FINAL REPORT

Groundwater Management Plan - 2014 Update

28 May 2014

Prepared for

Twentynine Palms Water District

72401 Hatch Road
Twentynine Palms, CA 92277-2935

Prepared by

Kennedy/Jenks Consultants

303 Second Street, Suite 300 South
San Francisco, California 94107

415-243-2150
www.kennedyjenks.com

K/J Project No. 1365022*00

Kennedy/Jenks Consultants

303 Second Street, Suite 300 South
San Francisco, California 94107
415-243-2150
FAX: 415-896-0999

Twentynine Palms Groundwater Management Plan 2014 Update

28 May 2014

Prepared for

Twentynine Palms Water District
72401 Hatch Road
Twentynine Palms, California 92277-2935

K/J Project No. 1365022*00

Table of Contents

Table of Contents (cont'd)

List of Tables

List of Figures

List of Appendices

A	Resolution of GMP Adoption
B	Monitoring Plan
C	Hydrologic Water Balance
D	Groundwater Model Update

List of Abbreviations

AB	Assembly Bill
af	Acre-feet
afy	Acre-feet per year
As	Arsenic
asl	Above sea level
bgs	below ground surface
BMOs	Best Management Objectives
BMPs	Best Management Practices
CDPH	California Department of Public Health
CEC	Contaminant of emerging concern
City	City of Twentynine Palms
County	San Bernardino County
CUWCC	California Urban Water Conservation Council
District	Twentynine Palms Water District
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
ET	Evapotranspiration
ft/d	Feet per day
ft^2/d	Square feet per day
GMP	Groundwater Management Plan
gpcd	Gallons per capita per day
gpm	Gallons per minute
GPP	Groundwater Protection Plan
K	Hydraulic Conductivity
Marine Base	Marine Air Ground Task Force Training Command Center
MBAS	Methylene Blue Activate Substances
MCL	Maximum Contaminant Level
mgd	Million gallons per day
μg/L	Micrograms per liter
mg/L	Milligrams per liter
μ□	micromhos
MSL	Mean Sea Level
MWA	Mojave Water Agency
MWD	The Metropolitan Water District of Southern California
OWTS	Onsite Wastewater Treatment System

PCAs	Potentially Contaminating Activities
PHG	Public Health Goal
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SOI	Sphere of Influence
Ss	Specific storage
Sy	Specific yield
SWRCB	State Water Resources Control Board
T	Transmissivity
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WSA	Water Supply Assessment

Section 1: Introduction

This updated Groundwater Management Plan (GMP) was prepared in accordance with Assembly Bill 3030 (AB 3030), also called the Groundwater Management Act (Section 10750 et. seq. of the California Water Code) for the Twentynine Palms Water District (TPWD or District) to protect the quantity and quality of groundwater within its service area.

1.1 Plan Objectives

The GMP serves as a planning tool to assist the District to maintain safe, sustainable, and high quality groundwater resources in the long-term. Groundwater management is planned and coordinated locally to ensure a sustainable groundwater basin to meet future water supply needs. The objective of the updated GMP is to address issues of "aquifer health" and "groundwater sustainability". These issues include:

- Maintain sustainable long-term water supplies
- Treatment of natural water quality constituents
- Wastewater management especially of septic tanks
- Providing water supply for anticipated population growth

The GMP is considered as a "living document" that the District intends to update periodically to report on the progress made in managing groundwater resources and to reflect the amendments to the California Water Code. This Groundwater Management Plan Update was prepared to expand further on the role of the District in the management of the local groundwater resources and water quality based on the substantial work that has been completed since the 2008 Update (Kennedy/Jenks, 2008).

1.2 Plan Requirements and Organization

AB 3030 was intended to provide local public agencies increased management authority over groundwater resources. Any local public agency which provides water service to all or a portion of its service area and whose service area includes all or a portion of a groundwater basin may adopt a GMP. AB 3030 was amended in 2002 with the passage of The Groundwater Management and Planning Act of 2002 (SB 1938).

The Twentynine Palms Groundwater Management Plan includes three types of components: SB 1938 and AB 359 mandatory components, AB 3030 and SB 1938 voluntary components, and DWR Bulletin 118-suggested components (DWR 2003). These components are addressed in the GMP, and Table 1-1 identifies where in this GMP the information addressing each of these components can be found.

A GMP is a required "baseline" document for agencies seeking State grant funding opportunities. SB 1938 requires that for an agency to be eligible for state funding from the Department of Water Resources (DWR), the GMP must incorporates the SB 1938 Mandatory Components listed in Table 1-1 (DWR, 2003).

TABLE 1-1
LEGISLATIVE REQUIREMENTS SUMMARY

Components Section	Section
SB 1938 and AB 359 Mandatory Components	
1. Documentation of public involvement statement	Sec. 1.3, App. A
2. Basin Management Objectives (BMOs)	Sec. 6
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping	Sec. 4,5.4 and 6.5, App. B
4. Plan to involve other agencies located in the groundwater basin	Sec. 6.6
5. Adoption of monitoring protocols	Sec. 6.5, App. B
6. Map of groundwater basin boundary, as delineated by DWR Bulletin 118, with agency boundaries that are subject to GMP	Sec. 2.3
7. For agencies not overlying groundwater basins, prepare the GMP using appropriate geologic and hydrogeologic principles	Not Applicable
8 Map identifying the substantial recharge areas to be provided to local planning agencies (new as of January 1, 2013	Sec. 5.5
AB 3030 and SB 1938 Voluntary Components	
1. Control of saline water intrusion	Sec. 5.6.1
2. Identify and manage well protection and recharge areas	Sec 5.6.3
3. Regulate the migration of contaminated groundwater	Sec 5.6.2
4. Administer well abandonment and destruction program	Sec. 5.6.5
5. Control and mitigate groundwater overdraft	Sec. 4.5.1
6. Replenish groundwater	Sec. 4.5.3 and 6.7
7. Monitor groundwater levels	Sec. 6.5, App. B
8. Develop and operate conjunctive use projects	Sec. 4.5.3 and 6.7
9. Identify well-construction policies	Sec. 5.6.4
10. Develop and operate groundwater contamination cleanup, recharge, storage,	Sec 4.5.3
11. Develop relationships with State and federal regulatory agencies	Sec. 6.6
12. Review land use plans and coordinate with land use planning agencies to assess activities that create reasonable risk of groundwater contamination	Sec. 6.6
DWR Bulletin 118 Suggested Components	
1. Manage with guidance of advisory committee	Sec. 6.6
2. Describe area to be managed under GMP	Sec. 2
3. Create links between BMOs and goals and actions of GMP	Sec. 6
4. Describe GMP monitoring programs	Sec. 6.5, App. B
5. Describe integrated water management planning efforts	Sec. 6.6
6. Report of implementation of GMP	Sec. 6.5
7. Evaluate GMP periodically	Sec. 6.7

1.3 Plan Preparation and Adoption Process

The District Board of Directors invited public comment by holding a public hearing on September 25, 2013 to consider adopting the intent to prepare the GMP. The item was included on the Board agenda and was published in local media outlets in the area. After the public hearing, the Board passed Resolution 13-17 declaring the District's intention to amend the District Groundwater Management Plan. The September 25, 2013 Board agenda, minutes and Resolution 13-17 are included in Appendix A. For those who could not attend, the meeting was televised on a local cable channel station (Time Warner Cable Channel 10).

The District Board of Directors held a second public hearing on April 23, 2014 to present a Draft GMP to the public and solicit comments to the plan. The Draft GMP was distributed to key stakeholders prior to the hearing. The public was given an opportunity to ask questions at the hearing and interested parties were invited to participate in development of the GMP. If the parties could not attend the public hearing, they could express their interest in writing to the District as explained in the public notice. Water managers at neighboring water agencies were also notified of the GMP process. The April 23, 2014 public hearing notifications, agenda, and minutes are included in Appendix A.

The District Board of Directors held a third public hearing on May 28, 2014 to consider adoption of the final GMP. The GMP was adopted by the District Board of Directors by passing Ordinance 95 on May 28, 2014. Ordinance 95 is presented in Appendix A.

Section 2: GMP Management Area

This section identifies the GMP management area and, as required, a map showing the DWR groundwater basins within and adjacent to the GMP area, as defined by DWR Bulletin 118 along with a description of the physical structure. A more detailed description of the local groundwater conditions in the TPWD area is presented in Sections 3 and 4.

2.1 Twentynine Palms Water District

The District encompasses approximately 87 square miles and includes the City of Twentynine Palms (City) and a portion of the areas outside the City (Figure 2-1). The management area for this GMP includes the groundwater basins and subbasins underlying the TPWD service area. Within the GMP management area, the groundwater basins are compartmentalized into a number of smaller subbasins that are more or less separated from one another by hydrologic barriers, including bedrock ridges, faults, and folds. The degree of separation between these subbasins is dependent upon the character of the barriers separating them. Figure 2-1 shows the subbasins in the TPWD area.

Groundwater is the primary source of water in the GMP management area. Increased pumping to meet the needs of an increasing resident population has resulted in groundwater overdraft in parts of the groundwater basin. Prior to 1954, the Twentynine Palms area was served by three privately owned water companies: Abell Water Company, Condor Mutual Water Company, and Pacific Water Company. TPWD was formed in 1954 and immediately purchased the three water companies. Their wells, storage facilities, and piping served as the initial water system for the District. Historical pumping and water deliveries by the District have steadily increased since its formation in the mid-1950s. Annual pumping in the 1990s regularly exceeded 900 million gallons, (approximately 2,760 afy), with an average daily delivery per service connection slightly under 400 gallons.

The District collects groundwater level, water quality and water production data in the management area for use in groundwater management and other reporting purposes. The GMP monitoring plan is presented in Appendix B. In addition, the USGS currently collects groundwater level monitoring primarily associated with the Marine Base that includes several wells in the Twentynine Palms area. These are posted on the DWR Water Data Library web site at http://www.water.ca.gov/waterdatalibrary/. These data are also posted on the DWR California Statewide Groundwater Elevation Monitoring (CASGEM) web site and can be downloaded from http://www.water.ca.gov/groundwater/casgem/.

2.2 Regional Water Purveyors

Figure 2-2 includes areas from the Town of Yucca Valley to Twentynine Palms where groundwater management is covered by several entities in addition to TPWD. Other local and regional entities located immediately adjacent or in the vicinity of the GMP area are shown in Figure 2-3. Figure 2-4 shows the name of the DWR Groundwater Basin underlying the other local and regional entities. A brief description of the neighboring water purveyors includes:

- Mojave Water Agency (MWA) is a regional wholesale water provider to retail water purveyors that serve a large area of the Mojave River Valley and the Morongo Basin. MWA was found in 1960 due to concerns over declining groundwater levels. MWA is one of the State Water Project (SWP) contractors and serves an area of 4,900 square miles of the High Desert in San Bernardino County. Through MWA, imported water has become available for groundwater recharge in the Town of Yucca Valley and Joshua Tree.

- Joshua Basin Water District (JBWD) is part of MWA and lies on the western boundary of TPWD. Its service area covers a 96-square mile area between Yucca Valley, Twentynine Palms, Joshua Tree National Park and the Marine Base. JBWD serves 4,426 connections in 2009 with local groundwater from the Joshua Tree (DWR Number 7-62) and Copper Valley Groundwater Basins (DWR Number 7-11) to the west of TPWD. The JBWD Recharge Project will create a mechanism for JBWD to use 1,000 afy of imported SWP water for local groundwater recharge.

- The Marine Corps Air Ground Combat Center (MCAGCC or Marine Base) is a United States Marine Corps base that lies along the northern boundary of TPWD. The developed portion of the base covers 1.4 square miles in the Morongo Basin and had a total population of 8,413 in 2000. The developed portion is included within the City. The Marine Base provides its own water supply from groundwater primarily from near Surprise Springs in the Deadman Valley Groundwater Basin (DWR Number 7-13), located north of the Twentynine Palms Valley Groundwater Basin (Figure 2-3). The Marine Base golf course operates an irrigation well in the Twentynine Palms Valley Basin; however, no records of pumpage are kept, but the volume is considered small (Li and Martin, 2011).

- Unincorporated areas outside the District to the east are covered by the San Bernardino County Desert Groundwater Management Ordinance adopted October 29, 2002, which gives the San Bernardino County (County) jurisdiction over the management of groundwater in the unincorporated, unadjudicated desert region of the County for areas of the County east of TPWD, MWA and the MCAGCC.

- Joshua Tree National Park lies on the southern boundary of TPWD. As a national park, much of the area is undeveloped natural space. Water supply is provided at park facilities including visitor centers, exhibits and campgrounds; however, all of the water is produced locally within the Park and is not derived from within the GMP area.

2.3 Delineation of DWR Groundwater Basins and Subbasins

TPWD is located within the Morongo Basin, which covers about 1,000-square-miles of several alluvium-filled valleys or basins surrounded by mountains. Previous investigators have divided the Morongo Basin into multiple groundwater basins. A required element of the GMP, Figure 2-4 shows the groundwater basin boundaries, as defined by DWR Bulletin 118, covered by this GMP along with the basins and agencies adjacent to this GMP management area.

This GMP addresses the portions of groundwater basins and subbasins that underlie or are immediately adjacent to the TPWD, but are outside the jurisdiction of other managing agencies such as JBWD. The GMP covers the Indian Cove, Eastern, and Fortynine Palms Subbasins of the Joshua Tree Basin, but does not cover the Joshua Tree Subbasin which underlies JBWD (Figure 2-1). TPWD overlies large portions of the Mesquite Lake and Mainside Subbasins in the Twentynine Palms Valley Basin and the GMP covers both of these subbasins (Figure 2-1 and 2-4). The District overlies a portion of the Dale Valley Groundwater Basin, but there is little to no pumping or historical data from this basin. Therefore, the GMP includes some discussion of the Dale Valley Groundwater Basin but does not consider it a part of the management area.

The Twentynine Palms Valley Groundwater Basin (Number 7-10) underlies Mesquite Lake (dry) and the City of Twentynine Palms covering a surface area of 62,400 acres (97.5 square miles) (Figure 2-4). The basin is bounded on the north by a structural barrier named the “transverse arch” (Schaefer, 1978; Mendez and Christensen, 1997) and on the south by the Pinto Mountain fault. The basin is bounded on the east by the southern Bullion Mountains and extends west to the flank of Copper Mountain. The basin is subdivided into the Mesquite Lake and Mainside Subbasins (Figure 2-1). The deposits in the region are interpreted to range to 10,000 feet in thickness (Moyle, 1984). However, in the Twentynine Palms Valley, wells have been drilled to a depth of 1,250 feet bgs without encountering bedrock. Total storage capacity of the basin is estimated to be 1,420,000 af (DWR, 1984). Groundwater in storage was estimated for a 100-foot thickness of saturated sediments to be about 132,000 af (DWR, 1984).

The Joshua Tree Basin (Number 7-62) includes the water-bearing sediments south of the Pinto Mountain fault beneath Joshua Tree, eastward to immediately south of the town of Twentynine Palms, which is outside the boundaries of the basin (Figure 2-4). The northern boundary of the Joshua Tree Basin (Number 7-62) is the Pinto Mountain fault, and the southern boundary is exposed consolidated basement of the Little San Bernardino Mountains within Joshua Tree National Park. The western boundary of the basin is coincident with a basement constriction located between the Town of Yucca Valley and Joshua Tree that causes a change in the groundwater level gradient. The eastern boundary of the basin lies along a line extending from the southern tip of the Mesquite fault to a basement outcrop of the Little San Bernardino Mountains. The basin is subdivided into four subbasins that include the Joshua Tree, Indian Cove, Fortynine Palms and Eastern Subbasins (Figure 2-1). Estimates of storage capacity of the Joshua Tree Basin have a wide range from 480,000 to 750,000 af (Krieger and Stewart, 1996), 975,000 af (Whitt and Jonker, 1998), and 1,010,000 af (DWR, 1984).

The Dale Valley Basin is located immediately to the east of the Mesquite Lake Subbasin (Figure 2-4). Little work has been done on the hydrogeology of the Dale Basin, as it is not a host to significant population, nor does it contain many wells. Its western boundary is the Mesquite Fault, which separates it from the Mesquite Lake Subbasin. The northern boundary is the Bullion Mountains. The southern boundary is the Pinto Mountains. The depth to bedrock in this basin is unknown. Groundwater levels have increased by 0 to 0.7 feet per year in the seven wells for which records exist, although most of the increases are due to single or few anomalously low water levels at the beginnings of the periods of record. Water levels within this basin have been basically stable since about 1960.The District has not pumped from this basin historically and has no production wells in this basin.

The Copper Mountain Valley (DWR #7-11), Warren Valley (#7-12), Deadman Valley (DWR #7-13), and Ames Valley (DWR #7-16) Groundwater Basins lie outside of management area for this GMP and are provided on Figure 2-4 for reference in demonstrating that the adjoining water districts obtain water from groundwater basins separate from those used by TPWD.

2.4 Geology

The geology in the Twentynine Palms area primarily consists of Tertiary to Quaternary alluvium deposits in the basins enclosed by bedrock materials in the surrounding hills and mountains (Riley and Worts, 1953). The geology of the region is complex due to the tectonic forces that created the Morongo Basin and surrounding mountains.

2.4.1 Geologic Units

The geology of the GMP area is typical of many extensional basins throughout the western United States. Basin-bounding ranges are fronted by normal faults along which they have risen relative to the basin floor (Riley and Worts, 1952). Over time, the basin has filled with highly heterogeneous deposits. The sediments within the basin have been buried progressively deeper as later sediments have been laid down on top of them; those at the greatest depth are more compacted than are those near the ground surface.

The geological materials in the region are grouped into stratigraphic units based on the geologic characteristics (Figure 2-5). The following brief description of the geologic units is summarized from earlier reports by Riley and Worts (1953), Rogers (1967), Londquist and Martin (1991), Nishikawa *et al. (*2004) and Li and Martin (2011):

- The Bedrock units are exposed in the mountain ranges but also underlie the groundwater basin. These units consist of Precambrian igneous and metamorphic rocks and Mesozoic-aged granitic and metamorphic rocks. The Mesozoic-aged rocks are primarily granite that intruded into the pre-existing Precambrian rocks.

- The Tertiary alluvium directly overlies the bedrock and consists of interbedded layers of clayey sand and sandy gravel. This unit is commonly consolidated with interstitial clay and calcium-carbonate cement. This unit is found only in the subsurface.

- The Quaternary alluvium overlies the Tertiary alluvium and is mostly made up of beds of coarse sand with little clay, with the rest composed of finer-grained beds made up of very fine silty sand to clay. This unit is divided into two subunits based on their characteristics. In general, the upper subunit is more permeable than the lower because of the predominance of the coarser-grained deposits and the lack of cementation. The upper Quaternary alluvium is the primary aquifer for the region.

- Playa lake deposits are typically composed of very clay rich sediments formed at the playa lakes. These deposits are as much as 45 to 50 feet thick beneath the Mesquite Dry Lake.

The alluvium is highly variable both vertically and horizontally. The coarsest alluvium tends to occur along the mountain fronts (Kennedy/Jenks, 2001, 2008, 2010) and progressively finer-grained sediments are found with distance away from the mountain fronts. The sediment size grades progressively to fine sand at the lower ends of the washes and eventually to silt and clay at the playas (Riley and Worts, 1952).

2.4.2 Faults and Folding

Structural features are very important to the hydrogeology of the Twentynine Palms area, as they act as flow limiting features that separate the groundwater subbasins from one another. These features are mainly faults, which crisscross this area due to an intense tectonic history in this area (Figure 2-5). There are three sets of faults running through the region (Riley and Worts, 1952). Several other unnamed faults do not fall into the three fault sets described herein, but are visible on geologic maps and may be important to the hydrogeology.

- The first set consists of normal faults that cross the basin in a generally north-northwest to northwest direction. The easternmost is the Mesquite Fault (Riley and Worts, 1952). Deadman and Mesquite Dry Lakes are located directly on top of this fault (Figure 2-5).

- The second set of faults includes the Elkins and Sand Hill Faults (Figure 2-5) that run generally north-south, with faults most important in the southern end of the basin and dying out toward the north (Riley and Worts, 1953).

- The third set of faults runs east-west along the southern end of the basin and includes the Oasis, Bagley, and Pinto Faults (Figure 2-5). The Oasis Fault (also known as the Pinto Mountain Fault in many references) was reported by Thompson (1929) as having a scarp 15 to 30 feet high next to the Oasis of Mara. The Bagley Fault is about half a mile north of the Oasis Fault in the area of Twentynine Palms, and intersects with the Oasis Fault west of the City of Twentynine Palms.

Faults make effective barriers for several possible reasons (Riley and Worts, 1952). With movement along the fault, beds of differing permeability can be juxtaposed across the fault. Groundwater flow across the fault may be reduced due to fault gouge consisting of clay or very fine particles or precipitation of calcium carbonate cement within the fault zone. The effectiveness of a fault as a barrier to groundwater flow does not require a great deal of movement along the fault (Riley and Worts, 1952). The fact that faults do act as barriers can be seen by the presence of significant areas of historical groundwater discharge as springs on the upgradient sides of some faults (e.g., Surprise Spring on the Surprise Spring Fault, Oasis of Mara on the Oasis Fault, and Mesquite Spring on the Mesquite Fault) as shown on Figure 2-5.

The area is seismically active as evidenced by the 7.3 magnitude Landers Earthquake in 1992, which is the largest magnitude earthquake in the lower 48 states since the 1906 San Francisco earthquake. The Landers Earthquake was centered on several faults about 20 miles west of Twentynine Palms. Earthquakes have been known to change the location and character of springs, change the flow character of wells, and cause fluctuations in groundwater levels (Roeloffs *et al*., 1995). However, the groundwater characteristics of the faults bounding the groundwater subbasins in the Twentynine Palms area have experienced numerous seismic events over their geologic history. It is these events that have defined the hydrogeologic characteristics of the faults that are observed today. Therefore, it is considered unlikely that a single seismic event in the future would significantly change the hydrologic characteristics of the groundwater subbasins.

In addition to the faulting in the area, folding has played a significant role in the geology and hydrology of the region. The USGS conducted a gravity survey to better understand the structure and thickness of subsurface fill by mapping the depth to the granitic or volcanic bedrock material (Roberts *et al*., 2002, Moyle, 1984). The estimated depth to bedrock is variable across the region. The estimated depth to bedrock beneath Mesquite Lake area is estimated to be more than 16,000 feet deep (Roberts *et al*., 2002). In other areas of the basin, bedrock highs bring bedrock units nearer to the surface. The Transverse Arch is bedrock high that brings bedrock to within 500 feet of land surface (Londquist and Martin, 1991) and forms the northern boundary of the Twentynine Palms Valley Basin (Figure 2-5). A second bedrock high exists in the southern part of the Mesquite Lake Subbasin that extends under the City of Twentynine Palms. This area likely represents an extension of Copper Mountain uplift which is composed of Precambrian and Mesozoic rocks (Figures 2-1 and 2-5) along the western margin of the Twentynine Palms Valley Basin.

2.5 Hydrology

In the arid to semiarid environment of the Twentynine Palms area, surface water is generally rare, localized, and short-lived. The climate in the Twentynine Palms area is classified as arid, upland desert climate, with hot summers and mild winters. The Twentynine Palms area is quite dry, with average annual precipitation of less than 5 inches. Most of the annual precipitation falls either during the summer monsoon or the winter wet season.

There are no perennial streams in the region, but there are several ephemeral streams that flow during high rainfall events. The largest of these is Fortynine Palms Creek (Figure 2-6). When runoff is generated by a storm, streamflow typically percolates into the alluvial soils in the stream channels (Kennedy/Jenks, 2001, 2008). Some areas contain caliche (layers of concentrated mineral salts), which can limit the downward movement of water, (Riley and Worts, 1953, USDA, 1994, Nishikawa *et al*., 2004).

Playa lakes form at the lowest elevations in a number of the surface drainage basins in the region (Figure 2-6). These dry lakes represent topographic low points where surface water ends up if runoff is high enough. The playa lakes are typically dry; however, a playa may represent an area of groundwater discharge that is typically lost to evaporation or taken up by vegetation. Playas with discharging groundwater are typified by rough surfaces with accumulations of alkali and other mineral salts (Thompson, 1929; USDA, 1994, Nishikawa et al., 2004). Among the playa lakes, the Mesquite Dry Lake is the largest in the area and is the lowest point in the area. South of Mesquite Dry Lake is a small unnamed playa that some older maps refer to as Shortz Lake (Figure 2-6). Due to erosion, ephemeral streams that formerly drained into Shortz Lake now bypass the lake so that the playa area is now largely covered with sand dunes. Two smaller playas occur just east of Copper Mountain.

Springs have historically been an important hydrologic feature as the only easily available source of water in this desert region. The Oasis of Mara is a mile long line of springs that form along the Oasis Fault. Mesquite Spring (Figure 2-6) once consisted of at least two pools, each 3 to 4 feet across and 2 feet deep, supporting a discharge of water that flowed about 200 feet into the desert (Thompson, 1929). However, Riley and Worts (1953) noted that by 1952 there was no water at the surface at the Oasis of Mara or flowing at Mesquite Springs.

Section 3: Groundwater Usage

This section provides the required GMP summary of historical data, historical and future water demand and supplies of the TWPD service area. The local groundwater basin conditions for the GMP area are presented in Section 4.

3.1 Historical Groundwater Pumpage by TPWD

Groundwater is the sole source of water supply for TPWD, thus, groundwater pumping by the District is a good indication of water use in the service area. The District has had eighteen total groundwater production wells in its history. As of 2013, the District has eight active production wells and pumps with wells located in four of different groundwater subbasins. Figure 3-1 shows the locations of the District's active and historical supply wells within the four groundwater subbasins in the Twentynine Palms area. Table 3-1 presents a summary of the District's well completion details grouped by subbasin.

Groundwater pumping by the District steadily increased since its formation in the mid-1950s until about 2002 (Figure 3-2). In the 1950's, groundwater pumping ranged from 500 to 1,000 acre-feet per year (afy). By the 1990s, groundwater pumping ranged from 2,730 to 3,145 afy with an average daily delivery per service connection slightly under 400 gallons.

The highest total groundwater pumping for one year was 3,569 acre-feet in 2002. Since 2002, groundwater pumping has shown a consistent decline. In 2012, total groundwater pumping in the District was 2,933 acre-feet (af), which as the lowest annual pumping volume since 1992.

Most TPWD water supply wells are located along the southern limit of the service area in the Indian Cove, Eastern, and Fortynine Palms Subbasins because of the superior water quality compared to that in the Mesquite Lake Subbasin, where fluoride concentrations are of concern. Figure 3-2 also shows the annual groundwater pumping by subbasin. In the 1950s and 1960s, groundwater pumping was primarily in the Fortynine Palms Subbasin; in the 1970s and 1980s, the pumping was shifted to be primarily in the Indian Cove Subbasin; and, in the mid-1980s, groundwater pumping in the Fortynine Palms Subbasin was increased in response to decreasing groundwater levels in the Indian Cove Subbasin. In 1993, groundwater pumping in the Eastern Subbasin was also increased.

In 2003, the first production well in the Mesquite Lake Subbasin (WTP-1) began providing water to TPWD, with that production now passing through the Twentynine Palms Fluoride Removal Water Treatment Plant. TPWD is considering increasing groundwater pumping in the Mesquite Lake Subbasin to 3.0 million gallons per day (mgd), with a concomitant decrease in pumping in the Indian Cove, Fortynine Palms, and Eastern Subbasins (Figure 3-2).

Since 2003, the District has worked to balance the pumping amongst the four groundwater subbasins to help reduce groundwater level declines. A more detailed discussion of the responses of groundwater levels to changes in pumping are discussed in Section 4.

TABLE 3-1
TPWD PRODUCTION WELL COMPLETION SUMMARY

Well Name	Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Well Status	Year Drilled	Years of Operation
Mesquite Lake Subbasin					
WTP-1	1,010	350-440; 460-620	Active	1993	2003-ongoing
Eastern Subbasin					
TPWD-1	-	-	Abandoned	-	1955-2011
TPWD-2	275	-	Inactive	-	1953-1993
TPWD-16	320	0-320	Active	1988	1991-ongoing
Fortynine Palms Subbasin					
TPWD-3	340	120-340	Abandoned	-	1953-1992
TPWD-3B	398	160-280; 300-320; 340-398	Abandoned	1992	1993-2006
TPWD-4	283	-	Inactive	1935	1953-2013
TPWD-5	-	-	Abandoned	-	1953-1996
TPWD-13	337	152-337	Abandoned	1985	1985-2004
TPWD-14	430	220-420	Active	1993	1993-ongoing
TPWD-17	-	-	Active	2009	2010-ongoing
Indian Cove Subbasin					
TPWD-6	406	195-403	Inactive	1956	1957-2010
TPWD-7	407	258-403	Inactive	1962	1963-2005
TPWD-8	785	80-100, 140-160, 215-600	Abandoned	1965	1969-1993
TPWD-9	530	318-510	Active	1968	1970-ongoing
TPWD-10	400	145-213; 238-312; 326-335; 365-382	Inactive	1968	1969-2006
TPWD-11	400	200 - 400	Active	1978	1966-ongoing
TPWD-12	410	310-330; 350-410	Active	1983	1983-ongoing
TPWD-15	352	250-350	Active	1987	1990-ongoing

Note: Data provided by TPWD.

3.2 TPWD Water Use Assessment

Currently, the District serves the area solely by groundwater pumping. Water demand in the service area, and in turn groundwater pumping, is anticipated to increase in response to population increase and groundwater will continue to be the sole source for meeting future demand. Population trends and water demand data for the District service area are described below for the current and 2035 conditions.

The majority of land use is designated for residential development and open space residential, with a small portion made up by commercial, institutional, and industrial. Residential development is currently the single largest land use in the area served by the District. Approximately 80 percent of the residential development is single-family homes. The remaining 20 percent of land use is made up of some multi-family residential units and commercial property. Industrial property makes up a minor amount of the land use. There is no large-scale agricultural development in the management area.

The population served by the District in 2010 is approximately 18,975, but the population for 2035 was projected to be 30,931 based on the estimate from the 2010 UWMP. Table 3-2 presents the historical population from 2000 to 2010.

Based on the 2010 UWMP, the District water demand during 2010 was 2,674 acre-feet (af), serving 7,983 connections, all of which are metered accounts. Based on the most recent water usage data available from the District for March 2010 through February 2012, total annual water use is estimated to be 2,552 acre-feet per year (afy). While this is slightly lower than the 2010 water use of 2,674 af presented in the 2010 UWMP, it is more representative of the current conditions.

The population for 2035 is projected to be 30,931 with water use in the District service area projected to increase to 5,119 af by 2035, based on the 2010 UWMP. Total residential water demand is projected to be 3,401 af for single family and 839 af for multi-family residential. The base daily per capita water use in 2010 was estimated to be 147 gallons per capita per day (gpcd). The District's future projected per capita water use is estimated to be 135 gpcd, for compliance with the SBX7-7 required water reduction by 2020 (Kennedy/Jenks, 2011).

TABLE 3-2
ESTIMATED ANNUAL WATER DEMAND 2000 TO 2035

	Annual Water Use (afy)					
Land Use	**2000[(a)]**	**2005[(a)]**	**2010[(a)]**	**2015[(a)]**	**2025[(a)]**	**2035[(a)]**
Single family	1,686	2,727	1,727	2,525	3,006	3,401
Multifamily	552	564	442	623	741	839
Commercial/institutional	339	392	278	417	496	561
Industrial	0	0	0	0	0	0
Landscape irrigation	111	108	125	112	134	151
Other (fire protection/non-potable)	131	153	102	124	148	167
Total	**2,818**	**2,832**	**2,674**	**3,801**	**4,525**	**5,119**

Note: (a) Data from 2010 UMWP (Kennedy/Jenks, 2011).

3.3 Groundwater Pumping Capacity

The District has a total pumping capacity of approximately 5,210 gpm (8,400 afy). Table 3-3 provides a breakdown of this capacity by subbasin. The 2012 total groundwater volume extracted utilizes about 33 percent of the current pumping capacity. Historically, total groundwater volume extracted has been about 18 percent higher than the annual water demand. Therefore, the estimated 2035 total groundwater volume extracted, using the same ratio, would be about 6,040 afy. The District's current pumping capacity is above the current pumping levels and should be sufficient to meet the projected 2035 water demand without expansion. This would represent about 72 percent of the District's current pumping capacity, which may be close to the practical pumping capacity limit. However, the estimated population increase assumes a substantially higher rate in population increase than has been experienced in the past. Therefore, the 2035 water demand estimate may an overestimation; however, it is reasonable to use such a conservative estimate for long-term planning considerations.

In addition, current pumping is limited by DWR's recommendations to prevent overdraft in the Indian Cove and Fortynine Palms Subbasins, as discussed further in Section 4. The District's current source capacity is 7.4 MGD which adequately meets the maximum daily demand. For reliability, CDPH recommends that a water system be able to meet its maximum daily demand with the highest capacity source offline, which is the well at the fluoride treatment plant. With that well offline, the capacity is 4.5 MGD, which would not meet the maximum daily demand. Although the District's system is in compliance with these source capacity requirements, the addition of a new well and treatment facility in the Mesquite Lake Subbasin is needed.

TABLE 3-3
TPWD PRODUCTION WELL CAPACITY AND USE SUMMARY

Well Name	Pumping Capacity (gpm)	Potential Maximum Annual Extraction (afy) [(a)]	2012 Groundwater Extracted (acre-feet)	2012 Percent of Capacity
Mesquite Lake Subbasin				
WTP-1	2,100	3,395	1,168	35%
Eastern Subbasin				
TPWD-16	500	800	311	39%
Fortynine Palms Subbasin				
TPWD-4	100	160	49	30%
TPWD-14	700	1,130	439	39%
TPWD-17	700	1,130	524	46%
Indian Cove Subbasin				
TPWD-6		0	0	--
TPWD-9	325	520	131	25%
TPWD-11	300	485	92	20%
TPWD-12	385	620	172	28%
TPWD-15	100	160	47	30%

Note: Data provided by TPWD.

(a) Potential Maximum Annual Extraction assumes the well operating at the pumping capacity for 24 hours per day for 365 days per year.

Section 4: Groundwater Supply Assessment

This section summarizes the groundwater basin conditions and groundwater management actions that have been taken previously. The section includes an assessment of the current status of the groundwater basins as supported by monitoring results.

4.1 Aquifers

The alluvial fan deposits are the principal water-bearing unit in the region. Li and Martin (2011) divide the upper alluvial fan deposits into two subunits based on their characteristics. In general, the upper subunit is more permeable than the lower subunit because of the predominance of the coarser-grained deposits and the lack of cementation. The thickness of the upper alluvial fan deposits reaches about 400 feet in the Joshua Tree Subbasin, with a saturated thickness of 300 feet. The thickness of the lower Quaternary alluvium varies from zero along the basin margins to a maximum of 400 feet in the western Indian Cove and eastern Mesquite Lake Subbasins and throughout much of the Joshua Tree Subbasin. The maximum saturated thickness of the Tertiary alluvium in the Twentynine Palms area is about 1,700 feet along the western edge of the Indian Cove Subbasin and reaches up to 3,000 feet, according to Nishikawa *et al.* (2004). Sediments that have become deeply buried tend to be more consolidated, compacted, and cemented with depth. Therefore, the deepest sediments tend to be less transmissive than the upper sediments.

The traces of two representative cross sections are shown on Figure 4-1. Cross Section A-A' (Figure 4-2) extends from west to east through the Indian Cove, Fortynine Palms and Eastern Subbasins. Cross section B-B' shown on Figure 4-3 runs from southwest to northeast starting in the Indian Cove Subbasin across the Fortynine Palms Subbasin, the Mesquite Lake Subbasin and into the Dale Valley Basin. The upper and middle aquifers shown on the cross sections correlate to subdivisions of the alluvial fan deposits of Tertiary-Quaternary age (QTf) and the Lower Aquifer correlates to the older sedimentary deposits of Tertiary age (Ts). The cross sections show the complex geology of the faulting and depth to bedrock. Groundwater elevations shown are representative of current groundwater levels and illustrate the differences in groundwater levels across the faults that form the boundaries for the various subbasins. Additional hydrologic cross sections across the area are found in Nishikawa *et al*. (2004), Kennedy/Jenks (2010), and Li and Martin (2011).

Groundwater flow directions in the Twentynine Palms area are largely determined by the structural geologic framework and the natural processes of recharge and ET. The faults act as a barrier that limits the volume of groundwater that flows into adjacent subbasins. These barriers are reflected on the map with distinct changes over small distances across some of the faults. Figures 4-4 shows the general flow direction based on the groundwater model results for 1982, 2008, and 2012, respectively (Kennedy/Jenks, 2010). Groundwater conditions are described here only for the subbasins within the boundary of TPWD.

4.2 Joshua Tree Basin

The Joshua Tree Groundwater Basin includes the three subbasins south of the Oasis Fault (Indian Cove, Fortynine Palms, and Eastern Subbasins). The following provides an overview of groundwater conditions and levels in the three subbasins.

4.2.1 Groundwater Conditions

In general, groundwater flows north and east across the subbasins (Figure 4-4). The highest groundwater levels are found along the mountain front of the Little San Bernardino Mountains to the south, which is the primary recharge area for these three subbasins. Flow between these three subbasins is considered limited due to the presence of hydrologic barriers that may consist of faults or bedrock highs. For example, the water level in the Indian Cove Subbasin is more than 250 feet above the water level in the Fortynine Palms Subbasin to the east, indicating that there is some barrier between the two subbasins, although its character is not defined. The groundwater elevation is approximately the same in the Fortynine Palms and Eastern Subbasins, which suggests that there is limited flow between the subbasins.

Within the Joshua Tree Basin, long-term water level declines are evident south of the Pinto Mountain Fault throughout the Indian Cove and Fortynine Palms Subbasins primarily near pumping centers. The following discussion provides additional details on groundwater level changes for each subbasin.

4.2.2 Indian Cove Subbasin Groundwater Level History

The Indian Cove Subbasin is located between the Joshua Tree Subbasin on the west and the Fortynine Palms Subbasin on the east (Figure 4-1). The basin is floored by bedrock, which generally slopes northward with depth to bedrock ranging from 100 to 1,200 feet bgs (Kennedy/Jenks, 2010).

In the Indian Cove Subbasin, pumping records go back to 1957, and varied from about 30 afy initially to a peak of 2,075 afy in 1985. In 2012, total pumping in the subbasin was 442 afy. The current production capacity for wells located within this subbasin is 1,785 afy (Table 3-3). The greatest annual pumping from a single well in the basin was about 620 afy, from TPWD-10 in 1976.

The groundwater levels vary more widely in the Indian Cove Subbasin than the other subbasins in the area. Hydrographs of the TPWD wells in the Indian Cove Subbasin are presented on Figure 4-5. The groundwater elevations in the northern part of the subbasin have declined between 1.5 and 2.5 feet per year from the 1960s to the 2000s. Groundwater elevation dropped most quickly from about 1970 to 1990 before decreasing more slowly to the present time. Over the past 10 years, water levels in most of these wells generally increased at the rate of about 0.5 to 1.5 feet per year.

Wells south of the Pinto Fault did not experience similar declines in the groundwater levels. The water levels in the southern group wells range from about 2,210 to 2,440 feet asl (Figure 4-5). This suggests that the Pinto Fault is an effective groundwater barrier that separates Indian Cove Subbasin into a northern and southern subarea.

4.2.3 Fortynine Palms Subbasin Groundwater Level History

The Fortynine Palms Subbasin is located directly east of the Indian Cove Subbasin (Figure 4-1). The known depth to bedrock in the subbasin is between 170 and 430 feet bgs making this the shallowest among the subbasins in the area (Kennedy/Jenks, 2010). The Pinto Fault also traverses the southern part of this basin; however, there are no wells exist south of the fault to verify whether or not the fault is a barrier to flow. No other significant faults are known within this subbasin.

In the Fortynine Palms Subbasin, pumping records go back to 1952. Since then, pumping has varied from about 260 afy in 1953 to a peak of 1,620 afy in 2002. In 2012, total pumping in the subbasin was 1,012 afy. The current production capacity for wells located within this subbasin is 2,420 afy (Table 3-3). The greatest discharge from a single well in the subbasin was about 920 afy, from TPWD-14 in 2007.

Hydrographs of the TPWD wells in the Fortynine Palms Subbasin are presented on Figure 4-6. From the 1940s to about 1970, groundwater levels declined by about 1 foot per year before leveling off about 1990, coinciding with a pumping decline in this basin. Starting around 1990, water levels declined as pumping again increased in the subbasin; until 2003, when pumping was reduced and water levels again leveled off. Water levels in TPWD-13 and TPWD-14, in the southwestern part of the subbasin, have experienced a much steadier decline than other TPWD wells in the subbasin. Measured groundwater elevations have decreased 150 feet from the 1940s, including about 100 feet since 1980.

4.2.4 Eastern Subbasin Groundwater Level History

The Eastern Subbasin is located immediately to the east of the Fortynine Palms Subbasin (Figure 4-1). Woodward-Clyde (1985) noted that groundwater supplies in the Eastern Subbasin appear limited due to most of the flow being confined to a shallow zone above or in the bedrock. The depth to bedrock varies from 160 to 750 feet bgs (Kennedy/Jenks, 2001, 2008, 2010). Test wells drilled in 1987 near the large housing tract encountered bedrock at depths ranging from 327 to 415 feet bgs, and the water table was inferred at depths ranging from160 to 170 feet bgs (BCI, 1988).

In the Eastern Subbasin, pumping records go back to 1952. Since then, pumping has varied from about 200 afy in 1953 to a peak of 829 afy in 2002. In 2012, total pumping in the subbasin was 311 afy. The current production capacity for wells located within this subbasin is 800 afy (Table 3-3). The greatest discharge from a single well in the subbasin was 580 afy from TPWD-16 in 2002.

Hydrographs of the TPWD wells in the Eastern Subbasin are presented on Figure 4-7. Groundwater elevations for wells with at least 20 years of record have mostly declined between 0.2 and 0.8 feet per year. Measured groundwater elevations have decreased 70 feet from the 1940s, including about 50 feet since 1990.

4.3 Twentynine Palms Valley Basin

The Twentynine Palms Valley Groundwater Basin includes two subbasins, the Mesquite Lake and Mainside Subbasins. The following provides an overview of groundwater conditions and levels in these two subbasins.

4.3.1 Groundwater Conditions

The Twentynine Palms Valley Groundwater Basin underlies much of the City of Twentynine Palms and includes the Mesquite Lake and Mainside Subbasins. Within the Mesquite Lake Subbasin, groundwater flows toward Mesquite Dry Lake from all directions (Figure 4-4). Riley and Worts (1952) noted that groundwater is confined by playa deposits along the western half of Mesquite Dry Lake. Within the Mesquite Lake Subbasin, several faults and a bedrock high form significant flow restrictions that further subdivide this subbasin into distinct groundwater zones. In the southwestern part of the subbasin, bedrock is at or near the land surface, so groundwater may flow around the southern part of this ridge. In the northwestern part of the subbasin, several faults including the Elkins and Surprise Spring Faults appear to form flow barriers that limit flow across this section of the Mesquite Lake Subbasin. Small playas associated with these faults further support this observation, but there are few wells in this area.

4.3.2 Mesquite Lake Subbasin Groundwater Level History

TPWD has one high-capacity supply well (WTP-1) in this subbasin (Figure 4-1). WTP-1 came on line in 2003 and has a discharge capacity of 3,395 afy. The well has pumped between 610 and 1,168 afy since then. Otherwise, groundwater pumping in this subbasin is limited due to naturally-occurring water quality issues. There are private irrigation wells for the Roadrunner Dunes Golf Course and Luckie Park that have been estimated to pump as much as 580 afy.

Hydrographs of the TPWD wells in the Mesquite Lake Subbasin are presented on Figure 4-8. The static water level in WTP-1 has dropped by about 6 feet over the 10-year period of record. A significant amount of historical data is available from the USGS. Most water level measurements through the past 60 years are from the eastern and southern parts of the subbasin, with limited data from the western half of the subbasin. Most wells with long records show relatively steady water levels over time with total variations in groundwater levels ranging within 5 feet.

4.3.3 Mainside Subbasin Groundwater Levels

TPWD does not have production or monitoring wells in the Mainside Subbasin. Estimated pumping from the Marine Base golf course well in not measured but has been estimated between 50 and 540 afy from the Mainside Subbasin. Groundwater level data available from the USGS are shown on Figure 4-9. Groundwater levels have increased by 0 to 0.7 feet per year in the eight wells for which the USGS has collected data, although most of the increases are due to single or few anomalously low water levels at the beginnings of the periods of record. Water levels within this basin have been basically stable since about 1990.

4.4 Summary of Hydrologic Water Budget

The calculation of hydrologic water budget can vary based on the input data and methodology. The following is a summary of the hydrologic water balance that is presented in Table 4-1. A more detailed discussion on the data and assumptions used for each water balance component is provided in Appendix B. Return flows from irrigation and septic systems are included for each subbasin. The methodology is provided in Appendix B.

In the Indian Cove, Fortynine Palms and Eastern Subbasins, groundwater recharge is primarily derived from surface runoff resulting from rainfall in the mountains. The surface runoff percolates into the soils of the mountain-front alluvial fans to recharge groundwater in the aquifer. Another form of recharge is infiltration of precipitation into fractured bedrock exposed in the mountains that later discharges to the subbasins at the bedrock-aquifer interface. Groundwater pumping is the primary outflow from the three subbasins. Natural groundwater outflow occurs across (or, more likely, overtopping) the Oasis Fault into the Mesquite Lake Subbasin since the Oasis Fault is considered an effective groundwater flow barrier. DWR (1984) noted a probable water level difference of at least 100 feet across the Oasis Fault between these subbasins and the Mesquite Lake Subbasin.

Recharge to the Mesquite Subbasin is primarily from subsurface groundwater flow from the Deadman Valley Groundwater Basin across the Transverse Arch, the Copper Mountain Valley Basin around the south end of Copper Mountain, and the Indian Cove, Fortynine Palms, and Eastern Subbasins across the Oasis Fault. Additional recharge may occur within the subbasin, as runoff from storm flows off of the Little San Bernardino Mountains to the south may flow occasionally (Riley and Worts, 1953). Recharge from percolation of precipitation falling directly on the subbasin floor is not considered to represent a major source of groundwater recharge (DWR, 1984). Discharge from this subbasin occurs at the area of Mesquite Spring and Mesquite Dry Lake as evapotranspiration and groundwater flow over the Mesquite Fault into the Mainside Subbasin. The Mesquite Fault is considered “highly impervious” by Riley and Worts (1952), with groundwater levels varying by 200 feet over a horizontal distance of 100 feet from the west to the east side of the fault. As noted above, the Mesquite Fault is expressed on the surface by discharge at Mesquite Spring and a sharp delineation in the vegetation on the surface of the Mesquite Dry Lake.

Recharge for the Mainside Subbasin is primarily from outflow from Mesquite Lake Subbasin and infiltration of runoff from the Bullion Mountains. Outflow is limited to flow across the Bullion Mountain Fault into the Dale Valley Basin, but this is considered to be a very low volume.

Groundwater pumping uses the 2012 TPWD pumping from Table 3-3 plus private pumping from the Roadrunner Dunes Golf Course, Luckie Park and Marine Base golf course wells. Return flows include both irrigation and septic return flows, but are predominantly septic return flows. The return flow range assumes an 80-percent water to sewer conversion based on 2012 TPWD pumping and distributed to the appropriate subbasin due to septic system density.

The Colorado River Basin Plan identifies overdraft as being a concern in the Twentynine Palms area. Long-term water level declines have been observed in the Indian Cove, Fortynine Palms, and Eastern Subbasins. The hydrologic water balance results shown in Table 4-1 indicate that more groundwater is being pumped than is being recharged during an average year. These results indicate that return flows, which are a return of water pumped from the basin, as the primary source of recharge. Natural recharge is limited because of the relatively low average rainfall in the area. Discharge is primarily pumping from wells. Natural outflows vary and are affected by changes in groundwater levels caused by pumping, such as the decrease in spring flows. The net effect is that discharge exceeds recharge and that is reflected in the declining groundwater levels as discussed in Sections 4.2 and 4.3.

TABLE 4-1
HYDROLOGIC WATER BUDGET SUMMARY

	Groundwater Inflow (AFY).			Groundwater Outflow (AFY).			
Subbasin	**Total Return Flow**	**GW Inflow**	**Natural Recharge**	**Wells**	**Natural Discharge**	**GW Outflow**	**Change in Storage**
Indian Cove	153	36 to 75	3 to 110	442	0	10 to 30	-260 to -134
Fortynine Palms	157	0 to 140	7 to 280	1,012	0 to 140	0 to 120	-848 to -695
Eastern	200	0 to 50	2 to 240	311	20 to 75	0 to 50	-129 to +54
Mesquite Lake	1,380	105 to 810	0 to 180	1,458	360 to 1,630	0 to 115	-333 to -833
Mainside	27	0 to 115	0 to 20	540	0 to 340	0	-513 to -718
Total	**1,917**	**141 to 1,190**	**12 to 830**	**2,933**	**380 to 2,185**	**10 to 315**	**-2,083 to -2,326**

4.5 Sustainability of Long-Term Water Supply

The District has employed several different practices to further enhance the long-term sustainability of water supplies for Twentynine Palms. The following summarizes several of the key management actions to address these issues including those of the voluntary 12 specific technical elements identified in the California Water Code that pertain to groundwater levels.

4.5.1 Mitigation of Conditions of Overdraft

The District has used the practice of shifting groundwater production between subbasins to help stabilize declining groundwater levels to provide intervals for groundwater levels to stabilize and recover in groundwater wells, especially in the Indian Cove and Fortynine Palms Subbasins,.

The District has increased groundwater production in the Mesquite Lake Subbasin to reduce the amount of groundwater pumped in the Indian Cove, Fortynine Palms, and Eastern Subbasins. The Mesquite Lake Subbasin contains a large volume of groundwater but that groundwater requires water treatment primarily for fluoride. The current Fluoride Removal Water Treatment Plant has a capacity of 3 mgd, but currently treats 1.2 mgd, operating at 40 percent of capacity. The District plans to expand the operation of the treatment plant up its design capacity of

3.0 mgd. This will allow further pumping reductions in the other basins and provide additional capacity for the practice of shifting groundwater production between subbasins.

Water conservation is an important method to reduce overdraft. The District utilizes public outreach to promote conservation, specifically water conservation brochures available through the District and distributed in new customer packages and water bills, as well as through speakers and events conducted at local schools and community events, which include poster contests and involvement in earth day activities. Additional water conservation measures are addressed in the BMOs and the current and planned water management strategies targeting conservation and water savings are described in the 2010 UWMP Update.

In evaluating potential future growth, SB 610 and SB 221 amended state law to improve the link between information on water supply availability and certain land use decisions made by cities and counties for defined project types and thresholds. These statutes require detailed information regarding water availability to be provided to city and county decision-makers prior to approval of specified large development projects. To provide that information, the governing body of the water agency that will serve the development must adopt an SB 610 Water Supply Assessment (WSA). Both statutes also require this detailed information be included in the administrative record that serves as the evidentiary basis for an approval action by the city or county on such projects. The District will continue to prepare SB 610 WSAs for the Twentynine Palms area to assess future water supplies and control overdraft.

4.5.2 Groundwater Model Analysis of Potential Future Conditions

The District has undertaken key efforts related to groundwater and management of groundwater resources to understand the state of the groundwater basins and to report on groundwater management activities. The 2010 Mesquite Lake Groundwater Study (Kennedy/Jenks, 2010) provided an updated hydrogeological conceptual model for the District. A numerical model was developed to help support informed decisions in future management of groundwater resources in a sustainable manner while meeting increased water demand. For the GMP, the numerical model was updated and used to evaluate potential future conditions. The following discussion summarizes the model analysis results. A more detailed discussion of the numerical model update and analysis is presented in Appendix D.

The Baseline Scenario assumes that pumping and septic recharge do not change over time, which is assumed to depend directly on pumping. This is not expected to be representative of actual conditions, but provides a condition against which the other scenarios can be compared. Groundwater model results are considered most representative when presented as a relative comparison to a baseline rather than as absolute numbers.

Scenarios 1, 2 and 3 use a linear growth rate of 2.58% per year to predict pumping and septic recharge over the 25-year simulation duration. The differences between the scenarios are the distribution of the groundwater pumping and septic tank return flows. In summary, the conditions of the three scenarios are:

- For Scenario 1, the increased pumping is distributed to the existing wells exactly proportional to their pumping in 2010. That is, if a well provided 5% of total demand in 2010, it would also experience 5% of the increased demand every year. Therefore, the increase is distributed amongst the Mesquite Lake, Indian Cove, Fortynine Palms and Eastern Subbasins.

- Scenario 2 assumes that all of the increased pumping over time occurs in the Mesquite Lake Subbasin. Pumping in the Indian Cove, Fortynine Palms and Eastern Subbasins remain at their initial pumping rates throughout the simulation.

- Scenario 3 uses the same pumping assumptions as Scenario 2, but septic return flow is eliminated immediately and totally at the beginning of the simulation. This represents the assumption that the septic systems present in the basin are converted to sewerage.

The results of the model analysis shown in Table 4-2 indicate the increased pumping in the Mesquite Lake Subbasin will result in some potential for recovery of groundwater levels in the Indian Cove, Fortynine Palms and Eastern Subbasins. The larger Mesquite Lake Subbasin is considered to have a higher capacity so that decreases in groundwater storage would result in lower declines in groundwater levels than would occur in the smaller Indian Cove, Fortynine Palms and Eastern Subbasins.

Scenario 3 indicates that the septic return flows play an important role in groundwater management since they account for a significant percentage of extracted groundwater being returned to the groundwater basin. Removing those return flows completely from the groundwater basin could potentially lead to a decrease in groundwater storage that would result in significantly lower groundwater levels (Table 4-2). However, water quality issues with septic tank return flows may also have an impact on the beneficial use of groundwater in the region. The results of Scenario 3 indicate that if all or part of City of Twentynine Palms were to be converted to a centralized sewer system, it will be important to include a provision to recycle the treated wastewater in a manner that would help maintain groundwater levels.

TABLE 4-2
RELATIVE CHANGE IN GROUNDWATER STORAGE FROM GROUNDWATER MODEL ANALYSIS

	Average Annual Change in Groundwater Storage Relative to the Baseline Scenario (AFY)		
Subbasin	**Scenario 1**	**Scenario 2**	**Scenario 3**
Indian Cove	-186	61	-203
Fortynine Palms	-46	14	-99
Eastern	-47	44	-216
Mesquite Lake	-4	-174	-1,286
Total	**-283**	**-55**	**-1,804**

4.5.3 Groundwater Recharge and Storage Projects

The District does not have access to surface, imported or recycled water sources; therefore, the options for mitigating overdraft conditions are limited. Should access to an alternative water source become available in the future, the District would initiate an assessment on how best to utilize these resources to reduce groundwater overdraft including the use of “artificial recharge,” “recycled water” or “conjunctive use” projects.

The only source of water currently available for replenishment is the impoundment or collection of stormwater runoff. Therefore, groundwater replenishment should be increased by maximizing the use of the only source of recharge available (precipitation) by providing recharge enhancement. The District should investigate the feasibility of implementing a recharge enhancement program. This program would involve the construction of berms to allow increased percolation of stormwater into the aquifer. Currently, this concept is in a conceptual stage and no detailed information is available.

The District has several reservoirs for system storage, which enable the District to provide adequate service for peak demands plus fire flow and emergency reserve. The District regularly evaluates its distribution and storage network. As part of this process, the need for new improvements including additional storage capacity is evaluated and a capital improvement program is developed in order to construct the necessary improvements. Existing storage facilities are operated and maintained by District staff. There are no plans for any large-scale storage projects or conjunctive use/groundwater storage facilities at this time. In addition, the need for additional extraction facilities is evaluated and wells are incorporated into the capital improvements program. District staff operates and maintain the wells.

4.5.4 Potential of Land Subsidence

Land subsidence can occur as a result of declining groundwater levels if a compressible sediment layer is present. In certain types of geologic formations, declining groundwater levels cause water to move out of the pore space causing the sediment to compress into a smaller volume. This primarily occurs in loose fine-grained mud deposits. Granular sediments, typical of the alluvial filled basins in the Twentynine Palms area, are generally not considered compressible.

Land subsidence has not been identified as an issue within the Twentynine Palms area; however, playa lake deposits such as those found in the Mesquite Lake and Mainside Subbasins have been noted as sources of land subsidence in Antelope Valley and other similar areas. Since there have not been any substantial historical groundwater level declines in these basins under current pumping conditions, it is unlikely to suspect that any subsidence has occurred. However, future increases in pumping in the Mesquite Lake Subbasin could lower groundwater levels to a degree that subsidence could be an issue if a compressible sediment layer is present.

In the Indian Cove, Fortynine Palms and Eastern Subbasins, no compressible sediment layers are known to exist; therefore, it is unlikely that subsidence would occur in these locations. Also, since groundwater levels have declined by up to 200 feet in parts of these basins, subsidence would have already occurred. Since none has been observed, this is consistent with the observation that no compressible sediment layer is present in these areas.

To address the potential for subsidence, the District should consider the presence of playa lake deposits when siting future production wells in the Mesquite Lake Subbasin and locate them outside of the playa area. In addition, the District should consider doing a benchmark survey that would evaluate historical data and provide a baseline of comparison for future surveys. A benchmark survey has been added to the Monitoring Plan in Appendix B.

Section 5: Groundwater Quality Conditions

This section summarizes the current status of the water quality in the groundwater basins as supported by monitoring results and groundwater management actions that have been taken.

5.1 Water Quality

District groundwater is typically of good quality. The historical and current use of septic systems for wastewater disposal has an effect on groundwater quality. In addition, high levels of naturally-occurring fluoride and arsenic are present in some water supply wells in certain areas of the District.

5.1.1 Salts and Nutrients

The historic and current use of septic systems for wastewater disposal in the District service area has the potential to affect groundwater quality. The key constituents considered for monitoring septic tank influence are nitrates and TDS. The maximum contaminant level (MCL) by the California Department of Public Health (CDPH) is 45 mg/L for nitrate as NO_3 or 10 mg/L for nitrate as N. Nitrate concentrations in public drinking water supplies exceeding the MCL require water system actions to provide safe drinking water. For the TPWD production wells, nitrate (as NO_3) ranges from non-detect to 36 mg/L, as summarized in Table 5-1. Historical and current data are below the MCL of 45 mg/L for nitrate. As part of the GPP and WMP that are currently being prepared to protect groundwater quality, the District and the City are proposing a groundwater monitoring plan to identify water quality issues related to the use of septic systems and future alternatives for wastewater management in the area.

The TDS content of groundwater within the District ranges from about 100 to 350 mg/L from the water supply wells, as summarized in Table 5-1. TDS has a secondary MCL by the CDPH of 500 mg/L. *Secondary MCLs regulate contaminant levels based on aesthetics such as taste, color or odor that do not pose a risk to health. These secondary MCLs are guidelines, not enforceable limits.* Higher levels of TDS noted in the area are typically associated with naturally-occurring, higher-salinity water shallow groundwater associated with playa deposits. Elevated TDS can also be associated with septic tank return flows.

5.1.2 Natural Constituents

Fluoride (F) naturally occurs in the local groundwater and is a constituent of concern for the water delivery system in the District service area. The CDPH-mandated MCL for fluoride in drinking water is 2.0 mg/L. Fluoride is relatively low in the Indian Cove, Fortynine Palms, and Eastern Subbasins, but several samples have exceeded the MCL for drinking water (Table 5-2). Average fluoride concentrations range from 0.4 to 2.3 mg/l, but some older wells did have higher fluoride levels. Groundwater in the Mesquite Lake Subbasin has a different chemical character with substantially higher fluoride concentrations. Fluoride has been measured in WTP-1 in the Mesquite Lake Subbasin, hovering around 6.0 mg/L in only two samples, above the 2.0 mg/L MCL. Samples reported by DWR (1984) throughout the Mesquite Lake Subbasin varied between 3.0 and 22.0 mg/L. Concentrations in the area of the Mesquite Dry Lake are mostly around 11 mg/L.

Arsenic (As) is a naturally occurring element in groundwater that forms from the erosion and breakdown of geologic deposits; however, arsenic is less commonly associated with contaminant plumes. The primary MCL for arsenic is 10 micrograms per liter (μg/L). The occurrence of arsenic in the Twentynine Palms area is from natural sources. Arsenic has been detected in concentrations up to 31 μg/L; however, the average arsenic concentration is below 10 μg/L in most of the District's wells (Table 5-2). Arsenic above the MCL is most prevalent in the Indian Cove Subbasin and Well #3B in the Fortynine Palms Subbasin. Arsenic is below the MCL in the Eastern and Mesquite Lake Subbasins as well as the other Fortynine Palms Subbasin wells. The elevated arsenic concentrations require treatment at some of the District wells.

5.2 Groundwater Quality Trends

Groundwater quality in the region is quite variable. Minerals are added to the groundwater as it flows through the aquifer; water that spends more time in the aquifer tends to have higher concentrations of chemical constituents than does water with a low residence time. Water near the mountain fronts, which has been recharged relatively recently, tends to be of high quality, with low concentrations of chemical constituents. This is the case in the Indian Cove, Fortynine Palms, and Eastern Subbasins, where groundwater is close to its source area. In the Mesquite Lake Subbasin, groundwater has had a longer residence time and, therefore, tends to have higher concentrations of minerals. A general summary of the spatial trends in groundwater quality are summarized below:

- The groundwater in the Mesquite Lake Subbasin is predominantly sodium sulfate character. Locally elevated levels of TDS can be found associated with the playas, but is not present in high concentrations in the District's water supply wells. TDS content ranges from about 300 to 1,300 milligrams per liter (mg/L), but reaches 3,100 mg/L (DWR, 1984). Some wells in the basin exceed the recommended levels for drinking water in fluoride, arsenic and sulfate concentrations. Thermal waters or hot springs are also known to occur in this basin (DWR, 1984).

- The groundwater in the Indian Cove, Fortynine Palms and Eastern Subbasins is predominantly sodium bicarbonate in character (DWR, 1984) or sodium calcium bicarbonate in character (Krieger and Stewart, 1996). TDS content ranged from 139 to 164 mg/L for water in production wells in 1994 (Krieger and Stewart, 1996). Data from 14 public supply wells show an average TDS content of 159 mg/L and a range of 117 to 185 mg/L. Fluoride concentration in water from some wells has reached 9.0 mg/L, exceeding recommended maximum concentration levels of 2.0 mg/L (DWR, 1984).

Water may take thousands of years to migrate from the recharge area to its discharge point. Nishikawa *et al*. (2004) used carbon-14 dating methods to determine that groundwater in the Copper Mountain Subbasin is likely to have been in the aquifer for approximately 10,000 years. This relationship can be complicated by the environment within the aquifer; groundwater that experiences elevated temperatures dissolves aquifer minerals more readily, and additional chemicals can be added from other aquifers or the ground surface. The minerals in groundwater may also be concentrated by evaporation when the water table is close to the ground surface. Water quality is described here only for the subbasins within the boundary of TPWD.

5.3 TPWD Water Treatment

The District has been historically pumping from the Indian Cove, Fortynine Palms and Eastern Subbasins in the south because of the generally good water quality in these areas. However, the District does have to treat water from certain wells for naturally-occurring constituents including fluoride and arsenic.

Elevated fluoride concentrations above the MCL are widespread across the TPWD service area. In 1993, TPWD was granted a variance from the California Primary MCL for fluoride, which states "the District shall not serve water containing fluoride levels in excess of 3.0 mg/L or 75 percent of the U.S. Environmental Protection Agency (USEPA) Primary Drinking Water Standard (currently at 4.0 mg/L), whichever is higher." The District made its request for the variance based on provisions outlined in SB 694 and AB 2681 which provide for the granting of a variance from the Primary Drinking Water Standard for fluoride by the CDPH for a period of up to 30 years, provided that a review of the variance status is conducted every five years. The CDPH finds that there is no need for a comprehensive fluorosis study based on present levels of fluoride being served. The variance is set to expire in 2023.

Fluoride concentrations in the Indian Cove, Fortynine Palms and Eastern Subbasins generally averages below 2 mg/L, but several wells, especially in the Eastern Subbasin, average above 3 mg/L. Several older wells with high fluoride concentrations were taken out of operation in the 1990s and replaced by newer wells located in areas with lower fluoride concentrations. Because of the variance, groundwater from these wells has been allowed for use without treatment for fluoride.

Because the fluoride concentrations in the Mesquite Lake Subbasin are generally well above 3 mg/L, groundwater from these subbasins cannot comply with the variance without treatment. In 2003, the District began pumping from the Mesquite Lake Subbasin; however, groundwater has high levels of fluoride. Water pumped from the Mesquite Lake Subbasin is treated to reduce fluoride before being distributed into the pipeline system using the Twentynine Palms Fluoride Removal Water Treatment Plant in the Twentynine Palms Valley Basin. The plant is designed to reduce fluoride concentrations in the groundwater to levels below the State maximum contaminant level (MCL) of 2 mg/L allowed by the CDPH for fluoride. The treatment plant is currently producing approximately 1.2 mgd and has a maximum capacity of 3 mgd. With the operation of the treatment plant, it is the District's long-term goal to maintain fluoride levels of not more than 2 mg/L.

In 2008, the CDPH lowered the MCL for arsenic from 50 µg/L to 10 µg/L. Arsenic concentrations from all of the District's wells complied with the earlier MCL, but several wells, especially in the Indian Cove Subbasin, have arsenic concentrations that exceed the new 10 µg/L MCL. Therefore, the District has been required to install an arsenic treatment system for compliance with the new MCL.

On August 23, 2013, CDPH proposed an MCL for hexavalent chromium of 10 µg/L and announced the availability of the proposed MCL for public comment through October 2013.

Completion of the rulemaking process may take up to 12 months after the proposal. In the absence of any major delays, an enforceable MCL is anticipated to be established in 2014. In response, the District began collecting samples to test for hexavalent chromium from the District's wells and provided comments on the proposed new MCL to CDPH and the Office of the Governor. The District will continue to evaluate the impact of this regulatory change on the treatment requirements for the District's water supply.

5.4 Wastewater Management

There is no community sewage system within the District service area and wastewater is disposed through individual septic tank and tile field disposal systems. There are two major categories of onsite wastewater treatment systems in the Twentynine Palms area – residential and non-residential. Single family and multifamily households all fall under the residential category. A variety of commercial (e.g., restaurants and hotels) and institutional (e.g., school) establishments and facilities fall into the non-residential wastewater category.

The District and City are currently working together to develop a Groundwater Protection Plan (GPP) to specifically address potential groundwater quality issues associated with existing septic tanks and a Wastewater Master Plan (WMP) to evaluate potential alternatives for future wastewater treatment especially for more developed areas with higher septic tank densities. This effort may lead to the development of a Local Area Management Plan (LAMP) under the new Onsite Wastewater Treatment System (OWTS) Policy issued by the SWRCB in 2012. The District and City will coordinate these efforts with the Colorado River RWQCB (Region 7).

As part of the GPP, the District and the City are preparing a monitoring plan to collect groundwater quality data to assess potential impacts to groundwater from septic system use in the Twentynine Palms area. This effort is intended to guide the development of a groundwater monitoring program by collecting water quality data that can be evaluated to support informed decisions on wastewater management. In the context of the GPP, the District and the City are developing a Septic System Management Program (SSMP) that will be implemented to more properly manage septic tanks and to protect both groundwater quality and the beneficial uses of the local groundwater basins. The SSMP includes a series of administrative and operational measures, as well as recommended specific studies to gather site data for future evaluation of potential impacts from septic tanks. The GPP is anticipated to be completed in 2014.

5.5 DWR Definition of Recharge Areas

As of January 1, 2013, DWR requires that the GMP include a map identifying the recharge areas for the groundwater basins that substantially contribute to their replenishment. This map shall be provided to local planning agencies after the adoption of the GMP.

As discussed in Section 4, natural recharge is primarily associated with storm water runoff from the Little San Bernardino Mountains that lie along the southern margin of the Joshua Tree Basin. During large summer storms, runoff in Fortynine Palms Creek can flow out across the highway toward the Twentynine Palms Valley Basin towards the Mesquite Dry Lake. The distribution of natural surface recharge shown on Figure 5-1 reflects this pattern.

Other areas of the basin are not considered to have substantial recharge from natural surface sources. However, the highly-permeable soils underlying most of the basin are susceptible to urban recharge from human activity. Urban recharge associated with return flows from septic tank leach fields, leaking water pipes and irrigation of lawns occurs in the developed areas of the District. These return flows account for a large volume of the annual recharge in the Basin. Figure 5-1 shows the current distribution pattern of urban recharge for the area.

5.6 Water Quality Management Actions

The District undertakes several actions for the protection of the water quality of groundwater delivered to its customers. The following summarizes several of the key management actions for issues including those of the voluntary 12 specific technical elements identified in the California Water Code that pertain to water quality.

5.6.1 Control of High-Salinity Waters

Areas near historical dry lakes, such as Mesquite Dry Lake and Shortz Dry Lake, tend to have higher salinity contents in both the groundwater and surface water. The District's groundwater supplies do not appear to be suffering from this phenomena and no action is recommended at this time. Monitoring wells near to the WTP-1 production well that is located in the vicinity of the Mesquite Dry Lake are periodically sampled for TDS to monitor for high salinity water.

5.6.2 Regulation of the Migration of Contaminated Groundwater

No contaminated groundwater from industrial or commercial sources has been identified in the District's service area. The responsibility for regulating and controlling the migration and cleanup of contaminated groundwater from industrial or commercial sources rests with various County, State, and Federal agencies, including the County of San Bernardino and the Colorado River RWQCB (Region 7).

5.6.3 Wellhead Protection Areas and Recharge Areas

The purpose of a recharge and wellhead protection area is to establish a protective zone around wells, well fields, and recharge areas to protect groundwater sources from contamination, eliminating the need for costly treatment to meet drinking water standards. The State has a formal wellhead and recharge protection program as part of the CDPH Drinking Water Source Assessment and Protection (DWSAP) Program, which is being incorporated into the District's own DWSAP Program. The District is active in efforts to protect groundwater sources, and recently worked with a developer, the City, and the Colorado River RWQCB (Region 7), to condition a housing tract development to incorporate a package wastewater treatment plant in an effort to protect water resources.

The District's DWSAP was completed in 2002 and indicates that the geology of the area places most of the District's wells in the moderate category (moderately vulnerable). This is because the District's wells are largely in unconfined aquifers. The DWSAP also indicates that very few potentially contaminating activities (PCAs) are located near the District's wells. PCAs that are located near the District's wells including roads and streets, wells (drinking water and/or monitoring), and golf courses, which are lower risk uses than industrial facilities.

As part of developing a wellhead protection area program, it is essential that the designated wellhead protection areas are communicated to the local land use planning agencies, namely the City and San Bernardino County, and that the land use planning agencies agree to make the necessary modifications to their zoning and/or General Plans to prevent any potentially contaminating activities from being sited within the wellhead protection areas. While the City of Twentynine Palms General Plan Update of 2012 identified actions for the general protection of groundwater from development, no wellhead protection policies were included.

5.6.4 Well Construction Policies

Improperly constructed wells can result in poor yields and contaminated groundwater. A properly constructed well can also minimize contaminant migration between aquifers. Sections 13700 through 13806 of the California Water Code require all water wells to meet certain minimum standards. DWR Bulletins 74-81 and 74-90 (DWR 1991) describe these minimum standards.

All District groundwater extraction, injection, and monitoring wells and all piezometer wells will be constructed according to applicable county and State, including CDPH regulations. Minimum state standards are specified in DWR Bulletin 74-90 (DWR 1991). District well drilling contractors will possess an active C57 (Water Well Drilling) Contractor's license. District well construction activities will be observed and inspected by District personnel.

The construction of private wells in the District is not within the District's jurisdiction. The County is responsible for enforcing well construction standards for these types of wells. However, outreach and coordination with private well owners is identified as an important component of the SSMP implementation. This includes working with private well owners to increase data collection efforts for better supply source management and management actions related to water quality.

5.6.5 Well Abandonment and Destruction Program

The continued presence of unusable wells creates several concerns. Older wells were often screened or perforated over a long depth, allowing vertical communication between various water bearing zones, which could lead to mixing of poor and good quality groundwater and/or interzonal movement of pollutants. Rusting, corrosion, and caving can compromise the integrity of the well casing, and older wells may lack the concrete sanitary seals that meet current standards. These wells are potential conduits for ground surface pollutants to enter groundwater and create a surface hazard to people and animals.

California Well Standards, Bulletin 74-81 (DWR 1991), and its supplements, provide minimum standards for well abandonment and destruction. The County of San Bernardino Public Health Department determines how those standards are implemented within the County. There are several methods of well abandonment and destruction in the Well Standards; the County would make a determination which method is appropriate for the particular well. Additionally, the

County does require a permit for all well destruction activities. These permits are required for activities within both incorporated and unincorporated areas of the County.

The District currently adheres to these minimum well abandonment and destruction standards for its own wells. In addition to abandoning and destroying unusable wells, the District will also strive to educate private well owners of the need for proper well abandonment and their responsibility under the law. Available information from the DWR, USGS, and CDWR, and the District indicate that more than 400 private wells have been constructed within the District's service area. Most of these wells are not currently operated. The District has field located and inspected approximately 250 (60 percent) of the private wells.

California Well Standards, Bulletin 74-81 and its supplements, require at least a 100 feet minimum horizontal separation of any septic tank or subsurface sewage leaching field from a well. In October 2009, a private well was tested and had an elevated nitrate concentration; however, subsequent investigation concluded that the water in the well was under the influence of wastewater from a septic system due to poor maintenance. This illustrates the need for both proper septic tank maintenance and destruction of private wells located close to septic systems, as well as the importance of educating private well owners on the matter.

TABLE 5-1 – NITRATES AND TDS SUMMARY FOR TPWD PRODUCTION WELLS

	Nitrate (as NO3) (mg/L)			*Total Dissolved Solids (TDS) (mg/L)*			*Years of Well Sampling History*	
	Primary MCL = 45 mg/l			**Secondary MCL = 500 mg/l**				
Well	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**	**Year first sampled[(a)]**	**Year last sampled[(b)]**
Indian Cove Subbasin								
TPWD-6	5.9	9.2	1.0	123	157	101	1958	2009
TPWD-7	5.4	8.0	1.0	118	140	102	1962	2003
TPWD-8	9.7	14.1	5.0	163	242	123	1964	1993
TPWD-9	10.0	14.4	2.0	160	257	120	1968	2013
TPWD-10	11.1	13.5	1.0	163	192	140	1968	2006
TPWD-11	12.6	24.0	9.0	171	202	149	1978	2013
TPWD-12	9.6	14.0	7.8	144	180	129	1983	2013
TPWD-15	10.8	12.0	8.8	145	178	126	1987	2013
Summary[(c)]	**9.4**	**24.0**	**1.0**	**148**	**257**	**101**		
Fortynine Palms Subbasin								
TPWD-3	8.7	13.4	3.0	151	173	135	1953	1992
TPWD-3B	9.2	12.1	6.9	132	151	121	1992	2006
TPWD-4	20.7	36.0	8.0	170	220	135	1951	2013
TPWD-5	10.1	16.0	3.0	149	173	121	1951	1996
TPWD-13	9.2	14.3	5.2	166	215	142	1985	2003
TPWD-14	9.8	14.0	5.5	131	150	100	1993	2013
Summary[(c)]	**11.3**	**36.0**	**3.0**	**150**	**220**	**100**		
Eastern Subbasin								
TPWD-1	6.1	10.0	1.0	250	304	198	1953	1998
TPWD-2	5.3	9.0	ND	176	190	154	1951	1993
TPWD-16	6.1	8.7	2.9	160	173	145	1991	2013
TPWD-17	8.3	9.0	7.6	n/s	n/s	n/s	2011	2013
Summary[(c)]	**6.5**	**10.0**	**ND**	**195**	**304**	**145**		
Mesquite Lake Subbasin								
WTP-1	3.5	5.0	ND	340	350	320	2006	2013
Summary[(c)]	**3.5**	**5.0**	**ND**	**340**	**350**	**320**		

Notes: MCL – maximum contaminant level; ND: non-detect; n/s: not sampled.
(a) Well first sampled is based on TPWD records
(b) Well last sampled is based on TPWD records.
(c) Summary provides the average, maximum and minimum of all samples in each subbasin.

TABLE 5-2 – FLUORIDE AND ARSENIC SUMMARY FOR TPWD PRODUCTION WELLS

Well	*Fluoride (mg/L)*			*Arsenic (µg/L)*			*Years of Well Sampling History*	
	Primary MCL = 2 mg/l			**Primary MCL = 10 µg/l**				
	Average	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**	**Year first sampled**[(a)]	**Year last sampled**[(b)]
Indian Cove Subbasin								
TPWD-6	0.8	1.9	0.3	2.8	6.4	ND	1958	2009
TPWD-7	0.6	2.1	0.3	2.7	6.0	ND	1962	2003
TPWD-8	1.2	2.6	0.5	ND	16.0	ND	1964	1993
TPWD-9	2.3	4.0	0.8	4.8	10.8	ND	1968	2013
TPWD-10	1.5	2.3	0.6	12.6	31.0	ND	1968	2006
TPWD-11	2.1	3.4	0.2	7.7	18.0	ND	1978	2013
TPWD-12	1.5	2.6	0.4	3.4	11.0	ND	1983	2013
TPWD-15	0.4	1.1	0.2	ND	ND	ND	1987	2013
Summary[(c)]	**1.3**	**4.0**	**0.2**	**5.7**	**31.0**	**ND**		
Fortynine Palms Subbasin								
TPWD-3	1.5	2.3	0.4	ND	ND	ND	1953	1992
TPWD-3B	2.1	3.6	0.4	16.3	31.0	ND	1992	2006
TPWD-4	1.7	2.6	0.6	3.0	7.0	ND	1951	2013
TPWD-5	1.5	2.7	0.8	ND	6.0	ND	1951	1996
TPWD-13	1.1	2.0	0.3	1.4	2.8	ND	1985	2003
TPWD-14	0.7	1.5	0.4	1.3	3.2	ND	1993	2013
Summary[(c)]	**1.4**	**3.6**	**0.3**	**5.5**	**31.0**	**ND**		
Eastern Subbasin								
TPWD-1	5.7	7.2	1.8	2.5	5.0	ND	1953	1998
TPWD-2	2.6	5.9	1.2	ND	4.0	ND	1951	1993
TPWD-16	1.7	2.1	0.4	1.0	2.7	ND	1991	2013
TPWD-17	0.8	1.9	0.7	n/s	n/s	n/s	2011	2013
Summary[(c)]	**2.7**	**7.2**	**0.4**	**1.8**	**5.0**	**ND**		
Mesquite Lake Subbasin								
WTP-1	5.9	6.4	5.1	2.4	4.8	ND	2006	2013
Summary[(c)]	**5.9**	**6.4**	**5.1**	**2.4**	**4.8**	**ND**		

Notes: MCL – maximum contaminant level; ND: non-detect; n/s: not sampled.
(a) Well first sampled is based on TPWD records.
(b) Well last sampled is based on TPWD records.
(c) Summary provides the average, maximum and minimum of all samples in each subbasin.

Section 6: Basin Management Objectives and Strategies

Basin Management Objectives (BMOs) are required under California Water Code (CWC) §10753.7(a)(1) to provide flexible guidelines for the management of groundwater resources that describe specific actions to be taken by stakeholders to meet locally developed objectives at the basin or sub-area scale. SB 1938 amended existing law related to groundwater management plans requiring a public agency seeking State funds administered through DWR to prepare and implement a groundwater management plan that includes BMOs. This section establishes Basin Management Objectives (BMOs) that are intended to help the District plan for a more reliable water supply for long-term beneficial uses in the plan area, and describes the existing or planned management actions to achieve the BMOs.

6.1 Goals

The overall goal of this GMP is to maintain the quality and long-term availability of groundwater to meet the current and future demands without adversely affecting groundwater resources within the GMP area. The objective of the updated GMP is to address issues of "aquifer health" and "groundwater sustainability". These key issues include:

- Sustainable long-term water supplies
- Treatment of natural water quality constituents
- Wastewater management, specifically septic tanks
- Water supply for anticipated population growth

The BMO method of groundwater management is intended to provide a flexible approach that can be adapted to changing local conditions and increased understanding of the groundwater resource as better monitoring data are collected. The more traditional way of managing groundwater basins typically focused on often difficult to define concepts such as safe yield, replenishment and overdraft. To meet the stated goal of addressing the key issues for the District, the following BMOs are proposed for the TPWD.

- BMO #1 – Manage Groundwater Levels to Maintain Water Supply Sustainability and Reliability
- BMO #2 – Maintain and Protect Groundwater Quality
- BMO #3 – Support Development of a Local Program for Septic Tank Management
- BMO #4 – Monitor and Track Groundwater Supply, Water Quality and Land Subsidence
- BMO #5 – Promote Public Participation and Coordination with Other Local Agencies
- BMO #6 – Address Planned or Potential Future Water Supply Needs and Issues
- BMO #7 – Identify and Obtain Funding Sources for Groundwater Projects

This section presents the BMOs developed by the District; a series of plan components that discuss and identify the actions necessary for BMO implementation.

6.2 BMO #1 – Manage Groundwater Levels to Maintain Water Supply Sustainability and Reliability

Of the two groundwater basins that underlie the District, most of the groundwater production has been from the Joshua Tree Basin because of higher groundwater quality, but this has led to long term declines in groundwater levels. The purpose of BMO #1 is to implement measures to manage the groundwater levels in a manner to increase the long-term sustainability and reliability of the water supply for TPWD in the Indian Cove, Fortynine Palms, Eastern and Mesquite Lake Subbasins. For BMO #1, the following actions are proposed:

- **Continue adaptive management by balancing pumping between the subbasins** – The District will continue the practice of shifting groundwater production between subbasins to help stabilize declining groundwater levels. This would include scheduling rest periods for groundwater wells, especially in the Indian Cove and Fortynine Palms Subbasins, to provide intervals for groundwater levels to stabilize and recover.

- **Expand groundwater production in the Mesquite Lake Subbasin** – The Mesquite Lake Subbasin contains a large volume of groundwater but that groundwater requires water treatment primarily for fluoride. Because the fluoride is naturally occurring, treatment is the most practical and effective means to achieve drinking water quality standards. The current Fluoride Removal Water Treatment Plant is designed to handle 3.0 mgd, but currently treats 1.2 mgd, so it is operating at 40% of capacity. The District will plan to bring the operation of the Fluoride Removal Water Treatment Plant up to the 3.0 mgd capacity. The District will install additional production wells at an appropriate well spacing to minimize drawdown in this subbasin.

- **Continue and expand water conservation measures** – Water conservation reduces the overall demand for groundwater, and thus helps to sustain groundwater levels and long-term groundwater production. The District will continue to implement water conservation policies and practices to promote water conservation among customers through public outreach activities. In addition, the District will continue implementing conservation management practices including water usage audits to customers, ongoing pipeline replacement and prompt leak repairs. In the future, the District may explore a tiered rate structure; however, with current outdoor usage relatively low in the District, it is not clear how this measure would provide significant water conservation.

- **Continue assessment for future infrastructure improvements** – To better manage groundwater resources, the District will continue to assess infrastructure improvements that provide greater flexibility in operating wells to manage water quantity and quality issues. The District will assess if sufficient source capacity is available to provide adequate redundancy in the system to cover possible future system failures and to allow flexibility for adaptive management practices that shift groundwater production between the various subbasins. The District will continue to monitor aging infrastructure and develop cost-effective schedules for replacing pipeline and aging infrastructure to reduce system water loss.

6.3 BMO #2 – Maintain and Protect Groundwater Quality

Groundwater in the District is typically of good quality; however, groundwater in some of the District's wells requires treatment for fluoride and arsenic. There is no known contamination in the District, yet the use of septic systems for wastewater disposal in certain areas of the District could potentially introduce nitrate to groundwater. The purpose of BMO #2 is to implement measures that maintain and protect groundwater quality in the District in a manner not to impact the beneficial use of the groundwater resources. For BMO #2, the following actions are proposed:

- **Continue measures to control spread of highly saline groundwater** – Highly saline groundwater is primarily limited to the vicinity of the existing or historic playa lakes in the Mesquite Lake and Mainside Subbasins. The District will continue to employ practices to control spreading of highly saline groundwater by locating wells away from the playa lakes areas if possible and minimizing drawdown to avoid its migration into areas of higher water quality. New production wells will be designed to avoid depth intervals with highly saline groundwater near the playa lakes. The monitoring program will include monitoring wells in these areas to monitor for changes in water quality trends.

- **Continue wellhead protection measures –** California's Drinking Water Source Assessment and Protection (DWSAP) Program was developed by the CDPH to protect the State's public water systems and includes both a source water assessment and wellhead protection program. The District will continue to complete these assessments for new production wells, and also consider updating the source assessments for older wells if there has been a significant change in the land use in the vicinity of these wells. The District will also work with the City to ensure that land use policies protect critical wellhead areas.

- **Monitor activities at environmental investigation and remediation sites** – The only environmental investigation and remediation sites that are currently being conducted are located at the Marine Base. The District will coordinate with the Colorado River RWQCB (Region 7) to be notified if any new environmental investigation and remediation sites are opened within the District boundaries.

- **Continue the District's well abandonment policy** – Abandoned wells provide a conduit for migration of contaminants and poor quality water through the aquifer. The District will continue to adhere to the requirements for well abandonment and destruction for all District-owned wells. These actions will be conducted according to County of San Bernardino Public Health Department requirements and California Well Standards, Bulletin 74-81 and its supplements. Information for private well owners on proper well abandonment procedures will be available at public outreach activities and the District Office. The District may also pursue outside funding sources to assist with private well abandonment if appropriate.

- **Conduct groundwater quality studies –** Vertical water quality profiling involves chemically profiling periodic samples from a new well being drilled. With the information gained through profiling, wells can be better designed to block off the source of poor quality water by sealing selected intervals during drilling, plugging the bottom of a hole, or building better surface seals. Vertical profiling on new wells will be undertaken when feasible and cost-effective including the pursuit of outside funding sources when appropriate.

6.4 BMO #3 – Support Development of a Local Program for Septic Tank Management

Wastewater disposal within the District is principally through septic tanks, which are currently regulated by San Bernardino County. Septic tank return flows are a significant component of groundwater recharge to the groundwater basins; however, these return flows can add nitrate, salts and possibly other contaminants to the groundwater. If properly managed, septic tanks return flows may not affect the beneficial use of the groundwater. The new state Onsite Wastewater Treatment System (OWTS) Policy issued in 2012 provides a mechanism for local management of septic tanks. The District and City will assess the potential for the development of a local management program for regulation of septic tanks in Twentynine Palms. For BMO#3, the following actions are proposed:

- **Finalize the GPP and WMP** – The District and City are currently finalizing the Groundwater Protection Plan (GPP) and Wastewater Master Plan (WMP) to evaluate potential groundwater quality issues from existing septic tanks and whether the continued discharges from septic systems would unreasonably degrade groundwater quality and result in widespread groundwater pollution. Next steps will be to present these reports to the Colorado River RWQCB (Region 7).

- **Continue to work with City on developing a plan to address septic tank use** – The District and the City are currently developing the GPP and WMP to specifically address water quality issues associated with septic tanks within the District service area. The District is a co-sponsor and will continue to participate in the development and implementation of the GWPP. The District will continue to participate in meetings and discussions regarding the septic tank issue.

- **Support development of a Local Area Management Plan** – The GPP and WMP are intended to lead up to the possible development of a LAMP under Tier 2 of the OWTS Policy for Twentynine Palms. Local regulation would provide a means to help address potential high-risk areas of nitrate loading from septic tanks and allow for continued septic tank operation in low risk areas. The District will continue to support efforts of cooperation with the City toward development of a LAMP for Twentynine Palms.

- **Pursue outside funding sources to support abandonment of private wells** – The District service area contains hundreds of unused private wells that may act as conduits for migration of contaminants to the aquifer. Jurisdiction for well abandonment lies with the County; however, the District can provide information to private property and well owners about the need to properly destroy wells that are no longer in use. This would especially include information on wells within 100 feet of a septic tank or leach field that can be distributed to customers and/or made available at local public meetings. This proposed action is dependent on the District's obtaining outside funding, preferably through a grant, to support local property owners in well abandonment.

- **Assess methods for recycled water use** – If future actions by the District and City include implementation of a centralized sewer collection and treatment system, the District will evaluate ways of utilizing recycled water to help reduce groundwater demand or provide for aquifer recharge. Septic tank system return flows currently comprise a large component of recharge to the basin; therefore, recycled water should be put to an appropriate beneficial use in-lieu of groundwater if available.

6.5 BMO #4 – Monitor and Track Groundwater Supply, Water Quality and Land Subsidence

A key element of a GMP is monitoring groundwater conditions. The District will maintain regular groundwater level and quality monitoring to improve the understanding of groundwater level fluctuations, potential impacts to groundwater quality and subsidence across the District. Changes to groundwater storage will be accounted for by tracking groundwater levels. The District currently conducts water quality monitoring per the CDPH standards which is sufficient for the purpose of tracking changes in the quality of the groundwater basin. For BMO #4, the following actions are proposed:

- **Collect groundwater supply monitoring data** – The District will collect data necessary to evaluate the change in the quantity of groundwater including the volume of groundwater pumped by the District and others, static and pumping groundwater levels from the production wells, groundwater levels from monitoring wells, and climatic data. Data will be collected according to the GMP Monitoring Plan with appropriate field record keeping that will be maintained. Relevant data will be kept in an electronic database so that the data can be readily used to support District decision-making needs. The District will continue to coordinate with the USGS on monitoring of groundwater levels in the region and will include these data into the District's monitoring database and the DWR California Statewide Groundwater Elevation Monitoring (CASGEM) Program records. Locations of District wells are shown on Figure 6-1.

- **Collect Groundwater quality monitoring data** – The District will collect water quality samples from production wells and selected monitoring wells according to the GMP Monitoring Plan. Emphasis will be on monitoring for regulated drinking water constituents following the CDPH and United States Environmental Protection Agency (USEPA) guidelines. Appropriate record keeping will be maintained for field records and lab reports. Relevant data will be kept in an electronic database so that the data can be readily used to support District decision-making needs. Locations of District wells are shown on Figure 6-1.

- **Incorporate GPP water quality monitoring data into monitoring database update** – The objective of the GPP monitoring is focused on defining spatial and temporal trends in nitrate, TDS and contaminants of emerging concern (CEC) associated with wastewater effluent from septic tanks. The GPP is being developed concurrently with this GMP update. Once a final GPP is approved by the Colorado River RWQCB (Region 7) and the monitoring plan is implemented, the data from the GPP monitoring will be incorporated into the District database.

- **Assess change in groundwater storage** – The District will include a regular assessment of the change in groundwater storage. The results of the groundwater model provide a historical assessment of the change in groundwater storage calibrated to measured changes in groundwater levels. An annual assessment based on the change in measured groundwater levels over the past year will be done to track the change in groundwater basins. The calibrated groundwater model may be updated periodically to verify the annual assessment. The proposed action for groundwater model updates is dependent on the District's obtaining outside grant funding.

- **Prepare annual report and monitoring database update** – The District will produce a concise annual report of groundwater conditions based on the monitoring data. The format of the annual report will be a brief management-level summary that contains up-to-date monitoring data, a brief analysis of the data, and description of groundwater conditions in each of the subbasins in order to track progress on the groundwater management process. The results will be presented at least once a year at a public meeting to the Board of Directors, keeping them up-to-date on groundwater issues.

- **Establish a baseline for evaluating potential future land subsidence** – Land subsidence has not been identified as an issue within the Twentynine Palms area; however, playa lake deposits such as those found in the Mesquite Lake and Mainside Subbasins have been noted as sources of land subsidence in Antelope Valley and other similar areas. The District will continue to employ practices to control subsidence in the Mesquite Lake Subbasin by locating wells away from the playa lakes areas when possible and minimizing drawdown to avoid the loss of aquifer storage. Therefore, the District will establish a baseline elevation assessment with historical US Geodetic Survey benchmark surveying data. Future assessments will be done periodically to verify whether land subsidence is occurring or not. Locations of benchmarks are shown on Figure 6-1.

- **Expand monitoring well network to evaluate recharge and other effects of pumping on groundwater** – The District will expand its groundwater monitoring well network to include additional monitoring wells that improve the ability to track changes in groundwater storage in each of the groundwater subbasins. The various purposes of these monitoring wells would include defining drawdown effects near active pumping wells, understanding groundwater recharge potential in key recharge areas, and providing better spatial coverage to define groundwater flow. The proposed action for the installation of additional monitoring wells is dependent on the District's obtaining outside grant funding.

6.6 BMO #5 – Promote Public Participation and Coordination with Other Local Agencies

The District will look to continue and expand communication and coordination with local, state and federal agencies to discuss regional water issues. The District is also committed to keeping customers up-to-date on groundwater issues. The GMP process encourages coordination with other local agencies and stakeholders. For BMO #5, the following actions are proposed:

- **Coordinate with the City of Twentynine Palms, Marine Base, neighboring water districts and other local water purveyors** – The District plans to coordinate with these agencies to discuss local water issues. A semi-annual meeting may be a helpful means of facilitating communication and providing a forum for discussing regional issues.

- **Participate in Integrated Regional Water Management Plan (IRWMP) Process** – The District will continue to participate in the IRWMP process within the Mojave region to coordinate with other regional water managers and to support obtaining outside funding to meet District needs. The updated Mojave Region IRWMP is due for completion by June 2014. The IRWMP provides a road map for a long-term, balanced water supply in the region and evaluates potential water supply projects and programs that provide regional benefit through collaboration with local stakeholders, such as water and wastewater agencies. The IRWMP also fulfills a requirement for acquiring State and federal funding for local water supply and management projects. The District has incorporated projects into the IRWMP.

- **Continue coordination with local land use planning agencies** – Land use in the City is governed by the City of Twentynine Palms General Plan under the Community Development Department. One of the policies of the City's General Plan is to "maintain a consistent level of quality water service by working with the TPWD while minimizing any impacts of land development on the existing system". Land use in the unincorporated portions of the District is governed by the County of San Bernardino General Plan. The County's General Plan addresses water supply issues and recognizes the jurisdiction and authority of all agencies providing water service within the County with consideration given to the County's diverse geographic region. The District coordinates with both the City and County by using General Plan information to provide the foundation for land use and population projections for planning purposes.

- **Maintain a working relationship with local and state regulatory agencies** – The District will continue to report to and communicate with these agencies, as required by law and to support mutual goals in the region. In addition, the District will continue and expand communication and coordination with local and state regulatory agencies to discuss groundwater issues especially pertaining to water quality. The management of District groundwater resources requires establishing and maintaining communication with the following state and federal regulatory agencies:

    - State Water Resources Control Board (SWRCB);
    - California Department of Public Health (CDPH)
    - Colorado River Regional Water Quality Control Board - Region 7 (RWQCB);
    - California Department of Water Resources (DWR); and
    - United States Environmental Protection Agency (USEPA).

- **Provide for regular public outreach opportunities** – The District will provide for regular public outreach and participation through one or more public meetings. Potential public outreach includes an annual presentation summarizing the annual report at a public meeting to keep the Board of Directors and public up-to-date on the management of the groundwater basin. The District newsletter is distributed every other month to the media, Chamber of Commerce and the City. The District will continue to provide information on water issues and water conservation through brochures, new customer information packages, speaking at public events, and providing educational materials at local schools

6.7 BMO #6 – Address Planned or Potential Future Water Supply Needs and Issues

Water supply needs and issues for the District could change due to future growth in the region, changes in regulations, or other outside factors. The District will take measures to plan for these contingencies. For BMO #6, the following actions are proposed:

- **Develop a plan for addressing the expiration of the fluoride variance in 2023** – The District received a variance for the California MCL for fluoride that allows the removal of fluoride from the groundwater to levels below 3 mg/L rather than the State MCL of 2 mg/L. In accordance with AB 2681, the variance from the Primary Drinking Water Standard for fluoride shall be in effect for period up to 30 years from the date of permit issuance on January 21, 1993; therefore, this variance is set to expire in 2023. The District will both develop a contingency plan for addressing water treatment at 2 mg/Land will explore the possibility to obtain an extension of the variance. The contingency plan will include an engineering study to assess the cost to upgrade infrastructure to meet the 2 mg/L MCL for fluoride.

- **Monitor changes to drinking water standards –** Water quality regulations by the CDPH are subject to change which may include lowering an existing MCL or adding a new compound to the list of regulated compounds. This can have a significant impact on the customers of the District if these changes in the water quality regulation result in the addition of new water treatment in order to continue serving water from existing wells. If new treatment is required, this may result in significant capital and O&M costs to upgrade and maintain the additional water treatment.

  The 2008 change in the arsenic MCL resulted in changes in use of groundwater production wells and treatment that required capital expenditures to address. Pending changes to the hexavalent chromium MCL may have similar impacts on the District. However, since in 1993 the District received a 30-year waiver for the revised fluoride MCL, the possibility of a variance or exemption may also be explored. The District will continue to monitor changes in state and federal drinking water standards and evaluate how best to address these with respect to both providing a safe water supply to customers and maintaining cost-effective District operations.

- **Review criteria for assessing water supply availability for large developments** – The District will review and update its policy on meeting the long-term water supply needs for large developments that would request water from the District. The goal is to establish internal guidelines for consistency of evaluating SB610/SB221 requests for water supply and to assess the availability of total water supply within the District. This will include developing potential mitigation measures for developers that may include water conservation or other measures to offset the costs of increasing the water supply.

- **Evaluate the feasibility of groundwater replenishment projects** – The local desert environment limits the potential recharge in the region; therefore, measures to maximize the use of existing local water sources are necessary. The most likely potential source of existing water is stormwater runoff. Recharge enhancement could be accomplished by constructing facilities such as berms that will slow down runoff and increase infiltration rates, wetted surface area, and contact time of flood runoff. Recharge enhancements may be viable in both the Indian Cove and Fortynine Palms Subbasins, potentially increasing the yield and/or reducing the overdraft in these basins. The District will pursue grant funding to identify alternatives and evaluate the feasibility of groundwater replenishments projects.

- **Evaluate the feasibility of potential new water sources** – If future growth in the Twentynine Palms area increases significantly as it has in other nearby areas in Southern California, water demand may potentially exceed the ability of the groundwater basin to provide adequate water supply without overdrafting the groundwater basin. Therefore, the District will evaluate whether there are other potential new water sources that could be developed. Potential sources may include further development of low quality groundwater resources requiring treatment, water conservation, water reuse, groundwater storage and recovery, or importation of water. Development of new water sources is anticipated to be more expensive than the use of current water sources; therefore, it is important to begin planning. The proposed action is dependent on the District's obtaining outside funding preferably through a grant, which the District will pursue.

- **Update the groundwater management plan periodically to address changing needs or conditions** – The DWR guidelines include a provision for the regular review and updating of the groundwater management plan to keep the BMOs, actions and implementation plan up-to-date. The District practice has been to update the plan every five years with the original plan in 2003 and an update in 2008. The District will continue the practice to update the GMP about every five years and include an update on the state of the groundwater basin and review and updating of the BMOs, actions and implementation plan.

6.8 BMO #7 – Identify and Obtain Funding Sources for Groundwater Projects

BMO #7 recommends an evaluation to identify potential funding sources for future groundwater projects. For BMO #7, the following actions are proposed:

- **Define projects that could be eligible for outside funding** – Some funding opportunities require that the project be "shovel ready" which would require existing designs, CEQA and other work already be prepared. The District will evaluate the priority of projects that could be designed and put on a shelf until funding is available.

- **Develop background and supporting materials** – Many grants have a short turnaround time. The District will develop background and supporting materials to respond quickly and successfully to grant funding opportunities.

- **Identify potential funding sources** – The District will identify potential outside funding sources. The District will work through the IRWMP process and also keep track of funding opportunities through State agencies. The District will also contact the Marine Base to determine the potential of federal grants for any joint projects undertaken with the Marine Base.

6.9 Implementation Plan

This section outlines a schedule to assist with the implementation and assessment of this GMP. An important aspect of this section is the identification of the BMOs and actions that will be implemented by the District over time. The schedule for the implementation plan for the BMOs, plan components, and actions is presented in Table 6-1.

Standing procedures and ongoing practices consist of groundwater management related activities that the District is already implementing and will continue to implement. As presented in Table 6-1, this includes several proposed actions as part of the BMOs #1, #2, #3, #4, and #5. The District intends to continue these activities on an ongoing basis. The actions under these BMOs will focus on managing, maintaining, and monitoring groundwater quantity, quality, and land subsidence, coordinating with other local agencies, and addressing planned or potential future water supply options.

- **Standing procedures and ongoing practices** lists that the District is already performing and will continue to perform in the future.
- **The short-term implementation plan** lists those actions that the District will plan to implement over the next five years. As presented in Table 6-1, this includes several proposed actions under the BMOs #1, #2, #4, and #6. These BMOs and actions will focus on activities related to managing and maintaining groundwater quantity and quality, coordinating with other local agencies, and seeking funding opportunities for groundwater projects.
- **The long-term implementation plan** lists those actions that the District will plan to initiate within the next five years, but full implementation is anticipated to extend beyond the next five years. As presented in Table 6-1, the long-term implementation plan includes several proposed actions as part of the BMOs #2, #3, and #5. These actions will focus on maintaining and protecting groundwater quality, coordinating with other local agencies, and seeking funding opportunities for groundwater projects.
- **Projects dependent upon obtaining outside funding** envision that implementation of the GMP, as well as many other groundwater management related activities, will be funded from a variety of sources, including State and Federal grant programs. This is a list of actions the District has identified that would be best accomplished through an outside funding source. As presented in Table 6-1, this includes several proposed actions as part of the BMOs #1, #2, #3, and #5.

The GMP is intended to be a living document, and it will be important to evaluate actions and objectives over time to determine how well they are meeting the overall goal of the GMP. The District intends to evaluate and update the GMP on a regular basis.

TABLE 6-1
GMP IMPLEMENTATION PLAN SUMMARY

Standing Procedures and Ongoing Practices	
BMO #1 – Manage Groundwater Levels to Maintain Water Supply and Reliability	Continue adaptive management of balancing pumping between subbasins
	Continue and expand water conservation measures
	Continue assessment for future infrastructure improvements
BMO #2 – Maintain and Protect Groundwater Quality	Continue measures to control spread of highly saline groundwater
	Continue wellhead protection measures
	Continue the District's well abandonment policy
BMO #4 – Monitor and Track Groundwater Supply, Water Quality, and Land Subsidence	Collect groundwater supply monitoring data
	Collect groundwater quality monitoring data
BMO #5 – Coordinate with Other Local Agencies	Continue Coordination with local land use planning agencies
	Maintain a working relationship with local and state regulatory agencies
Short-Term Implementation Plan	
BMO #3 – Support Development of a Local Program for Septic Tank Management	Finalize the GPP and WWMP
	Explore development of a Local Area Management Plan
	Continue to work with City on developing a plan to address septic tank use
BMO #4 – Monitor and Track Groundwater Supply, Water Quality, and Land Subsidence	Assess change in groundwater storage
	Prepare annual report and monitoring database update
BMO #5 – Coordinate with Other Local Agencies	Coordinate with the City of Twentynine Palms, neighboring water districts and local land use planning
	Participate in Integrated Regional Water Management Plan (IRWMP) Process
	Provide for regular public outreach opportunities
BMO #6 – Address Planned or Potential Future Water Supply Needs and Issues	Monitor changes to drinking water standards
	Review criteria for assessing water supply availability for large developments
BMO #7 – Identify and Obtain Funding Sources for Groundwater Projects	Define projects that could be eligible for outside funding
	Develop background and supporting materials
	Identify potential funding sources
Long-Term Implementation Plan	
BMO #1 – Manage groundwater Levels to Maintain Water Supply and Reliability	Expand groundwater production in the Mesquite Lake Subbasin
BMO #2 – Maintain and Protect Groundwater Quality	Monitor activities at environmental investigation and remediation sites
BMO #3 – Support Local Regulation of Septic Tanks	Assess methods for recycled water use

Long-Term Implementation Plan (continued)	
BMO #4 – Monitor and Track Groundwater Supply, Water Quality, and Land Subsidence	Incorporate GPP water quality monitoring data into monitoring database update
	Establish a baseline for evaluating potential future land subsidence
BMO #6 – Address Planned or Potential Future Water Supply Needs and Issues	Develop plan for addressing the expiration of the fluoride variance in 2023
	Update the groundwater management plan periodically to address changing needs or conditions
Projects Dependent Upon Obtaining Outside Funding	
BMO #2 – Maintain and Protect Groundwater Quality	Conduct groundwater quality studies
BMO #3 – Support Local Regulation of Septic Tanks	Obtain funding to support abandonment of private wells
BMO #4 – Monitor and Track Groundwater Supply, Water Quality, and Land Subsidence	Expand monitoring well network to evaluate recharge and other key areas
BMO #6 – Address Planned or Potential Future Water Supply Needs and Issues	Evaluate feasibility of groundwater replenishment projects
	Evaluate feasibility of potential new water sources

References

BCI Geonetics, Inc. (BCI), 1990, Determination of Active Recharge to the Twentynine Palms Water District, Twentynine Palms, California, report prepared for Twentynine Palms Water District, dated November 1990, BCI Geonetics, Inc., Santa Barbara, CA.

California Department of Water Resources (DWR). Southern District. 1984. *Twentynine Palms ground water study.* District Report. 109 p.

California Department of Water Resources (DWR), 2003. *California's Groundwater, Bulletin 118*, Update 2003, California Department of Water Resources, Sacramento, CA, 265pp.

California Department of Water Resources (DWR), California Well Standards, Bulletin 74-90, June 1991.

California Regional Water Quality Control Board Colorado River Region 7 (RWQCB), 2006, Water Quality Control Plan Colorado River Basin – Region 7. http://www.waterboards.ca.gov/rwqcb7/publications_forms/publications/docs/basinplan_2006.pdf.

Haley and Aldrich, Baseline Report, 2000, Compilation of Groundwater and Wells Information within the Twentynine Palms Water District Service Area, December 2000.

Kennedy/Jenks Consultants, 2008. Groundwater Management Plan Update, report prepared for Twentynine Palms Water District, Kennedy/Jenks, Los Angeles, CA, 126pp.

Kennedy/Jenks Consultants, 2009. Shallow Groundwater Investigation- Twentynine Palms Water Treatment Plant Revised Report of Waste Discharge, letter report prepared for Twentynine Palms Water District, dated 22 October 2009, Kennedy/Jenks, Irvine, CA, 10pp.

Kennedy/Jenks Consultants, 2010. Groundwater Study for the Mesquite Lake Subbasin, report prepared for Twentynine Palms Water District, dated March 2010, Kennedy/Jenks, San Francisco, CA, 328 pp.

Kennedy/Jenks Consultants, 2011. 2010 Urban Water Management Plan Update, report prepared for Twentynine Palms Water District, Kennedy/Jenks, Ventura, CA.

Krieger and Stewart, 1996, Joshua Basin Water District Groundwater Management Plan, Joshua Basin Water District, Joshua Tree, California.

Li and Martin, 2011, Geohydrology, simulation of regional groundwater flow, and assessment of water management strategies, Twentynine Palms area, California, USGS Scientific Investigations Report: 2010-5249.

Londquist, C.J. and P.R. Martin, 1991. Geohydrology and ground-water-flow simulation of the Surprise Spring basin aquifer system, San Bernardino County, California, *U.S. Geological Survey Water-Resources Investigations Report 89-4099*, U.S. Geological Survey, Sacramento, CA, 48pp.

Mendez, G.O. and A.H. Christensen. 1997. *Regional water table (1996) and water-level changes in the Mojave River, the Morongo, and the Fort Irwin ground-water basins, San Bernardino County, California.* U.S. Geological Survey Water-Resources Investigations Report 97-4160. 34 p.

MWH, 2009a. High-Desert Water District Sewer Master Plan Final Report. January 2009.

MWH, 2009b. High-Desert Water District Water Reclamation Facility Preliminary Design Report. Volume 1, January 2009.

Moyle, W.R., Jr. 1984. *Bouguer gravity anomaly map of the Twentynine Palms Marine Corps Base and vicinity, California.* U.S. Geological Survey Water-Resources Investigations Report 84-4005.

Nishikawa, T., J.A. Izbicki, J.A. Hevesi, C.L. Stamos, and P. Martin, 2004. Evaluation of geohydrologic framework, recharge estimates, and ground-water flow of the Joshua Tree area, San Bernardino County, California, *U.S. Geological Survey Science Investigations Report 2004-5267*, U.S. Geological Survey, Reston, VA, 127pp.

Riley, F.S. and G.F. Worts, Jr., 1952 [Retyped 2001]. Geologic reconnaissance and test-well drilling program, Marine Corps Training Center, Twentynine Palms, California, *U.S. Geological Survey Open-File Report 98-166*, U.S. Geological Survey, Long Beach, CA, 71pp.

Riley, F.S. and G.F. Worts, Jr., 1953 [Retyped 2001]. Geology and ground-water appraisal of the Twentynine Palms Marine Corps Training Center, California, *U.S. Geological Survey Open-File Report 98-167*, U.S. Geological Survey, Long Beach, CA, 131pp.

Roberts, C., R. Jachens, A. Katzenstein, G. Smith, and R. Johnson, 2002. Gravity map and data of the eastern half of the Big Bear Lake, 100,000 scale quadrangle, California and analysis of the depths of several basins*, U.S. Geological Survey Open-File Report 02-353*, U.S. Geological Survey, Reston, VA, 1 map.

Schaefer, D.H. 1978. *Ground-water resources of the Marine Corps Base, Twentynine Palms, San Bernardino County, California.* U.S. Geological Survey Water-Resources Investigations Report 77-37. 29 p.

Troxell, H.C. and others, 1954. Hydrology of the San Bernardino and eastern San Gabriel Mountains, California, U.S. Geological Survey Hydrologic Atlas HA 1, *U.S. Geological Survey*, Washington, D.C., 30pp.

Thompson, D.G., 1929. The Mohave Desert Region, California: a geographic, geologic, and hydrologic reconnaissance, U*.S. Geological Survey Water-Supply Paper 578*, U.S. Government Printing Office, Washington, D.C., 817pp.

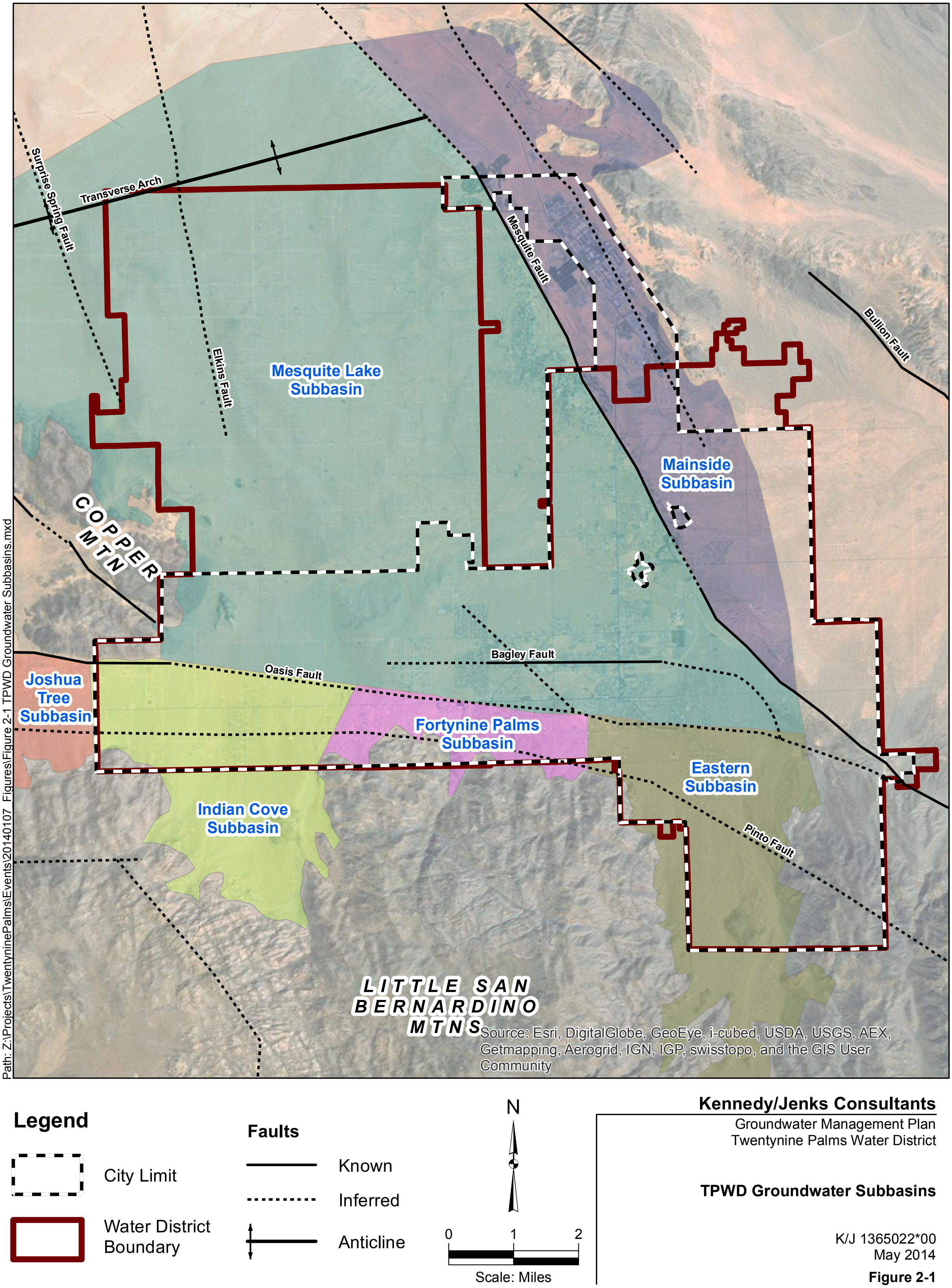
U.S. Department of Agriculture (USDA), 1970. Report and General Soil Map of the Southwestern Desert Area of San Bernardino County, California, U.S. Department of Agriculture, Fort Worth, TX.

U.S. Department of Agriculture (USDA), 1994. State Soil Geographic (STATSGO) Data Base – Data Use Information, *Miscellaneous Publication No. 1492*, U.S. Department of Agriculture, Fort Worth, TX.

Whitt, A. and K.L. Jonker, 1998. Groundwater survey of the Joshua Tree and Copper Mountain subbasins, Joshua Tree, California, Western Water Surveys report prepared for the Joshua Tree Water District.

Woodward-Clyde Consultants, 1985, Twentynine Palms Groundwater Study Final Report, report prepared for Twentynine Palms Water District, dated 6 May 1985, Woodward-Clyde Consultants, Santa Ana, CA.

Figures



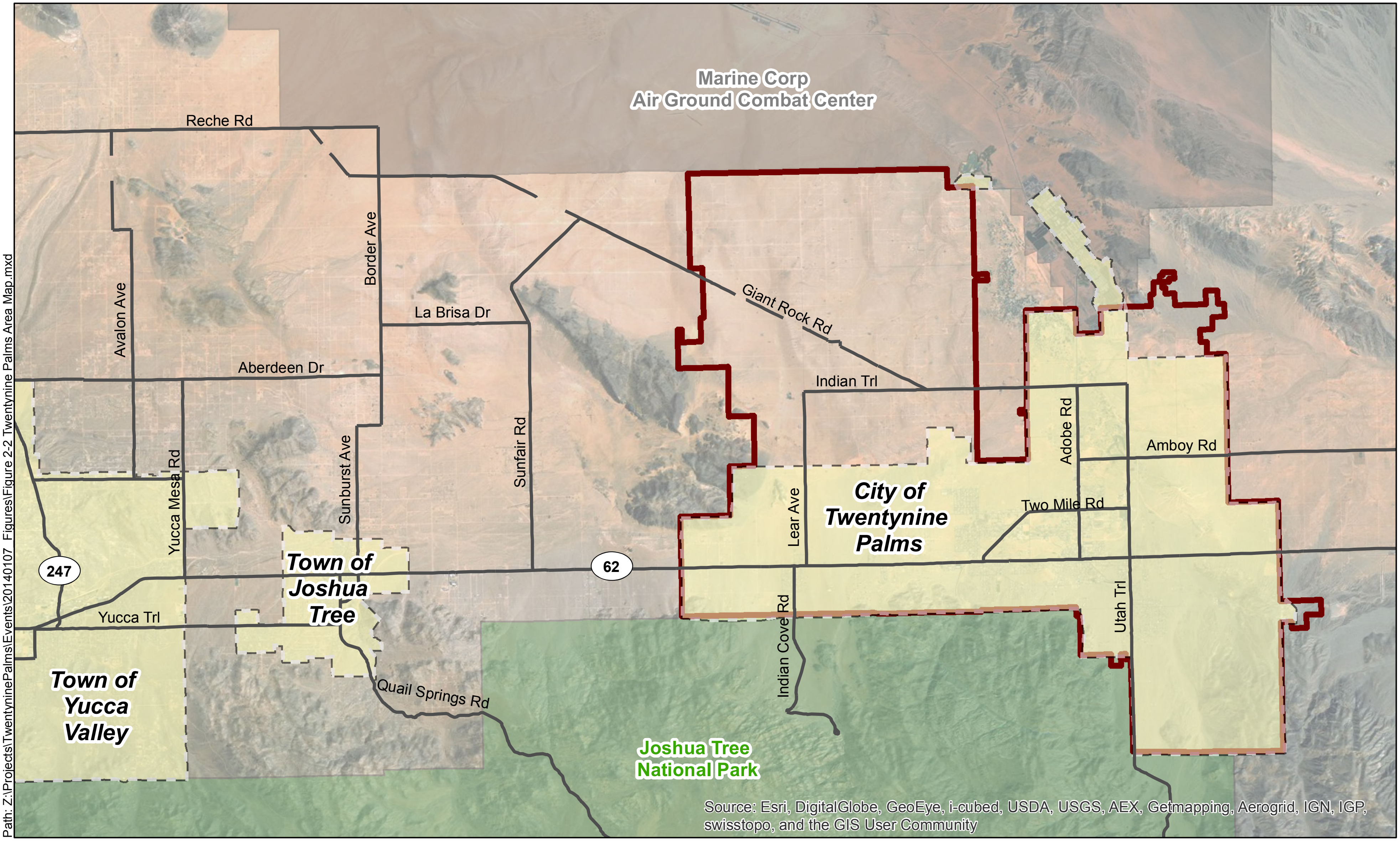
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

TPWD Groundwater Subbasins

K/J 1365022*00
May 2014

Figure 2-1



Path: Z:\Projects\TwentyninePalms\Events\20140107_Figures\Figure 2-2 Twentynine Palms Area Map.mxd

Legend

- Road
- City Limit
- Water District Boundary
- Marine Corps Base
- National Park

N

0 1 2

Scale: Miles

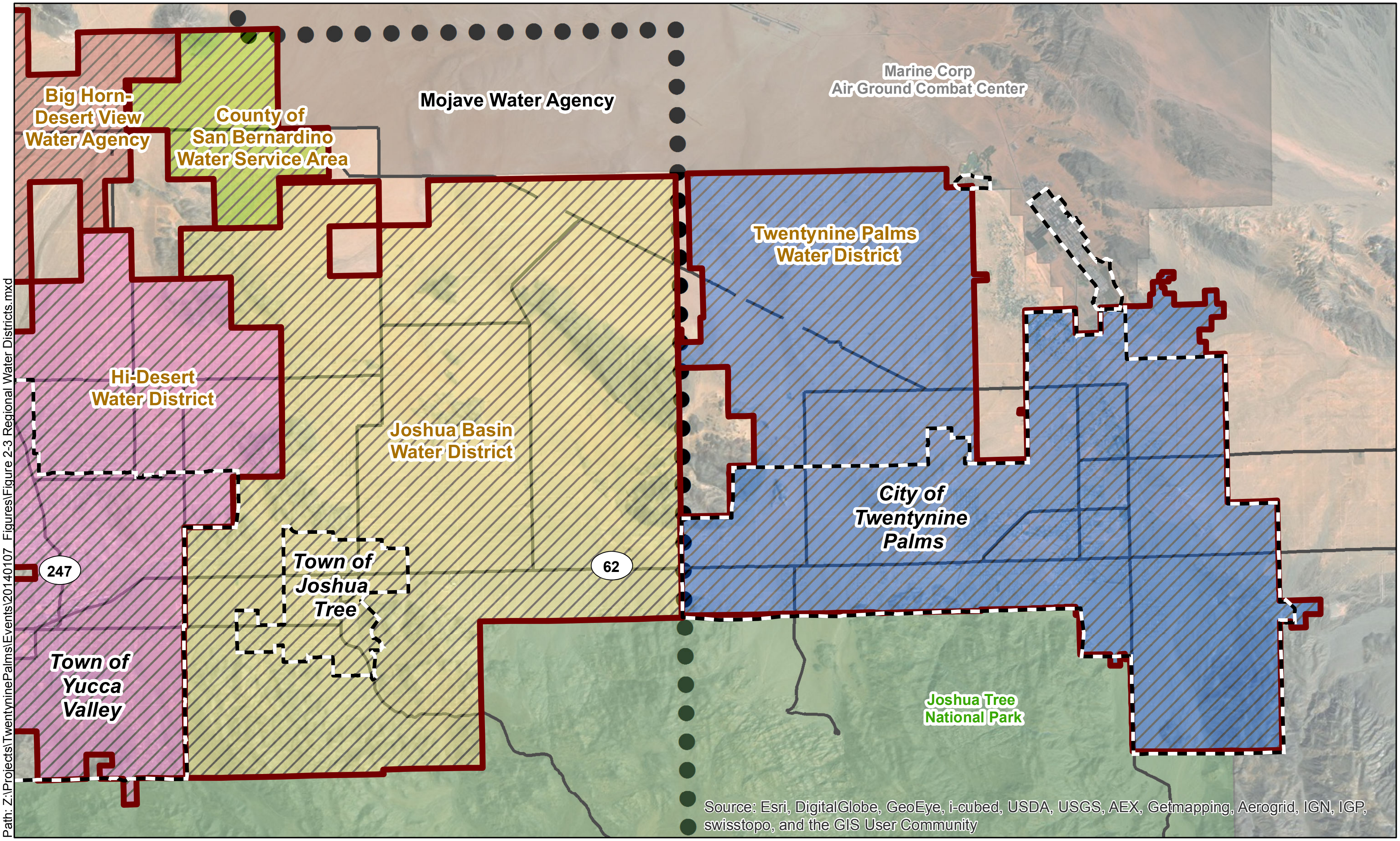
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Twentynine Palms Area Map

K/J 1365022*00
May 2014

Figure 2-2



Path: Z:\Projects\TwentyninePalms\Events\20140107_Figures\Figure 2-3 Regional Water Districts.mxd

Legend

- Road
- City Limit
- Water District Boundary
- Mojave Water Agency
- Marine Corps Base
- National Park

N

0 1 2

Scale: Miles

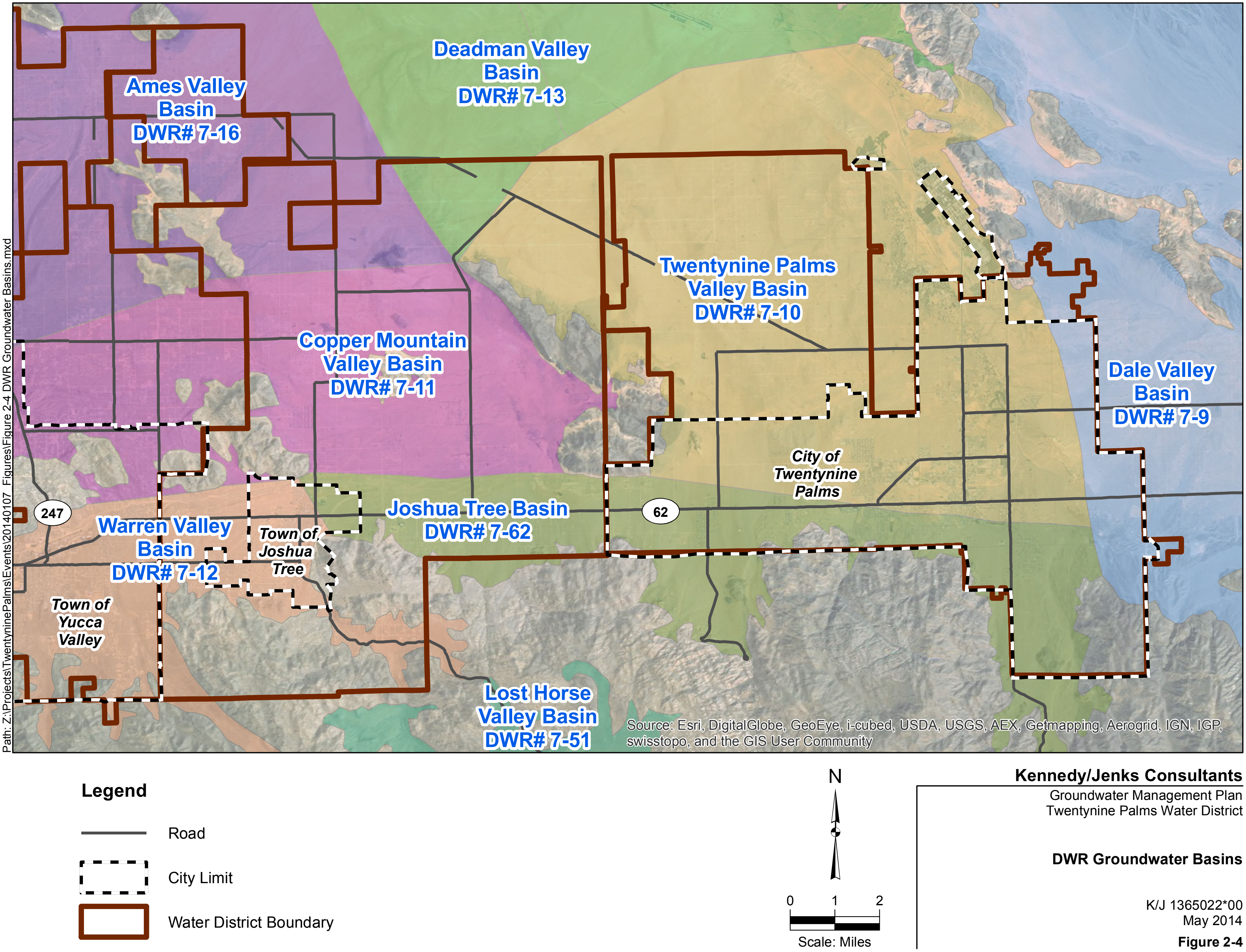
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Regional Water Districts

K/J 1365022*00
May 2014

Figure 2-3



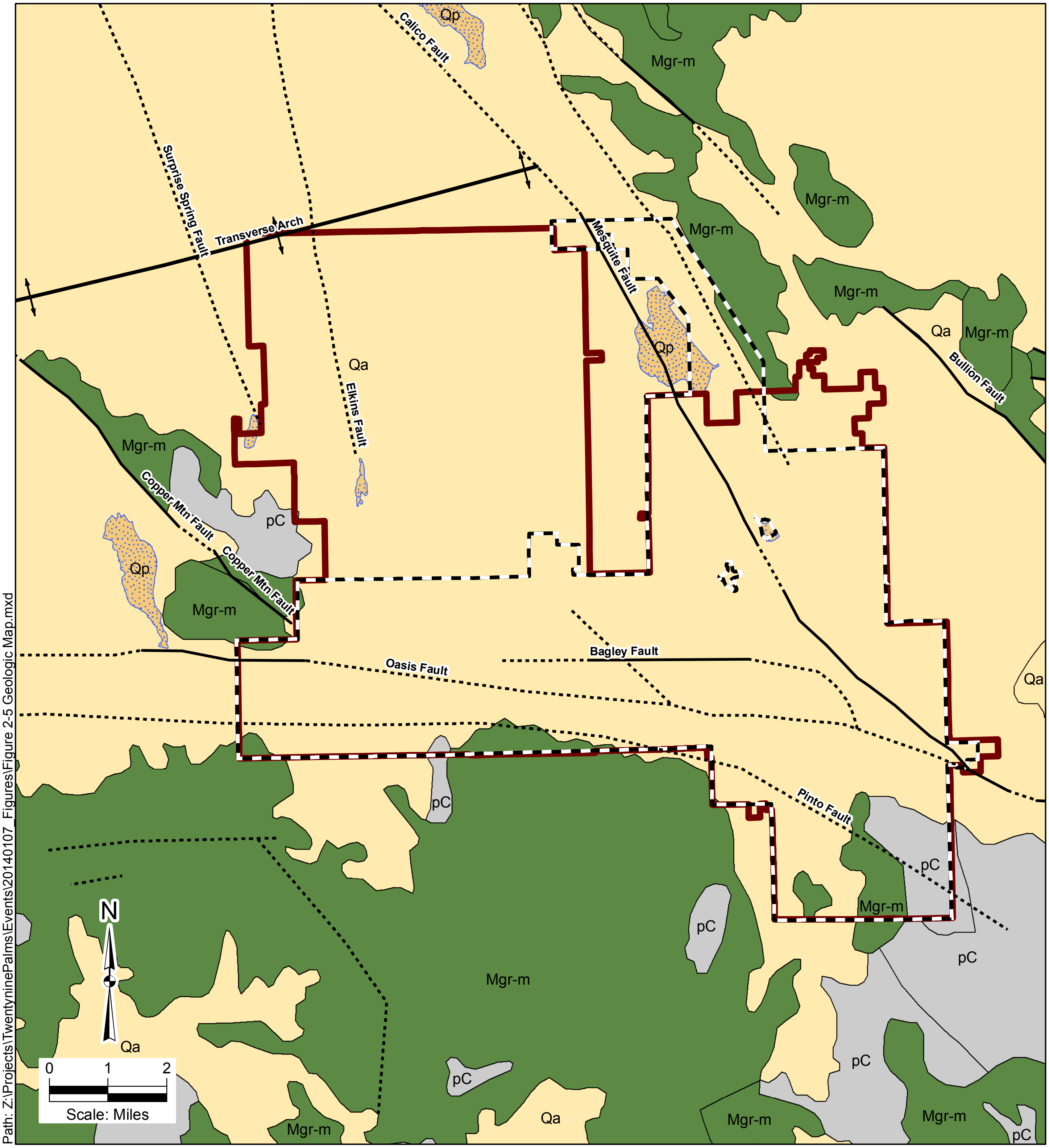
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

DWR Groundwater Basins

K/J 1365022*00
May 2014

Figure 2-4



Path: Z:\Projects\TwentyninePalms\Events\20140107_Figures\Figure 2-5 Geologic Map.mxd

Legend

City Limit

Water District Boundary

Faults

Known

Inferred

Anticline

Geologic Units

Qp: Playa lakes

Qa: Quaternary alluvium

Mgr-m: Mesozoic igneous and metamorphic rocks

pC: Precambrian igneous and metamorphic rocks

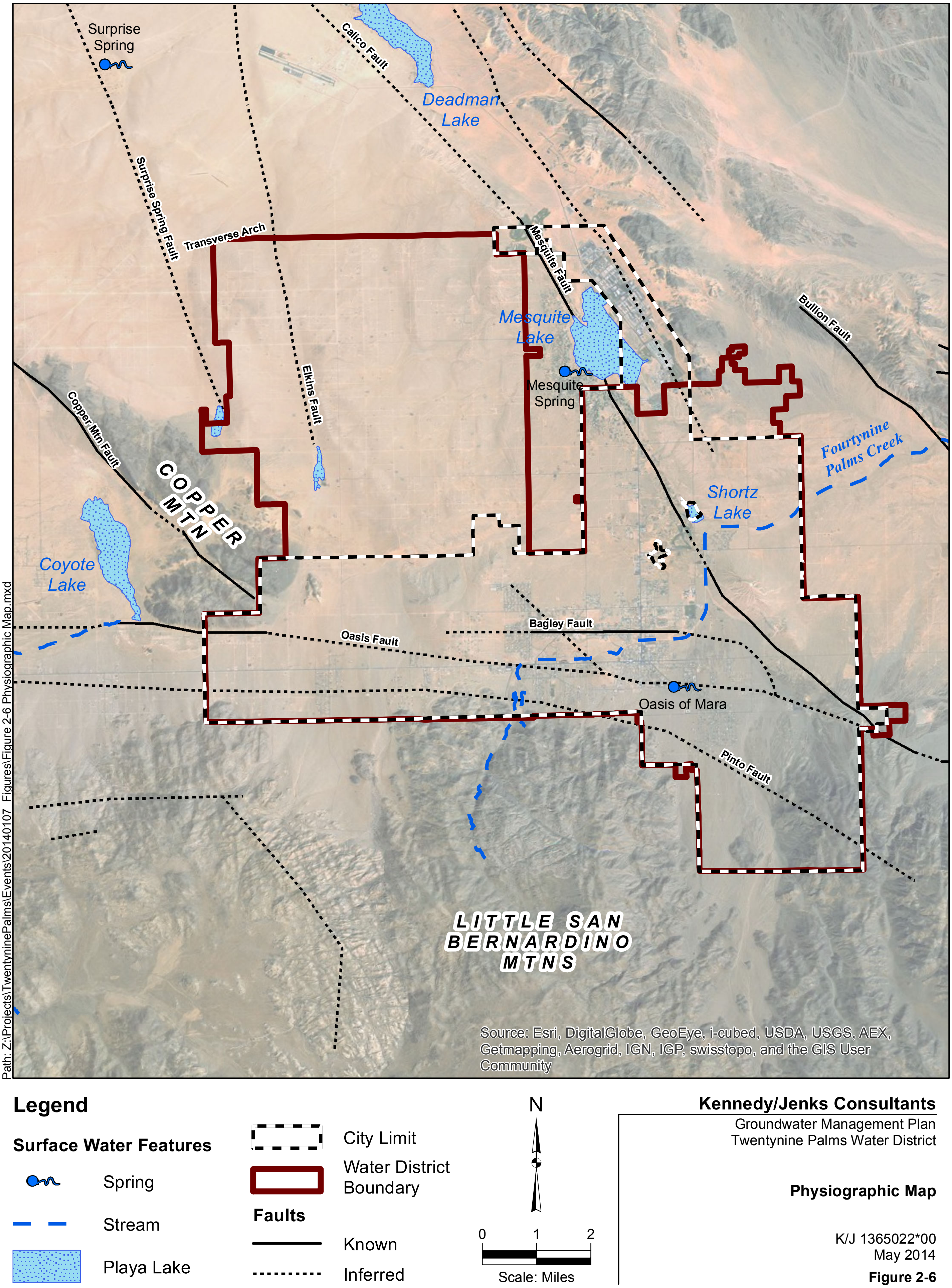
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Geologic Map

K/J 1365022*00
May 2014

Figure 2-5

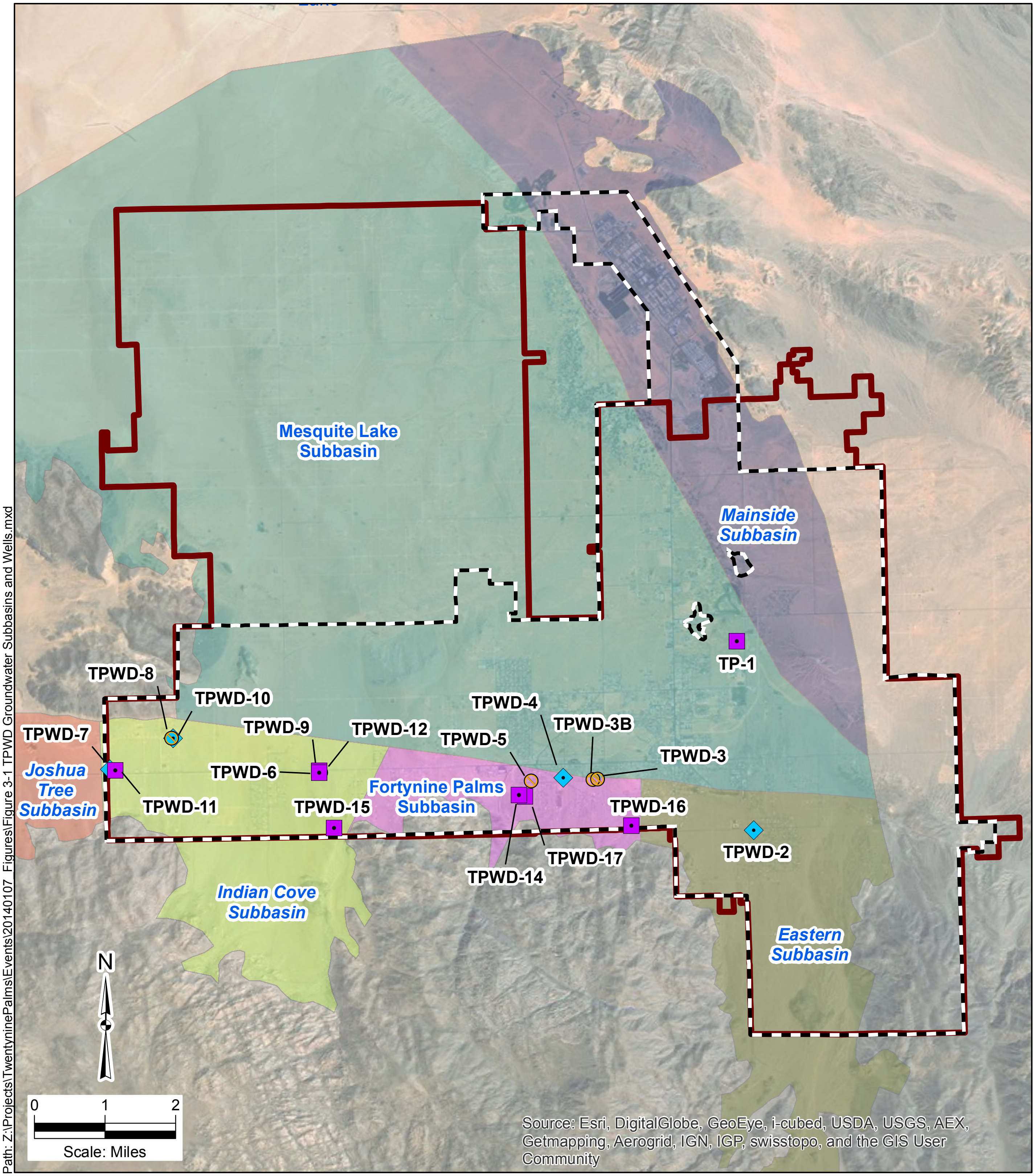


Kennedy/Jenks Consultants
Groundwater Management Plan
Twentynine Palms Water District

Physiographic Map

K/J 1365022*00
May 2014

Figure 2-6



Path: Z:\Projects\TwentyninePalms\Events\20140107_Figures\Figure 3-1 TPWD Groundwater Subbasins and Wells.mxd

Legend

- TPWD Active Water Supply Well
- TPWD Inactive Water Supply Well
- TPWD Abandoned Well
- City Limit
- Water District Boundary

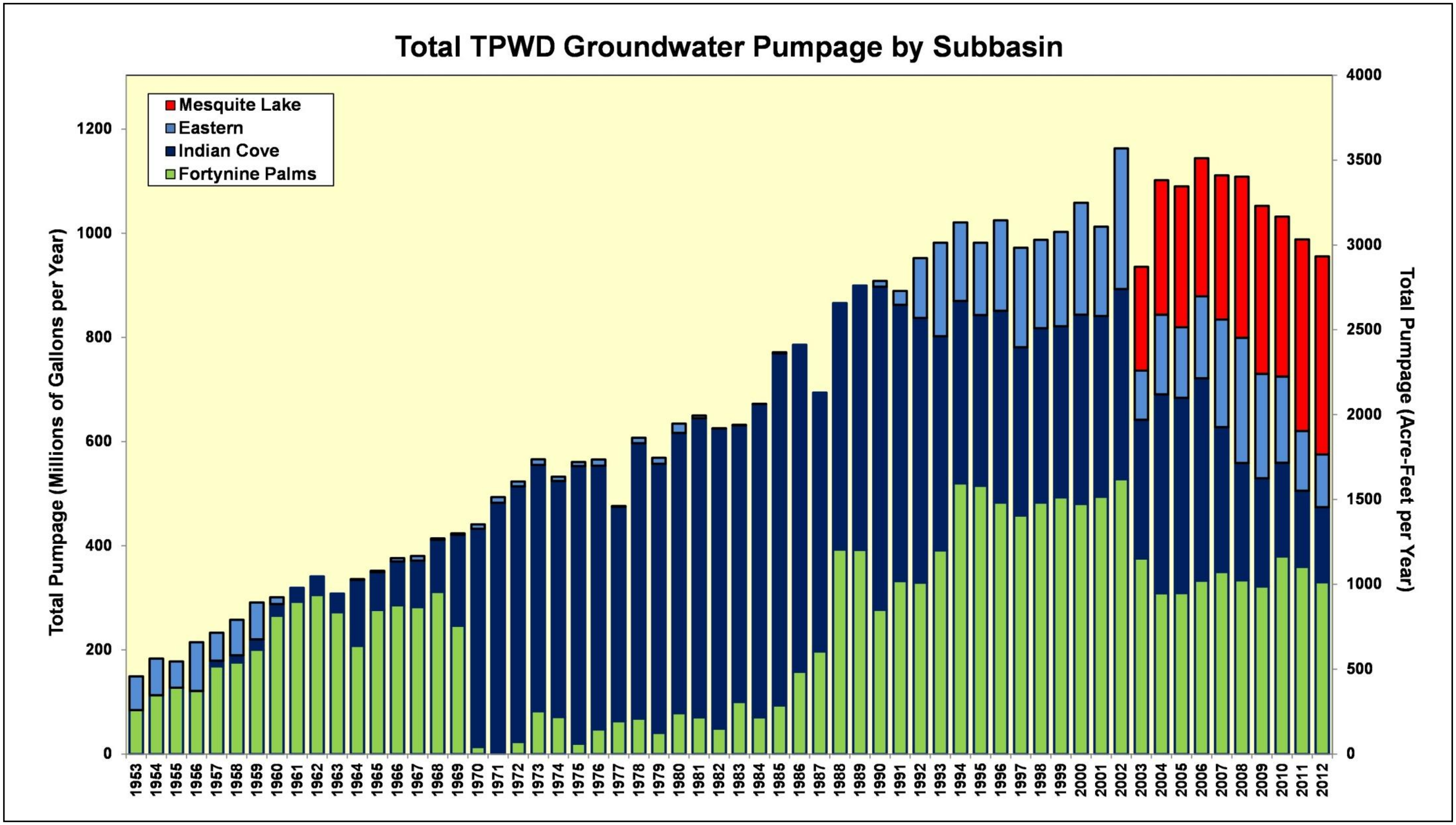
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

TPWD Groundwater Subbasins and Wells

K/J 1365022*00
May 2014

Figure 3-1



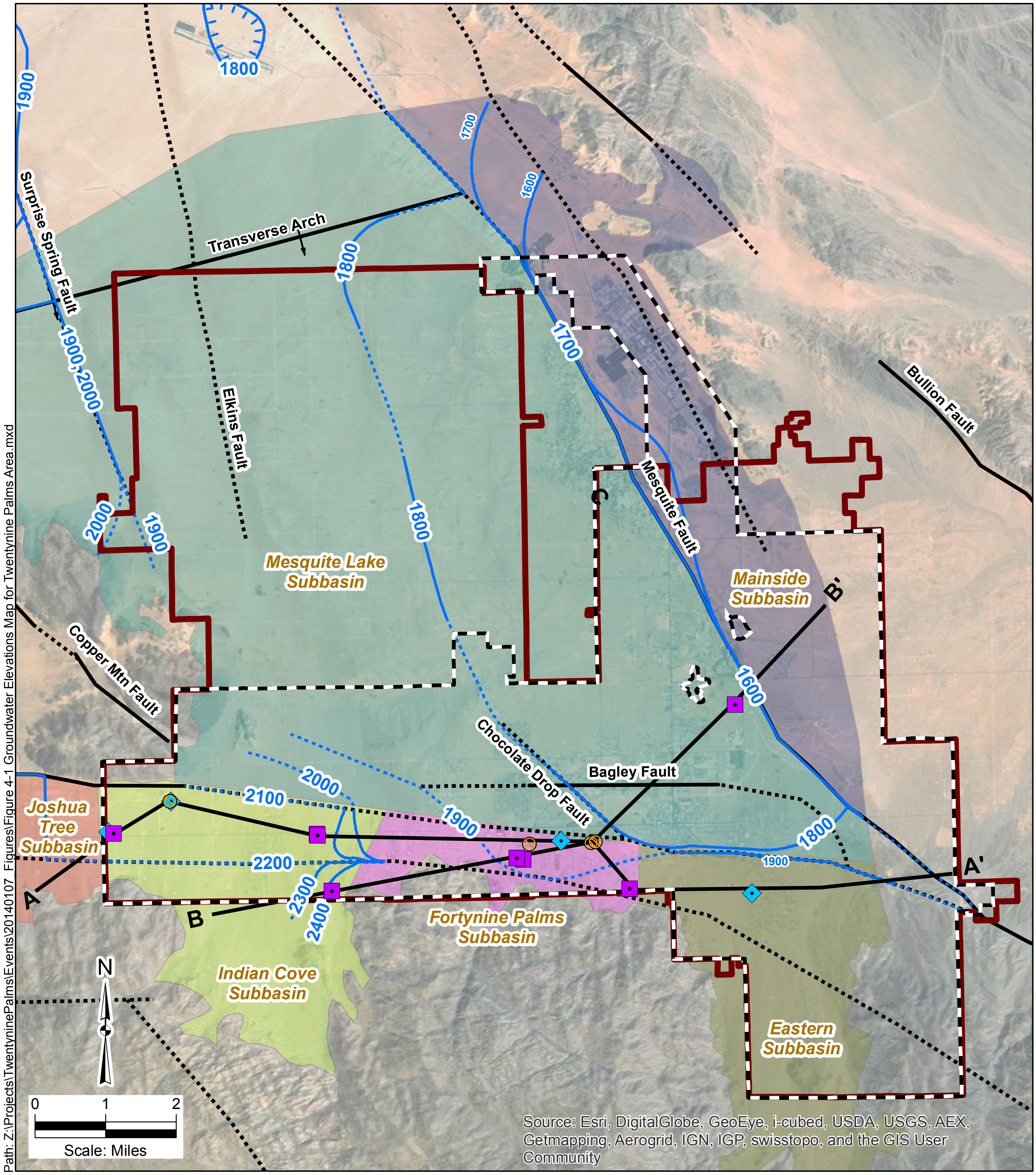
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Annual Pumping from TPWD Wells by Subbasin

K/J 1365022*00
May 2014

Figure 3-2



Legend

- TPWD Active Water Supply Well
- TPWD Inactive Water Supply Well
- TPWD Abandoned Well
- City Limit
- Water District Boundary
- Cross Section Trace

2008 Groundwater Elevation Contours

- Known
- Inferred
- Closed Depression

Faults

- Known
- Inferred
- Anticline

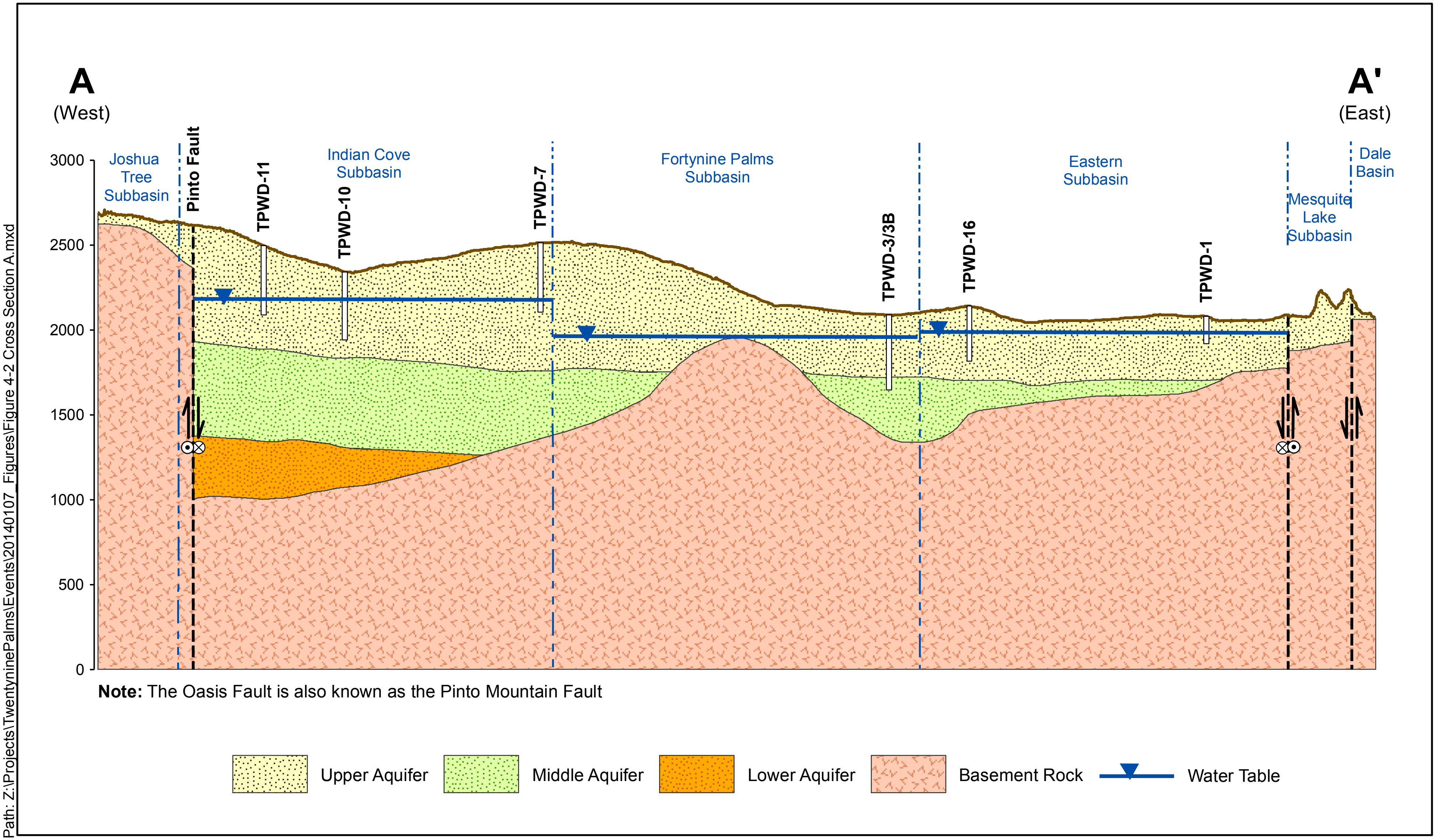
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation Map with Cross Section Locations

K/J 1365022*00
May 2014

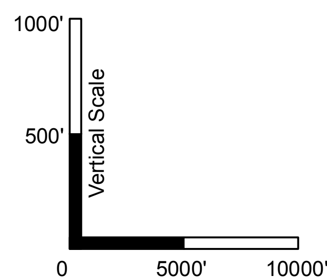
Figure 4-1



EXPLANATION

TPWD-1 Well and Identifier

Fault (Dashed where inferred)
Arrows indicate direction of movement
Cross Circle indicates movement away from observer
Dot Circle indicates movement toward observer



Exaggeration: 10x

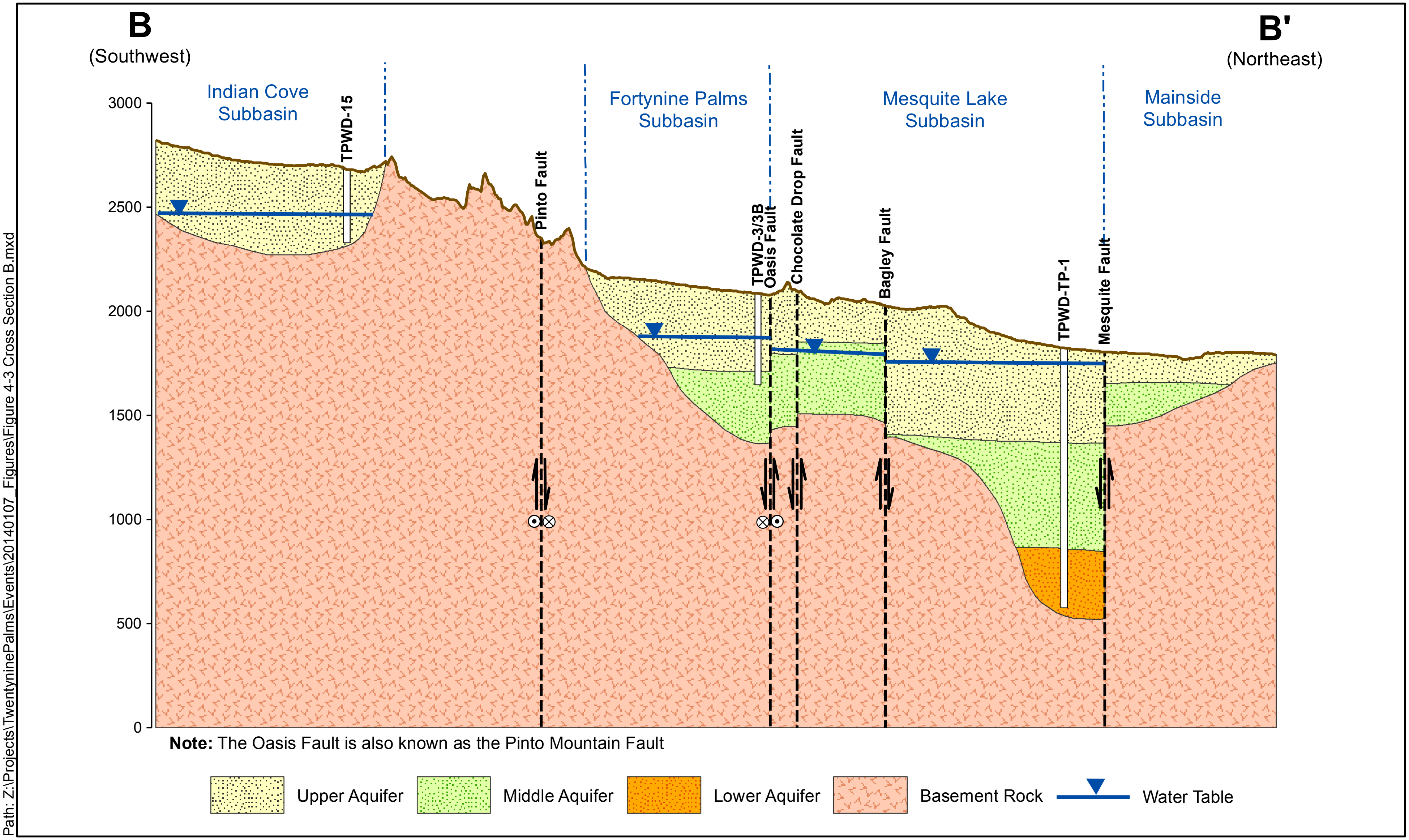
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Cross Section A

K/J 1365022*00
May 2014

Figure 4-2



Path: Z:\Projects\TwentyninePalms\Events\20140107_Figures\Figure 4-3 Cross Section B.mxd

EXPLANATION

TPWD-1 Well and Identifier

Fault (Dashed where inferred)
Arrows indicate direction of movement
Cross Circle indicates movement away from observer
Dot Circle indicates movement toward observer

Vertical Scale: 0, 250', 500'
Horizontal Scale: 0, 2500', 5000'
Exaggeration: 10x

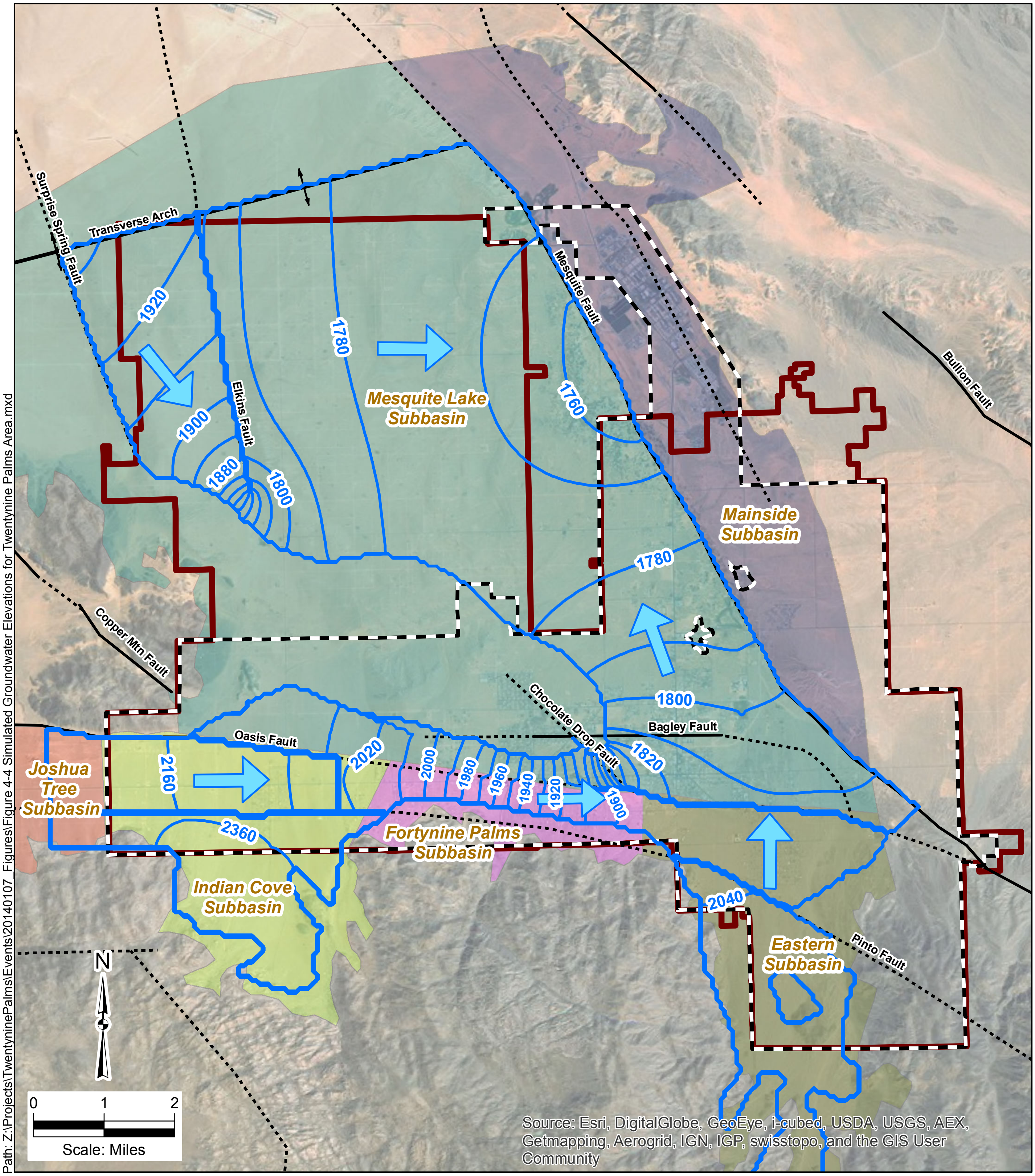
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Cross Section B

K/J 1365022*00
May 2014

Figure 4-3



Legend

- Groundwater Flow Direction
- Groundwater Elevation Contour (feet)
- City Limit
- Water District Boundary

Faults

- Known
- Inferred
- Anticline

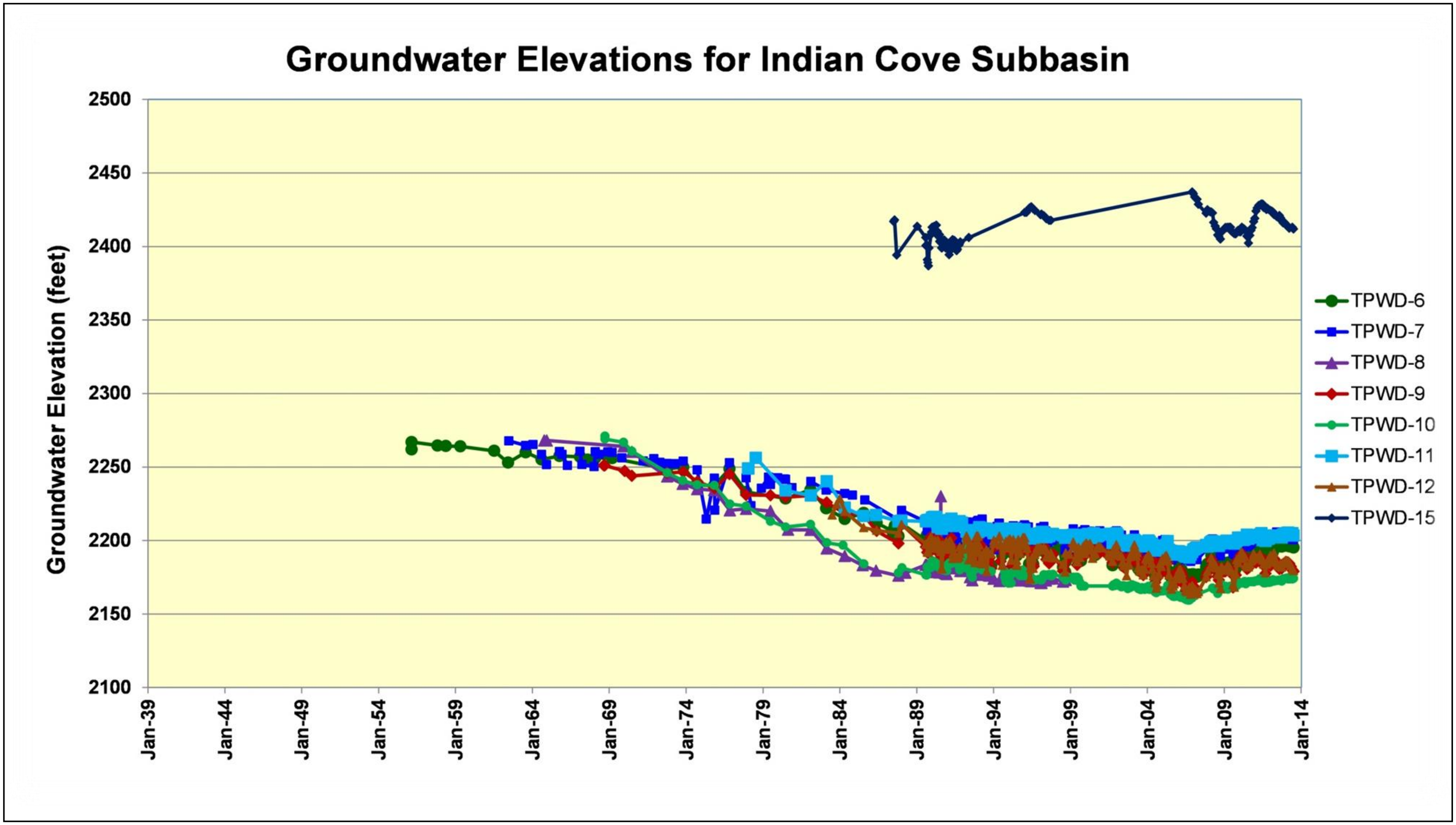
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Simulated Groundwater Elevations for Twentynine Palms Area

K/J 1365022*00
May 2014

Figure 4-4



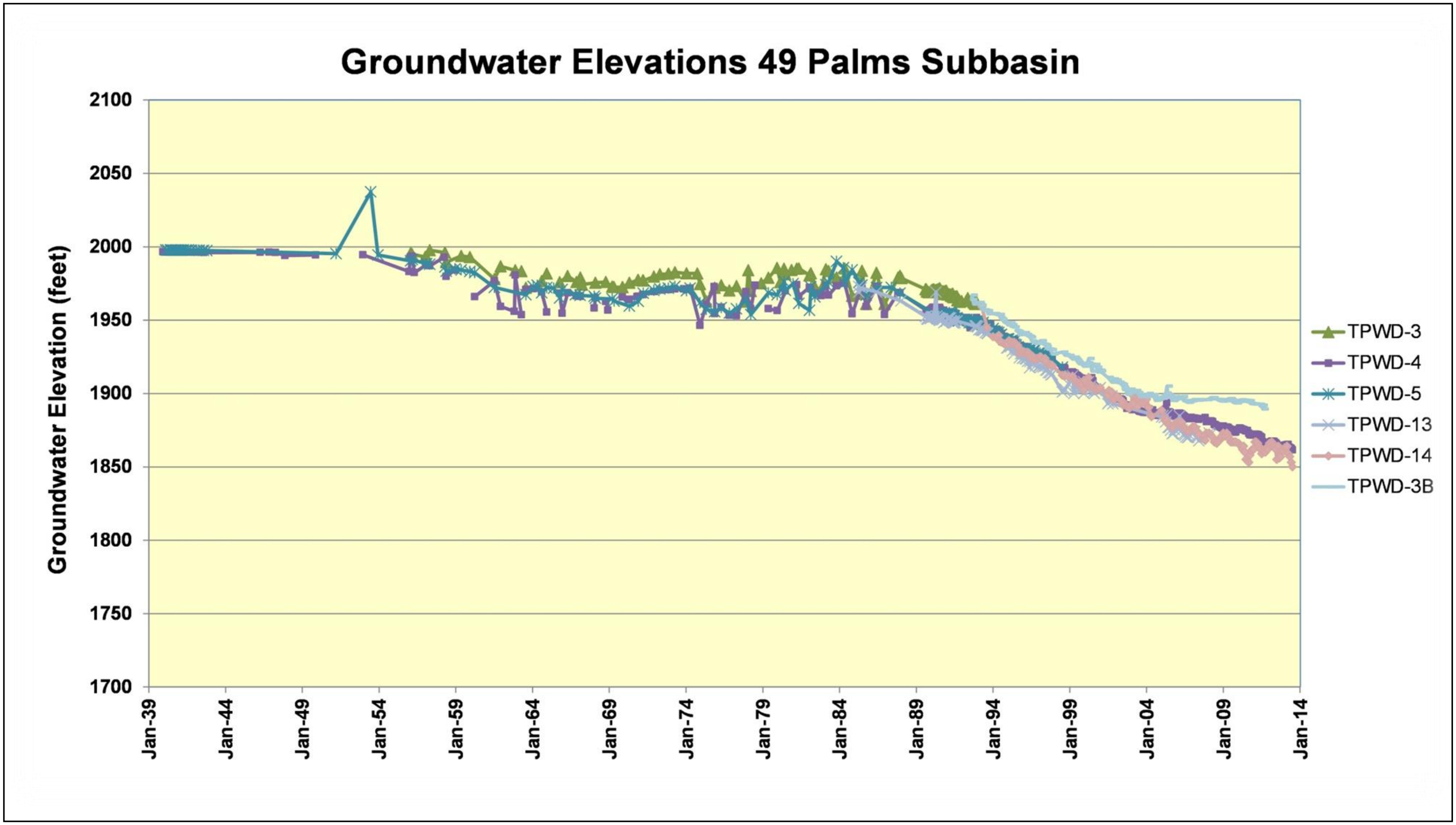
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation History for Indian Cove Subbasin

K/J 1365022*00
May 2014

Figure 4-5



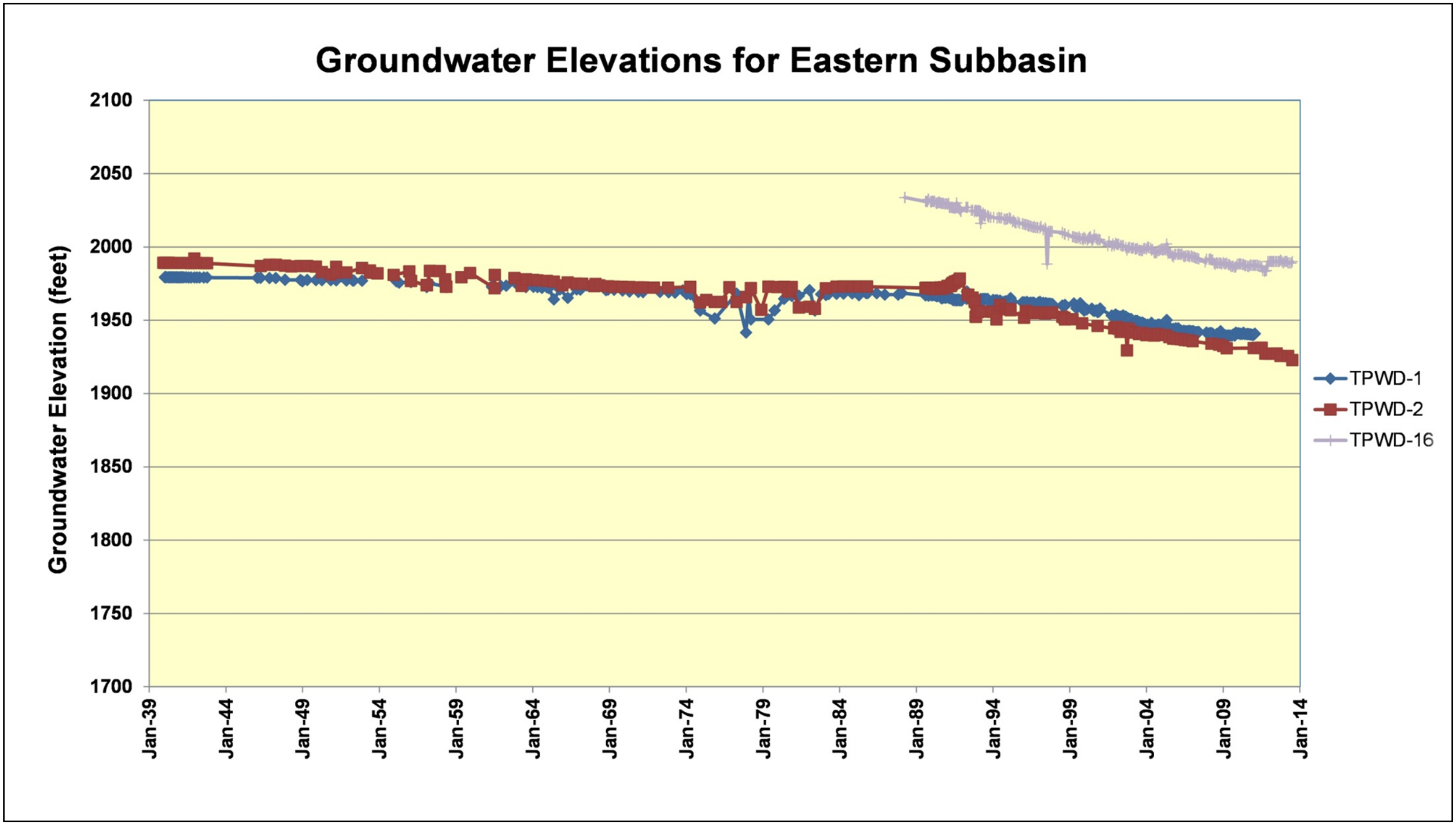
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation History for 49 Palms Subbasin

K/J 1365022*00
May 2014

Figure 4-6



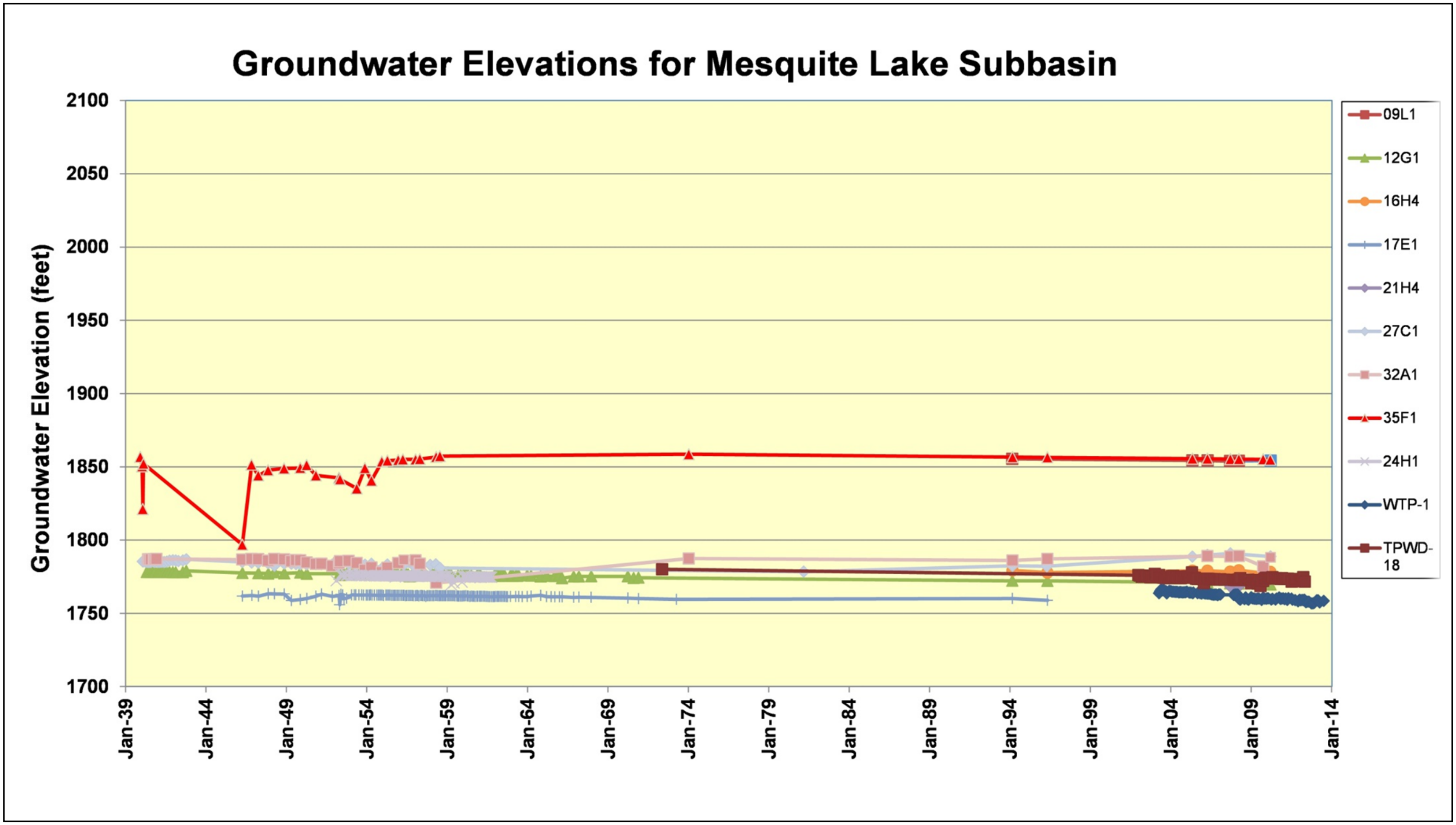
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation History for Eastern Subbasin

K/J 1365022*00
May 2014

Figure 4-7



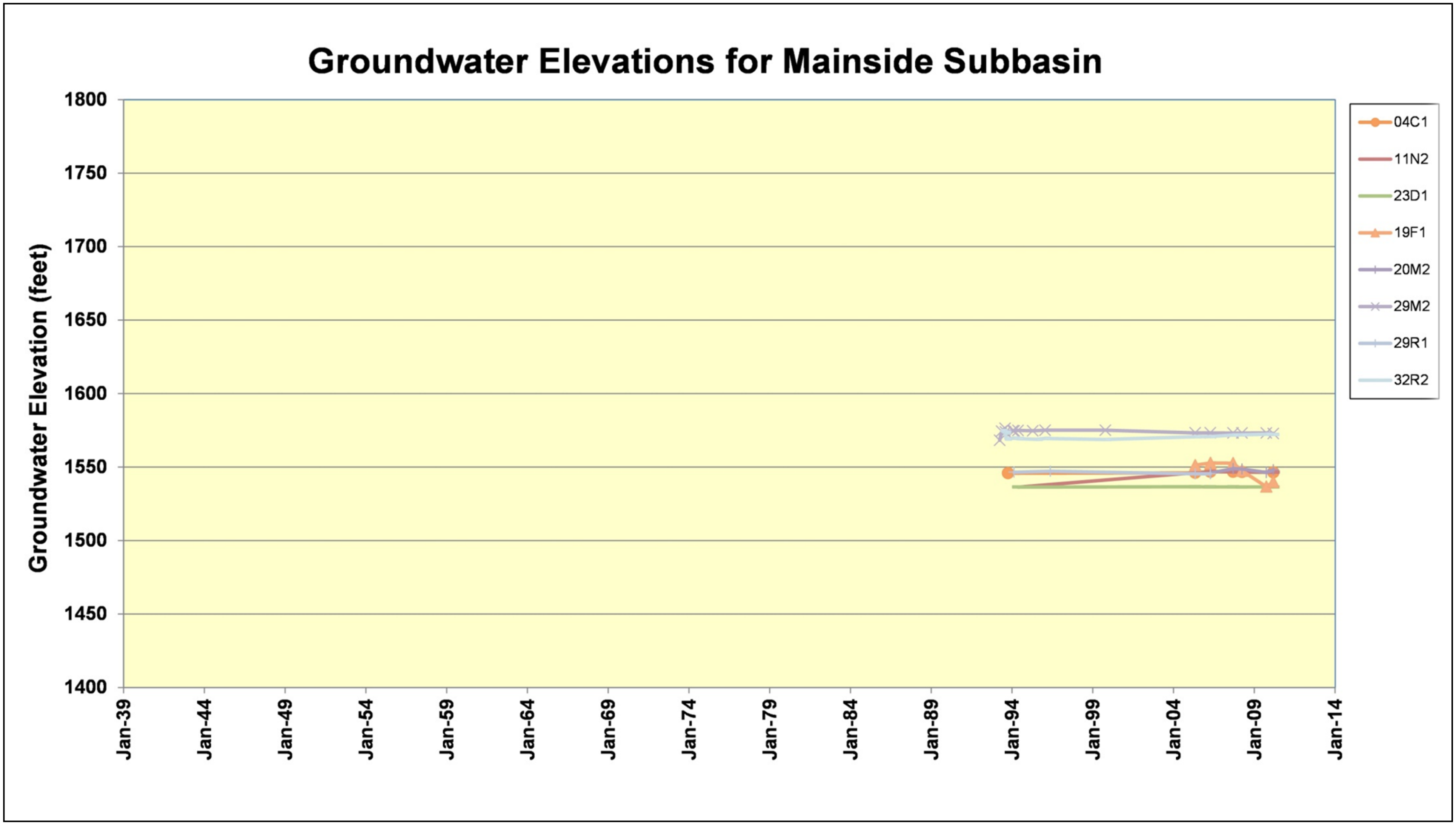
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation History for Mesquite Lake Subbasin

K/J 1365022*00
May 2014

Figure 4-8



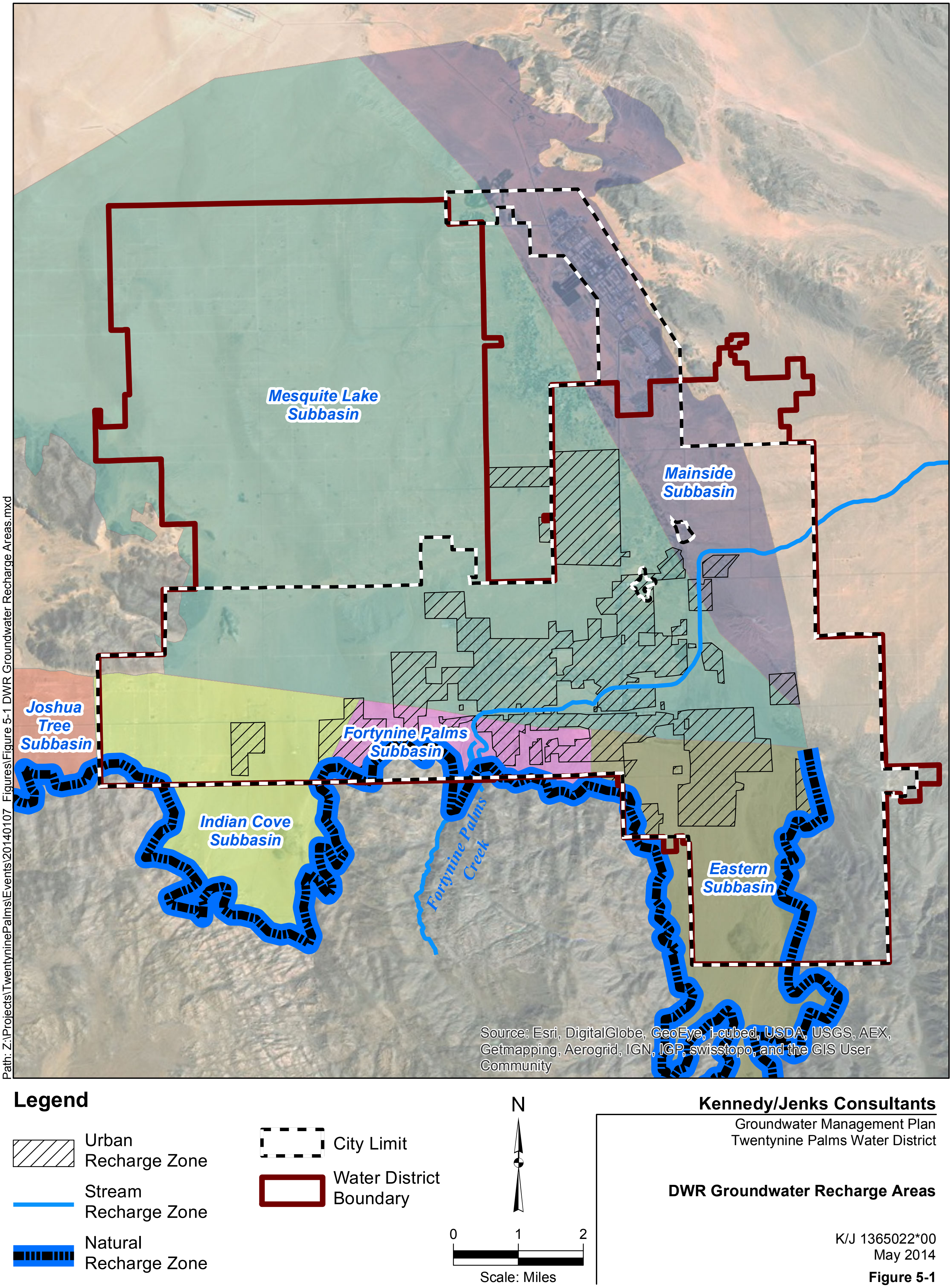
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Groundwater Elevation History for Mainside Subbasin

K/J 1365022*00
May 2014

Figure 4-9



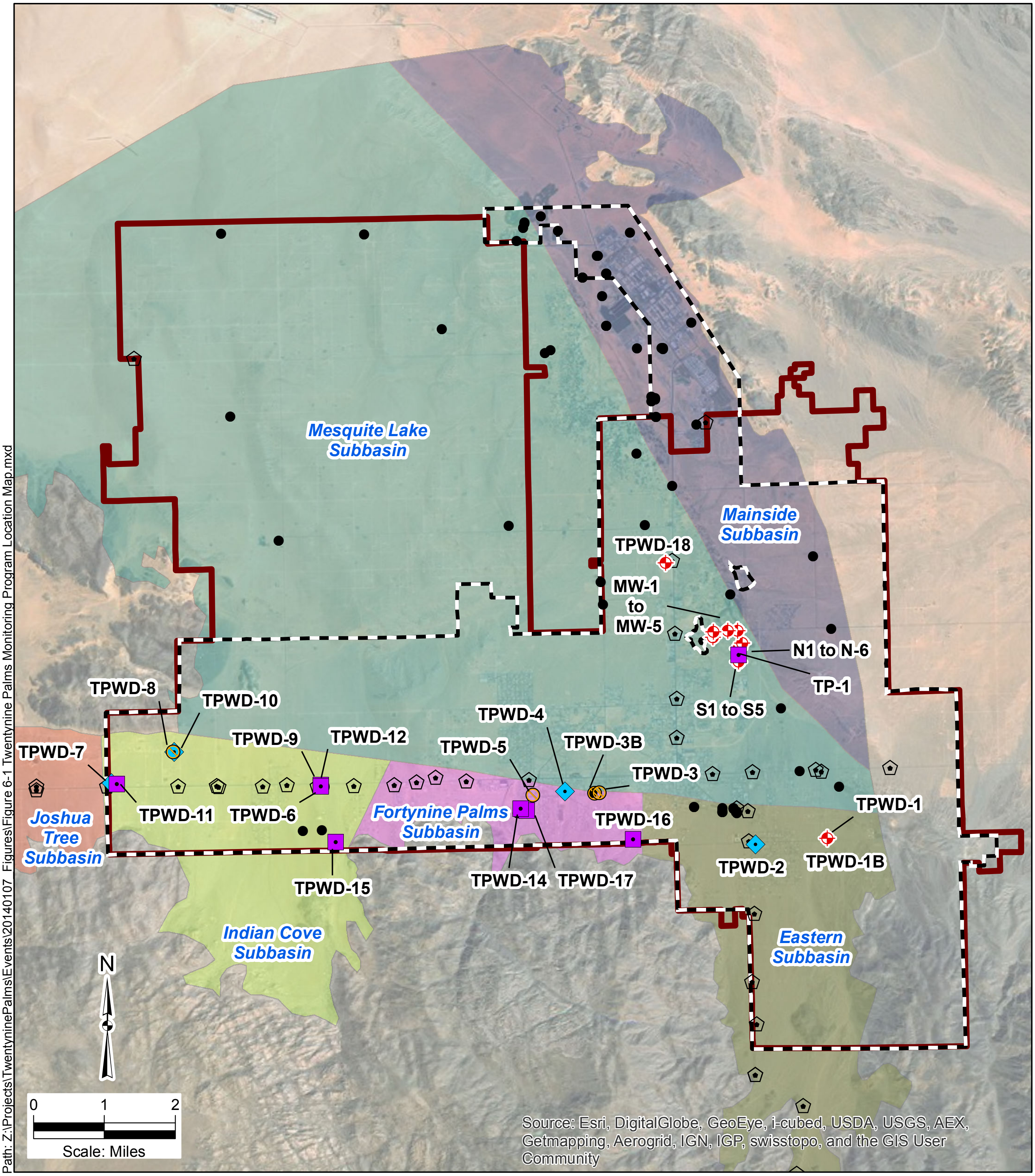
Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

DWR Groundwater Recharge Areas

K/J 1365022*00
May 2014

Figure 5-1



Legend

- TPWD Active Water Supply Well
- TPWD Inactive Water Supply Well
- TPWD Abandoned Well
- TPWD Monitoring Well
- USGS Monitored Well
- Survey Benchmark
- City Limit
- Water District Boundary

Kennedy/Jenks Consultants

Groundwater Management Plan
Twentynine Palms Water District

Twentynine Palms Monitoring Program Location Map

K/J 1365022*00
May 2014

Figure 6-1

Appendix A

Resolution of GMP Adoption

A REGULAR MEETING OF THE BOARD OF DIRECTORS OF THE TWENTYNINE PALMS WATER DISTRICT 72401 HATCH ROAD, TWENTYNINE PALMS, CA 92277

SEPTEMBER 25, 2013 / 6:00 P.M.

AGENDA

This meeting will be televised on Time Warner Cable Channel 10
on Saturdays at 10:00 AM and Sundays at 5:00 PM

Next Resolution #13-18
Next Ordinance #95

Call to Order and Roll Call

Pledge of Allegiance

Additions/Deletions to the Agenda

Public Comments
Please complete a "Request to be Heard" form prior to the start of the meeting. The public may address the Board for 3 minutes on District-related matters. Government Code prohibits the Board from taking action on matters that are not on the agenda. However, the Board may refer matters for future consideration.

1. Public Hearing on Proposed Adoption of a Resolution of Intention to Amend the District's Groundwater Management Plan

    1.1 Board to Hear Public Testimony at This Time

2. Consider Adoption of Resolution 13-17 a Resolution of Intention to Draft a Groundwater Management Plan for the Purposes of Implementing a Plan and Updating the Groundwater Management Program

3. Review and Adjust Schedule of Board Meeting in November and December

4. Consent Calendar
   Matters under the Consent Calendar are to be considered routine and will be enacted in a single motion. There will be no separate discussion of these items unless the Board, staff or the public requests specific items be removed for separate discussion and action before the Board votes on the motion to adopt.

    - Minutes of the Regular Meeting held on August 28, 2013
    - Audit List

5. Items Removed from the Consent Calendar for Discussion or Separate Action

6. Management Reports

   6.1 Operations

   6.2 Finance

   6.3 General Manager

7. Future Agenda Items and Staff Tasks/Directors' Comments and Reports

8. Adjournment

The Board reserves the right to discuss only or take action on any item on the agenda.

Notice of agenda was posted on or before 3:00 p.m., September 20, 2013.

Tamara Alaniz

Tamara Alaniz, Board Secretary

Upon request, this Agenda will be made available in appropriate alternative formats to persons with disabilities, as required by Section 202 of the Americans with Disabilities Act of 1990. Any person with a disability who requires a modification or accommodation in order to participate in a meeting should direct such request to Cindy Fowlkes at (760) 367-7546 at least 48 hours before the meeting, if possible.

Pursuant to Government Code Section 54957.5, any writing that: (1) is a public record; (2) relates to an agenda item for an open session of a regular meeting of the Board of Directors; and (3) is distributed less than 72 hours prior to that meeting, will be made available for public inspection at the time the writing is distributed to the Board of Directors. Any such writing will be available for public inspection at the District offices located at 72401 Hatch Road, Twentynine Palms, CA 92277. In addition, any such writing may also be posted on the District's website.

MINUTES OF A REGULAR MEETING OF THE BOARD OF DIRECTORS OF THE TWENTYNINE PALMS WATER DISTRICT 72401 HATCH ROAD, TWENTYNINE PALMS, CA 92277

SEPTEMBER 25, 2013 / 6:00 P.M.

Call to Order and Roll Call
President Moore called the meeting to order at 6:00 p.m., 72401 Hatch Road, Twentynine Palms, California. Those responding to roll call were Directors Chancey Chambers, Philip Cisneros, Sam Moore, and Roger Shinaver. Director Bo Bourikas was absent. Also present were General Manager Tamara Alaniz, Operations Manager Ray Kolisz, Financial Consultant Cindy Byerrum, and District Secretary Cindy Fowlkes.

Pledge of Allegiance
Director Shinaver led the pledge.

Additions/Deletions to the Agenda
None

Public Comments
No public comments.

1. Public Hearing on Proposed Adoption of a Resolution of Intention to Amend the District's Groundwater Management Plan

1.1 Board to Hear Public Testimony at This Time
Director Moore opened the Public Hearing at 6:02 p.m. There being no public testimony to be heard, Director Moore closed the public hearing at 6:02 p.m.

2. Consider Adoption of Resolution 13-17 a Resolution of Intention to Draft a Groundwater Management Plan for the Purposes of Implementing a Plan and Updating the Groundwater Management Program
Staff recommends the Board approve the routine adoption of the resolution.

Director Cisneros moved to approve Resolution 13-17 a resolution of intention to draft a Groundwater Management Plan for the purposes of implementing a plan and updating the Groundwater Management program, seconded by Director Chambers and approved by the following roll call vote:

Ayes:	Directors Chambers, Cisneros, Moore, and Shinaver
Noes:	None
Abstain:	None
Absent:	Director Bourikas

3. Review and Adjust Schedule of Board Meeting in November and December
Following discussion, it was the consensus of the Board to reschedule the regular Water and Fire Department Board meetings from the original dates of November 27, 2013 and December 25, 2013, to Wednesday, November 20, 2013, and Wednesday, December 18, 2013. Meetings will begin at their regular time, 6:00 p.m.

4. Consent Calendar
   - Minutes of the Regular Meeting held on August 28, 2013
   - Audit List

Director Chambers moved to approve the Minutes, seconded by Director Cisneros and approved unanimously.

5. Items Removed from the Consent Calendar for Discussion or Separate Action

Director Moore moved to remove the Audit List, questioning the Prudential Overall, Protection One, and Joshua Basin Water District annual water availability assessment items. Following a brief discussion, Director Cisneros moved to approve the Audit List as published, seconded by Director Shinaver and approved unanimously.

6. Management Reports

6.1 Operations

Mr. Kolisz reported that the District responded to 17 Underground Service Alerts, had (1) 8" water main leak due to tree roots, and performed 5 leak audits. The cathodic protection system contract for the Stockwell Reservoir was awarded to GMC Electrical Inc. Production was down 9% compared to the same time last year. Meter change-out procedures have been implemented.

6.2 Finance

Ms. Byerrum reported that the Audit has been completed and will be presented to the Board in October. The format of the Financials has been revised to show a comparison to the previous month and prior year to date. Water sales are down, as indicated by Mr. Kolisz' report on lower production rates.

6.3 General Manager

Ms. Alaniz reported that drafts of the Groundwater Management Plan and Wastewater Master Plan are moving forward. Ms. Alaniz met with City Manager, Joe Guzzetta, and discussed a joint meeting between the Water Board and City Council to discuss a Local Agency Management Plan. The meeting is tentatively scheduled for November 7, 2013. The Board agreed that the meeting should be held at the Community Center. Ms. Alaniz asked the Board to provide her with their availability to attend a Board Workshop some time during the first week in January. The Workshop will include discussion of The Brown Act and Robert's Rules of Order. The Board was reminded that requests to serve on ACWA and CSDA committees are nearing the closing date.

10. Future Agenda Items and Staff Tasks/Directors' Comments and Reports

Director Chambers would like to see voter turnout history and election costs on the next agenda for discussion.

11. Adjournment

On motion by Director Cisneros seconded by Director Shinaver and approved by the Board, the meeting was adjourned at 6:28 p.m.

Kerron E. Moore, President
Board of Directors

Attest:

Tamara Alaniz, Board Secretary
Twentynine Palms Water District

RESOLUTION 13-17

A RESOLUTION OF THE BOARD OF DIRECTORS OF THE TWENTYNINE PALMS WATER DISTRICT DECLARING AN INTENTION TO AMEND THE DISTRICT GROUNDWATER MANAGEMENT PLAN

WHEREAS, the Twentynine Palms Water District ("District") is a County Water District Duly formed and operating pursuant to Section 31000 et seq. of the California Water Code and has the authority to provide water service to customers within its service area;

WHEREAS, groundwater is a valuable resource within the State of California and particularly within the boundaries of the District and such groundwater must be monitored and evaluated;

WHEREAS, in recognition of the value of groundwater as a resource, the California State Legislature passed AB 3030 which encourages local water purveying agencies to develop and implement groundwater management plans;

WHEREAS, in keeping with this state mandate and assuring that District water users are supplied with their water needs, the District adopted and implemented a groundwater management plan;

WHEREAS, the District has now determined that it is prudent to amend its groundwater management plan;

WHEREAS, as required by Water Code Section 10753.2(a) and Government Code Section 6066, notice of a public hearing was published in the Desert Trail on September 19, 2013 and September 21, 2013;

WHEREAS, a public hearing was conducted on September 25, 2013 by the Board of Directors of the District in order to receive oral and written testimony on whether or not to adopt a Resolution of Intention to Amend the Groundwater Management Plan.

NOW, THEREFORE, the Board of Directors of the Twentynine Palms Water District hereby resolves as follows:

1. Declaration of Intention. It is hereby declared that the District intends to prepare an amended groundwater management plan within two (2) years of the date of adoption of this Resolution of Intention, pursuant to Section 10750 et seq. of the California Water Code that will afford conservation, protection and enhancement of groundwater supplies within the District service area.

2. Publication of Notice. Pursuant to Section 10753.3 of the California Water Code, the Secretary of the District is hereby authorized and directed to publish this Resolution of Intention in a newspaper of general circulation within the affected area twice, in two (2) successive weeks. Upon written request, the Secretary

shall also provide any interested persons with a copy of this Resolution of Intention.

PASSED, APPROVED AND ADOPTED on this 25th day of September 2013, at a regular meeting of the Board of Directors of the Twentynine Palms Water District by the following vote:

Ayes:	Directors Chambers, Cisneros, Moore, and Shinaver
Noes:	None
Abstain:	None
Absent:	None

Kerron E. Moore, President
Board of Directors

Attest:

Tamara Alaniz, Board Secretary
Twentynine Palms Water District

A REGULAR MEETING OF THE BOARD OF DIRECTORS OF THE TWENTYNINE PALMS WATER DISTRICT 72401 HATCH ROAD, TWENTYNINE PALMS, CA 92277

APRIL 23, 2014 / 6:00 P.M.

AGENDA

This meeting will be televised on Time Warner Cable Channel 10
on Saturdays at 10:00 AM and Sundays at 5:00 PM

Next Resolution #14-06
Next Ordinance #95

Call to Order and Roll Call

Pledge of Allegiance

Additions/Deletions to the Agenda

Public Comments
Please complete a "Request to be Heard" form prior to the start of the meeting. The public may address the Board for 3 minutes on District-related matters. Government Code prohibits the Board from taking action on matters that are not on the agenda. However, the Board may refer matters for future consideration.

1. