2.0 Physical Characteristics and Setting of the Study Area

This section presents a summary of the physical characteristics and setting of the study area based on published geologic and previous technical reports prepared for the site. Surface features, meteorology, site geology, surface water hydrology, site hydrogeology, land use, cultural resources, and ecology are discussed below. Detailed information regarding hydrogeology and groundwater/surface water investigations completed to date for the RFI/RI are presented in Volume 2; soil investigation results are presented in Volume 3.

2.1 Surface Features and Topography

The study area is located in the southern portion of the Mohave Valley, along the California-Arizona border in eastern San Bernardino County, California. The study area is bounded by the Chemehuevi Mountains to the south, Park Moabi Road to the west, and the Colorado River to the east and north. Figure 2-1 shows the surface features and setting of the Mohave Valley and surrounding region. The study area encompasses approximately 3 square miles of the north-sloping piedmont alluvial terrace and floodplain along the northern margin of the Chemehuevi Mountains.

Topography in the study area is abrupt, rising from around 455 feet above mean sea level (msl) along the Colorado River to over 1,200 feet msl within 1 mile to the south and southwest. The Chemehuevi Mountains and drainage area to the south exceed 2,000 feet msl in elevation. As shown in Figure 2-2, the surface topography is characterized by moderate to deeply-dissected alluvial terraces, with elevations ranging from 650 to 500 feet msl, extending northward to the Colorado River floodplain. The Colorado River flows along the eastern and northern boundary of the site at an approximate elevation of 455 feet msl. The compressor station is located south of I-40, on a prominent alluvial terrace, at an elevation of 600 to 625 feet msl.

The land forms in the area are characterized by alluvial terraces and incised drainage channels. One of the largest incised channels is Bat Cave Wash, a north-south dry wash (ephemeral) stream adjacent to the Topock Compressor Station. Bat Cave Wash flows only briefly following intense rainfall events and drains to the Colorado River (Figure 2-2).

Locally, a floodplain borders both sides of the Colorado River, although the river no longer floods due to upstream dams and flow regulation. Topography on the floodplain is subtle, with elevations typically less than 40 feet above the river elevation. The width of the floodplain adjacent to the site averages 500 feet and narrows to the south of the site as the river enters the Topock Gorge where the shoreline becomes consolidated Miocene- and pre-Tertiary-aged bedrock.

Vegetation is very sparse except in portions of the river floodplain. The floodplain overstory predominately consists of non-native tamarisk (*Tamarix ramosissima*) trees. Native tree and shrub species also occur, including arrow weed (*Pluchea sericea*), palo verde (*Cercidium*

microphyllum), and an occasional honey mesquite (*Prosopis glandulosa*) and screwbean mesquite (*Prosopis pubescens*) tree.

2.2 Meteorology

The climate is typical of low desert areas along the Colorado River, with hot summer and mild winter seasons. The nearest weather station is 6.3 miles upriver in the Havasu National Wildlife Refuge (HNWR) and is operated by the BLM. The closest National Weather Service station is at the Needles airport, approximately 7.5 miles northwest of the compressor station.

The average daily maximum temperature ranges from 63.8 degrees Fahrenheit (°F) in January to 108.6°F in July. The average daily maximum temperature exceeds 100°F during June, July, August, and September (NOAA 2000), and rarely does the temperature drop below freezing.

Based on the 30-year period of 1961 through 1990, average precipitation was 4.67 inches per year in Needles. Between 1950 and 1990, the maximum annual rainfall was 9.6 inches (WRCC 2006). In a typical year, rain primarily occurs during summer thunderstorms from July through early September, or during the winter from January to March. May and June are typically the driest months. Figure 2-3 provides a graph of monthly precipitation and average monthly daytime highs and lows for the Needles meteorological station.

As summarized in *Current Conditions Report* (Alisto 1997), the predominant wind direction is south-southwest, with an average speed of 8.8 miles per hour, based on data from the Needles airport. The second most predominant wind direction is north-northwest, with an average speed of 10.7 miles per hour. Wind direction and speed are more variable at the compressor station site and adjoining areas and are largely controlled by the site topography. Station personnel report that winds at the compressor station are predominantly to the southeast (Russell 2006a).

2.3 Site Geology and Stratigraphy

This section summarizes the regional geologic setting and site stratigraphy of the study area based on published geologic studies, maps, and reports. Additional discussion and description of the geologic setting and the site stratigraphic units are presented in Volume 2 of the RFI/RI Report.

2.3.1 Regional Geology

The Topock site and study area are the Basin and Range geomorphic province, characterized by roughly parallel north/south fault-block mountains, separated by alluvial valleys (Figure 2-1). The dominant geologic feature in the vicinity of the site is the Chemehuevi Mountains, one of several metamorphic and plutonic basement core complexes exposed in southeastern California and western Arizona (Miller et al. 1983; Miller and John 1999). The Topock Compressor Station and the study area lie on the north-sloping piedmont terrace along the northern margin of the Chemehuevi Mountains.

Figure 2-4 presents a generalized geologic map of the Topock site and surrounding areas. The geologic features shown on Figure 2-4 include the principal geologic units, geologic contacts, and geologic faults mapped in the study area (Metzger and Loeltz 1973; John 1987; Howard et al. 1997). The oldest rocks in the study area are exposed in the Chemehuevi Mountains and include Precambrian and Mesozoic-age metamorphic and igneous rocks, primarily metadiorite, gneiss, and granite. Miocene-age sedimentary and volcanic rocks—associated with the tectonic uplift and faulting in the region—were deposited on the metamorphic and plutonic bedrock complex (John 1987; Miller and John 1999). Near-surface sedimentary units in the study area include Quaternary- to Recent-age alluvial fan deposits, Pliocene lacustrine deposits, and Tertiary- and Quaternary- to Recent-age fluvial deposits of the Colorado River (Figure 2-4). The alluvial fan and lacustrine deposits are generally found in the western portion of the study area, while the fluvial deposits predominate in the eastern portion of the study area adjacent to the Colorado River. The geologic formations and primary stratigraphic units at the Topock site are described in Section 2.3.3.

