its aquatic connection to the Virgin River drainage. However, recovery and maintenance of amphibian populations will require that appropriate riparian habitat corridors be established and barriers to terrestrial movement of amphibians be removed. Given the extent of disturbance, that would be a very ambitious undertaking.

Challenges to reaching and/or maintaining sustainable population

- Land and water ownership/rights: Most of the Muddy River drainage is privately owned and the water rights are completely allocated. Dramatic restructuring of landscapes will require permission of the landowners. Maintenance will require ownership of, or easement on land, and water rights ownership or other agreement for keeping spring flow and in-stream river water at appropriate levels.
- Invasive plant species: Numerous plant weeds have invaded the Muddy River drainage. Some are well established, e.g., Tamarisk and Palm; and others are relatively new, e.g. Perennial pepperweed (aka, Tall White Top), and Russian Knapweed. The specific effects of Tamarisk on amphibian populations may include salinization of soils (to which amphibians are very sensitive) and very dense restructuring of the riparian

shrubland and woodland to reduce useable terrestrial habitat. Palm and tamarisk also contribute to deep channelization of the river and to dramatic reduction of sunlight to the river, which reduces breeding and larval feeding opportunities. Both Perennial pepperweed and Russian Knapweed grow in dense monocultures. At this time, there is a reasonable expectation that the dense monocultures are not structurally consistent with what is known about amphibian habitat use, but specific effects for this area are unknown.

- Invasive animal species: There are several species of animal that may present a risk to amphibian community reestablishment that either have invaded already, or occur on an expected invasion route and may become a threat to long-term management. These include: *Tilapia*, crayfish (*Procambarus clarkii*) , Bullfrogs (*Rana catesbeiana*), Woodhouse's Toad (*Bufo woodhousii*) and the Great Basin Toad (*Bufo cognatus*). The effects of Tilapia on amphibian populations is not known from this area, however, it is reasonable to expect that if Tilapia eat small fishes they will also eat at least the non-toxic amphibian larvae (e.g., *Rana onca*). Bullfrogs and crayfish are aggressive and effective predators on both aquatic and terrestrial species. They represent a threat to the native amphibian community as well as to the native fishes. The two invader toad species do well in disturbed areas including lawns, gardens, pasture, agricultural fields, ditches and artificial ponds. Often development of water resources results in a contraction of the range of breeding and foraging habitats to only such disturbed areas. All amphibian species will seek out the remaining available water for breeding and hybridization of compatible species is likely. The large, weedy toad species have reproductive capacities (20,000+ eggs) that far exceed the toads with more specialized habitat associations (a few hundred eggs for *B. punctatus*, a few thousand eggs for *B. m. microscaphus*) and can genetically dominate hybrid populations very quickly. Also, with constriction of all habitat and limitations on suitable habitat for juvenile dispersal, the larger, more aggressive species are likely to eat some portion of the smaller or slower growing species, as they are all opportunistic cannibals.
- Management constraints: long-term management will require the cooperation of all landowners along the river corridor. Mixed public and private ownership make consistent management difficult.
- Financial constraints: Initial cost for acquisition of, or access to, resources is likely to be very high. Removing undesirable species and developing effective control programs will also be costly. Long-term management requirements are likely to include some recreational use and public education, as well as control of undesirable species. Management will be an ongoing expense that will eventually dwarf the initial costs.

Potential management options to reach DFC (with Pros + and Cons -)

- Aggressive restructuring of the landscape and reestablishment of native desert riparian all at once
  - \+ Obtain desired future condition more quickly
  - \+ Reduce overall restoration and management cost
  - – Short time frame for payment of restoration cost
  - – Gigantic, possibly prohibitive, initial costs

- Piecemeal, low intensity restoration of landscape with compromises to existing land ownership and without a consistent management plan
  - \+ Restoration cost distributed over longer time period
  - – DFC may never be reached

  - – Gigantic long-term management costs

- Artificial disturbance (e.g., clearing veg) to imitate flooding events
  - \+ Reintroduces an ecological process that is less common than during historic times
  - \+ Not too expensive
  - – must to continued over long term or until more natural flash flooding events returns to UMR

- Continual removal efforts for bullfrogs, *B. woodhousii*, crayfish, and other exotics, which would be expensive.
  - \+ Direct threat abatement
  - – long term and labor intensive effort

Ecological and Management Uncertainties

- Habitat requirements of the desired amphibian community are inferred from descriptions of occupied habitat that often includes some degree of disturbance. As such, optimal habitat and habitat preference is probably not sufficiently known for some species to provide security for restoration planning. Highly structured experimental habitat construction is desirable.
- Hybridization among *Bufo* species has been described from many areas, but there are no well tested and established management prescriptions for maintenance of desired species composition. Exact scope and configuration of habitat types to maintain separation of hybridizing species is unknown. Also, it is possible that the weedy toad species are very flexible in their habitat requirements and cannot (by landscape manipulation alone) be excluded from the specialist' preferred habitat.
- Natural pressure on amphibian populations is high. They are eaten in large numbers by native predators and in extreme cases, whole breeding choruses can be consumed in a single night. They also specialize in breeding in transient habitat (such as pools that occur after spring rains or flooding) that, by definition, vary from year to year and may cause recruitment to fail completely in bad years. Current models of amphibian metapopulations include extirpation and reestablishment of local populations connected by persistent or occasional habitat corridors. The scope and configuration of such a complex in the Muddy River area is not definable now with any degree of certainty. However, general considerations and cautionary notes include that such complexes be large and that the smaller the area to be managed for amphibians, the higher the per unit cost and the greater the risk of extirpation.

Information Source(s) and Reviewers

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Appendix IV–J. Upper Muddy River Bird Community Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Maintain current species diversity. The Upper Muddy River (UMR) bird community has one of the highest number of species for a geographical area in Clark County. Reasons include: 1) the high quality and mix of vegetation habitats and structure, and 2) reliable year round water including pools, streams, river, ponds. Of 230 species on the attached bird list, 162 may be categorized as “regular”species defined as 1) year round residents, 2) species that utilize the UMR habitats during migration, 3) seasonal nesters, and 4) winter residents. Another 68 are defined as “occasional” species defined as 1) species with five or less individual birds recorded in four data years, 2) species recorded in UMR adjacent habitats. **Spatial** Maintain existing native riparian habitats, man-made habitats and land management actions in order to maintain the bird species that tend to be associated with them. (Riparian Woodland – 86 species; Riparian Shrubland – 79 species; Riparian Marsh – 13 species including Sora, Virginia Rail, Marsh Wren obligates; Mesquite Bosque – 60 species; man-made habitats [ponds and reservoirs, sewage lagoons – 17 species]; and man-made land management actions; sheet flooding fields/pastures, livestock grazing.) **Management Actions** Seek protection of existing habitat by various methods (education, real estate, best management practices, etc).	**Condition** Maintain high level of species diversity. Increase densities of all species. **Spatial** Expand existing native riparian habitats and man-made habitats. Prioritize actions to provide most benefit to 1) to endangered species and 2) priority species in key bird conservation programs such as the Clark County Multiple Species Habitat Conservation Plan and Nevada Partners in Flight Plan. **Management Actions** Employ selected artificial management actions for specific species and/or habitat-dependent species. For example, strategic removal of tamarisk and native plant restoration of mesquite, willows, and cottonwoods. Partial hydrologic and geomorphic restoration of Upper Muddy River.	**Condition** See alternative 1 **Spatial** See alternative 1 **Management Actions** Extensive hydrologic, geomorphic, and vegetation restoration of the Upper Muddy River. Need additional information and modeling to plan and implement.

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Total Acreage: currently from 200-300 acres (81-121 ha)	**Total Acreage:** between 300 and 6,000 acres (121-2429 ha)	**Total Acreage:** 6,000-7,000 acres (2429-2839 ha)
Other Focal Targets Captured: Moapa dace, Virgin River roundtail chub, 2 other Muddy River native fish species and 5 aquatic invert species; CMHSCP Covered bat, herptile, butterfly species.	**Other Focal Targets Captured:** Moapa dace, Virgin River roundtail chub, 2 other Muddy River native fish species and 5 aquatic invert species; CMHSCP Covered bat, herptile, butterfly species.	**Other Focal Targets Captured:** Moapa dace, Virgin River roundtail chub, 2 other Muddy River native fish species and 5 aquatic invert species; CMHSCP Covered bat, herptile, butterfly species.

Preferred DFC: Alternative 1

Upper Muddy River Bird Community

NATURAL HISTORY DESCRIPTION OF UPPER MUDDY RIVER BIRD COMMUNITY:
The "Upper Muddy River" (UMR) is defined as the river and its associated riparian habitats from river mile 15 above Lake Mead to river mile 34 in the Warm Springs headwater area.

The author's UMR bird list is a compilation of four years of year-round personal observations, records that other researchers and birders that have provided, and historical records gleaned from references as Alcorn's *Birds of Nevada*. The list totals 230 species. After omitting records of species with five or less individual birds recorded in four data years, 2) species recorded in UMR adjacent habitats, a more representative UMR bird list is 162 species.

BIRD COMMUNITY DISTRIBUTION
While birds are highly mobile and may occur in any habitat, different species tend to be associated with different habitats. The following habitat/bird distribution information is summarized from field observations by the author, NDOW reports, Muddy River Christmas Bird Counts. Habitat types are adapted from The Nature Conservancy Upper Muddy River Site Plan (October 1999)

Interior Riparian Woodland species include Fremont Cottonwood, Velvet Ash, Goodding's Willow, Fan Palm and is distributed mainly as narrow (10-30 meters wide) bands mainly in the upper 3.5 miles along the river main stem, streams, springs, and wetland drainage ditches. Tree heights range from 10 –25 meters. Historic research suggests the pre-european settlement riparian woodland was predominantly mesquite woodland (bosques) that was cut down to put the land into agriculture production. Present riparian woodlands are the result of over a century of agricultural, recreational, industrial, and residential activities. Fremont Cottonwood and Fan Palm are introduced and naturalized species. Along the entire river, the introduced salt-cedar varies from total to negligible dominance.

86 species are associated with woodland habitat including neotropical migrants as Yellow-billed Cuckoo, Summer Tanager, Blue Grosbeak, Yellow Warbler, Lucy's Warbler, Western Kingbird. 9 native species have been documented eating Fan Palm fruits as a winter food.

Interior Riparian Shrubland species includes Quailbush, Arrow Weed, Coyote Willow, Seep-willow, Wolfberry, Emory's Baccharis, and Desert Grape. This habitat occurs as a mostly continuous linear habitat along the banks of the river. It also occurs at the perimeters of seasonally or permanently flooded wetlands, along irrigation ditches, streamside, and at margins of springs. This habitat ranges from 3 to 10 meters in height. The shrubland is often invaded and sometimes extensively replaced by salt-cedar.

79 species are associated including Yellow-breasted Chat, Blue Grosbeak, Indigo Bunting, Bullock's Oriole, Loggerhead Shrike, Crissal thrasher.

Interior Riparian Marsh species include sedges, Cattail, graminoids, Yerba Mansa and other wetland forbs. The vegetation ranges from 1 –2 meters and occurs on seasonally or perennially flooded soils.

Riparian marsh has been significantly reduced in area by historical agricultural drainage actions. Marshlands are found mainly in the Warm Springs headwater area and below the Moapa Valley dairy along river miles 21-22.

Although small in area, 13 species are correlated with marshes. Marsh obligate species include Virginia rail, Sora, and Marsh wren.

Mesquite Bosque is characterized by Honey and Screwbean Mesquite growing up to 5m in height. This woodland habitat occurs throughout the riparian floodplain terrace and varies from dense to open depending upon a variety of factors as groundwater availability and number of years without disturbance. 60 associated bird species includes Phainopepla, Lucy's Warbler, Verdin, Vermilion Flycatcher.

Man-made Habitats worthy of note: In addition to the natural communities, other suites of birds are observed to be associated with man-made habitats:

- **Open water ponds** at the Reid Gardner Power Plant and on the Perkins Property, and temporary livestock ponds on the Warm Springs Ranch have produced sightings of Osprey, ducks, geese, wading birds, shorebirds, and even terns.

- **Sewage lagoons** (2 acres) at the Moapa Valley Dairy are utilized by the pond species listed above, and are hotspots for shorebird migrants. 17 associated species including Long-billed/Short-billed Curlews, Red-necked/Wilson's Phalarope, Pectoral Sandpiper, and other shorebirds.

- **Some short-term man-made land management activities** result in predictable bird responses.

- **Sheet flooding fields/pastures** is associated with sixty (60) species including Snow Geese, Green Heron, White-faced Ibis, Peregrine Falcon (drinking and hunting), Sandhill Crane, Long-billed Curlew. Cattle/Great/Snowy egret, Green-winged teal, Cinnamon teal, American robins, American pipits. Some species may appear at any time of year while others are seen as winter residents or during migration.

- **Livestock pastures** : Where former ag fields have been modified with irrigation ditches, planted with livestock grasses (Bermuda, Crested wheat), forbs (Bird's-foot trefoil, clovers) and been lightly to moderately grazed for years, the fields are usually interspersed with mesquite groves of varying size and densities. These are heavily utilized by Neotropical flycatchers, blue grosbeaks, Yellow-billed cuckoos that prefer to nest in dense cover that is immediately adjacent to open fields for foraging. Grassland species include Western meadowlark, Lark/Chipping/Lincoln's/Savannah and other sparrows, Say's Phoebe, Vermilion Flycatcher, and others.

KEY ECOLOGICAL PROCESSES: Since the key to bird diversity is habitat, maintaining and/or establishing ecological processes relating to habitats is essential

- Maintenance of flash flood events
- Maintenance of groundwater levels near surface
- Maintenance of undisturbed natural habitats
- Establishment and maintenance of a mix of native and man-made habitats and land management actions.

FEDERAL AND STATE LISTING STATUS:

Listed Federal Bird Species (LE)

- Southwestern Willow Flycatcher *(Empidonax traillii extimus)*

Federal Species of Concern (SOC)

- Bell's Vireo *(Vireo bellii arizonae)*
- Phainopepla *(Phainopepla nitens)*

Nevada Partners In Flight Lowland Riparian – Obligate Species

- Yellow-billed Cuckoo *(Coccyzus americanus)*
- Southwestern Willow Flycatcher *(Empidonax traillii extimus)*
- Bank Swallow *(Riparia riparia)*
- Bell's Vireo *(Vireo bellii arizonae)*
- Blue Grosbeak *(Guiraca caerula)*

Lowland Riparian – Other Species

- Lewis's Woodpecker (*Melanerpes lewis)*
- Ash-throated Flycatcher *(Myiarchus cinerascens)*
- Phainopepla *(Phainopepla nitens)*
- Western Bluebird *(Sialia mexicana)*
- Lucy's Warbler *(Vermivora luciae)*
- Yellow-breasted Chat *(Icteria virens)*

Wetlands and Lakes- Obligate Species

- White-faced Ibis *(Eudocimus albus)*
- American Avocet *(Recurvirostra americana)*

Wetlands and Lakes – Other Species

- Sandhill Crane *(Grus canadensis)*
- Long-billed Curlew *(Numenius americanus)*

Clark County Multiple Species Habitat Conservation Plan – Covered Species

- American Peregrine Falcon (*Falco peregrinus anatum)*
- Western Yellow-billed Cuckoo *(Coccyzus americanus)*
- Vermilion Flycatcher *(Pyrocephalus rubinus)*
- Phainopepla *(Phainopepla nitens)*
- Southwestern Willow Flycatcher *(Empidonax traillii extimus)*
- Summer Tanager *(Piranga rubra)*
- Blue Grosbeak *(Guiraca caerula)*
- Arizona Bell's Vireo *(Vireo bellii arizonae)*

Desired structure, composition, and landscape context and configuration

III. Structure

- Present demographic knowledge is limited. Relative or absolute density/abundance of various species and foraging guilds per and across habitat types not known. The following studies should document structure of community.

- NDOW Vermilion flycatcher nesting surveys conducted at the Warm Springs

Ranch by Polly Sullivan during 2000 and 2001 counted 85 broods in 2001.

- Yellow-billed cuckoos have been surveyed by Murrelet Halterman and NDOW on the Warm Springs Ranch in 2001. 4 nests and 12 adult birds were counted. Both are the highest counts for a single site in Nevada.
- Clapper Rail surveys by NDOW in 2001 produced no sightings.
- UNR Phainopepla PhD (Cali Crampton) research began in 2001 on the Warm Springs Ranch (in part) and is ongoing as of this writing.

IV. Species composition

- COMPOSITION: See description of communities above in Minimum DFC and Embedded Communities.

- NDOW has conducted two seasons of general systematic inventorying during May and June along the MRREIAC and Warm Springs Ranch areas. 72 species were documented in 2001.

- Three Muddy River Christmas Bird Counts (1999, 2000, 2001) provide winter resident information. The highest CBC count was 92 species, indicating the high number of wintering species.

III. LANDSCAPE CONTEXT AND CONFIGURATION

- Because the UMR ecosystem 1) is a year round oasis of green and water in a sea of Mojave Desert, 2) is ground water supplied with a constant, reliable water supply, 3) supports a diversity of natural and man-made vegetative habitats, the diversity of year-round resident, seasonal resident, and migrant bird species is one of the highest in Clark County. In short, there is no other landscape scale area known to have more birds year round. Another area of high diversity is the Overton Wildlife Management Area at the mouth of the river contains endangered species such as the Southern Willow Flycatcher and Yuma Clapper Rail. But Overton is managed for waterfowl, so not easily compared to the UMR.
- The UMR avian diversity is the result of a mix of natural and man-made habitats. Historical documentation is scant, however anecdotes in the diaries of the earliest Mormon settlers and personal communication from their resident descendants describes the upper Muddy River riparian zone to be dominated by dense Mesquite woodlands (bosques) and marsh habitats. Mesquite woodlands were cleared and the ground plowed and planted in hay and other crops, being watered by extensive irrigation systems. More difficult to drain Marsh habitats were eventually ditched and drained and used for livestock pasturing. Fremont Cottonwoods and Fan Palms were apparently introduced early in the 1900's and are naturalized. Within the last 50 or so years, the croplands and irrigation systems were abandoned and many of the fields were converted to pastures. Within the past 40 years, more or less coinciding with the designation of the Desert tortoise as an threatened species, the pastures were neglected and the mesquites have grown back in a variable pattern of individual trees and groves interspersed with areas of grasses and forbs. Where former ag lands have succeeded to mesquite woodlands, associated riparian woodland and mesquite birds listed occur to varying degrees.

Challenges to reaching and maintaining sustainable population

Threats to ecological processes: For more complete descriptions, see Upper Muddy River Site Conservation Plan, The Nature Conservancy, August, 2000.

- Regional aquifer withdrawal – Groundwater table lowering due to excessive water withdrawals
- Incompatible land development, especially residential lot clearing = native tree/shrub removal
- Inappropriate grazing practices
- Introduced non-native plants and animals
- Conversion to agriculture
- Woodcutting

Potential management options to reach DFC (with Pros + and Cons -)

Even though historical research indicates that mesquite woodlands were the main UMR woodland type, the author recommends the Riparian Woodland habitat that exists today be expanded through the river corridor because it supports a significant suite of bird species during different seasons through the year.

- Geomorphic, riverine restoration to reconnect floodplain with river
  + Rehydrate desert riparian forests and allow tree and shrubs recruitment to form future bird breeding habitat.
  + Increase extent desert riparian forests.
  – Expensive, even with passive geomorphic restoration.
  – Land ownership patterns, water rights, and access to river could prevent management.

- Native plant restoration by reducing abundance of tamarisk and planting native species
  + Creates future breeding habitat
  – Highly dependent on geomorphic riverine restoration for long-term success
  – Land ownership patterns, water rights, and access to river could prevent management
  – Short term loss of bird breeding habitat

Other management strategies identified by The Nature Conservancy. For more complete descriptions, see Upper Muddy River Site Conservation Plan, The Nature Conservancy, August, 2000

- Acquire conservation easements or fee interests in floodplain lands
- Build long-term local support for conservation management
- Engage key partners including US Fish and Wildlife Service, Bureau of Land Management, Clark County MHSCP
- Outreach and Education to increase community awareness of importance of Muddy River and birds
- Development of a Muddy River water budget that assures adequate surface and groundwater for birds and their habitats
- Research and Monitoring strategies for bird species to develop restoration plans for the natural fluvial geomorphology, including flooding events.

Ecological and Management Uncertainties

- More year round inventory work needs to be carried out on other UMR properties (Tribe land, Dairy, Perkins Ranch, etc.) to establish and evaluate the presence, densities, nesting, etc. of avian species.
- An all-bird, long term monitoring program needs to be implemented to document short and long term avian responses to short and long term land use changes.
- It is not clear or well documented how tamarisk removal patterns affects the breeding success of or habitat choice of some bird species.

Information Source(s) and Reviewers

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Muddy River Christmas Bird Count, National Audubon Society, 1999, 2000, 2001. http://www.audubon.org

Nevada Natural Heritage Program Scorecard 2000, October 2000

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TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ NNH STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Desert riparian vegetation matrix	NATURAL COMMUNITIES/ASSOCIATIONS			
	UPPER MUDDY RIVER Interior Riparian Forest & Woodland Interior Riparian Shrubland Interior Riparian Marsh & Seep			

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK/ NNH STATE RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
	BIRDS			
	latin name	common name	rank	listing

Falco peregrinus	Peregrine Falcon		PS:LE/S2
		G4/N4B,N4	
Coccyzus americanus	Western Yellow-billed Cuckoo	H	C/S1B
Calypte costae	Costa's Hummingbird	G5T3/N3B	/S3?B
		G5/N5B,	
Empidonax traillii extimus	Southwestern Willow	N4N	LE/SIB
	Flycatcher	G5T1T2/	
Pyrocephalus rubinus	Vermilion Flycatcher	N1B	/S3?B
Vireo bellii arizonae	Arizona Bell's Vireo	G5/N5B,N5	/S2?B
Lanius ludovicianus	Loggerhead Shrike	N	PS/S3
Phainopepla nitens	Phainopepla	G5T4/N4B	/S2B
Toxostoma crissale	Crissal Thrasher	G4/N4	/S3S4
Guiraca caerulea	Blue Grosbeak	G5/NS	/S3
		G5/N5	
Vermivora luciae	Lucy's Warbler		/S3B
Dendroica petechia	Yellow Warbler	G5/N5B,NZ	/S3B
		N	
Piranga rubra	Yellow-breasted Chat	G5/N5B	/S4?B
Icteria virens	Summer Tanager		/S3B
Pipilo aberti	Abert's Towhee	G5/N5B,N5	/S3
		N	
		G5/N5B	
		G5/N5B	
		G3G4/N3N	
		4	

Census, Bird Population - 4 Years, starting January, 1998
Muddy River – No Checklist selected

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GREBES													
Pied-billed Grebe	3	0	1	0	5	3	0	0	2	13	1	14	42
O Eared Grebe	0	0	0	0	165	0	0	0	0	0	0	3	168
O Western Grebe	3	0	1	0	35	0	0	0	0	1	4	4	48
O Clark's Grebe	0	0	0	0	7	0	0	0	0	0	0	0	7
CORMORANTS													
Double-crested Cormorant	0	0	2	2	3	1	1	1	0	5	0	0	15
PELICANS													
American White Pelican	0	0	1	0	8	0	0	0	0	0	0	0	9
DUCKS, SWANS, GEESE													
X O Ruddy Duck	50	0	1	0	0	0	0	0	0	2	0	29	82
Snow Goose	0	0	5	0	0	0	0	0	0	0	10	8	23
Canada Goose	110	50	3	2	6	15	0	0	0	0	150	16	352
American Wigeon	30	0	36	4	0	0	0	0	0	0	8	76	154
O Gadwall	7	0	1	0	0	0	0	0	0	0	0	18	26
Green-winged Teal	0	192	107	2	0	0	0	0	0	0	0	1	302
Mallard	307	94	380	145	71	48	42	30	31	67	60	83	1358
Northern Pintail	14	4	1	0	4	0	0	0	0	0	1	0	24
Blue-winged Teal	0	0	0	18	0	0	0	0	0	1	0	0	19
Cinnamon Teal	0	0	54	242	8	0	0	29	74	1	0	0	408
O Northern Shoveler	0	0	1	0	0	2	0	0	0	0	2	0	5
X O Canvasback	0	0	0	0	0	0	0	0	0	3	0	13	16
Redhead	4	0	0	0	0	8	0	0	0	0	0	23	35
Ring-necked Duck	12	0	2	3	0	0	0	0	0	3	40	186	246
X O Lesser Scaup	3	0	0	0	0	0	0	0	0	3	2	73	81
O White-winged Scoter	0	0	1	0	0	0	0	0	0	0	0	0	1
X O Bufflehead	0	0	1	0	1	0	0	0	0	0	0	0	2
O Red-breasted Merganser	0	0	0	2	1	0	0	0	0	0	0	0	3
O Common Merganser	1	0	0	0	0	0	0	0	0	0	0	5	6
HERONS, EGRETS AND BITTERNS													
Snowy Egret	0	0	1	17	17	0	1	0	59	0	1	3	99
Great Blue Heron	61	36	41	20	31	17	12	23	80	40	40	22	423
Great Egret	11	25	8	5	2	3	1	0	1	0	2	0	58
Cattle Egret	24	1	0	14	0	0	0	0	4	0	5	0	48
Green Heron	0	0	0	1	9	9	0	4	1	1	0	0	25
Black-crowned Night-Heron	0	0	0	1	12	0	0	1	1	0	0	0	15
O Least Bittern	0	0	0	0	0	1	0	0	0	0	0	0	1
O American Bittern	0	0	0	0	1	0	0	0	0	0	0	0	1
IBIS AND SPOONBILLS													
White-faced Ibis	0	0	0	195	309	46	58	63	281	0	0	0	952
NEW WORLD VULTURES													
Turkey Vulture	0	41	1052	784	1235	762	1111	911	2300	221	0	0	8417
OSPREY													
Osprey	0	0	0	6	5	1	0	0	0	0	1	0	13
HAWKS, EAGLES AND KITES													
X Mississippi Kite	0	0	0	0	0	1	0	0	0	0	0	0	1
X Bald Eagle	0	0	1	0	0	0	0	0	0	0	0	0	1
Northern Harrier	20	4	5	4	3	0	0	2	7	10	23	35	113
Sharp-shinned Hawk	19	12	7	5	5	0	0	0	12	27	26	36	149
Cooper's Hawk	9	5	4	6	3	7	1	6	15	14	14	13	97
X Common Black-Hawk	0	0	2	0	1	0	0	0	0	0	0	0	3
Red-shouldered Hawk	0	0	0	2	4	3	11	27	62	49	27	13	198
Swainson's Hawk	0	0	0	8	0	1	0	0	0	0	0	0	9
X Zone-tailed Hawk	0	0	0	0	0	1	0	0	0	0	0	0	1
Red-tailed Hawk	128	103	91	47	46	33	85	40	45	72	104	141	935
Ferruginous Hawk	11	5	0	5	2	0	0	0	0	0	0	20	43
X Rough-legged Hawk	2	1	0	0	0	0	0	0	0	0	0	2	5
Golden Eagle	1	0	1	0	0	1	0	0	0	0	2	2	7
FALCONS AND CARACARAS													

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Census, Bird Population - 4 Years, starting January, 1998
Muddy River – No Checklist selected

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
American Kestrel	28	10	10	14	11	8	45	53	110	37	26	30	382
XO Merlin	0	0	0	1	0	0	0	0	0	0	0	4	5
Prairie Falcon	2	4	1	2	2	0	0	1	0	0	0	6	18
Peregrine Falcon	0	0	0	3	1	3	5	1	4	2	2	7	28
PHEASANTS, GROUSE, QUAIL AND TURKEYS													
Ring-necked Pheasant	1	4	12	38	55	35	21	5	23	18	2	0	214
Wild Turkey	2	0	5	2	4	11	20	0	0	8	5	33	90
WOOD-PARTRIDGES													
Gambel's Quail	104	67	217	210	838	647	804	446	482	336	323	501	4975
RAILS AND COOTS													
O Clapper Rail	0	0	0	0	2	0	0	0	0	0	0	0	2
Virginia Rail	2	3	12	9	33	9	3	8	7	9	7	8	110
Sora	8	4	4	7	5	2	2	3	13	9	8	2	67
X Common Moorhen	0	0	0	0	3	0	0	0	0	0	0	0	3
American Coot	68	12	5	24	30	1	0	0	2	33	51	91	317
CRANES													
Sandhill Crane	0	0	56	0	0	0	0	0	0	124	3	0	183
SANDPIPERS													
Common Snipe	64	34	360	60	1	0	0	1	12	71	140	22	765
X Long-billed Curlew	0	0	0	0	0	0	0	0	3	0	0	0	3
Greater Yellowlegs	0	0	0	5	0	2	0	2	4	3	1	0	17
Lesser Yellowlegs	0	0	0	16	0	0	0	0	0	0	0	0	16
Solitary Sandpiper	0	0	0	6	5	0	0	2	1	0	1	0	15
Spotted Sandpiper	0	0	0	7	2	1	3	3	3	1	0	0	20
X Willet	0	0	0	3	0	0	0	0	0	0	0	0	3
X Short-billed Dowitcher	0	0	0	0	1	0	0	0	0	0	0	0	1
Long-billed Dowitcher	0	0	2	15	7	0	0	0	0	0	0	0	24
Western Sandpiper	0	0	0	215	0	0	0	0	0	4	1	0	220
Least Sandpiper	3	0	0	31	2	0	0	0	3	11	11	18	79
Baird's Sandpiper	0	0	0	0	0	0	0	0	0	2	0	0	2
Pectoral Sandpiper	0	0	0	0	0	0	0	0	0	6	1	0	7
Wilson's Phalarope	0	0	0	8	84	0	0	0	0	0	0	0	92
Red-necked Phalarope	0	0	0	0	1	0	0	0	0	0	0	0	1
AVOCETS AND STILTS													
Black-necked Stilt	0	0	0	50	39	24	0	0	1	0	0	0	114
American Avocet	0	0	0	7	1	3	0	0	0	0	0	0	11
PLOVERS AND LAPWINGS													
X Black-bellied Plover	0	0	0	0	0	0	0	0	0	0	1	0	1
Semipalmated Plover	0	0	0	8	0	0	0	0	0	0	0	0	8
Killdeer	55	234	608	104	185	54	111	155	376	296	358	107	2643
GULLS AND TERNS													
Ring-billed Gull	13	0	1	26	0	0	0	0	0	1	0	2	43
X Bonaparte's Gull	0	0	0	2	1	0	0	0	0	0	0	0	3
O Franklin's Gull	0	0	0	0	6	0	0	0	0	0	0	0	6
X Caspian Tern	0	0	0	0	1	0	0	0	0	0	0	0	1
X Forster's Tern	0	0	0	0	1	0	0	0	0	0	0	0	1
LOONS													
X Common Loon	0	0	2	0	1	0	0	0	0	0	1	1	5
PIGEONS AND DOVES													
Rock Dove	71	5	1	6	210	8	0	0	50	1	0	45	397
Mourning Dove	0	2	19	276	1584	600	535	304	177	19	4	52	3572
X White-winged Dove	0	0	0	0	4	1	0	0	0	0	0	0	5
Inca Dove	0	0	2	0	21	0	1	1	22	31	25	1	104
NEW WORLD CUCKOOS													
Yellow-billed Cuckoo	0	0	0	0	1	85	91	15	0	1	0	0	193
GROUND-CUCKOOS AND ALLIES													
Greater Roadrunner	8	6	18	16	37	43	23	12	26	27	19	29	264
BARN-OWLS													
Barn Owl	1	1	1	0	2	6	0	0	0	1	0	0	12
OWLS													

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Page 2

Census, Bird Population - 4 Years, starting January, 1998
Muddy River -- No Checklist selected

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Great Horned Owl	4	3	5	5	13	3	18	15	7	16	5	6	100
X Burrowing Owl	0	0	0	0	0	0	0	0	0	1	0	0	1
X Northern Saw-whet Owl	0	0	0	0	0	0	0	0	0	0	1	0	1
NIGHTJARS													
Lesser Nighthawk	0	0	0	9	88	48	103	17	43	0	0	0	308
Common Nighthawk	0	0	0	0	0	20	8	0	0	0	0	0	28
Common Poorwill	0	0	1	1	0	2	0	0	0	7	0	0	11
SWIFTS													
White-throated Swift	344	199	39	26	167	127	84	0	12	56	100	109	1263
HUMMINGBIRDS													
Black-chinned Hummingbird	0	0	3	75	151	105	142	117	36	0	0	0	629
X Anna's Hummingbird	0	0	0	0	3	0	0	0	0	0	0	0	3
X Costa's Hummingbird	0	0	0	3	1	1	0	0	0	0	0	0	5
X Broad-tailed Hummingbird	0	0	0	2	0	2	1	0	0	0	0	0	5
Rufous Hummingbird	0	0	0	0	0	0	9	38	36	0	0	0	83
KINGFISHERS													
Belted Kingfisher	9	11	19	19	3	1	0	6	16	23	11	8	126
WOODPECKERS													
Lewis's Woodpecker	0	0	0	1	6	0	0	0	0	8	5	2	22
Red-naped Sapsucker	0	0	1	0	0	0	0	0	0	5	2	8	16
Ladder-backed Woodpecker	18	17	19	18	37	29	16	9	19	20	22	16	240
Northern Flicker	446	368	274	0	0	1	0	0	67	482	657	746	3041
X Gilded Flicker	0	0	1	0	0	1	0	0	0	0	0	0	2
TYRANT FLYCATCHERS													
Olive-sided Flycatcher	0	0	0	2	34	6	0	4	23	0	0	0	69
Western Wood-Pewee	0	0	0	1	48	12	0	0	4	0	0	0	65
Willow Flycatcher	0	0	0	0	5	5	1	0	1	0	0	0	12
X Hammond's Flycatcher	0	0	0	2	1	0	1	0	0	0	0	0	4
Gray Flycatcher	0	0	0	2	2	2	0	0	2	0	0	0	8
Dusky Flycatcher	0	0	0	1	8	0	0	0	0	0	0	0	9
X Cordilleran Flycatcher	0	0	0	1	1	1	0	0	0	0	0	0	3
Say's Phoebe	120	81	82	39	101	97	52	27	59	90	66	102	916
Black Phoebe	103	94	85	81	96	86	104	97	161	106	85	69	1167
Vermilion Flycatcher	40	23	51	65	288	301	188	128	208	43	21	3	1359
Ash-throated Flycatcher	0	0	0	5	51	79	54	8	2	0	0	0	199
Brown-crested Flycatcher	0	0	0	0	15	21	4	0	0	0	0	0	40
X Cassin's Kingbird	0	0	0	0	1	0	1	0	0	0	0	0	2
Western Kingbird	0	0	0	51	170	126	153	115	20	2	0	0	637
CROWS AND JAYS													
Western Scrub-Jay	36	27	31	26	5	1	0	1	162	236	118	260	903
American Crow	0	0	300	30	1	1	0	0	0	144	4518	3034	8028
Common Raven	61	34	44	90	92	77	85	78	79	44	361	1336	2381
VIREOS AND ALLIES													
Bell's Vireo	0	0	0	1	23	24	0	0	0	0	0	0	48
X O Gray Vireo	0	0	0	0	1	26	0	0	0	0	0	0	27
X O Plumbeous Vireo	0	0	0	0	4	2	0	0	0	0	0	0	6
X Red-eyed Vireo	0	0	0	0	1	0	0	0	0	0	0	0	1
Warbling Vireo	0	0	0	0	20	2	2	9	4	2	0	0	39
SHRIKES													
Loggerhead Shrike	81	32	13	25	25	11	19	63	123	100	82	116	690
X Northern Shrike	2	0	0	0	0	0	0	0	0	0	0	1	3
WAXWINGS AND SILKY-FLYCATCHERS													
Phainopepla	92	77	88	122	633	151	19	28	2	22	86	192	1512
Cedar Waxwing	0	0	2	8	94	7	0	4	10	85	86	390	686
THRUSHES													
X Varied Thrush	0	0	0	0	0	0	0	0	0	1	0	0	1
Western Bluebird	15	26	0	1	0	0	0	0	2	4	26	35	109
Mountain Bluebird	24	79	38	0	0	0	0	0	0	0	16	57	214
Townsend's Solitaire	0	0	0	2	1	0	0	0	0	1	0	4	8
X Hermit Thrush	0	0	0	0	0	0	0	0	0	0	0	1	1

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Muddy River -- No Checklist selected

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
American Robin	16	66	111	5	24	0	0	0	0	537	749	821	2329
MOCKINGBIRDS AND THRASHERS													
Northern Mockingbird	83	77	69	73	228	168	293	209	176	159	130	125	1790
Sage Thrasher	1	0	1	1	0	0	0	0	0	0	0	0	3
X Le Conte's Thrasher	0	0	0	0	0	0	0	0	0	0	0	1	1
Crissal Thrasher	2	1	2	5	27	35	5	14	16	7	7	31	152
STARLINGS													
European Starling	215	3	65	16	21	8	4	7	3	25	7981	2921	11269
NUTHATCHES													
X Red-breasted Nuthatch	0	0	0	0	1	0	0	0	0	0	0	0	1
X White-breasted Nuthatch	0	0	0	0	0	0	0	0	0	0	1	0	1
CREEPERS													
Brown Creeper	0	1	0	0	0	0	0	0	0	1	0	1	3
WRENS													
Cactus Wren	0	0	2	0	4	3	1	0	0	0	1	9	20
Rock Wren	3	3	10	15	5	5	0	0	4	8	1	12	66
O Canyon Wren	0	0	3	7	21	5	0	0	4	0	0	0	40
Marsh Wren	30	27	56	22	4	2	2	2	152	71	54	34	456
Bewick's Wren	9	11	38	40	135	104	24	12	10	18	14	40	455
X Winter Wren	0	0	0	0	0	0	0	0	0	0	1	1	2
X House Wren	0	0	0	0	0	0	0	0	0	0	0	1	1
GNATCATCHERS													
Verdin	24	21	36	51	137	200	78	54	62	37	37	89	826
Blue-gray Gnatcatcher	5	1	0	5	8	11	2	0	0	0	0	18	50
Black-tailed Gnatcatcher	3	6	4	0	44	33	15	3	11	0	4	26	149
LONG-TAILED TITS													
Bushtit	181	50	0	11	0	9	0	0	0	12	158	241	662
SWALLOWS													
Tree Swallow	0	0	74	161	3	0	67	6	5	0	0	0	316
Violet-green Swallow	0	0	121	246	243	137	112	30	2	0	0	4	895
Northern Rough-winged Swallow	0	8	107	419	401	310	94	94	35	0	0	0	1468
Barn Swallow	0	0	0	9	24	1	1	0	70	28	0	0	133
Cliff Swallow	0	0	0	81	16	12	3	0	0	0	0	0	112
KINGLETS													
Ruby-crowned Kinglet	81	38	30	17	3	0	0	0	0	16	22	111	318
X Golden-crowned Kinglet	0	0	0	0	0	0	0	0	0	1	0	3	4
CHICKADEES, TITS													
Mountain Chickadee	6	0	0	0	0	0	0	0	0	6	0	3	15
Juniper Titmouse	0	0	0	0	0	14	0	0	0	0	0	0	14
LARKS													
Horned Lark	0	1	15	0	2	4	1	0	12	0	20	270	325
OLD WORLD SPARROWS													
House Sparrow	150	0	8	1	343	439	101	1	0	21	0	92	1156
WAGTAILS AND PIPITS													
American Pipit	507	382	392	446	0	0	0	0	15	136	1349	1073	4300
SISKINS, CROSSBILLS AND ALLIES													
Pine Siskin	0	0	0	0	0	0	0	0	18	169	38	0	225
American Goldfinch	29	40	0	0	0	1	1	1	0	17	36	17	142
Lesser Goldfinch	84	39	32	81	132	176	33	37	149	141	137	112	1153
X Cassin's Finch	0	0	0	0	0	0	0	0	0	1	0	0	1
House Finch	135	370	188	184	409	380	189	104	323	348	34	150	2814
X Evening Grosbeak	0	0	0	0	0	0	0	0	0	1	0	0	1
NEW WORLD WARBLERS													
Orange-crowned Warbler	5	2	2	7	0	1	0	2	14	29	2	4	68
X Nashville Warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
X Virginia's Warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
Lucy's Warbler	0	0	1	25	146	172	51	0	0	0	0	0	395
X Northern Parula	0	0	0	1	0	0	2	0	0	0	0	0	3
Yellow Warbler	0	0	0	6	205	19	14	2	1	0	0	0	247
Yellow-rumped Warbler	190	110	159	30	2	0	0	0	31	219	80	130	951

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Muddy River -- No Checklist selected

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
X O Black-throated Gray Warbler	0	0	0	0	3	4	0	1	0	0	0	0	8
X Townsend's Warbler	0	0	0	0	2	0	0	0	0	0	0	0	2
X Hermit Warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
X American Redstart	0	0	0	0	0	1	0	0	0	0	0	0	1
X Worm-eating Warbler	0	0	0	0	0	0	1	0	0	0	0	0	1
Common Yellowthroat	0	0	4	58	101	113	90	11	12	3	0	0	392
Wilson's Warbler	0	0	0	1	20	3	0	2	0	0	0	0	26
Yellow-breasted Chat	0	0	0	0	311	250	87	14	3	1	0	0	666
BUNTINGS, SPARROWS, TANAGERS, ALLIES													
Song Sparrow	265	214	96	13	21	19	21	10	46	36	98	197	1036
Lincoln's Sparrow	0	0	1	3	2	0	0	0	4	2	0	0	12
X Swamp Sparrow	0	0	0	2	0	0	0	0	1	0	0	0	3
White-crowned Sparrow	1069	763	436	265	56	1	0	0	90	1258	1359	3022	8319
Dark-eyed Junco	77	55	8	3	0	0	0	0	0	10	202	274	629
Savannah Sparrow	0	0	0	42	0	0	0	0	0	13	3	3	61
Chipping Sparrow	0	0	0	0	8	0	0	0	6	0	0	0	14
Brewer's Sparrow	0	0	0	2	21	0	0	0	0	0	0	59	82
O Black-chinned Sparrow	0	0	0	0	0	5	0	0	0	0	0	0	5
Vesper Sparrow	0	0	0	1	0	0	0	0	1	2	1	3	8
Lark Sparrow	0	0	0	0	9	2	2	15	13	0	0	0	41
X O Black-throated Sparrow	0	0	7	1	14	12	0	0	1	0	0	0	35
Sage Sparrow	0	0	0	0	0	0	0	0	0	1	4	166	171
Green-tailed Towhee	0	0	0	1	3	0	0	1	6	0	0	0	11
Spotted Towhee	11	7	8	6	0	4	0	0	6	14	20	37	113
Abert's Towhee	112	111	81	65	401	331	133	166	181	125	116	275	2097
Summer Tanager	0	0	0	0	28	25	8	0	1	0	1	0	63
Western Tanager	0	0	0	0	17	2	24	11	74	0	0	0	128
Rose-breasted Grosbeak	0	0	0	0	4	2	0	0	0	0	0	0	6
Black-headed Grosbeak	0	0	0	1	8	2	7	7	7	0	0	0	32
Blue Grosbeak	0	0	0	1	155	163	164	90	46	0	0	0	619
Lazuli Bunting	0	0	0	1	17	20	14	3	0	0	0	0	55
Indigo Bunting	0	0	0	0	10	9	6	0	0	0	0	0	25
BLACKBIRDS, GRACKLES, ORIOLES													
Hooded Oriole	0	0	0	27	70	67	71	45	5	0	0	0	285
Bullock's Oriole	0	0	0	9	169	126	107	52	1	0	0	1	465
X Orchard Oriole	0	0	0	0	1	0	0	0	0	0	0	0	1
Scott's Oriole	0	0	0	0	0	17	1	0	0	0	0	0	18
Yellow-headed Blackbird	4	0	0	18	138	61	79	2	15	1	0	0	318
Red-winged Blackbird	2117	3366	1380	586	531	276	629	429	2358	3381	2247	2972	20272
Western Meadowlark	600	781	398	73	315	217	75	31	113	725	1060	1022	5410
Great-tailed Grackle	7	0	1	25	47	5	14	0	0	6	9	0	114
Brewer's Blackbird	50	0	0	5	13	1	0	0	15	80	50	911	1125
Brown-headed Cowbird	3	0	0	106	849	382	317	306	40	3	0	44	2050
Totals	8729	8584	8189	6705	13305	8253	6994	4687	9550	10751	23807	23619	133173
Species Totals	84	69	101	136	156	125	86	80	104	106	96	106	

230 Total Species

KEY:
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Appendix IV–K. Yellow-billed Cuckoo: Desired Future Condition Summary

Minimum DFC	Alternative 1	Alternative 2
Abundance 25 pairs of successfully reproducing cuckoos along the Muddy Rive west of I-15. This is a minimum population size. Spatial Removal of tamarisk along the river corridor, allowing for some regeneration of native habitat. Management Actions Tamarisk removal	Abundance <50 pairs of successfully reproducing cuckoos along the Muddy Rive west of I-15. Spatial The minimum habitat requirement is for mixed native/exotic vegetation lining the river Management Actions Removal of tamarisk and planting of native vegetation along the river corridor.	Abundance 50-100 pairs of successfully reproducing cuckoos along the Muddy Rive west of I-15. Spatial In addition to the mixed native/exotic vegetation lining the river, there should be areas where the riparian is wider. Patches varying from 49.4-247 acres (20-100 ha) in extent should be in close proximity (less than 2 km) other habitat patches. Management Actions Purchase land from willing sellers, alteration of water flow to support riparian vegetation, and habitat restoration.
Total Acreage: 494 acres (200 ha) of riparian vegetation	**Total Acreage:** 741 acres (300 ha) of riparian vegetation	**Total Acreage:** 2470 acres (1000 ha) of riparian vegetation
Other Focal Conservation Targets Captured: Desert riparian vegetation and birds	Other Focal Conservation Targets Captured: **Desert riparian vegetation and birds**	**Other Focal Conservation Targets Captured:** Desert riparian vegetation. Restoration of other wetland habitats such as marshes, and establishment of ponds.

Preferred DFC: Alternative 2.

Yellow-billed Cuckoo

The Yellow-billed Cuckoo (*Coccyzus americanus*) is a medium sized bird identified by the rufous in the wings, brown back with white belly, long tail with white spots on a black background, and yellow lower mandible. This neotropical migrant species inhabits deciduous riparian woodlands found along rivers and streams throughout the western United States. They give a variety of calls, including a series of "coo" calls, and variations on a wooden knocker call. They nest in a variety of riparian trees, including willow, mesquite, and tamarisk. They eat large prey items such as katydids, cicadas tree frogs, and caterpillars. They require a relatively intact riparian system for successful breeding.

Yellow-billed Cuckoos historically bred throughout most of western North America from southern British Columbia to Mexico and in most regions of California, as well as in most of the eastern United States. The number of breeding pairs of cuckoos in western North America has declined dramatically during the past 80 years. The Yellow-billed Cuckoo has been extirpated (or nearly extirpated) from much of its previous range, including southern British Columbia, Washington, Oregon, Idaho, and Nevada. The early decline of the species was linked mostly to extensive loss of riparian habitat in nesting areas. During the late 1800s and early 1900s, large areas of continuous riparian habitat in western United States were destroyed or degraded such as inundation by reservoirs, channelization for flood control, conversion to agriculture and grazing, and urban development. Much of the remaining riparian habitat in the west exists only as patches of varying size, shape, and isolation. They are currently listed as a candidate for federal Endangered status (rank: G5, SR for NV).

Desired abundance, population structure, habitat requirements, and landscape context and configuration.

I. Abundance and population structure

- Eastern population (east of the Rockies) stable, though possibly showing some decline
- Western population: CA 50-100 pairs; AZ 200-300 pairs; NM and TX unknown but probably over 200 pairs; NV, UT, ID unknown, but very small – probably varies greatly from year to year.
- 4-5 breeding pairs at Warm Springs Ranch, several pairs at Virgin and Muddy Rivers above Lake Mead.
- Cuckoo populations can vary greatly over several years. The population on the Bill Williams River NWR varied from 6 to 36 pairs between 1999 and 2001
- Based on current occupancy of the habitat on Warm Springs Ranch: the Muddy River could potentially support 50-100 pairs of cuckoos if the habitat were greatly improved.
- **Productivity:** Cuckoos may nest up to three times in a very short season (June to September), and produce 1-4 young per nest.

- **Population growth rate:** unknown – cuckoo movements between sites are unknown, so colonization of new habitats in unknown. This is a critical information gap for the purposes of managing cuckoo populations.
- **Limiting factors:** habitat availability and food resources. The exact habitat factors and their relationship to food resources are unknown. This is a critical information gap for managing cuckoo populations.
- **Adult sex ratio:** Unknown. It is not currently possible to distinguish cuckoo sexes, either in the field or in the hand.

II. Habitat Requirements

- **Vegetation structure:** Riparian Woodland vegetation, which typically contains some native vegetation, such as willow, cottonwood and/or mesquite, and may contain tamarisk. They have not been found successfully nesting in monotypic stands of tamarisk. The exact habitat requirements are unknown; this is a critical information gap for managing cuckoo populations.
- **Vegetation composition and age/size vegetation requirements:** Typically found in a mix of older vegetation with younger trees. They nest in trees with fairly dense foliage ranging in age from 1 year to 50+ years, often in subcanopy trees.
- **Home range size:** Varies greatly, and is possibly related to food abundance. On the Kern and Sacramento Rivers in CA, home ranges varied from 10 to 18 ha of riparian. At Warm Springs Ranch in 2001 home ranges appeared to be about 5 ha.
- **Food Resources:** They are usually seen foraging in larger trees, but occasionally will go into tall grass and lower shrubs for large insects. They have been known to eat cicadas, caterpillars, grasshoppers, tree frogs, mantids, and moths. No differences have been observed in adult vs. nestling diet.

III. Landscape context and Configuration

- The closest known, other breeding cuckoos (1-3 pairs observed in 2001) are approx. 15-20 miles from Warm Springs Ranch, along the Virgin River. The nearest source population is approx. 110 miles south on the Bill Williams River NWR, in Arizona.
- Nothing is known of cuckoo movement between subpopulations. It seems probable based on the fluctuation in numbers seen at several sites that there is movement between sites from year to year. This is a critical information gap for the purposes of managing cuckoo populations.
- There has been little modeling of cuckoo habitat. Limited work from California suggests that cuckoos require large tracts riparian with sufficient habitat for multiple pairs, in close proximity to other large clumps.
- Based on long-term survey results of the Kern River in CA and the Bill Williams River NWR in AZ, it appears that greater than 25 pairs is required for a stable population.

Challenges to reaching and maintaining DFC

I. Threats

- The main threat is loss of riparian habitat through active removal or loss of water and woodlands. All sites where cuckoos are successfully breeding are either humid or have nearby surface water.
- Long-term grazing may to lead to degradation of the habitat. This may be due to lack of regeneration of trees resulting in a limitation of potential nest sites. Grazing may also result in decreased food resources.

II. Management Constraints:

- Extensive conversion of monotypic tamarisk to mixed riparian will be expensive, and difficult to maintain without hydrologic control. Once established, however, the riparian should be able to maintain itself with only intermittent management.
- Fee title will probably be required for successful management for cuckoos. There may be negative social and political sentiment to the purchase of land and alteration of use.

Potential management options to reach sustainable population

- Management Method 1: Remove tamarisk along the river.
  - \+ May result in colonization by native vegetation
  - \+ Relatively inexpensive
  - \+ May work well to remove competition where some native habitat exists.
  - – Tamarisk is currently providing habitat, albeit of low quality, to a number of bird species. Removal will result in decreased habitat until native vegetation has returned.
  - – This method typically works very poorly in dry areas, but can be fairly successful if sufficient water is available.
  - – Recovery of native vegetation will likely require native species plantings.

- Management Method 2: Purchase land along the river and begin habitat restoration including tamarisk removal and planting of native trees.
  - \+ Will eventually result in high quality riparian habitat along the river.
  - – Tamarisk is currently providing habitat, albeit of low quality, to a number of bird species. Removal will result in decreased habitat until the plantings reach sufficient size to provide suitable nesting and foraging habitat.
  - – Expensive
- Management Method 3: Same as #2 but *gradual* replacement of tamarisk with planting of native trees.
  - \+ Will allow use of tamarisk as the native habitat grows
  - \+ Will eventually replace tamarisk with native habitat
  - – Very high-intensity, and therefore expensive

Ecological and Management Uncertainties

- Habitat use is variable from site to site, and little is known about what attracts them to a particular site. They use riparian, but it is not known if preferences for different plant community types or hydrologic factors exist.
- Minimum size of sustainable subpopulations is unknown, but is probably greater than 25 pairs
- Minimum home range is variable, and may be a factor of food

resources. What these factors may be is unknown.

- Site fidelity, and colonization of new sites, is unknown, and of great importance to effective management.
- Population growth rate unknown.
- Movement between distant sites and its effect on large yearly population fluctuations is not known.
- Is it known whether different grazing practices cause less or acceptable levels of degradation of cuckoo habitat (e.g., at Warm Springs Ranch)?

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Appendix IV–L. Phainopepla:
Desired Future Condition Summary

Minimum DFC	Alternative 1	Alternative 2
Abundance Density: <1 *breeding pair*/ha of infected mesquite Population size unknown (~ couple hundred pairs?) Spatial Need many tracts (minimum10 ha) of host trees *infected with vigorous, healthy, berry-producing mistletoe.* Habitat tracts should be in more mesic areas. Management Actions Encourage recruitment and persistence of honey mesquite and catclaw acacia and their infection by mistletoe in more mesic areas (by restricting grazing and removing salt cedar)	Abundance Density: 1 *breeding pair*/ha of heavily infected mesquite Population size unknown (~ several hundred pairs?) Spatial Need several large tracts (minimum100 ha) of host trees continuously *infected with vigorous, healthy, berry-producing mistletoe.* One tract could be situated in upland xeric acacia, but most tracts should be in mesic areas. Management Actions Encourage recruitment and persistence of honey mesquite and catclaw acacia and their infection by mistletoe in more mesic areas (by restricting grazing, removing salt cedar, replanting host trees, ensuring proximity of restoration plots to currently infected trees)	Abundance Density: 1-2 *pairs (at least 1 breeding)*/ha of heavily infected mesquite Population size unknown (~ several hundred pairs?) Spatial Need many tracts (minimum10 ha) of host trees *infected with vigorous, healthy, berry-producing mistletoe,* connected by tracts of less infected host trees. Multiple habitat tracts should be in more mesic areas. Management Actions Encourage recruitment and persistence of honey mesquite and catclaw acacia and their infection by mistletoe in more mesic areas (by restricting grazing, removing salt cedar, replanting host trees, maintaining water tables, ensuring proximity of restoration plots to currently infected trees and if necessary, manually infecting host plants)
Total Acreage: Unknown, but at least 242 acres (98 ha) of mesquite habitat available	**Total Acreage:** Unknown, but likely more than 500 ha of habitat	**Total Acreage:** Unknown, but likely more than 500 ha of habitat (historic habitat of mesquite may be 2603 acres [1054 ha])
Other Focal Conservation Targets Captured: Vermillion Flycatcher, Arizona Bell's Vireo, Blue Grosbeak	**Other Focal Conservation Targets Captured:** Vermillion Flycatcher, Arizona Bell's Vireo, Blue Grosbeak	**Other Focal Conservation Targets Captured:** Vermillion Flycatcher, Arizona Bell's Vireo, Blue Grosbeak

Preferred DFC: Alternative 2

Phainopepla

General Natural History: The phainopepla, (*Phainopepla nitens),* a small-mid-sized passerine, is the only representative of the silky flycatcher family (Ptilogonatidae) in the United States. Males are a shiny black with white wing patches and females are a dark grey with buffy wing patches. Both sexes sport a crest and red eyes. From October-June, phainopeplas occupy portions of the Mojave and Sonoran deserts, breeding in these areas from February-May. The rest of the year, they are uncommon in these areas. In the desert, phainopeplas are limited to stands of arborescent legumes such as mesquite, acacia, palo verde, ironwood and smoke tree, which are the host trees of the desert mistletoe (*Phoradendron californicum*). This mistletoe produces berries from October to May. Phainopeplas are highly specialized frugivores, and as nothing else is fruiting at this time, they subsist almost entirely on mistletoe berries. They also often build nests in mistletoe clumps. Mistletoe is considered a limiting resource for phainopeplas. The quantity of food resources (mistletoe berries and insects) available during the breeding season and the weather all have been reported to influence breeding behavior and success. In southern Nevada, phainopeplas and desert mistletoe are both at the edge of their range, where cold and drought may produce dramatic fluctuations in bird and mistletoe berry abundance and productivity not observed at the range core. The Upper Muddy River may be one of the most important breeding areas in the northern part of the species' distribution.

Key ecological processes: Phainopeplas track resource availability – their density and productivity are variable in time and space.

Status: not well known. Apparently declining in NV but NDOW surveys on wintering grounds in southern NV reveal increasing trends since 1992. Species of concern in CC MSHCP. Priority Bird Species in the Nevada Bird Conservation Plan.

Desired abundance, population structure, habitat requirements, and landscape context and configuration

I. Abundance and population structure

I. Total abundance of whole area is not known and needs to be assessed. NDOW has abundance numbers (not density) for wintering grounds in southern NV based on once/year surveys.

II. Population structure is not known and needs to be assessed. Dispersal and gene flow among habitat patches needs to be studied.

III. Breeding density in moderate-good quality habitat (lots of mistletoe) at Warm Springs Ranch and Meadow Valley Wash appears to be about 1 pr/ha

IV. Productivity: varies from year to year

V. 2-3 egg clutches in a year of good rainfall

VI. only 2 egg clutches in a drought year

VII. breeding success (%nests that fledged $\geq$ 1 young) in a drought year poor in xeric areas

VIII. breeding success at WS Ranch: ~50% of nests

IX. probably limited by berry and insect availability and by drought-related increases in predation

- Population growth rate: not known and needs to be determined

- Abundance: probably limited by density and extent of mistletoe berries and in the breeding season by insect abundance

II. Habitat requirements

- Honey mesquite and catclaw acacia of sufficient size/age/health to support mistletoe with berries
- These resources are available in patches and their spatial distribution will vary over decades depending on mesquite regeneration
- Prefer areas of higher tree density, especially infected trees, especially when breeding
- Respond at small scales to differences in mistletoe abundance
- Utilize mistletoe on pinyon and juniper in Spring Range and Sheep Range
- Also associated with cottonwoods and willows
- Prefer to nest high (mean 2.6 m up) in large (mean 4.8 m tall), infected, shaded trees near berry sources
- Territory size: mean 0.4 ha
- Flycatch from taller trees for a variety of insects. Eat mistletoe, Lycium, Rhamnus and other berries

III. Landscape context and configuration

- Area requirements in terms of both host tree patch size and mistletoe patch size are not known
- However, large (>200 ha) continuous tracts of heavily infected host trees appear to support higher densities than smaller or less infected tracts.
- However, breeding success does not appear to depend on fragment size
- Distance and causes of daily and seasonal movements within and among habitat patches are not known. It is not known if, or on what time scale, phainopeplas travel between the upper Muddy River and the lower Muddy, Virgin, or Colorado Rivers.
- The mesquite habitat along the upper Muddy River is the most continuous and largest extent of mistletoe-supporting mesquite in the area. Pahrump Valley has large extent of mesquite, but mistletoes are not very common outside of town.
- Mesquite habitat along the Virgin and Colorado Rivers generally consists of a few very small, isolated patches. On the lower Muddy River, a few patches of ~20 ha exist, but these are separated by several km from the upper Muddy River habitat.
- Much of the mesquite in the Warm Springs area appears quite healthy and is not being degraded. In some areas, mesquite is regenerating and becoming infected by mistletoe.
- Warm Springs Ranch is used mostly for breeding but not for wintering.
- However, closer to I-15, mesquite patches are small and interspersed with salt cedar and little regeneration is occurring.
- The mesquite in lower Meadow Valley Wash, where it meets the Muddy River, has been severely impacted by anthropogenic disturbances such as fire, dumping and wood cutting, and perhaps lowering of the water table. In the mid-1990s, this area supported a breeding population (12-16 pairs); however, no phainopeplas bred there the last two years.
- Landscape configuration should be of a size and shape that allows for colonization and extinction dynamics of mistletoe patches within and among host tree tracts so that some areas of host trees (> 10 ha) always support berry-producing mistletoe.

Challenges to reaching and maintaining DFC

- lack of habitat
- grazing restricting recruitment of young mesquite and mistletoe and fostering unsuitable growth forms of mesquite
- fire wiping out mesquite stands and allowing salt cedar encroachment
- salt cedar crowding out mesquite and affecting soil conditions
- lowering of water table and downcutting of river
- excessive water in flooded areas promoting screwbean mesquite growth over honey mesquite
- having large enough and numerous enough patches to allow for turnover of mistletoe
- opposition from ranchers to restrictions on grazing
- salt cedar removal is labor-intensive and expensive
- without (trans)planting, amendments to soil and watering, mesquite may be slow to regenerate (especially in former salt cedar areas)
- perception that mistletoe harms trees and is a parasite to be eradicated
- woodcutting mesquite

Potential management options to reach DFC (with Pros + and Cons -)

- Promotion of honey mesquite growth (density, area, and size of trees)
  - Restricting grazing

  + much mesquite will quickly regenerate without further input
  + inexpensive and not time consuming
  + benefits other grazing-limited species
  - socio-politically unpopular

  - Removing salt cedar

  + will allow mesquite growth in most mesic areas
  + will allow other plant and animal species to repopulate former areas
  - inexpensive
  - time consuming
  - loss of tree structure
  - loss of erosion control
  - incomplete action without mesquite regeneration

  - Maintaining/raising water table or other water sources

  + help maintain other water dependent species, increase biodiversity
  - expensive
  - labor intensive

- Promotion of mistletoe growth
  - Promote healthy mesquite (see above)
  - Maintain area and proximity of habitat patches that allow for mistletoe to self-propagate

  + does not require human intervention (lower cost and time investment)
  - a larger area of habitat must be set aside to allow for time and spatial scale of natural processes

  - Infect host trees

  + may be able to reduce area required and speed up growth of mistletoe
  - very labor intensive
  - may be socially/culturally undesirable

- Promotion of phainopepla productivity
  - Situate habitat tracts near the river

  + will provide suitable habitat for other species
  - costs of salt cedar removal
  - will take several years

  - Irrigate more upland sites (in drought years)

  + expands potential habitat
  + more immediate result
  - expensive and time consuming

Ecological and Management Uncertainties

- The natural variability of population size and density of phainopeplas is not characterized
- The density and area of resources (mistletoe) and habitat (host trees) required are not well quantified
- At the landscape scale, the metapopulation dynamics (extinction and colonization rates) and host patch requirements of mistletoe are not known
- The scale and timing of the movements of phainopeplas are not known
- How do we incorporate the potentially large scale effects of drought and freezing into our plans?
- Population growth rate is not known
- Population structure is not known

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Appendix IV–M. Vermilion Flycatcher: Desired Future Condition Summary

Minimum DFC	Alternative 1	Alternative 2
Abundance 18-35 breeding pairs (current) **Spatial** Single habitat patch on Warm springs Ranch. Must be in proximity of running water (stream, river, ditch). Breeding pairs appear to require proximity of other breeding pairs, thus suggesting minimum habitat size. **Management Actions** 1. Maintain running water (ditches) in occupied areas (Warm Springs Ranch). 2. Partial tamarisk removal and replanting of mesquite and riparian tree species (velvet ash and cottonwoods) 3. Protect large riparian trees (ash and cottonwood).	**Abundance** 18 –180 breeding pairs **Spatial** See Minimum DFC. Two to three large habitat patches, including downstream of Hidden Valley dairy. **Management Actions** 1. See Minimum DFC. 2. Partial hydro-geomorphic restoration of WSR, adjacent properties, and marsh habitat downstream of Hidden Valley dairy.	**Abundance** 180-350 breeding pairs (uncertain) **Spatial** Continuous habitat of riparian trees and mesquite along Muddy River to allow for contact among breeding pairs. **Management Actions** 1. See Minimum DFC. 2. Full hydro-geomorphic restoration of Upper Muddy River
Total Acreage: ~300 acres (121 ha) of mesquite, wetlands, and riparian forests	**Total Acreage:** 600 – 800 acres (242 – 324 ha; uncertain)	**Total Acreage:** 3509 acres, max historical riparian habitat available (1420 ha; uncertain)
Other Focal Conservation Targets Captured: Phainopepla	**Other Focal Conservation Targets Captured:** Phainopepla, Yellow-billed Cuckoo, Southwestern Willow Flycatcher	**Other Focal Conservation Targets Captured:** Phainopepla, Yellow-billed Cuckoo, Southwestern Willow Flycatcher

Preferred DFC: Alternative 1

Vermilion Flycatcher

General Natural history: The Vermilion Flycatcher (*Pyrocephalus rubinus*) a small Neotropical migrant, has a vast breeding range that extends southward to central Argentina, and northward as far as southern California, southern Nevada and Texas. The extreme northern and southern populations migrate while the more centrally located populations within the breeding range do not. In North America the California and Texas breeding populations are in decline due to unknown reasons. Breeding habitat consists of arid scrub, farmland and riparian woodland located near water. The male plumage is a showy red and blackish-brown while the female coloration is a nondescript brown and cream with a slight blush of pink or yellow on the lower abdominal area. Diet includes flying and terrestrial insects. Southern Nevada breeding populations have been documented in Bunkerville, Logandale and Warm Springs in habitat consisting of large deciduous trees and mesquite that is flanked by open fields and is near a source of permanent or ephemeral running water. The Warm Springs population was studied for population density, nesting success and Brown-headed Cowbird (*Molothrus ater*) parasitism during the 2000 and 2001 breeding seasons. Research was supported by the U.S. Geologic Survey, Nevada Division of Wildlife and Southern Nevada Water Authority.
Key Ecological Processes: Flooding, natural hydrological regime
Federal and State Listing status: Declining is southwestern USA, Rank: G5; in NV S3?B.

Desired abundance, population structure, habitat requirements, and landscape context and configuration

I. Abundance and population structure

- Population size over time: 18-35 breeding pairs observed at Warm Springs Ranch during two years
- Minimum acceptable population size: not known
- Productivity:
  9-12 eggs per year
  2-4 eggs per brood
  2-3 broods/year
  1-3 nests per year same pair
  1.8-2.3 fledglings/brood
  fledglings/brood/year
  Population growth rate: not declining but highly variable
- Limiting factors: running water, large riparian trees, mesquite for nesting
- Adult sex ratio: >50% for males in spring, but decreases to less than 50% during migration
- 15% polygamy
- Potentially communal

II. Habitat requirements

- running water
- home range must incorporate a mixture of riparian habitat and mesquite bosque
- large riparian trees: velvet ash and cottonwood
- Nests found in mesquite, typically 4-6 m high in branch fork, and in cottonwood and ash at heights >10 m
- Home range size for successful reproduction: varies with habitat quality, maybe several 200-300 meters radius
- Food resources: flying insects such as moths, grasshoppers, etc

III. Landscape context and configuration

- Species in northern edge of its distribution
- Closest breeding populations known: Bunkerville, Logandale. Unknown if in Meadow Valley Wash. Large population in Arizona.
- Threat of tamarisk invasion from surrounding landscape

Challenges to reaching and maintaining sustainable population

Threats
- lack of habitat
- ground water pumping
- woodcutting of large riparian trees and mesquite
- surface water withdrawal
- cowbird parasitism

List all management constraints
- restoration socially unacceptable
- land ownership prevents restoration and tamarisk control
- presence of large dairy may be a source of cowbird parasitism

Potential management options to reach sustainable population (with Pros + and Cons -)

- Protect large riparian trees and mesquite from woodcutting
  - \+ large riparian trees are a required habitat feature
  - \+ preserves nesting habitat (mesquite)
  - – stopping woodcutting, especially of mesquite, will meet social resistance
- Tamarisk removal and native tree plantings
  - \+ Tamarisk does not appear to be used, thus its removal and tree native planting is creating future flycatcher habitat
  - – Very high-intensity, and therefore expensive
- Restoration of fluvial geomorphologic processes
  - \+ creates breeding habitat and processes that maintain it
  - – expensive
  - – social resistance
  - – conflicts with land ownership

Ecological and Management Uncertainties

List all research uncertainties
- Effect of tamarisk on abundance and habitat quality not known
- Not known if cowbird parasitism affects flycatcher during second brood (first brood before cowbird breeding)
- Communal behavior and effect on minimum habitat size needs to be documented
- Simple demographics not well known
- Role of cowbird parasitism needs to be determined on UMR.

List all management uncertainties
- Unknown if tamarisk removal will make a difference to population size
- Confounded effects of cowbirds and tamarisk where all other habitat features are present at dairy wetland

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- Author: Polly Sullivan (tzp@lvcm.com)
- Reviewers

Appendix IV-N. Southwestern Willow Flycatcher: Desired Future Condition Summary

Minimum DFC	Alternative 1	Alternative 2
Abundance 1 breeding pair (species does not currently breed in UMR) **Spatial** Thick coyote willow/tamarisk either in proximate patches or large tracts **Management Actions** ▪ Progressive tamarisk removal followed by coyote willow planting	**Abundance** 3 breeding pairs **Spatial** Thick coyote willow either in (small) patches or large tracts **Management Actions** ▪ Partial fluvial geomorphic restoration: reconnect floodplain to river. ▪ Progressive tamarisk removal followed by coyote willow plantings.	**Abundance** 5 breeding pairs (uncertain if possible) **Spatial** Thick coyote willow either in close patches or large tracts **Management Actions** ▪ Full fluvial geomorphic restoration. ▪ Tamarisk removal. ▪ Willow and cottonwood plantings.
Total Acreage: max 5 acres (2.02 ha; uncertain)	**Total Acreage:** 5 -10 acres (2.02-4.05 ha)	**Total Acreage:** max 15 acres (6.07 ha; uncertain)
Other Focal Conservation Targets Captured: desert riparian vegetation, Yellow-billed Cuckoo, butterflies	**Other Focal Conservation Targets Captured:** desert riparian vegetation**,** Yellow-billed Cuckoo, butterflies	**Other Focal Conservation Targets Captured:** desert riparian vegetation, desert fishes, aquatic invertebrates, Yellow-billed Cuckoo, Yellow Warbler, Yellow-breasted Chat, other riparian birds, butterflies

Preferred DFC: Alternative 1

Southwestern Willow Flycatcher

General Natural history: The southwestern willow flycatcher (*Empidonax traillii extimus*) is a neotropical migratory land bird that breeds in riparian habitat of seven southwestern states including New Mexico, Arizona, California, Utah, Nevada, Colorado, and Texas (Sogge 1997). It is one of the four or possibly 5 subspecies of willow flycatchers currently recognized. *E. t. extimus* is known to winter in Mexico, Central and South America. Dense vegetation near watercourses or inundated wetlands is required for flycatcher nesting. In southern Nevada there have been recent advancements in the overall knowledge of breeding distribution and abundance of *E. t. extimus*. For the 1997 through 2001 seasons, standardized surveys were conducted at sites on the Virgin and Muddy Rivers, and their confluence with Lake Mead, as well as Pahranagat National Wildlife Refuge (NWR), Ash Meadows NWR, Oasis Valley, and Meadow Valley Wash. The surveys were conducted by the: U.S. Geological Survey, Biological Resources Division, San Bernardino County Museum and the Nevada Division of Wildlife. Only one individual has been reported for the Upper Muddy River.

Key Ecological Processes: Flash flood, recruitment of desert riparian forests, especially willow. The loss of riparian habitats (altered hydrology, livestock grazing, wood cutting), invasion of exotic plant species, brown-headed cowbird (*Molothrus ater*) brood parasitism, and loss of wintering habitats have contributed to the decline of this subspecies.

Federal and State Listing status: The United States Fish and Wildlife Service (USFWS), listed the southwestern willow flycatcher as an Endangered Species in March 1995 and designated critical habitat in July of 1997 (Federal Register 60 (38): 10694). A Recovery Plan for *E. t. extimus* is now written with a final product expected by 2002. Consequently, information on the status and distribution of *E. t. extimus* in Nevada is needed to assist in this effort.
U. S. ESA status; LE. Rank G5T1T2/, N1B, S1B.

Desired abundance, population structure, habitat requirements, and landscape context and configuration

II. Abundance and population structure

- Population size over time: Only one (1) individual observed on UMR, but elsewhere densities can be 9-14 pairs/100 acres.
- Minimum acceptable population size on UMR: not attainable.
- Productivity:
  - generally one clutch per season
  - nest success: highly variable – 20-100% observed
  - population growth rate: >1 for upper Colorado river area
- Breeding Chronology: SW willow flycatcher typically arrive on breeding ground between early May and early June. Nest building begins within a week of pair formation. Egg laying begins as early as late May, but more often starts in early to mid June. Young typically fledge from nests from late June through mid-August.
- Nests and eggs: SW willow flycatchers build open cup nests constructed of leaves, grass, fibers, feathers and animal hair. Females build the nest with little assistance from the male.
- Predation and predators: snakes, corvids, hawks, and owls

III. Habitat requirements

- Vegetation composition and age/size vegetation requirements: cottonwood-willow forests; thickets and scrubby areas, open second growth, swamps, and open woodlands.
- Nests primarily in swampy thickets, especially willow, alder, boxalder, tamarisk, vines, or other plants, where vegetation is 4-7 m or more in height. Tamarisk is commonly used in the eastern part of the range. Habitat patches as small as 0.1 ha (0.25 acre, southwest NV) can support one or two nesting pairs. Nests in fork or on horizontal limb of small tree, shrub, or vine, at height of 0.6-6.4 m (mean usually about 2-3 m), with dense vegetation above and around the nest.
- Home range size for successful reproduction: 1.5 acres breeding territories
- Food resources: Overall wasp and bees are the most common food items, with beetles, flies and butterflies/moths and caterpillars being other components. Nestlings are fed similar (albeit smaller) food items.

IV. Landscape context and configuration

- Proximity to other individuals or groups: Virgin River population is closest to UMR.
- Dispersal among Virgin River, Pahranagat Valley and lower Muddy River populations was observed

Challenges to reaching and maintaining sustainable population

List all threats:

- Decline is due mainly to destruction and degradation of cottonwood-willow and structurally similar riparian habitats via livestock grazing, urban and agricultural development, water diversion and impoundment, off-road vehicle and other recreational uses, and hydrological changes resulting from these and other land uses.
- Tamarisk has replaced native riparian vegetation in many areas. Value of tamarisk-dominated habitat to SWWF is unknown and controversial.
- In some areas, heavy brood parasitism by cowbirds has contributed to the decline. Cowbirds have increased range and abundance with irrigated agriculture and livestock grazing. UMR dairies support high densities of cowbirds.
- Proposed reservoirs threaten the habitat of some populations.

List all management constraints:

- Resistance to restoration of hydrology and fluvial geomorphic processes
- Expense of restoration
- Expense of tamarisk removal vs. research uncertainty associated with value of tamarisk-dominated habitat
- Perceived negative impact of tamarisk removal on habitat removal, but may not apply to UMR, which is marginal habitat.

Potential management options to increase population (with Pros + and Cons -)

- Restoration of fluvial geomorphologic processes
  - \+ creates breeding habitat and processes that maintain it
  - – expensive
  - – social resistance
  - – conflicts with land ownership
- Habitat restoration (willow restoration and tamarisk removal)
  - \+ creates breeding habitat
  - – depends on fluvial geomorphic restoration
  - – expensive

  - – need to consider effects of tamarisk removal on bird habitat, but not currently an issue in UMR for SWWF
- Reduction in grazing
  - + allows willow/cottonwood recruitment
  - – local resistance
- Manage cowbirds if determined to be a barrier to establishment
  - + remove major sources of attractions for cowbirds (i.e. cattle or horses)
  - – trapping cowbirds is expensive and anon-going effort (not recommended, except where par. reaches greater than 50%)

Ecological and Management Uncertainties

List all research uncertainties

- Will birds from adjacent populations colonize or use the UMR following restorations efforts such as tamarisk removal and tree plantings, and geomorphic restoration?

List all management uncertainties

- Is tamarisk removal an issue in this marginal population?

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NDOW annual Section 6, ESA reports (the introduction):

Data presented in NatureServe Explorer at http://www.natureserve.org/explorer were updated to be current with NatureServe's central databases as of **November 1, 2001**.

- Author: L. Provencher compiled information supplied by Cris Tomlinson and NatureServe ©

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Appendix IV-O. Bat Species Assemblage: Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Mature stands of riparian woodland habitats, primarily cottonwood galleries, but also including mixed ash and willow stands. Restoration acreage estimate currently unavailable but needs to be determined. Current condition and acreage of riparian marsh, riparian shrubland, and mesquite bosque habitats as of Spring 2002. **Spatial** Current conditions as of Spring 2002.	**Condition** Mature stands of riparian woodland habitats, primarily cottonwood galleries, but also including mixed ash and willow stands. Restoration acreage estimate currently unavailable but needs to be determined. **Spatial** Cottonwood trees should be formed into multiple galleries, containing a minimum of ten mature trees each. Spatial distribution of riparian habitats within the drainage is not critically important, as long as acreage estimates for each habitat type are met.	**Condition** Mature stands of riparian woodland habitats, primarily cottonwood galleries, but also including mixed ash and willow stands. Restoration acreage estimate currently unavailable but needs to be determined. Increased acreage of mesquite woodland habitat. Ideal acreage currently unavailable but needs to be determined. **Spatial** Cottonwood trees should be formed into multiple galleries, containing a minimum of ten mature trees each. Spatial distribution of riparian habitats within the drainage is not critically important, as long as acreage estimates for each habitat type are met.
Total Acreage: at least 200 acres (81 ha)	**Total Acreage:** Unknown	**Total Acreage:** max 3509 acres (1420 ha; 100-yr floodplain)
Other Focal Targets Captured: Desert riparian vegetation and associated species	**Other Focal Targets Captured:** Desert riparian vegetation and associated species	**Other Focal Targets Captured:** Desert riparian vegetation and associated species

Preferred DFC: Alternative 2

Bat Species Assemblage

Natural history description of community: Twenty-three species of bats have been documented in Nevada, 15 of which have been documented in the Muddy River drainage (*Antrozous pallidus*, *Corynorhinus townsendii*, *Eptesicus fuscus*, *Euderma maculatum*, *Lasiurus blossevillii*, *Lasiurus cinereus*, *Lasiurus xanthinus*, *Lasionycteris noctivagans*, *Macrotus californicus*, *Myotis californicus*, *Myotis thysanodes*, *Myotis yumanensis*, *Nyctinomops macrotis*, *Pipistrellus hesperus*, and *Tadarida brasiliensis*).

Riparian communities in desert ecosystems are crucially important for resident and migrating bats in providing foraging and roosting habitats. Bats use all four of the habitats categorized by The Nature Conservancy in the Muddy River drainage (riparian woodland, riparian shrubland, mesquite bosque, and riparian marsh) for foraging.

Bats roost in four general habitat categories: trees, caves and mines, cliffs and crevices, and urban environments. Bats found in the Muddy River drainage use all four of these roosting habitats, including urban habitats.

While some bat species found in the Muddy River drainage occupy the area year-round, species richness and abundance fluctuate substantially on a seasonal basis. Other species primarily use the drainage during the Spring and/or Fall months for annual migration.

Federal and State Listing Status: *Euderma maculatum* (Spotted Bat) is the only species in Nevada presently afforded state protection as a threatened species. All other bats in Nevada are unprotected. No bat species in Nevada are federally listed as endangered or threatened.

The Nevada Bat Working Group is currently developing the Nevada Bat Conservation Plan, which proposes to afford all bat species in Nevada at least state protected status.

Embedded communities: Developing conservation management strategies for bats in the Muddy River drainage is best done by segregating bat species into guilds based upon habitat use. The riparian habitats currently recognized by The Nature Conservancy serve as a good tool for this purpose. Williams (2001) used a combination of capture and acoustic monitoring equipment to describe community structure and examine riparian habitat use by bats in the upper Moapa Valley. Based upon a yearlong quantitative assessment of acoustic activity in each habitat type, the following was determined:

> **Riparian marsh:** All species except one (*E. maculatum*) spent less than 20% of their time in riparian marsh habitat. *E. maculatum* spent 28% of its time in this habitat type.
>
> **Mesquite bosque:** *E. maculatum* and *Myotis californicus* spent more time in mesquite bosque habitat than the other three habitats combined. Mesquite bosque were not used by *A. pallidus*, *E. fuscus*, and *L. xanthinus*.
>
> **Riparian woodland:** This habitat accounts for more than half of all bat activity. *A. pallidus*, *E. fuscus*, *L. xanthinus*, and *M. yumanensis* spent more time in riparian woodland habitat than in all three other habitats combined. All species, except *E. maculatum* (< 1%) spent at least 26% of their time in riparian woodlands.

Riparian shrubland: L*asiurus blossevillii*, *Macrotus californicus*, and *T. brasiliensis* spent at least 27% of their time in riparian shrubland habitat. *A. pallidus*, *E. maculatum*, *L. xanthinus*, and *Myotis californicus* appeared to not use riparian shrubland habitat.

Desired structure, composition, and landscape context and configuration

I. Habitat requirements

- Foraging requirements –
    - **Riparian marsh** – While an important foraging habitat for at least one species, most bats do not heavily rely upon this habitat for foraging.
        - ► Goal: Maintain current acreage and condition of this habitat.
    - **Mesquite bosque** – This habitat proved to be used much more heavily than other habitat types by at least two species of bats. Other species relied upon this habitat regularly for at least foraging.
        - ► Goal: Maintain current condition of existing habitat.
        - ► Goal: Increase mesquite bosque acreage.
    - **Riparian woodland** – While this is the most scarce habitat type in the drainage, acoustically it accounts for more than half of all bat activity. The bat community in the area would greatly benefit from more woodland areas, including mature cottonwood galleries. Cottonwood, ash, and willow trees should be much more beneficial to most bats than exotic California palm trees. Some dense California palm groves must be maintained for *L. xanthinus*, while increasing other types of riparian woodland.
        - ► Goal: Restore cottonwood tree habitat into multiple dense congregations of trees, not single trees distributed across the landscape.
        - ► Goal: Increase abundance of ash and willow trees along stream banks.
        - ► Goal: Manage cottonwood, willow, and ash habitat to obtain mature stands.
        - ► Goal: Incrementally replace some exotic California palm tree habitat with different age classes of cottonwood, willow, and ash habitat.
        - ► Goal: Maintain a few dense stands of California palm groves for yellow bats (*L. xanthinus*) to roost in. An example of suitable sites are the Apcar property, the palm grove adjacent to Cardy Lamb pool, and the Plummer property on the Moapa Valley NWR.
        - ► Goal: Manage current stands of California palm groves to prevent against widespread fire, while at the same time leaving at least one-half of the trees with skirting of dead palm fronds for roosting *L. xanthinus*.
    - **Riparian shrubland** – This habitat is important for at least three species of bats.
        - ► Goal: Maintain current condition of this habitat.
        - ► Goal: If loss of this habitat is necessary to meet restoration goals of other habitat types, then maintain and manage at least 80% of the current acreage of this habitat type.

- **Water sources** – Water sources are arguably the single most important resource determining bat distribution in the desert southwest. Water sources are crucial resources for bats to drink from and forage over.
  - Goal: Maintain open bodies of water, such as Cardy Lamb pool, the lilypond, Perkin's reservoir, and the dairy pond as open water sources for bats. Vegetation must be kept clear of the surface water, as bats drink on the wing.

II. Roosting requirements

- **Trees** – This is the most limited roosting resource in the drainage. At least two of the primary tree roosters require cottonwood trees for roosting.
  - Goal: Restoration of riparian woodlands, including ash and willow trees, but primarily cottonwood trees will offer valuable opportunities for tree roosting bats.
  - Goal: Although not verified, it is possible that some species may temporarily roost in screwbean mesquite trees. Determine if mesquite bosque habitat is used by roosting bats.
- **Caves and Mines** – No mines or caves are known from within the project area in upper Moapa Valley. It is unknown if mines and/or caves are within the project area in the lower reaches of the Muddy River drainage.
  - Goal: Any caves or mines located in the project area should be properly inventoried for bat use to determine if conservation measures are necessary.
- **Cliffs and Crevices** – Numerous rock shelters and cliff faces are found in the project area. Several of the species use crevices in rock, rock shelters, and cliffs for critical day roosts. Night roosting occurs in small rock shelters.
  - Goal: Protection should be afforded to cliffs and rock shelters.
- **Urban areas** – Identification of active urban roost sites should be made and afforded protection if possible.

III. Landscape context and configuration

- As long as the unique roosting and foraging habitats for each species of bats are available in the project area, the drainage should continue to be a viable bat resource, regardless of the exact configuration of the individual habitat types. This applies to both resident and migratory species.
- The sheer size and diversity of suitable roosting and foraging habitat in the Moapa Valley likely facilitate the migration of bats into and through Nevada.

Challenges to reaching and/or maintaining sustainable population

- Threats: loss of foraging or roosting habitat

- Management constraints: financial cost of habitat restoration and maintenance (man power, oversight, long-term management); cooperation with land owners required

Potential management options to reach DFC (with Pros + and Cons -)

- Management method #1 – Restoration of landscape in 1-3 years

+ Determine the response of bat matrix to restoration efforts more quickly
+ Obtain desired future condition more quickly
+ Removal of tamarisk and re-vegetation of native plants in tamarisk disturbed areas should benefit the bat community. Preliminary investigations suggest that bats do not heavily forage over tamarisk.
+ Lower restoration cost overall
– Short time frame for payment of restoration cost

- Management method #2 – Restoration of landscape over 4+ years
  + Restoration cost distributed over longer time period
  – Some riparian woodland tree species require decades to reach maturity

Ecological and Management Uncertainties

- Emphasis should be placed on quantifying the types of roosting habitats that tree roosting bats use in the project area (e.g., mesquite bosque).
- Bats were detected more often in palm groves that all three other habitat types combined. Of the three palm groves included in the study (Plummer palms, Pederson palms, and Cardy Lamb palms), the Plummer palms were by far used by bats the most often.
- Emphasis should focus on determining the size of palm groves that are most favorable by roosting yellow bats. Areas containing palm tree densities like the Plummer property and the Apcar property are the best roosting habitat for yellow bats. It is not necessary that the palm trees be directly over streams for the bats to roost in, but these locations are the only place that palm groves are in high enough densities to be favorable roosting sites for yellow bats.
- Trimming the dead leaf skirts of palm trees will remove the roosting habitat that yellow bats require. If palm trees must be trimmed for management reasons, they should only be trimmed during the winter season, after the majority of the yellow bat population migrates south for the winter. Effects of trimming needs to be assessed.
- The upper Moapa Valley is the only location in the state where yellow bats are known to occur. Yellow bats roost in the dead palm skirts. If a significant amount of the dense palm groves in the upper Moapa Valley are altered or removed, it is probable that Nevada will lose it's yellow bat population. Planned removal or modification of palm groves should be discussed on a case by case basis with someone sufficiently knowledgeable of yellow bats and very familiar with the palm groves in the project area.

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  - Personal communications: Michael J. O'Farrell, O'Farrell Biological Consulting, Las Vegas, Nevada

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TABLE. Focal conservation target with associated tracked communities/plant associations and species, including Federal and State listed species recorded on the upper Muddy River. The working assumption is that if the focal conservation target is protected that all associated communities and species are also conserved. Highlighted text indicates species listed in The Nature Conservancy's Mojave Desert Ecoregional Plan. **Bold** text indicates species which are most related to a specific focal conservation target. Underline text indicates species that are dependent on multiple targets.

TARGET	**LISTED, TRACKED AND RARE SPECIES**		**GLOBAL RANK**	**FEDERAL/ STATE STATUS**
	SCIENTIFIC NAME	COMMON NAME		
Bat Species Assemblage	BATS			
	Euderma maculatum	spotted bat	G4	S1S2
	Antrozous pallidus	pallid bat	G5	S3B
	Corynorhinus townsendii	Townsend's big-eared bat	G4	S3B
	Eptesicus fuscus	big brown bat	G5	S5
	Lasiurus blossevillii	western red bat	G5	S?
	Lasiurus cinereus	hoary bat	G5	S3?
	Lasiurus xanthinus	western yellow bat	G5	S1
	Lasionycteris noctivagans	silver-haired bat	G5	S3N
	Macrotus californicus	California leaf-nosed bat	G4	S2
	Myotis californicus	California myotis	G5	S3B
	Myotis thysanodes	fringed myotis	G4	S2B
	Myotis yumanensis	Yuma myotis	G5	S4B
	Nyctinomops macrotis	big free-tailed bat	G5	S1N
	Pipistrellus hesperus	western pipistrelle	G5	S4
	Tadarida brasiliensis	Brazilian free-tailed bat	G5	S4

Appendix IV–P. Desert Pocket Mouse: Desired Future Condition Summary

Minimum DFC	Alternative 1	Alternative 2
Abundance At one small site of UMR, 1-2 mice per 80 traps At Las Vegas Well Field Preserve: 5-20 mice/ha **Spatial** Occupies small area of stabilized fluvial sands at edge of riparian and desert vegetation. Limited habitat. **Management Actions** 1. Protect stability alluvial sand habitat from further soil compaction (OHV, cattle) 2. Prevent livestock grazing of desert shrubs.	**Abundance** Unknown **Spatial** Unknown **Management Actions**	**Abundance** Unknown **Spatial** Unknown. **Management Actions** 1. See Minimum DFC. 2. Planting of desert shrubs. 3. Limit encroachment of tamarisk
Total Acreage: small, unknown	**Total Acreage:**	**Total Acreage:** all stabilized alluvial sands patches between desert and riparian vegetation
Other Focal Conservation Targets Captured: desert riparian shrubland vegetation	**Other Focal Conservation Targets Captured:**	**Other Focal Conservation Targets Captured:** desert riparian shrubland vegetation

Preferred DFC: Minimum DFC in the absence of more data

Desert Pocket Mouse

General Natural history:

Distribution. Coarse-haired pocket mice in the genus *Chaetodipus* and family Heteromyidae include about 15 species distributed primarily in warm deserts in western North America (Hall 1981). One such species, the desert pocket mouse (*Chaetodipus penicillatus*), occurs throughout the Sonoran and Mojave deserts of the United States and Mexico and consists of six subspecies (Hall 1981; subsequently modified by Lee et al. [1996], who designated Desert pocket mice in the Chihuahuan Desert as the new species *Chaetodipus eremicus*) that vary primarily in size and pelage. *C. p. sobrinus* Goldman is a large-size subspecies that is associated with sandy soils and typically found in arid riparian washes that border the Colorado, Virgin, and Muddy rivers in southeastern Nevada and northwestern Arizona (Hall 1946; Hoffmeister 1986). A few adjacent populations also occur in the extreme southwestern corner of Utah near the Beaver Dam Wash (Hoffmeister 1986). Assessment of intraspecific phylogeography and population genetics, with particular reference to the evolutionary and biogeography history of populations classified as *C. p. sobrinus* is currently under investigation (Marshall, unpublished data).

Management Background. Prior to 1997, the subspecies of the desert pocket mouse originally native to the southern Nevada, *C. p. sobrinus*, had not been documented within the Las Vegas Valley subsequent to Vernon Bailey's documentation of their occurrence here in March of 1891 during the U.S. Biological Survey Death Valley Expedition. Currently, *C p. sobrinus* is included as an "Evaluation-High Priority" species under the Clark County Multiple Species Habitat Conservation Plan (MSHCP). Evaluation species are those that need more background information collected in order to provide informed management prescriptions. High priority species are those that are at higher risk of extinction and therefore could be listed under the Endangered Species Act (ESA) in the foreseeable future. Due to considerable modification of the native geographic distribution of this subspecies (generally, the Colorado River drainage system; Hall, 1981; Hoffmeister, 1986) the population structure currently is highly fragmented and extant populations are effectively isolated from one another. Small, isolated populations are vulnerable to human disturbances, stochastic events, and loss of genetic variation, all of which tend to increase their extinction probability. The recently documented occurrence of the desert pocket mouse, *C. p. sobrinus,* within the Las Vegas Valley (O'Farrell 1998) has initiated additional research into this subspecies' geographic distribution, genetic variability within and among extant populations, and basic population trends and potential threats.

Ecology of C. penicillatus. Desert pocket mice are nocturnal granivores and collect seeds by sifting through light organic litter. All have fur-lined cheek pouches that serve to transport seeds back to their burrows to be eaten in safety or stored for later use. Previous studies have found that C. penicillatus tend to prefer large seeds regardless of texture (Price 1983). Smigel and Rosenzweig (1974) found that C. penicillatus had a more specialized diet when seed densities were high and became adaptively flexible when seed densities were low. C. penicillatus is fully independent of exogenous water (Grubbs 1974). This ability to exist entirely on a metabolic water supply is due to enhanced behavioral and physiological abilities to reduce water lost to the environment. One individual C. penicillatus was documented as having urine concentration of 7,500 mOsm/kg (Altshuler et al.1979).

Seed caching in the family Heteromyidae has been well documented (Price & Heingz 1984, Jenkins & Breck 1998, and Price and Waser 1997. Price & Heinz (1984) found that the number of seeds harvested was positively correlated to seed and soil density in C. penicillatus. The number of seeds harvested was negatively correlated with soil particle size. Jenkins & Breck (1998) found that in laboratory arenas, larger kangaroo rat species larder hoarded (stored seeds inside the burrow system) more than smaller pocket mice species (C. formosus). C. formosus made larger scatter hoards (caches buried at shallow depths in soil) when compared to larger kangaroo rat species and deposited multiple seed loads within each scatterhoard. However in field studies C. formosus larder hoarded more than Dipodomys merriami (Jenkins and Breck 1998, Price and Waser 1997). C. penicillatus has also been observed climbing on forbs and grasses in order to obtain seeds (Daly pers.comm.to Reichman & Price).

Many studies have reported that C. penicillatus forages under shrubby canopy cover rather than out in open areas (Rosenzweig 1973, Price 1978,and Wondolleck 1978). C. penicillatus shifted microhabitat use in response to cleared and augmented areas. The augmented areas were made up of plant debris that had been cut. This study demonstrated that it was the physical structures of the vegetation not the food resource associated with the vegetation that C. penicillatus preferred (Rosenzweig 1973). However, when microhabitat was modified (cleared), C. penicillatus did forage up to 4 m into open areas. In field studies C. penicillatus occurred in sandier soils with higher heat buffering capacity when compared to C. intermedius. In laboratory settings C. penicillatus aggressively defended sandy soil habitat against C. intermedius (Hoover 1977). Rosenzweig and Winakur (1969) did not detect an increase in density related to soil depth or soil particle size for C. penicillatus.

Desert pocket mice typically reproduce during the growing season when seed abundance is high, usually during spring or late summer. Females have a gestation time averaging 26 days and will produce litters that range from 2-4 young and have a mean litter size of 1-2 (Price 1998). Female young that are born in spring may even have one litter by late summer when seed production is high (Brown and Harney 1993). Reproduction trends may vary due to extreme climate differences across the large geographic range of this species.

Torpor is used as an energy-conserving mechanism for short periods of time and as a form of hibernation during the cold season, during which individuals abandon surface activity for months at a time (MacMillen 1982). Brower (1970) found mean length of torpor in C. penicillatus increased as ambient temperature decreased. Seeds stored during the fall months are used as a reserve during the winter season (Price 1998).

The maximum lifespan of C. penicillatus varies per location. Porter (1994) reported high annual turnover rates in a previous study. Only 5% of C. p. woodhouse individuals captured during the peak season of activity survived one year. However, mortality may be overestimated if undetected dispersal occurs (Zeng & Brown 1987). Brown and Zeng (1989) found that the maximum longevity for C. penicillatus was twenty-six months.

Key Ecological Processes: climate variation, lack of flooding, predation
Federal and State Listing status: Found in very few locations in southern NV. Rank: G5; for NV: S2.

Desired abundance, population structure, habitat requirements, and landscape context and configuration

III. Abundance and population structure

- Population size over time: unknown and variable
- Minimum acceptable population size: unknown
- Productivity:
  breeds twice a year
  2-4 offspring/litter
- Population growth rate: unknown
- Limiting factors: presence of stabilized alluvial sands with particle size <2mm; temperature, requires temperatures in excess of 100oF?? to be active
- Adult sex ratio: varies through year; male bias during spring, closer to 50% later in year
- Dormancy: winter
- Dispersal ability: not known

- Importance of metapopulation linkages between currently small, isolated populations: not known but could be critical in relation to expectation of stochastic events (floods, fires, etc.) in riparian corridors.

IV. Habitat requirements
- Vegetation structure: desert shrubs (e.g., quailbush) >0.5 m high and greater vegetation cover is better
- Vegetation composition: desert riparian shrubland vegetation transition between riparian and desert vegetation
- Soil: stabilize alluvial sands with <2 mm particle size
- Home range size for successful reproduction: unknown for UMR but estimated 25- 30 m^2 at Las Vegas Well Field Preserve (better habitat, no rodent competition)
- Food resources: seeds of acacia, mesquite, and other shrubs

V. Landscape context and configuration
- Landscape configuration of critical habitat: not known
- Closest known populations: Overton WMA, lower Virgin River, Meadow Valley Wash
- UMR is northern edge of species' distribution with disjunct populations

Challenges to reaching and maintaining sustainable population

List all threats
- soil compaction
- domestic cats from houses
- reduction of shrub height and vegetation cover by livestock and mechanical disturbances
- physical isolation of small populations historically connected through metapopulation dynamics.

List all management constraints
- resistance to limit livestock grazing areas
- resistance to changing OHV use areas
- resistance of people to put domestic cats on leash
- house building at edge of riparian corridor
- distribution of stabilized alluvial fans not documented

Potential management options to reach sustainable population (with Pros + and Cons -)

- Protect stabilized alluvial sands from compaction
  - \+ obligate habitat conserved
  - \+ easy to map, if known
  - – will require land transaction (acquisition, conservation easement, etc) to conserve habitat on private, which can be expensive
  - – may be expensive
- Protect stabilized alluvial sands from livestock
  - \+ prevents soil compaction
  - \+ prevents reduction of shrub height and cover, which are critical
  - – cost of fencing small pocket of habitat
  - – resistance to changes in grazing practices
- Limit encroachment of tamarisk and other non-native weeds on critical habitat and replace with native shrubs
  - \+ prevents reduction of habitat size
  - – expensive and on-going
- Pass town ordinance to enforce pet leashes for house in proximity of critical habitat
  - \+ reduce unnatural levels of predation
  - – resistance to put pets on leashes

Ecological and Management Uncertainties

List all research uncertainties

- estimates of densities
- temporal population variability as a function of food and climate
- distribution of stabilized alluvial sands along UMR
- locations of other population along UMR

List all management uncertainties

- relationship between shrub cover and height, livestock grazing, and mouse population size
- When does tamarisk encroachment become a source of population decrease?
- the relationship between housing density, pet density, an predation rate on mouse population size
- effect of industrial development in UMR on desert pocket mouse populations
- how do current population sizes and levels of isolation differ from a pre-anthropogenic disturbance configuration?

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- Reviewers:

Appendix IV–Q. Aquatic Macroinvertebrate Community: Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition Integrated system of springbrooks (approx. 5.5 km long from approx. 20 thermal springs); more than 90% of the habitat has been altered (e.g., channelized, diverted, impounded, captured, etc.), and exotic macroinvertebrate species are common. Potential for *Tilapia zilli* to functionally alter macroinvertebrate community structure. Riparian system often poorly developed or dominated by early seral stage vegetation (e.g., cattail, *Typha* spp. arrow weed, *Pluchea sericea,* fan palm, *Washingtonia filifera*). Submerged aquatic vegetation often dominated by *Vallisneria* spp. Current condition and acreage springbrook habitat as of Spring 2002. **Spatial** Current conditions as of Spring 2002. **Management actions** ▪ Continue existing management actions ▪ Preserve existing habitat	**Condition** Integrated system of springbrooks (approx. 5.5 km long from approx. 20 thermal springs); more than 50% of the habitat has been altered (e.g., channelized, diverted, impounded, captured, etc.), and exotic macroinvertebrate species are common. Potential for *Tilapia zilli* to functionally alter macroinvertebrate community structure. Approx. 50% of riparian system poorly developed or dominated by early seral stage vegetation (e.g., cattail, *Typha* spp. arrow weed, *Pluchea sericea* fan palm, *Washingtonia filifera*), and *Vallisneria* spp. reduced to 50% coverage. **Spatial** Aquatic habitat diversity in all springbrooks increased to include backwaters, range of current velocities from 0 cm/sec to 100 cm/sec, fewer substrate fines, and increased gravel and cobble. Spatial distribution of habitats within the drainage is not critically important, as long as habitat diversity is present. **Management actions** ▪ Factors altering aquatic habitat should be removed, sites restored, and habitats stabilized to historical conditions. ▪ Desert riparian vegetation reestablished along springbrooks.	**Condition** Integrated system of springbrooks (approx. 5.5 km long from approx. 20 thermal springs) and the upper Muddy River to 300 m downstream from the low-head dam; all altered habitat has been restored to naturally functioning condition, and exotic macroinvertebrate and vertebrate species are uncommon and do not functionally alter natural aquatic communities. Early seral stage vegetation (e.g., cattail, *Typha* spp. arrow weed, *Pluchea sericea,* fan palm, *Washingtonia filifera*), and *Vallisneria* spp. reduced to 10% coverage. **Spatial** Aquatic habitat diversity in all springbrooks and the upper Muddy River restored to natural conditions. Spatial distribution of habitats within the drainage is not critically important, as long as habitat diversity is present. **Management actions** ▪ Factors altering aquatic habitat should be removed, sites restored, and habitats stabilized to historical conditions. ▪ Diverse desert riparian vegetation reestablished along springbrooks. ▪ All exotic species reduced so they do not functionally alter aquatic macroinvertebrate community or cause rare species extinction, throughout springbrooks and the upper Muddy River.
Total Acreage: < 5 acres, 5.5 km of aquatic habitat	**Total Acreage:** < 5 acres, 5.5 km of aquatic habitat	**Total Acreage:** ~ 8 acres, 10 km of aquatic habitat
Other Focal Targets Captured: Fishes, desert riparian vegetation, and associated species	**Other Focal Targets Captured:** Fishes, desert riparian vegetation, and associated species	**Other Focal Targets Captured:** Fishes, desert riparian vegetation, and associated species

Preferred DFC: Alternative 2

Aquatic Macroinvertebrate Community

Natural history description of community: More than 100 species of aquatic macroinvertebrates are known from thermal springs at the source of the Muddy River. A number of these species are globally rare (e.g., *Rhagovelia becki, Ambrysus mormon, Pelocoris biimpressus shoshone, Tryonia clathrata*, and others), and five species are endemic (*Pyrgulopsis avernalis, Pyrgulopsis clathrata, Stenelmis moapa, Limnocoris moapensis*, and *Microcylloepus moapus moapus*). All of these crenobiontic species are most abundant in the upper 150 m of spring brooks. Communities near springs differ from those downstream where crenobiontics are scarce (or do not occur) and the macroinvertebrate community is dominated by species that are more adapted to harsh environmental conditions.

Healthy, diverse aquatic habitats are crucially important for the aquatic macroinvertebrate community, and this community is one of the few local terrestrial and aquatic communities that is not dominated by introduced species. Macroinvertebrates utilize all types of aquatic habitat that occur in the Muddy River drainage, and most endemic species do not prefer habitats occupied by endemic fishes. Maintaining the aquatic macroinvertebrate community also requires a diverse and healthy riparian community for nutrients, cover, and bank stability.

Little is known about macroinvertebrate demography. Sada (2000) observed seasonal variation in the abundance of the three species of springsnails that occur in the upper Muddy River (greatest abundance during spring time and lowest during winter). The abundance of most species in the macroinvertebrate community is believed to follow this pattern, which is in response to seasonal variation in photoperiod. Sada and Herbst (1999) identified environmental parameters influential in structuring the macroinvertebrate community and quantified habitat preferences for all rare and endemic aquatic macroinvertebrates.

Federal and State Listing Status: No macroinvertebrate species are listed as endangered or threatened by the U.S. Fish and Wildlife Service or State of Nevada.

Embedded communities: Developing conservation management strategies for the aquatic macroinvertebrate community in the Muddy River drainage is best done by segregating rare and endemic species into guilds based upon habitat use. Work done by Sada and Herbst (1999) indicated that these species occupy a diverse suite of habitats that are utilized by all other macroinvertebrates in the aquatic community. By quantifying habitat preferences and avoidance of these rare species and determining environmental factors that affect structure of the entire macroinvertebrate community, they identified the following key habitat types:

Swift water, comparatively deep with gravel/cobble substrate and sparse aquatic vegetation: Occupied by both endemic species of *Pyrgulopsis* where current velocities range between 50-110 cm/sec (*P. avernalis*) and 30-40 cm/sec (*P. carinifera*). Habitats also utilized by *Ambrysus mormon* and *Limnocoris moapensis,* and *Microcylloepus moapus moapus* where roots and coarse particulate organic matter (CPOM) occur. *Stenelmis moapa* occurs in these habitats and prefers moderate current velocities (30-50 cm/sec), cobble substrate, stable, overhanging spring brook banks, and CPOM.

Slow, shallow backwater with sand substrate: Occupied primarily by *T. clathrata* that prefers shallow (< 5 cm), open habitats along springbrook margins with sand substrate and slow current (< 10cm/sec). This habitat also occupied by *M. tuberculata*, but habitats are partitioned between the two species by *M. tuberculata* preferring slower water (0-3 cm/sec) and muck substrate.

Slow, deeper backwater with fines and emergent vegetation: Occupied by *Pelocoris biimpressus shoshone*

Comparatively swift, deeper backwater with gravel and dense riparian cover: Occupied by *Rhagovelia becki, Ambrysus mormon,* and *Limnocoris moapensis*.

Deep, slow, mid-channel habitat with fine substrate: Habitat type highly unusual (and probably did not occur) in natural conditions; a habitat type that has been constructed during fish restoration projects. Supports depauperate macroinvertebrate community, occupied primarily by *Melanoides tuberculata*, an introduced, highly deleterious, parthenogenic mollusk. Creation of this habitat type should be avoided.

Desired structure, composition, and landscape context and configuration

I. Habitat

- Restore and maintain diverse suite of aquatic habitats.
  - **Aquatic habitat** – Habitats must include a wide range of current velocities, water depth, substrate composition, and emergent vegetation.
    - Goal: Increase habitat diversity to naturally functioning conditions.
    - Goal: Avoid creating habitats preferred by non-native species.
    - Goal: Restore spring sources and spring brooks to naturally functioning condition.
  - **Riparian habitat** – This habitat is necessary for nutrients and as mating, resting, and adult habitat for may aquatic insects.
    - Goal: Restore riparian habitat to naturally functioning conditions at all springs and along all spring brooks.
    - Goal: Control non-native species and increase species diversity.

II. Community Structure

- **Native species** – Restore habitats for native species.
  - Goal: Restore spring and spring brook habitat to naturally functioning conditions that support native species of macroinvertebrates and fishes.
- **Non-native species** – Minimize habitat preferred by non-native fishes and macroinvertebrates to decrease their abundance and maximize habitat for native species.
  - Goal: Restore spring and spring brook habitat to naturally functioning conditions that do not include habitats preferred by non-native species of plants and animals.

III. Landscape context and configuration

- Most aquatic habitat in the upper Muddy River has been severely altered by channelization and diversion, such that current conditions poorly resemble historical conditions. These habitats are occupied by a highly endemic fauna whose distribution and abundance have been reduced by these activities.
- Goal: Restore spring and spring brook habitat to naturally functioning conditions and allow these species to occur within historically occupied areas.

Challenges to reaching and/or maintaining sustainable population

Threats:

- Continued decrease in spring brook habitat heterogeneity by diversion, endangered fish recovery, and channelization; continued introductions of non-native species, potential reduction in spring discharge by diversion and/or excessive ground water pumping.

Management constraints:

- Financial cost of habitat restoration and non-native species control, potential conflicting demands regulated by Nevada water law, cooperation with land owners required, Moapa dace recovery tasks affects of macroinvertebrate community structure.

Potential management options to reach DFC (with Pros + and Cons -)

- Management method #1 – Restoration of landscape in 1-3 years
  - \+ Determine current distribution of rare aquatic macroinvertebrates.
  - \+ Initiate restoration programs in all springs and spring brooks.
  - \+ Reestablish extirpated populations.
  - \+ Remove/control non-native plants and animal.
  - \+ Lower restoration cost overall
  - – Short time frame to expect restoration to be accomplished
- Management method #2 – Restoration of landscape over 4+ years
  - \+ Restoration cost distributed over longer time period.
  - – Riparian woodland tree species require decades to reach maturity and aquatic systems are so badly degraded that may years may be required to reach recovery.

Ecological and Management Uncertainties

- Macroinvertebrate response to fish restoration activities uncertain. Initiate monitoring to quantify spatial and temporal aspects of macroinvertebrate abundance and community structure, and their response to fish restoration.
- Macroinvertebrate/riparian vegetation relationships are poorly understood. Determine riparian vegetation restoration strategies that maximize benefits to aquatic macroinvertebrates.
- Influences of decreased spring discharge on the macroinvertebrate community are unknown. Ergo there is no information to quantify discharge rates that are necessary to maintain either the aquatic macroinvertebrate community or rare macroinvertebrate species.

Information Source(s) and Reviewers

- Information Sources

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Appendix IV–R. Butterfly Species Assemblage: Desired Future Condition Summary

Minimum DFC	Alternative 1 (medium)	Alternative 2 (ambitious)
Condition *not provided* Spatial not provided **Management actions** not provided	Condition *not provided* Spatial not provided **Management actions** not provided	Condition *not provided* Spatial not provided **Management actions** not provided
Total Acreage: not provided	**Total Acreage:** not provided	**Total Acreage:** not provided
Other Focal Targets Captured: Desert riparian vegetation and associated species	**Other Focal Targets Captured:** Desert riparian vegetation and associated species	**Other Focal Targets Captured:** Desert riparian vegetation and associated species

Preferred DFC: Alternative ?

Butterfly Species Assemblage

Summary of Desired Future Conditions: not provided

Natural history description of community: Of 200 species of butterflies known from Nevada (120 in Clark County) about 50 have been documented in the muddy River drainage. These include species strictly dependent on vegetation growing in riverine or other wet habitats to those which extend into the valley from the surrounding desert scrub habitats. Riparian habitats are crucially important for the occurrence of certain species of butterflies within desert ecosystems. Three species of riparian associated butterflies occur nearly exclusively in Nevada within the Muddy River drainage: *Hesperopsis gracielae, Calephelis nemesis*, and *Limenitis archippus*. All three use plants occurring in the riparian zone as their only larval hostplants. Another species (*Ochlodes yuma*) is found as scattered populations throughout most of Nevada at seeps, springs, and other wet areas where its larval hostplant, *Phragmites*, occurs. These areas are dwindling in Clark County and beyond and several populations have been extirpated. Three additional species *(Apodemia palmerii, Atlides halesus, Ministrymon leda*) are nearly entirely restricted to mesquite dominated habitats in southern Nevada; two feed as larvae on mesquite and the other on its common parasite, mistletoe. Two other taxa, *Lycaeides melissa* and *Chlosyne lacinia*, now occurring in southern Nevada only in the Muddy Valley, are restricted to agricultural and other distributed habitats. Many of these and other butterfly species occurring in the Muddy River drainage use flowers along the riparian corridor as important nectar sources.

Filing statuses: No species of butterfly occurring in the Muddy River drainage is listed as threatened or endangered by the federal government or the state of Nevada. Some, however,. Are globally insecure and threatened in the state of Nevada.

Desired structure, composition and landscape context and configuration

Larval hostplants:
The following are the knows larval hostplants of the nine species of butterflies of concern in the Muddy River drainage. Without their hostplants present, these species would not occur in the valley and any recovery and management must consider larval hostplants in large enough stands and perhaps several of each (metapopulation dynamics have not been investigated) to maintain viable populations.

Butterfly – Hostplant

Hesperopsis gracielae – Atriplex lentiformis

Ochlodes yuma – Phragmites australis

Calephelis nemesis – Baccharis salicifolia

Apodemia palmerii – Prosopis especially *Prosopis glandulosa*

Atlides halesus – Phoradendron californicum

Ministrymon leda – Prosopis glandulosa

Lycaeides melissa various Fabaceae, the sole larval hostplant known in the Muddy River drainage is *Medicago sativa*

Chlosyne lacinia – various composites, may use only *Helianthus annuus* in the Muddy River drainage

Limenitis archippus – Salix (will use several species), secondarily feeds on young *Populus fremontii*

Adult nectar sources:
Many flowering plants provide nectar for adult butterflies. Some species forage on narrow range of flowers while others are more catholic. Likewise, some flowers are used by many species of butterflies and others are not used at all. Little information exists on these resources in the Muddy River drainage. *Medicago sativa* is undoubtedly a major nectar sources for butterflies in the area include *Tamarix, Prosopis, Heliotropium, Pluchea* and *Cirsium*.

Challenges to reaching and/or maintaining sustainable population

Threats:
The major threats to the butterflies in the Muddy River drainage (especially those of concern) are the ongoing crowding of native vegetation by *Tamarix*, development and phraetophytic control. For example, a very large population of *Il. Gracielae* was lost over a decade ago to development near Longandale and populations of *C. Nemesis* and *I. Archippus* were destroyed a few years ago with the clearing of trees and shrubs along the canal to Bowman's Reservoir.

Potential management options to reach DFC (with Pros + and Cons -)

The goal for butterflies is to manage and increase the area of all natural plant communities in the Muddy River drainage with an elimination of *Tamarix* (which apparently effectively outcompetes native riparian vegetation), but to maintain sufficient disturbance (e.g., alfalfa fields) to assure the continued existence of *C. lacinia and I. melissa* in the valley and county.

Ecological and Management Uncertainties

not provided

Information Source(s) and Reviewers

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Reviewers: none

Butterfly species of concern and their conservation status (based on TNC criteria) in the Muddy River drainage.

SPECIES	Common name	Global rank/ NV State Rank
Hesperopsis gracielae	MacNeill's Saltbush Sootywing	G2T2S1
Ochlodes yuma yuma	Yuma Skipper	G3T3S2
Calephelis nemesis nemesis	Fatal Metalmark	G5T3S1
Apodemia pulmerii palmerii	Palmer's Metalmark	G4T3S3
Atlides halesus corcorani	Great Purple Hairstreak	G5T5S3
Ministrymon leda	Leda Ministreak	G5T5S1
Lycaeides melissa alateres	Melissa Blue	G5T3S1
Chlosyne lacinia crocale	Bordered Patch	G5T5S1
Limenitis archippus obsoleta	Viceroy	G4T4S1

12. Appendix V. Original priority research and management questions identified during the upper Muddy River Integrated Science Plan workshop, 17-19 July 2002, Las Vegas, NV.

Hydrology

Is 2-yr of test pumping in Coyote Springs enough to detect change?
Other straws in carbonate aquifer: Coyote Springs vs. Pahranagat
Time delay in pumping given existing water rights
Immediate response vs. long-term trend to pumping
If water level declines (triggers), what is the effect on fishes & other biological responses?
What mitigation actions given existing water rights use?
Should we expand hydrologic model to the regional scale?
Is water diversion to springs an acceptable mitigation strategy?
Influence of flooding on springs?

Geomorphology

Entrenchment of UMR - human made or natural?
Contribution of constant spring flow versus flash-flooding effect on geomorphology?
Can existing water rights on WS Ranch undo restoration efforts?
Status of historic data
Involvement of UMR residents?
How will fish barriers for Tilapia fit in the restoration?
What will be the sequence of restoration events?
Will the placement of the pipeline and fish trap (?) along river constrain restoration?
Is partial restoration enough or do we need full restoration?

Vegetation

Is fan palm native? Effect on management?
Flora not known for UMR other than dominants
What will cessation of irrigation do to existing, non-native communities?
If partial geomorphology restoration, do we manage for fixed successional stages?
Effect of invasive chemical control on fish & amphibians?
Should restoration restore plant functional characteristic instead of dominant species, which may be non-native? DNA fingerprinting???

Dace

During refuge restoration: Is thermal load transition harmful to dace & other endemics?
Phased approached to restoration - what will be the timeline?
Should fire danger (palm & ungrazed grass) determine restoration priorities?
Is habitat maintenance included in restoration plan?
Are there tradeoffs between species for restoration priorities? Should we stop supporting irrigated habitats?
Can we jump start succession to minimize work during and after restoration?
Should the Refuge be staffed full time?
Can bullfrogs, crayfishes, and tilapia be controlled by restoration of processes (e.g., King Pool) alone?
How much habitat needed for dace? Plummer area should be a priority.
Is there a relation between water temp, change in water level (pumping), water velocity, and invasives?
Should restoration include a range of water velocity for dace?
Should we put restoration gages in restoration areas?

Bird Community
Should we support artificial habitats that harbor high bird diversity?
Should generalists species limit extent of restoration?
Can bird diversity be maintained with native habitat?

Yellow-billed Cuckoo
Should the species biology (habitat requirements & source of prey) be studied in greater detail for restoration?
How different is UMR than CA and Bill Williams Delta populations in terms of habitat choice? Is this a range expansion? What is natural condition of habitat?
Will the WSR be acquired?
What are our objectives? 1.Natural systems? 2. Biodiversity? Or Target resources?
Do YBC respond more to composition than structure?
What are relative contributions of flooding and fire?
Will geomorphic study reveal historic habitat openess?

Southwestern Willow Flycatcher
Are SWFL becoming adapted to cowbirds?
Is livestock (private lands) management compatible with reduced fire hazard (thus willow protection) and willow grazing?
Should UMR management include artificial flooding to create habitat?
Should cowbird trapping be investigated more?

Phainopepla
Need research on mistletoe, mistletoe diversity?
What affects mistletoe infection?
How fast can mesquite and mistletoe grow before Phainopepla start using it?
What kind of law enforcement is needed to prevent mesquite cutting on BLM lands?
Is there a conflict between screwbean and honey mesquite with respect to different birds that use them?
What will be effect of climate change on mistletoe?
Do we need to study the basic demography and dispersal of species?

Vermilion Flycatcher
How do we maintain open habitat patches between trees?
Effect of removing ditches? Why birds not nesting along river?
Ownership of water rights of WSR - impact on restoration activities?
Would restoration of springs provide habitat for VEFL?

Aquatic invertebrates
Staged restoration to minimize disturbance. Do we need monitoring?
Tilapia effects quantified?
Effect of incremental water decline on endemics?
Springsnail demography - indicators?
How do springs recover from disturbance - basic research needed?
Where does habitat restoration has an effect on invert populations?
Do we need to verify correlation between fish endemics and invert endemics by experimental methods?

Amphibians
Can *Rana onca*/southwest toad be reintroduced to UMR springs?
Will hybridization undo reintroduction efforts?

Should we amphibian farm to help reintroduction program?
Can species be kept genetically separate?
Which invaders can be controlled by habitat structuring and does habitat restoration cause problems that need maintenance or will restoration of natural processes handle invaders?
Do we need more habitat choice study of *Rana onca*? SW toad?

Bats

Where are dense stands of palms that could be compatible with restoration?
Do we need palm expansion control in restoration plan? Can palms in dense stands of ash and cottonwood suffice for habitat?
What trees, habitat feature, and resources are the bats using? Research needed.
Is incremental palm removal and planting of cottonwoods feasible during the long term? 25 years.
Need pollen analysis in ponds to determine date of palm establishment?
We do not know if palm plantations will support yellow bat populations elsewhere?

Desert Pocket Mouse

Need to describe habitat characteristics?
Need to locate population on UMR and measure densities.
When do nonnatives have an effect?
Need demography in natural settings?
Will restored developed lands be adequate and how fast? (500-yr. Floodplain)
How does species responds to reintroductions?

Tamarisk

Need community analyses (animals and plants) in older stands to measure natural recovery
What is the peak flow for UMR?
What is the natural regeneration after tamarisk removal?
Is tamarisk invasion mostly a case of invasion of fallow agricultural fields?
Can older stands be colonized by other species? Natives and nonnatives?
Can we use late successional trees that can outcompete tamarisks as a restoration strategy?

13. Appendix VI. Milestones #4 & 5 by Otis Bay, Inc—HEC-RAS Modeling and Preliminary Restoration Recommendations

Upper Muddy River
Geomorphic Assessment

Prepared by
Otis Bay Inc
1049 South 475 West
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Report for Deliverables 4 and 5
September 30, 2003 – December 31, 2003

Prepared for
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Table of Contents

Upper Muddy River Geomorphic Assessment

HEC-RAS Modeling
Restoration Recommendations

1.0 Introduction

The following is a preliminary summary of deliverables 4 and 5 for the UMR Geomorphic Assessment and includes HEC-RAS modeling results and habitat restoration and conservation recommendations. A brief summary of work completed since the last submittal on September 30, 2003 is presented in the following paragraph. More detailed descriptions of the work completed to date are presented in the following sections; HEC-RAS Modeling and Restoration Recommendations.

Channel cross section and invertebrate surveys were completed October 23 through October 28 in Segments 1, 3, 4, 5, 8, and 9. Vegetation surveys were completed within the previous segments November 7 through November 9. Access to the Moapa Indian Reservation (Segment 2) was not granted until November 18, 2003. Therefore, channel, invertebrate, or vegetation surveys were not completed within Segment 2. However, reconnaissance level surveys were completed following the granting of access and sufficient information was gathered in order to provide recommendations throughout the entire UMR valley. Vegetation and invertebrate survey data will be discussed in future reports. Segments 6 and 7 are spring channels or spring channel complexes and were not included in detailed surveys, but are recognized as essential components within the UMR valley and are included in the overall assessment and recommendation discussions. Historical interviews were completed with several individuals, some of which have lived in the Moapa Valley area for over 70 years.

2.0 HEC-RAS Modeling

Topographic survey data were collected at five channel cross sections within each of the surveyed segments. The locations of each cross section within the individual segments are shown in Figures 1 through 6. Topographic survey data were collected using a total station and were obtained at major breaks in slope outside of and within the channel. Water surface elevations were obtained on both sides of the channel. A separate HEC-RAS model was constructed for each set of five surveyed channel cross sections. Each model was calibrated using the surveyed water surface elevations, approximate roughness values based on channel and floodplain characteristics, and a measured discharge or approximate discharge based on stream gage records at the Muddy River gage station 09416000. A discharge of 30.0 cfs was used as an approximation of the flow during channel cross section survey activities for segments 1, 3, and 4 while measured discharges of 21.0 and 4.0 cfs were used to model flows for segments 5 and 8, respectively.

The Log Pearson Type III recurrence intervals for the 2, 5, 10, 25, 50, and 100 year floods were determined from stream gage records at Muddy River gage station 09416000 and were modeled in order to exhibit approximate discharge elevations for the respective flows. The discharges associated with the Log Pearson Type III recurrence intervals for the 2, 5, 10, 25, 50, and 100 year floods are 273, 851, 1,622, 3,359, 5,496, and 8,690 cfs, respectively. A downstream view (river left to river right) of a single and representative cross section within each segment as well as results from the hydraulic modeling is shown in Figures 7 through 12. Flood flows cannot be accurately modeled without elevation data that exceeds the maximum elevation of the flow of interest. Therefore, exhibited model results containing water surface elevations that exceed the elevations at either end of the channel cross section (such as the 100 year flood in many examples) should be viewed with the recognition of this limitation.

As shown in Figures 7 through 12, most of the largest floods are contained within the current channel and only the largest floods discharge on to the present valley floor with the exception of tributary wash flooding. Minor floodplain surfaces have formed within the oversized channel in a limited number of locations. Indications of minor inset floodplain development were observed within segment 1. In addition, a small degree of inset floodplain was observed to occur within segments 4 and 5. However, these features were largely obscured by dense vegetation. Although subtle, an example of an inset floodplain is visible in Figure 7 as a slight break in slope directly above the observed water surface (OWS) on the left side of the river. A mid-channel bar is exhibited in Figure 10 as a surface above the OWS in the center of the channel. Both of these features provide examples of the balance between slope and sediment supply within the incised channel following disturbances that have occurred in the past.

3.0 Restoration Recommendations

Clearly defined objectives are an integral part of a successful restoration project. Although broad and encompassing, the primary objective of habitat restoration within the UMR valley is to establish, to the maximum extent possible, a self maintaining ecological system. Specific restoration objectives include the maintenance, recovery, and/or reestablishment of the priority conservation targets and associated species. These objectives can be accomplished, primarily, by the restoration of processes such as restoring the connection between the channel and floodplain. However, physical limitations to the restoration of process may exist in the form of agriculture, housing, and lowering of the alluvial aquifer water table due to groundwater extraction. Specific restoration objectives are listed below:

- Improve riparian habitat by increasing the riparian corridor width where possible
- Restore the hydraulic connection between river and floodplain where possible
- Increase biological productivity and diversity, with emphasis on target species
- Restore and improve hydraulic habitat for native aquatic species
- Restore a mosaic of riparian, transitional, and wetland aquatic habitat types
- Provide public access to the river and other natural features for low-impact recreational activities

By identifying the restoration objectives and priority conservation targets, restoration results will be measurable. Restoration objectives have been identified in order to restore suitable conditions for the priority conservation targets. The priority conservation targets include the Warm Spring/Stream Aquatic, Muddy River Aquatic, Interior Riparian Woodland, Interior Riparian Shrubland, Interior Riparian Marsh, and Mesquite Bosque assemblages. These priority conservation targets have been accurately delineated and described by TNC (2000). These assemblages represent distinct community types that require similar ecological and physical processes for sustainability.

Each priority conservation target contains target species and was selected and organized based on 1) viable, vulnerable, rare, and endangered species; 2) species of special concern due to declining numbers, disjunct distribution, or regional endemism; 3) viable ecological communities; and 4) assemblages of ecological communities and species (TNC, 2000). The priority conservation targets describe a specific assemblage of plant and animal species that are adapted to similar ecological and physical factors and will require similar restoration approaches. Therefore, restoration recommendations will focus on the locations where and methods by which these six priority conservation targets can be restored.

Restoration recommendations provided in Table 1 are based on the recovery of individual priority conservation targets and the general ecological and physical requirements of species within each priority conservation target. Priority conservation targets, as defined by TNC (2000), were used to evaluate the relative benefits or number of priority conservation targets captured for each recommendation. Restoration recommendations are organized by segment and by the relative level of effort and cost of implementation. The relative degree of effort and cost shown in Table 1 is in increasing order from top to bottom within each set of segment specific recommendations.

Although a self maintaining ecological system is desired, the need for mechanical and human intervention will be likely following future restoration efforts. Because restoration recommendations include human and wildlife needs, continued management of the UMR valley habitat resources will be necessary. Monitoring of the priority conservation targets will allow for the direct measurement of restoration success or failure. Habitat restoration activities present significant potential for the learning process to enhance restoration efforts. Completing the restoration in phases will allow the learning experience to increase the value and success rate of restoration efforts. An adaptive management approach following restoration is recommended due to the resource management needs and the likelihood that changes in habitat needs and goals will occur. Post-restoration intervention that would likely be required would include exotic species control, prescribed and selective vegetative thinning, and channel maintenance activities.

Complete restoration of the UMR valley to pre-settlement conditions would most likely meet all restoration objectives, restore balance among the habitat assemblages, and meet specific ecological and physical requirements for both the assemblages and related species. However, physical limitations exist due to historical and present land use and changes in the hydrologic conditions within the UMR valley. Therefore, restoration efforts within the UMR valley will consist of a balance between both human and wildlife needs. Similarly, future restoration planning will require designs based on current physical conditions and limitations rather than historical conditions.

A balance between historical conditions, restoration goals, present conditions, and physical limitations will be required. Both active and passive restoration strategies will be necessary. For example, certain factors, such as a diminished alluvial aquifer, will continue to limit restoration efforts where a shallow depth to groundwater previously supported wetland vegetation. Likewise, the present channel dimensions preclude most of all except the largest flood flows from dispersing onto the floodplain. Therefore, active restoration strategies may be required where physical limitations to restoration must be overcome. However, passive restoration strategies are also suggested where physical limitations are not present, are present to a minor degree but are recoverable, or where a minimum amount of active restoration will allow passive restoration to complete the specific restoration goal.

4.0 References

The Nature Conservancy. 2000. Upper Muddy River Site Conservation Plan

Appendix A

Figures

Figure 1. Segment 1 surveyed channel cross section locations.

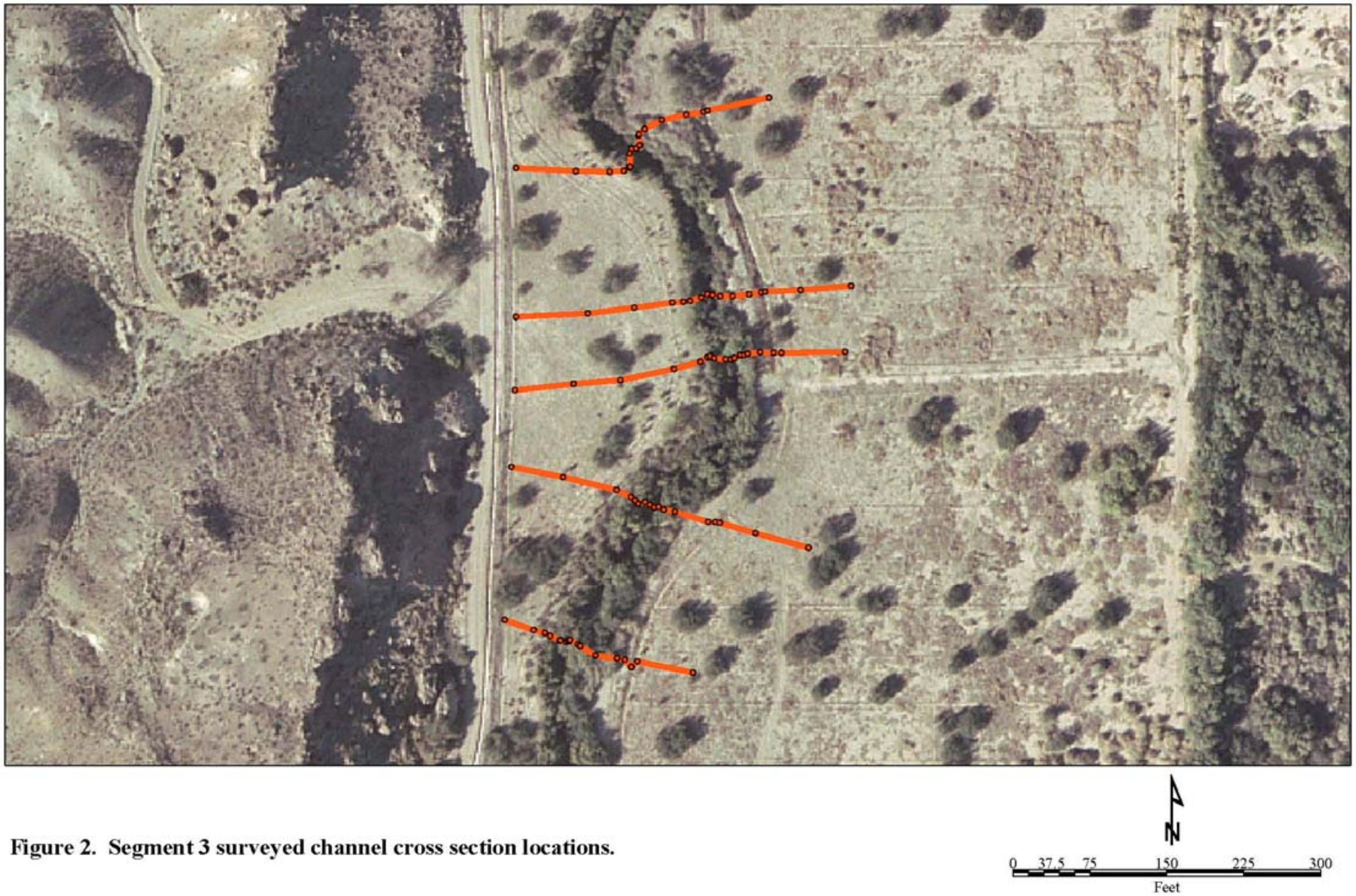

Figure 2. Segment 3 surveyed channel cross section locations.

Figure 3. Segment 4 surveyed channel cross section locations.

Figure 4. Segment 5 surveyed channel cross section locations.

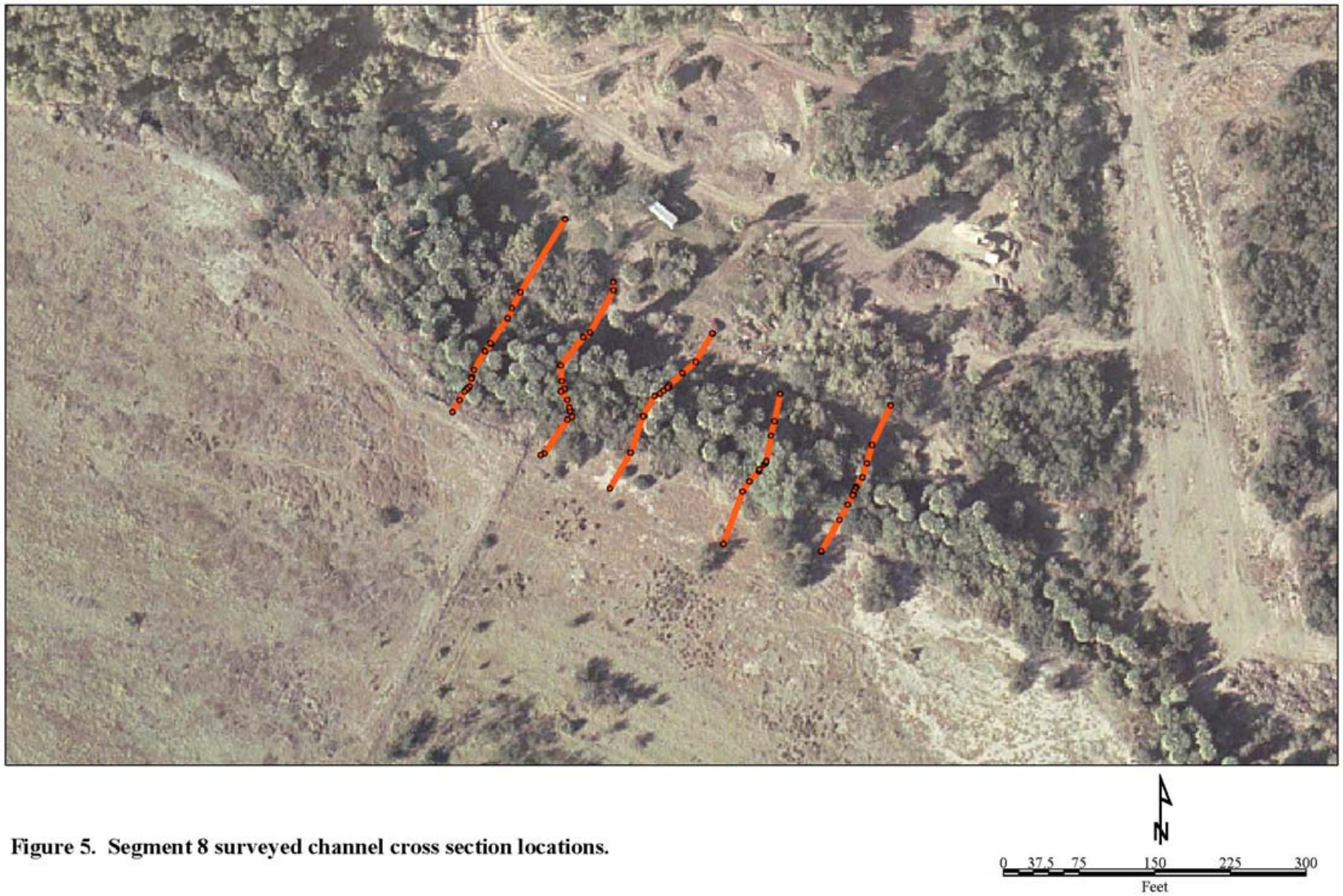

Figure 5. Segment 8 surveyed channel cross section locations.

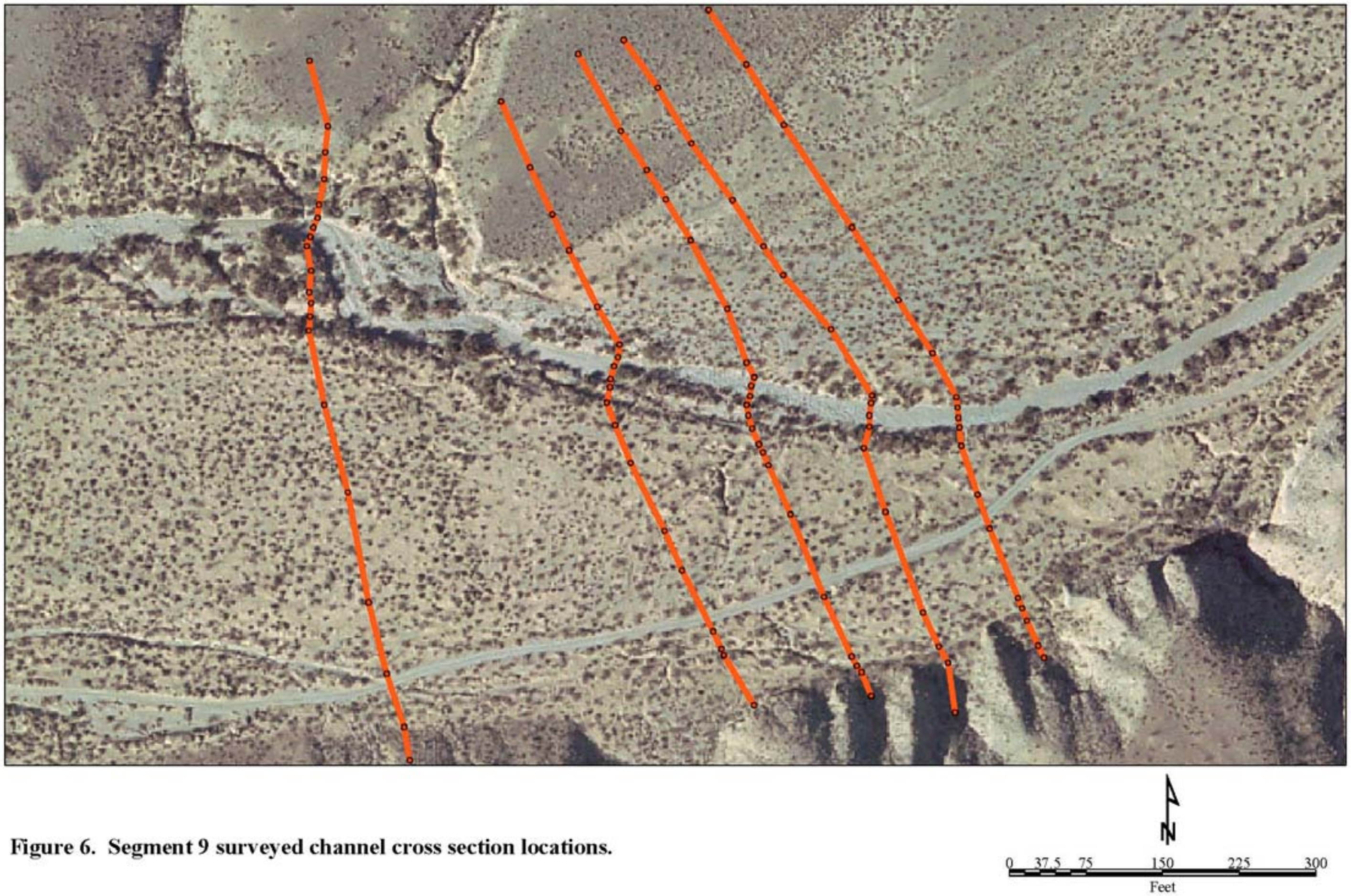

Figure 6. Segment 9 surveyed channel cross section locations.

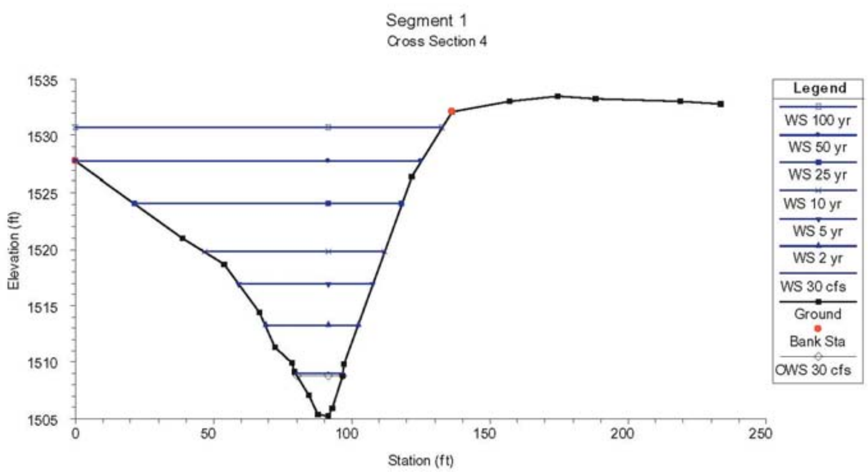

Figure 7. HEC-RAS modeling results for 30 cfs and the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 1 cross section 4.

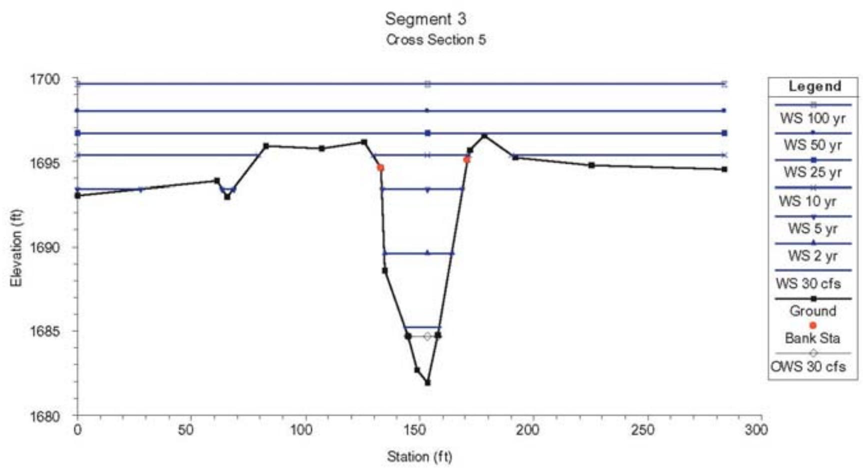

Figure 8. HEC-RAS modeling results for 30 cfs and the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 3 cross section 5.

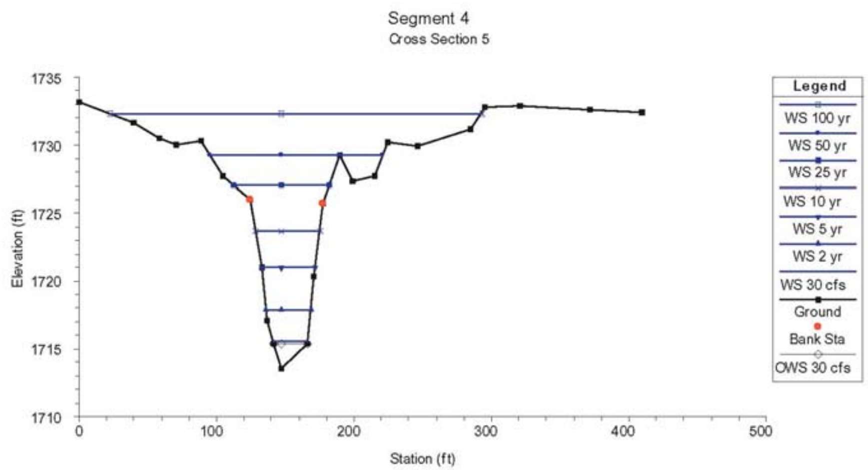

Figure 9. HEC-RAS modeling results for 30 cfs and the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 4 cross section 5.

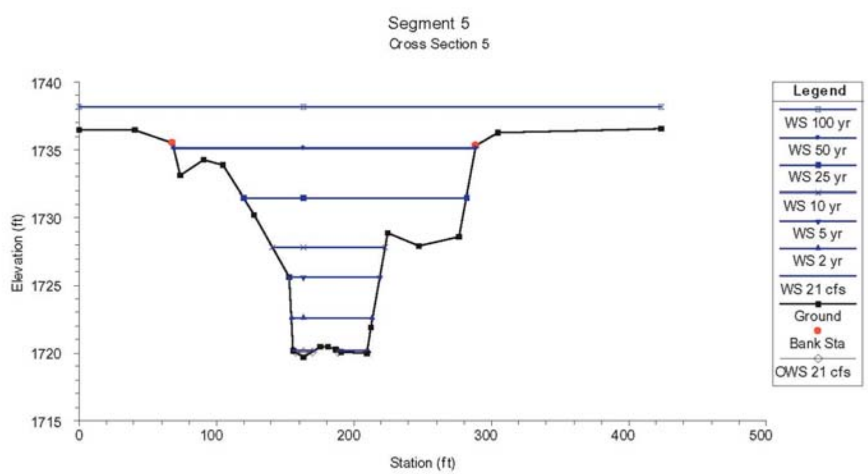

Figure 10. HEC-RAS modeling results for 21 cfs and the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 5 cross section 5.

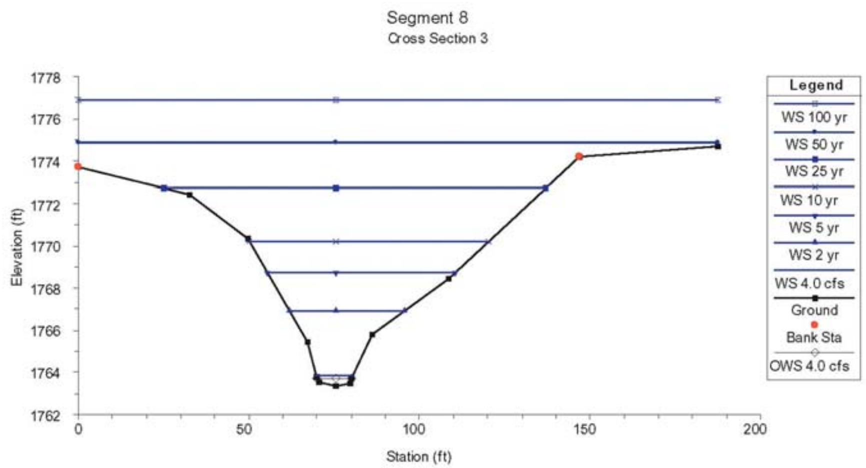

Figure 11. HEC-RAS modeling results for 4 cfs and the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 8 cross section 3.

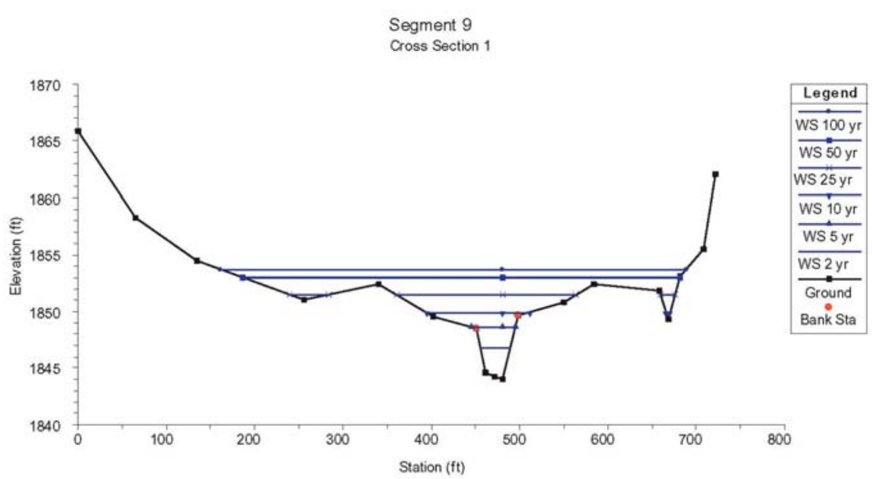

Figure 12. HEC-RAS modeling results for the 2, 5, 10, 25, 50, and 100 year flood recurrence intervals at segment 9 cross section 1.

Appendix B

Tables

Table 1. Upper Muddy River habitat conservation and restoration recommendations.

Segment	Relative Level of Effort and Cost	Recommendation	Priority Conservation Targets Captured*
1 - I-15 Bridge to Reid Gardner RR Bridge			
	Low	Continued invasive vegetation control (manual and goat grazing)	3, 4, and 6
	Medium	Revegetation following invasive vegetation removal activities	3, 4, and 6
	Medium	Coarse substrate augmentation within present channel	2
	Medium	Conservation easement for ponds/wetlands	3, 4, and 5
	Medium	Conservation easement for floodplain real estate	3, 4, 5, and 6
	High	Acquisition of functional ponds/wetlands from willing sellers	3, 4, and 5
	High	Small scale channel reconstruction and demonstration sites	2, 3, 4, and 5
	High	Acquisition of floodplain real estate from willing sellers	3, 4, and 6
	High	Excavation/Construction of floodplain within present incised channel	2, 3, 4, and 5
	High	Complete reconstruction of channel within acquired/easement property	2, 3, 4, 5, and 6
2 - Reid Gardner RR Bridge to White Narrows			
	Low	Continued invasive vegetation control (manual and goat grazing)	3 and 4
	Low	Formation of partnership/agreement and cost sharing of conservation efforts with Tribe	variable
	Medium	Revegetation following invasive vegetation removal activities	3 and 4
	Medium	Coarse substrate augmentation within present channel	2
	Medium	Construction of permanent grade control structure and fish barrier at White Narrows	1 and 2
3 - White Narrows to Warm Springs Road			
	Low	Invasive vegetation removal (manual and goat grazing)	3, 4, and 6
	Medium	Conservation easements for remaining floodplain real estate	3, 4, 5, and 6
	Medium	Coarse substrate augmentation within present channel	2
	Medium	Acquisition of remaining floodplain real estate from willing sellers	3, 4, 5, and 6
	High	Small scale channel reconstruction and demonstration sites	2, 3, 4, and 5
	High	Excavation/Construction of floodplain within present incised channel	2, 3, 4, and 5
	High	Complete reconstruction of channel within BLM property	2, 3, 4, 5, and 6
	High	Removal of flood/silt control dams on tributary washes	2, 3, and 4
4 - Warm Springs Road to Warm Springs-Muddy River Confluence			
	Low	Invasive vegetation removal	3 and 4
	Medium	Invasive fish exclusion above Warm Springs Road	1 and 2
	Medium	Coarse substrate augmentation within present channel	2
	High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
	High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

5 - Warm Springs-Muddy River Confluence to North-South Fork Confluence

Low	Invasive vegetation removal	3, 4, and 6
Medium	Conservation easements for riparian habitat	1, 2, 3, 4, 5, and 6
Medium	Conservation easements within Muddy Spring area/LDS recreation area	1, 2, 3, 4, 5, and 6
Medium	Coarse substrate augmentation within present channel	1 and 2
Medium	Construction/Enhancement of wetlands	3, 4, and 5
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

6 - Warm Springs-Muddy River Confluence to Warm Springs

Low	Continued invasive vegetation removal	1, 2, 3, 4, and 5
Medium	Defined instream flows for Warm Springs NWR spring channels	1 and 2
Medium	Defined instream flows for Apcar channel	1 and 2
Medium	Spring channel habitat enhancement with conservation easements off NWR	1, 2, 3, 4, and 5
Medium	Spring pool and channel enhancement/restoration within Moapa NWR	1, 2, 3, 4, and 5
High	Restoration of remaining former recreational structures within Moapa NWR to spring pools and channels	1, 2, 3, 4, and 5
High	Development of public use and education areas/trails within Moapa NWR	non-habitat benefits, public outreach
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

7 - North-South Fork Confluence to North Fork Headwaters

Low	Invasive vegetation removal	1, 3, 4, 5, and 6
Medium	Conservation easements throughout riparian and wetland areas	1, 3, 4, 5, and 6
Medium	Conservation easements on private property within headwater area for dace habitat preservation	1, 3, 4, and 6
Medium	Coarse substrate augmentation within present channel	1
Medium	Construction/Enhancement of wetlands within desert riparian habitat where wet meadows exist	1, 2, 3, 4, 5, and 6
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

8 - North-South Fork Confluence to South Fork Headwaters

Low	Invasive vegetation removal	1, 3, 4, 5, and 6
Medium	Conservation easements throughout desert riparian habitat	1, 3, 4, 5, and 6
Medium	Construction/Enhancement of wetlands within desert riparian habitat where wet meadows exist	3, 4, and 5
High	Acquisition of desert riparian habitat from willing sellers for ecological preservation	1, 2, 3, 4, 5, and 6

9 - North Fork Headwaters to Arrow Canyon

Low	Invasive vegetation removal	4 and 6
High	Acquisition of water rights and/or limitation of future shallow groundwater aquifer decline	1, 2, 3, 4, 5, and 6

* Individual conservation targets shown below
1 - Warm Spring/Stream Aquatic Assemblage
2 - Muddy River Aquatic Assemblage
3 - Interior Riparian Woodland
4 - Interior Riparian Shrubland
5 - Interior Riparian Marsh
6 - Mesquite Bosque