2.3.2 Geologic Structure

The most prominent geologic structural feature in the study area is a Miocene-age, low-angle normal fault (referred to as a detachment fault) that forms the northern boundary of the Chemehuevi Mountains (Figure 2-4). The Chemehuevi detachment fault is part of a series of low-angle detachment faults exposed within and surrounding the Chemehuevi Mountains that separate lower plate Precambrian and Mesozoic-age metamorphic and plutonic rocks from overlying upper plate pre-Tertiary metamorphic/plutonic, and Miocene volcanic and sedimentary rocks (John 1987; Howard et al. 1997).

The surface expression of the Chemehuevi detachment fault is evident as the pronounced northeast-southwest lineament that can be traced along the northern boundary of the Chemehuevi Mountains, terminating at the abrupt bend in the Colorado River east of the compressor station (see Figure 2-4 and site aerial photographs in Section 3.0). The surface trace of the detachment fault is partially concealed by younger alluvial deposits in the southwestern portion of the study area.

A major unconformity separates the bedrock formations from the overlying unconsolidated alluvial/fluvial deposits (Metzger and Loeltz 1973). In the area east of the compressor station, the thick-bedded Miocene Conglomerate has structural dip up to 40° to the northeast beneath the unconformity. Overlying alluvial deposits comprising the piedmont terraces are undeformed and have gentle structural dip of approximately 5° to 10° to the north. According to the geologic literature (Howard et al. 1997) and PG&E technical reports (PG&E 1995a), there is no evidence of continued fault movement on the detachment faults or evidence of other more recent active faulting in the study area.

2.3.3 Site Stratigraphy

The definition of geologic units and the stratigraphy at the Topock site is based on the published geologic maps and reports for the study area (Metzger and Loeltz 1973; Howard et al. 1997; John 1987) and PG&E's drilling investigations and other studies (described in Volume 2). For this RFI/RI, the stratigraphic terminology used in published reports has been modified to differentiate the site hydrostratigraphic units observed in the drilling

investigations. The terminology is considered informal stratigraphic unit naming, intended solely for the Topock project RFI/RI.

The geologic and stratigraphic units present in the study area are summarized in Table 2-1. Bedrock formations include pre-Tertiary metamorphic and igneous rocks and the Miocene Conglomerate. Overlying the bedrock formations are alluvial basin-fill deposits that include, from oldest to youngest: Basal Alluvium, Tertiary Alluvium, Bouse Formation, Older Quaternary Alluvium, and Younger Alluvium. The fluvial (river) deposits present at the Topock site include older Colorado River gravels and sediments (assumed Pleistocene-age) and younger Colorado River channel fill and fluvial deposits. Figure 2-5 presents a schematic section illustrating the distribution and relative age of the stratigraphic units encountered in the study area. The geologic formations and primary stratigraphic units are summarized below.

2.3.3.1 Bedrock Units

The consolidated bedrock that underlies the basin-fill deposits consists of Pre-Tertiary metamorphic and igneous rock (primarily grayish metadiorite, gneiss, and granitic rocks) and the Miocene Conglomerate (red-brown, cemented conglomerate, gravelly sandstone, and megabreccia). The metamorphic and igneous rocks are exposed in the Chemehuevi Mountains and surface outcrops immediately south of the compressor station. The Miocene Conglomerate is exposed in outcrops east of the compressor station along the Colorado River (Figure 2-4). In surface outcrops, both bedrock formations are locally fractured and weathered.

2.3.3.2 Tertiary Alluvium Units

Tertiary Alluvium refers to the oldest, undeformed alluvial deposits that overlie the Miocene Conglomerate and older bedrock formations in the study area. These alluvial fan deposits, termed “Tertiary Fanglomerate” by Metzger and Loeltz (1973), are composed primarily of moderately-consolidated sandy gravel and silty/clayey gravel. In surface outcrops west of the compressor station (Figure 2-4), the Tertiary Alluvium is exposed as deeply-dissected alluvial terraces with steep canyon walls. Based on hydrogeologic characteristics observed in the drilling investigations, the Tertiary Alluvium sequence is subdivided into three stratigraphic units: a Basal Alluvium depositional unit (previously referred to as either “Basal Saline unit” or “reworked Miocene Conglomerate”), and overlying lower and upper Tertiary Alluvium units (Figure 2-5).

2.3.3.3 Bouse Formation

The Bouse Formation consists of interbedded silty clay, claystone, and sandstone and is exposed in alluvial terraces and outcrops only in the western portion of the study area. Where present, the Bouse unit separates the Tertiary Alluvium from younger (Quaternary age) alluvial deposits. The Bouse represents a lacustrine (lakebed) deposit left by a Pliocene lake that covered a large portion of Mohave Valley (Howard et al. 1997). Most of the Bouse was eroded away by the Colorado River during Pleistocene and Holocene time. Although the Bouse Formation is exposed in outcrops in the Park Moabi area (Figure 2-4), the Bouse deposits were not encountered in the RFI/RI drilling investigations at the Topock site.

2.3.3.4 Quaternary Alluvium

Older (Pleistocene-age) Quaternary Alluvium, consisting of unconsolidated, sandy gravel and silty/clayey gravel, is exposed in the moderately-dissected alluvial terraces in the study area. The Older Quaternary Alluvium overlies either the Bouse Formation (where preserved in the western area) or the Tertiary Alluvium (where the Bouse was removed by erosion). In outcrop, Quaternary Alluvium is distinguished from older Tertiary Alluvium by alluvial terrace/wash slopes with moderate angle (i.e., 45-degree slopes).

Younger Alluvium includes unconsolidated, sandy gravel, and silty/clayey gravel alluvial deposits of Holocene and Recent age. This stratigraphic unit includes the youngest alluvial deposits (alluvium in streams and washes, recent alluvial/talus deposits, and windblown sand).

2.3.3.5 Fluvial (River) Deposits

Fluvial deposits of the Colorado River are present in surface outcrop and in the subsurface underlying the present Colorado River floodplain and channel. Based on geologic mapping and published reports (Metzger and Loeltz 1973; Howard et al. 1997), the Colorado River fluvial deposits within the study area are grouped into an older sequence (assumed Pleistocene-age) and a younger sequence (Holocene to Recent age). The relative age and informal stratigraphic unit descriptions of the fluvial deposits defined for this RFI/RI are shown on Figure 2-5 and Table 2-1.

Older fluvial sediments and river gravel, designated units Qrs and Qrg in Table 2-1, are exposed only in surface outcrops (above the water table) at the Topock site. The Older River Gravels include sandy, pebble-cobble gravel containing well-rounded clasts of rock types from distant and local sources, and reflects fluvial deposits of the early (Pleistocene-age) Colorado River. Fine-grained sand and silt/clay fluvial deposits (Qrs unit) also occur in surface outcrop remnants on alluvial terraces within the study area (above the water table).

The younger Colorado River fluvial deposits occur within the saturated zone underlying the floodplain and the present Colorado River channel and Topock Marsh area. For the RFI/RI hydrogeologic characterization, the younger fluvial deposits have been subdivided into four depositional units (Qr0, Qr1, Qr2, and Qr3, as depicted on Figure 2-5). The available drilling information indicates that the sediments in the younger fluvial sequence include sandy gravel, gravelly sand, well-sorted fine sand, and silt/clay deposits, which vary in thickness and distribution in the floodplain area.

2.4 Colorado River and Surface Water Features

The primary surface water feature at the site is the Colorado River and its adjacent wetlands and marshes. Figure 2-1 shows the geomorphic setting of the Colorado River and major drainages and surface water features in the region. The river system upstream of Topock, Arizona is characterized by the wide Mohave Valley floodplain, marsh, and alluvial valley. Downstream of Topock, the river traverses the exposed bedrock of the Chemehuevi Mountains of California and the northern portion of the Mohave Mountains in Arizona. The river channel narrows in the area of the Topock Gorge. Sacramento Wash is the principal dry wash surface drainage to the Colorado River from the Sacramento basin in Mohave

County, Arizona. Lake Havasu, formed in 1938 with the closure of Parker Dam, extends approximately 24 miles upstream from the city of Parker, Arizona.

The Colorado River channel ranges from approximately 600 to 700 feet wide in the area upstream of the bridge crossing at Topock. According to the BOR, when profiled near the site in 1994, the river channel was typically less than 9 feet deep with a maximum depth of 21 feet. The last major dredging in this area occurred in 1960 (Metzger and Loeltz 1973).

The flow of the Colorado River is very dynamic, fluctuating seasonally and daily largely due to upstream flow regulation. The flow of the Colorado River at the Topock site is primarily controlled by water releases at Davis Dam on Lake Mohave, approximately 33 miles upstream. River levels at the site fluctuate by 2 to 3 feet per day, and flows vary anywhere from 4,000 to 25,000 cubic feet per second according to the dam releases.

Figure 2-2 shows more detailed surface water features at the site including the Park Moabi inlet/slough, dry wash drainages, and the river floodplain and sand dune shoreline features in the study area. One of the largest incised channels is Bat Cave Wash, a north-south dry wash (ephemeral stream) adjacent to the Topock Compressor Station. Bat Cave Wash flows only briefly following intense rainfall events and drains to the Colorado River.

2.5 Site Hydrogeology and Groundwater Conditions

This section provides a general description of the Alluvial Aquifer and hydrogeologic setting at the Topock site. Additionally, this section presents a general summary of groundwater quality and groundwater flow conditions in the study area. The data and results of the specific hydrogeologic investigations and characterization completed for the RFI/RI are presented in Volume 2.

2.5.1 Hydrogeologic Setting of the Alluvial Aquifer

Following the nomenclature of Anderson, Freethey, and Tucci (1992), the study area is within the Mohave groundwater basin, which is bisected by the Colorado River. Groundwater in the Mohave basin occurs in the Tertiary and younger alluvial basin-fill deposits which include the fluvial deposits associated with the Colorado River. Based on drilling investigations and published reports, bedrock water-bearing zones occur locally where bedrock formations are weathered or fractured. No areas or locations where saturated bedrock formations are capable of significant storage, or sustained production or yield have been identified in the Mohave groundwater basin.

Figure 2-6 presents a schematic cross-section to illustrate the hydrogeologic setting at the Topock site. Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the site. The saturated portion of the alluvial fan and fluvial deposits are collectively referred to as the Alluvial Aquifer. In the floodplain area adjacent to the Colorado River, the fluvial deposits interfinger with, and are hydraulically connected to, the alluvial fan sediments. It should be noted that the divisions between the stratigraphic units do not correspond to any aquitards dividing the aquifer. The Alluvial Aquifer at the Topock site is considered to be hydraulically undivided.

The unconsolidated alluvial and fluvial deposits are underlain by the Miocene Conglomerate and pre-Tertiary metamorphic and igneous bedrock with very low permeability; therefore, groundwater movement occurs primarily in the overlying unconsolidated deposits. As noted in Table 2-1, four of the site stratigraphic units—Younger Alluvium, Older Fluvial Sediments, Older River Gravels, and the Bouse Formation—occur above the water table at the Topock site and, hence, are not part of the Alluvial Aquifer at the Topock site.

The water table in the Alluvial Aquifer is very flat throughout the study area and is typically within 1 to 2 feet of the mean river level. Due to the variable topography at the site, the depth to groundwater ranges from as shallow as 5 feet below ground surface (bgs) in floodplain wells next to the river to approximately 170 feet bgs at the upland alluvial terrace areas. The saturated thickness of the Alluvial Aquifer is about 100 feet in the floodplain and thins to the south, pinching out along the Miocene Conglomerate and bedrock surface (Figure 2-6). The available drilling information indicates the saturated Alluvial Aquifer is over 250 feet thick in the central and western areas, and more than 350 feet thick in the northern portion of the study area, where the depth to bedrock increases significantly.

2.5.2 Groundwater Quality Characteristics

The general water chemistry of the Topock study area is dominated by sodium and chloride, with a few exceptions. The TDS content of site groundwater varies considerably, ranging from as low as 300 milligrams per liter (mg/L) to over 40,000 mg/L. Most site monitoring wells are in the 1,000 to 8,000 mg/L TDS range. For comparative purposes, the state of California does not consider groundwater with TDS concentrations above 3,000 mg/L to be a potential source of drinking water. In general, high TDS at the site is associated with bedrock wells, deep alluvial/fluvial wells, and a few shallow fluvial wells. Low TDS is found in shallow floodplain wells located close to the river and in shallow wells in the western portion of the site.

Groundwater samples from both the Miocene Conglomerate and metamorphic/igneous bedrock are sodium-chloride dominated with very high TDS, which ranges from about 8,000 to 13,000 mg/L. Alluvial fan deposits, which comprise the Alluvial Aquifer in all areas of the site except the floodplain, exhibit a wide range of TDS concentrations. In general, groundwater in the alluvial deposits is sodium-chloride dominated and ranges from relatively low TDS (<1,000 mg/L) in shallow water table wells to high TDS (>10,000 mg/L) in deeper portions of the aquifer. Although the fluvial deposits are of different origin than the alluvial deposits, the two are in hydraulic communication and groundwater flows from the alluvial sediments into the fluvial deposits. The general groundwater chemistry in most of the fluvial wells in the floodplain is sodium-chloride dominated with variable TDS, and similar to alluvial deposits in groundwater chemistry. Wells very close to the river and screened at shallow depths reflect Colorado River water chemistry (consistently low TDS averaging about 600 mg/L).

2.5.3 Groundwater Flow Conditions

The Topock site is located at the extreme southern (lower) end of the Mohave Valley along the western floodplain of the Colorado River. Bedrock outcrops to the south and west of the site create barriers to groundwater flow. While the overall trend of groundwater flow

throughout most of the Mohave Valley is southerly, groundwater flow directions at the Topock site are predominantly easterly to northeasterly. Groundwater moving south down Mohave Valley is diverted to an easterly / northeasterly by the low-permeability bedrock of the Chemehuevi Mountains. Because of the relatively high permeability of the aquifer material and the limited amount of groundwater underflow and local recharge, the groundwater gradients at the Topock site are very slight. Thinning alluvial material at this end of the basin acts to force groundwater upward and toward the Colorado River.

2.5.3.1 Surface Water – Groundwater Interaction

The Colorado River is by far the greatest influence on groundwater levels at the Topock site. The stage of the Colorado River varies both daily and seasonally in response to upstream dam discharges regulated by the Bureau of Reclamation to meet water and power delivery obligations. The fluctuations in river stage cause the surface water-groundwater interaction at this site to be very dynamic. Figure 2-7 presents hydrographs for the Colorado River and selected groundwater monitoring wells located varying distances from the river. As shown on the weekly hydrograph, the river level typically fluctuates up to 3 feet in one day, and the wells closest to the river show a corresponding rapid response in groundwater elevation. Water levels in all wells located within several hundred feet from the river typically rise and fall on the order of several feet twice daily due to fluctuations in river stage. Prior to interim measures pumping, which began in March 2004, groundwater could flow toward or away from the river, depending on the river stage.

The influence of river stage on water levels is also evident in the interior wells located more than 2,000 feet from the river. The six-month hydrograph (June 2005 through June 2006) shown on Figure 2-7 further illustrates the seasonal trend in river stage and its influence on groundwater elevations at the site.

2.5.3.2 Horizontal Gradient

Horizontal groundwater flow within the Alluvial Aquifer is primarily easterly across the majority of the site, outside of areas influenced by active IM extraction or injection. In the vicinity of the IM extraction system and floodplain, horizontal gradients are strongly westward towards the actively pumping wells TW-3D and PE-1. In recent 2006 compliance monitoring data, evidence of hydraulic mounding is present in the middle and deep wells around active IM injection well IW-2.

Figures 2-8a through 2-8c present June 2006 groundwater elevation contour maps for the three depth intervals of the Alluvial Aquifer. Figure 2-8a shows the groundwater elevations for shallow wells from a manual water level measurement survey conducted on June 14, 2006. Consistent with previous sitewide maps of shallow wells, flow outside of the IM pumping center is easterly towards the Colorado River, whereas flow on the floodplain is westerly or landward towards the extraction wells.

Figure 2-8b presents groundwater elevation data taken with pressure transducers during the month of June for the mid-depth interval, along with the contours from the June 2006 IM performance monitoring report (CH2M HILL 2006a). Also shown are the groundwater elevations for monitoring wells in the IM injection area. Strong landward gradients towards the pumping center are evident in the floodplain. Mounding from injection into well IW-2 is observed in the adjacent wells (data not contoured).

Figure 2-8c presents groundwater elevation data taken with pressure transducers during the month of June for wells in the deep interval, along with the contours from the performance monitoring report. Also shown are data from the deep monitoring wells in the IM injection area. Induced landward gradients are evident throughout the floodplain, while mounding is present close to injection well IW-2 (data not contoured). The horizontal gradients in all depth intervals of the Alluvial Aquifer are strongly affected by the IM pumping and river elevations.

2.5.3.3 Vertical Gradient

Monitoring well clusters are available at the Topock site to evaluate vertical hydraulic gradients within the Alluvial Aquifer and between bedrock and the Alluvial Aquifer. In areas beyond the influence of active IM extraction or injection, the groundwater elevations in the Alluvial Aquifer wells typically display upward hydraulic gradients.

The data available from bedrock wells indicate upward hydraulic gradients between the bedrock formations and the Alluvial Aquifer. The vertical and horizontal hydraulic gradients observed in the Alluvial Aquifer and bedrock wells indicate that the study area is primarily an area of groundwater discharge, with flow upward and to the east/northeast.

The hydraulic gradients and groundwater flow in the area of the IM extraction system are described and further characterized in the June 2006 IM performance monitoring reports (CH2M HILL 2006b). Additional description of the hydraulic gradients and groundwater flow conditions at the Topock site is provided in Volume 2 of the RFI/RI Report.

2.6 Land Use and Demography

Land use and demography in the area is described in the *Current Conditions Report* for the Topock Compressor Station area (Alisto 1997). The land-use information obtained for that report is still generally applicable and updated and briefly summarized below.

The compressor station is located in a sparsely-populated, rural area. The surrounding land is publicly owned (mostly by the federal government) and has important spiritual meaning to the Fort Mojave Indian tribe and other lower Colorado River Indian tribes Industrial or commercial developments within a 1-mile radius include the existing compressor station and IM No. 3 treatment plant facility. The nearest residents are located in Topock, AZ, a community of about 20 people in a small mobile home park near the Topock Gorge Marina. Most of the residents in Topock are retired senior citizens who live in the area part of the year, typically from late fall through spring. There are also a few permanent homes (i.e., the homes are occupied all year) located on the southern side of I-40.

The largest nearby community is Golden Shores, Arizona (population approximately 3,000), located approximately 8 miles to the northeast and on the opposite side of the Colorado River from the compressor station. The city of Needles, California, with a population of approximately 4,800, is located approximately 15 miles northwest of the facility.

Moabi Regional Park is a recreational facility operated by the San Bernardino County Department of Parks and Recreation. It is located on land leased from BLM and lies approximately 1 mile northwest of the compressor station on the west shore of the Colorado River. The park encompasses approximately 1,050 acres, includes a boat marina and 105

campsites, and provides access to the river for various sport and recreational activities. There are no year-round residents because campers are limited to 5-month stays. The park does not keep records of residency; therefore, the number of people at the park at any given time is unknown.

A major gas utility and transportation corridor is located within the project site. This corridor includes PG&E's two natural gas transmission pipelines, four natural gas transmission pipelines operated by other companies, the Burlington Northern Santa Fe Railway, and the I-40 freeway. Other developed land uses within the project site include, National Old Trails Highway, former Route 66, and various unnamed access roads. In addition, numerous groundwater well clusters, related to the ongoing groundwater investigation activities, are located throughout the site.

The HNWR encompasses approximately 37,515 acres along the Colorado River in Mohave and La Paz Counties, Arizona and in San Bernardino County, California (USFWS 2006). Most of the refuge extends from the upper end of Topock Marsh southward to the head of Lake Havasu on the Arizona side of the river. A small portion of the refuge borders the compressor station. Recreational activities at the HNWR include sightseeing, bird watching, fishing, hunting, camping and canoeing. Prior damming and channelization of the Colorado River have significantly altered the aquatic, marsh, and riparian habitats associated with the river. These water control and diversion actions have contributed to increased housing development along the river and facilitated an increase in the amount of river-related recreation (including watercraft, fishing, and hunting).

2.7 Cultural Resources

The study area lies within the Lower Colorado River Valley, a large area with important cultural and/or spiritual meaning to Native American Tribes. The area is the homeland of the Aha Makav, or Mojave tribe, and a place of great traditional and spiritual use that knows no physical boundaries for the Mojave. The plants, the animals, the river, the landforms, and the material remains of the past all hold deep meaning.

2.7.1 Ethnography and Ethnohistory

The Aha Makav were agricultural people who occupied the Colorado River Valley from just below Black Canyon (Hoover Dam) to the mouth of the Bill Williams River (near Parker Dam, Arizona). The core of the Mojave territory was the Mohave Valley (Stewart 1983). Mojave ethnography and ethnohistory have been documented by Kroeber (1925, 1974), Castetter and Bell (1951), Stewart (1983), Sherer (1994), and Furst (2001), and are summarized by CH2M HILL (2004).

The Aha Makav were generally far removed from the sixteenth- and seventeenth-century Spanish influences that affected the native inhabitants of western and southwestern North America. Although the first known contact with Spaniards occurred relatively early, when Juan de Oñate encountered the Mojave in 1604, no missions or Spanish settlements were ever established in the territory. They retained their autonomy and continued their traditional lifeways until the mid-nineteenth century, when the flow of emigrants en route to California began to increase. A United States military post—later named Fort Mojave—

was established in the area after the Aha Makav reportedly had attacked a wagon train bound for California in 1858.

Three federally-recognized tribal organizations currently hold large reservations in the general area. The Fort Mojave Indian Tribe of Arizona, California and Nevada holds 32,959 acres north of Needles. The Indian Tribe of the Chemehuevi Reservation, California has a reservation of 30,653 acres south of the project area along Lake Havasu. Farther south, the Colorado River Indian Tribes of the Colorado River Indian Reservation, Arizona and California hold 134,500 acres in California and Arizona. Six other tribes were consulted by the BLM: Quechan Tribe of the Fort Yuma Indian Reservation, California & Arizona; Cocopah Tribe of Arizona; Havasupai Tribe of the Havasupai Reservation; Hualapai Indian Tribe of the Hualapai Indian Reservation; Yavapai-Prescott Tribe of the Yavapai Reservation; and Twenty-Nine Palms Band of Mission Indians of California.

2.7.2 Prehistory

The prehistory and archaeology of the area are not well understood by archaeologists for various reasons. Dispersed settlement patterns, poor conditions for preservation, the destruction or inundation of sites during dam and reservoir construction, and limited inventory and investigation of known sites have contributed to the lack of knowledge about the region. Based on investigations in the areas to the east and west, most archaeologists agree that initial occupation occurred during terminal Pleistocene time, and that Paleoindian adaptations were replaced by Archaic hunter-gatherers some 7,500 years ago. Around 1,500 years ago, Archaic adaptations gave way to the intensified agricultural practices followed by the historic Yuman inhabitants of the study area.

Among others, Rogers (1945), Irwin-Williams (1979), Schroeder (1979), McGuire and Schiffer (1982), Moratto (1984), and Huckell (1996) have offered syntheses of local prehistory and archaeology. These are summarized in some detail by CH2M HILL (2004) and Applied EarthWorks (2005).

2.7.3 History

As summarized by CH2M HILL (2004), the principal historical themes related to the study area are transportation and energy development. Between 1846 and 1869, the US military surveyed the area for wagon roads and, in 1857, Captain Edward Beale surveyed a route between Fort Defiance, New Mexico and the Colorado River (Jackson 1964). Beale's wagon road, however, reached the river about 20 miles north of the project area at the north end of the Mohave Valley. Early wagon routes crossed the river at that point and continued west toward Barstow.

The Southern Pacific Railroad first bridged the Colorado River near Needles in 1883. A crossing near Topock was not built until 1890, when the Red Rock Bridge replaced several earlier structures near Needles that had been repeatedly washed away by the river (Rowe 1947). An automobile ferry was built the same year but could not survive the river's swift currents and many shoals. The Old Trails Arch Bridge, a highway bridge erected in 1916, became part of the National Old Trails Highway, the precursor to Route 66.

Subsequent transportation developments included the establishment of the original Route 66 in the 1920s; a mid-1940s realignment and expansion of the railroad right-of-way

(including the construction of a new railroad roadbed and bridge); and the rerouting of Route 66 to the old railroad roadbed and bridge. Additional federal highway construction occurred in the 1950s, and I-40 was built in the 1960s. Today the project area remains an important transportation corridor, with railroad traffic using the Burlington Northern Santa Fe Railroad bridge, truck and automobile traffic crossing the river on the I-40 bridge, and natural gas passing through several large interstate pipelines.

No features associated with ranching, farming, or historical settlements are located in the study area. The project area does contain several abandoned segments of the National Old Trails Highway and Route 66 and some associated features and refuse deposits. A portion of the National Old Trails Highway and Route 66 is currently used as the entrance road to the compressor station. The "Teapot Dome" restaurant and gas station was formerly located on a stretch of the National Old Trails Highway/Route 66 on a bench above the river just west of the Old Trails Arch Bridge. The former site of the Teapot Dome is located at the very northeast of corner of the compressor station. It is unknown when the Teapot Dome was built; however, based on aerial photography, the Teapot Dome was present at the site in 1936 (the earliest aerial photograph available). It was still present in 1947 but appears to have been demolished prior to, or during construction of, the compressor station in 1951.

2.7.4 Previous Archaeological Surveys

Between the mid-1970s and 2004, nine archaeological surveys were conducted within the project area. The first survey was conducted by Arizona State University (Fryman 1976); the study identified 16 cultural sites or features. Other important studies included Van Bueren (1986) who recorded an abandoned section of the original Route 66 between Park Moabi Road on the west and existing U.S. Route 66 on the east and Peyton's (1986) study that focused on the Topock Maze.

More recently, CH2M HILL (2004) inventoried approximately 155 acres of the study area. In total, CH2M HILL (2004) documented eight newly discovered sites and revisited three others. In addition, the survey identified five new features associated with Route 66.

In 2004 and 2005, Applied EarthWorks (2005) conducted a cultural resources survey of an approximately 1,528-acre area. A total of 149 prehistoric and historic resources have now been documented; this includes 136 prehistoric archaeological sites and 13 historic resources. In addition, 33 isolated finds (32 prehistoric and one historic) were also documented.

The Topock Maze is an important archeological feature located within the project site. The maze was created by modifying the desert landscape through creation of long parallel rows of stacked or piled dark colored desert-varnished rocks. These dark lines alternate with light bands formed where the varnished desert pavement was removed. The resultant pattern, also called the "Mystic Maze," carries cultural and spiritual significance for the Fort Mojave Indian tribe. One of the three manifestations of the Maze in the vicinity was included in the National Register of Historic Places in 1978 for its unique scale and design and for its potential to provide data on geoglyph (ground markings) construction and use. Although the physical aspects of the Maze have been damaged by highway and railroad construction, and other forms of modern land use, the entire area originally occupied by the Maze holds important spiritual meaning to the Fort Mojave Indian tribe.

The vast majority of recorded prehistoric cultural resources are located north of Interstate 40 (I-40) and the Burlington Northern-Santa Fe Railroad on dissected terraces and mesa tops and edges. According to Applied EarthWorks (2005), the 136 prehistoric sites that occur within the surveyed area consist of 57 lithic assay stations, 34 lithic assay/reduction stations, and 17 lithic quarry/assay/reduction areas. Other prehistoric site types documented within the project area include: lithic reduction areas (6); desert geoglyph/intaglio sites (4); possible temporary camps (3); trail alignments (3); rock alignments (3); simple lithic scatters (2); lithic assay/reduction stations that also contain prehistoric ceramics (2); rock rings (2); one complex lithic scatter (i.e., a site containing both flaked stone and ground stone artifacts); one ceramic scatter; and one rock shelter.

Historical resources documented in the 155-acre survey area (CH2M HILL 2004) include various segments of the oil and soil roadbed of the original 1926-1947 alignment of United States Route 66 and associated features, and a segment of the 1947-1966 paved alignment of United States Route 66 (currently National Trails Highway). Segments of the prepared gravel roadbed of the National Old Trails Highway and associated features are within the survey area. Also in the survey area are the razed remains of the El Rancho Colorado Roadhouse and Gas Stop, located along the 1947–1966 paved alignment of United States Route 66, and a tourist rest stop located along a newly recorded segment of the National Old Trails Highway, which is directly adjacent to Locus C of the Maze. Other historical resources include a segment of the 1890–1947 Atlantic & Pacific/Atchison Topeka & Santa Fe Railroad (AT&SF) Right-of-Way which was capped by the 1947–1966 paved alignment of United States Route 66, and a short segment of a railroad grade or siding within the survey area. Other historic sites are detailed in the CH2M HILL report (2004) and Applied EarthWorks (2005).

2.8 Ecology Resources

The area is characterized by arid conditions and high temperatures. The site consists of a series of terraces divided by dry desert washes. The landscape within the proposed project area is considerably eroded and can most suitably be described as badlands. The lands are made up of small- to moderately-sized terraces with very steep slopes. Terraces occurring in the project area are homogeneous, comprising rocky soils with very sparse vegetation.

The Colorado River is the primary aquatic habitat. The river is approximately 700 to 900 feet wide and 8 to 15 feet deep in this area. The main surface water drainage from the project area into the Colorado River is from Bat Cave Wash and a large unnamed desert wash with several tributaries located to the west. These ephemeral desert washes are dry most of the year.

As described in *Current Conditions Report* (Alisto 1997), the site is located either within the Mojave Desert province of California (Vasek and Barbour 1977), the Colorado Desert (Rowlands et al. 1982), or the boundary between these two deserts (Johnson 1976). However, the boundary between these deserts in this area is rather arbitrary, having a broad transition area (Vasek and Barbour 1977). Structurally-diverse vegetation in the project area is primarily limited to the Colorado River floodplain and the ephemeral washes.

Plant and wildlife species that are listed as threatened or endangered by the USFWS and species having equivalent status under the California Department of Fish and Game are provided protection under the Federal Endangered Species Act (FESA) and California Endangered Species Act, respectively. Critical habitat for a listed species is defined by FESA as specific areas within the geographic range of the species that contain the physical and biological features that are essential for the conservation of the species.

Federal agencies are required, under Section 7 of FESA, to consult with the USFWS for any federal action that may adversely affect listed species or modify critical habitat. A biological opinion is issued by the USFWS to determine if the action will jeopardize the continued existence of the species. PG&E has been issued a non-jeopardy biological opinion for ongoing maintenance activities PG&E's gas pipeline system in the California desert on lands managed by the BLM and its effects on the desert tortoise (*Gopherus agassizii*) and its critical habitat (USFWS 2000).

2.8.1 Flora

There are five types of plant communities in the vicinity of the project area, with the boundary between these communities characterized by a transitional zone in which representative species from each community are found. The plant communities at the site consist of Mojave creosote bush scrub, Mojave wash scrub, desert riparian, tamarisk thicket, and freshwater marsh.

- Mojave Creosote Bush Scrub: The dominant plant community is creosote bush scrub. The area is sparsely vegetated with widely-distributed creosote bushes (*Larrea tridentata*). Other plant species that occur within this plant community include burrobush (*Ambrosia dumosa*), allscale (*Atriplex polycarpa*), split grass (*Schismus* sp.), spineflower (*Chorizanthe* sp.), desert trumpet (*Eriogonum inflatum*), beavertail cactus (*Opuntia basilaris*), golden cholla (*Opuntia echinocarpa*), brittlebush (*Encelia farinosa*), cheesebush (*Hymenoclea salsola*), dalea (*Dalea mollisma*), red barrel cactus (*Ferocactus pilosus*), sweetbush (*Bebbia juncea*), and ratany (*Krameria erecta*). Also, during normal to wet years, dense growth of annuals occurs, including brittle spineflower (*Chorizanthe brevicornu*), buckwheat (*Eriogonum sp.*), plantain (*Plantago sp.*), Mediterranean grass (*Schismus sp.*), scattered pebble pincushion (*Chaenactis carphoclinia*), langloisia (*Langloisia setosissma*), peppergrass (*Lepidium sp.),* and Arizona lupine (*Lupinus arizonicus*).

- Mojave Wash Scrub: Another common community of the Mohave Desert, it is found in the sandy, gravelly bottoms of the washes and drainages in the area. The wash floors are relatively barren of vegetation and have a sand, gravel, and cobblestone substrate. Although the drainages occur within the creosote bush scrub plant community, these ephemeral washes contain small patches of acacia *(Acacia* and*greggii),* smoke tree (*Dalea spinosa*), palo verde (*Cercidium microphyllum*), and honey mesquite (*Prosopis glandulosa*). Additionally, this community typically consists of scattered sweetbush and burrobush, with occasional *brittlebush (Encelia farinosa*), wire-lettuce (*Stephanomeria pauciflora*), desert-lavender (*Hyptis emoryi*), and creosote bush. Common annuals include Mediterranean grass, Arizona lupine, brittle spineflower, and phacelia (*Phacelia sp.*).

- Desert Riparian: Desert riparian habitat exists at the confluence of Bat Cave Wash and other washes with the Colorado River. This plant community comprises scattered honey

mesquite (*Prosopis glandulosa*), palo verde (*Cercidium microphyllum*), and tamarisk (*Tamarix ramosissima*) amongst drifting sand dunes.

- Tamarisk Thicket: Tamarisk thicket exists along the shoreline of the Colorado River. This plant community consists of dense monotypic stands of tamarisk. This exotic plant has invaded several riparian habitats. Although this plant species is not known to provide optimal wildlife habitat, it does provide a roosting structure for several avian species.
- Freshwater Marsh: Little submergent vegetation exists within the river. Submergents include hydrilla (*Hydrilla verticillata*) and eel grass (*Zostera sp.*). Bat Cave Wash and other unnamed washes empty into freshwater marshes adjacent to the Colorado River. Like other freshwater marshes associated with the river, this community is characterized by perennial, emergent monocots that form completely closed canopies and is dominated by bulrush (*Scirpus sp.*) and cattail (*Typha sp.).* Other species typical of this community include woolly sedge (*Carex lanuginosa*), sedge (*Carex sp.*), spikerush (*Eleocharis sp.*), hydrocotyle (*Hydrocotyle sp.*), and common reed (*Phragmites australis*).

The slender-horned spineflower *(Dodecahema leptoceras)* is listed as an endangered plant species by the California Department of Fish and Game and the USFWS. This plant may occur in the Mojave creosote bush scrub and Mojave wash scrub communities within 1 mile of the project site. Additionally, the BLM has identified several sensitive plants, including the ocotillo (*Fouquieria splendens*), palo verde, acacia, mesquite, and all cactus species. The following BLM-listed sensitive species occur at the project site: ocotillo, palo verde, acacia, mesquite, golden cholla, and beavertail cactus.

2.8.2 Fauna

The aquatic habitat of the Colorado River supports several fish species listed as endangered, including the Colorado pikeminnow (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), and bonytail chub (*Gila elegans*). Additionally, game fish species, including striped bass (*Morone saxatillis*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), flathead catfish (*Pylodictis olivaris*), and channel catfish (*Ictalurus punctatus*), were introduced into the river. Avian species commonly associated with the river include American coot (*Fulica americana*), mallard (*Anas platyrhynchos*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), great blue heron (*Ardea herodias*), and belted kingfisher (*Ceryle alcyon*). Mammalian species may include coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), beaver (*Castor canadensis*), and raccoon (*Procyon lotor*).

Terrestrial wildlife diversity and abundance are considered low at the site. In addition, due to the disturbed nature of the land at the project site and adjacent natural barriers such as the Chemehuevi Mountains and Colorado River, a continuous wildlife corridor is not available. This greatly inhibits movement of terrestrial wildlife species onto the site. However, the occurrence of trees and patches of native vegetation near the Colorado River may provide limited habitat for avian species and other common wildlife species.

Although the tamarisk thicket provides habitat and nest sites for some wildlife, many biologists conclude that it provides low-quality habitat for most native amphibians, reptiles, birds, and mammals. However, some literature has documented southwestern willow flycatchers (*Empidonax traillii extimus*), which are listed as endangered, as nesting in the

tamarisk thickets near watercourses, including the Colorado River (McLeod et al. 2005). Although tamarisk is not known to provide optimal wildlife habitat, the trees appear to provide the only significant roosting and nesting structure due to limited structural tree diversity in the area.

The terrestrial habitat supports various wildlife species. Reptiles that may occur in the area include chuckwalla (*Sauromalus obesus*), side-blotched lizard (*Uta stansburiana*), western whiptail lizard (*Cnemidophorus tigris*), zebra-tailed lizard (*Callisaurus draconoides*), desert iguana (*Dipsosaurus dorsalis*), coachwhip (*Masticophis flagellum*), gopher snake (*Pituophis melanoleucus*), western diamondback rattlesnake (*Crotalus atrox*), and Mojave rattlesnake (*Crotalus scutulatus*). Avian species include red-tailed hawk (*Buteo jamencensis*), California quail (*Callipepla californica*), mourning dove (*Zenaida macroura*), common raven (*Corvus corax*), song sparrow (*Melospiza melodia*), Canyon wren (*Catherpes mexicanus*), and brewer's blackbird (*Euphagus cyanocephalus*). Small mammals may include deer mouse (*Peromyscus maniculatus*), Merriam's kangaroo rat (*Dipodomys merriami*), desert woodrat (*Neotoma lepida*), California ground squirrel (*Spermophilus beecheyi*), desert cottontail (*Sylvilagus audubonii*), and black-tailed hare (*Lepus californicus*). Predators may include coyote (*Canis latrans*), desert kit fox (*Vulpes macrotis)*, American badger (*Taxidea taxus*), and bobcat (*Lynx rufus*).

2.8.3 Threatened or Endangered Species

Several threatened or endangered species (state-listed and federally-listed) could occur in or near the project area.

The desert tortoise (*Gopherus agassizii*) is the only threatened (state and federal) wildlife species that could occur in the Mojave creosote bush scrub or Mojave wash scrub communities. Designated critical habitat for the desert tortoise is not located within the study area but is within the project region. Threats to the tortoise include predation, disease, and habitat loss. The 2005 and 2006 tortoise protocol surveys have not detected recent activity of the species within the study area. However, several old desert tortoise carcasses have been documented within the study area indicating historical use.

The listed threatened or endangered wildlife species that could occur within the riparian plant community in the study area vicinity include the endangered (state) western yellow-billed cuckoo *(Coccyzus americanus occidentalis)*, the endangered (state) and threatened (federal) bald eagle *(Haliaeetus leucocephalus)*, the endangered (state) Gila woodpecker *(Melanerpes uropygialis)*, the endangered (state) elf owl *(Micrathene whitneyi)*, and the threatened (state) Arizona Bell's vireo *(Vireo bellii arizonae)*. In addition, the endangered (federal and state) southwestern willow flycatcher has historically been observed breeding along the Colorado River. According to the Southwestern Willow Flycatcher Recovery Plan, the largest breeding population (21 territories) currently known along the Colorado River is found at Topock Marsh (USFWS 2002) located approximately 1.3 miles northeast of the project site. Designated critical habitat for the southwestern willow flycatcher does not exist within the study area. The 2005 and 2006 flycatcher protocol surveys have not positively detected this species within the study area.

Within the freshwater marsh habitat, a listed species that occurs in the study area is the threatened (state) and endangered (federal) Yuma clapper rail *(Rallus longirostris yumanensis)*. Habitat requirements for the rail comprise large areas of emergent marsh

containing cattails and bulrush that are dissected by narrow water channels. Habitat loss is a major threat to the rail. Critical habitat has not been designated for this species. Based on past USFWS protocol surveys, this avian species has been observed at the Topock Marsh and Marina on the Arizona side of the Colorado River.

The fish species that are federally listed as threatened or endangered wildlife species that may occur within the Colorado River in the study area vicinity include the bonytail chub *(Gila elegans)*,[1] Colorado pikeminnow *(Ptychocheilus lucius)*, and the razorback sucker *(Xyrauchen texanus)*. Designated critical habitat for the bonytail chub is within the study area. Threats to these species include predation by introduced game fish species, poor water quality and flows, dams, and poor land management.

The Nelson's bighorn sheep (*Ovis canadensis nelsoni*) is not listed under FESA or California Endangered Species Act. However, it is a California species of concern. This species inhabits steep, rocky terrain in the higher mountains of the area including the White, Chocolate, Chemehuevi, and Sacramento Mountains. The sheep do not inhabit the lowlands near the river. The primary threat to the sheep is disease.

[1] This fish is also often referred to as the bonytail.

TABLE 2-1
Site Hydrostratigraphic Units, June 2006 Update
RCRA Facility Investigation/Remedial Investigation Report (Volume 1)
PG&E Topock Compressor Station

Stratigraphic Age	**Site Hydrostratigraphic Units**			
	Alluvial Deposits		**Fluvial Deposits**	
Holocene	**Younger Alluvium** surficial deposits & recent alluvial sediments in washes	**Qya**	**Upper Fluvial Sand & Silt** (Floodplain Area)	**Qr3**
			Middle Fluvial Deposits (Floodplain Area)	**Qr2**
			Lower Fluvial Deposits (Floodplain Area)	**Qr1**
			Colorado River Channel Fill fluvial deposits in paleo-channel	**Qr0**
Pleistocene	**Older Quaternary Alluvium** alluvial terraces, composed of unconsolidated sandy gravel & silty/clayey gravel	**Qoa**	**Older Fluvial Sediments** (surface outcrop)	**Qrs**
			Older River Gravels (surface outcrop)	**Qrg**
Pliocene	**Bouse Formation (Tb)** lacustrine deposits (clay & sand)			
Pliocene to Late Miocene	**Tertiary Alluvium - Upper**	**Toa2**	Moderately consolidated, undeformed, older alluvial fan deposits (sandy gravel, gravelly sand, silty/clayey gravel) = Tertiary Fanglomerate of Metzger & Loeltz, 1973	
Late Miocene	**Tertiary Alluvium - Lower**	**Toa1**		
	Basal Alluvium	**Toa0**		
angular unconformity (post-extension erosion)				
Middle Miocene	**Miocene Conglomerate**	**Tmc**	consolidated conglomerate & sandstone containing rock fragments & megabreccia derived from Chemehuevi Mountains	
unconformity & detachment faulting				
Pre-Tertiary	**Metamorphic & Igneous Bedrock**	**pTbr**	metadiorite, gneiss & granitic bedrock exposed in Chemehuevi Mountains & underlying the groundwater basin	

Notes:

1. Hydrostratigraphic units that comprise the Alluvial Aquifer in the Topock site area are shaded yellow.
2. Bedrock formations, grey shaded, are essentially impermeable but may locally yield water where fractured.
3. Within the Topock site area, the Bouse Formation, Younger Alluvium, Older Fluvial Sediments and Older River Gravels occur above the water table.
4. Stratigraphic age assignments are from published geologic reports and are generalized for units in the study area .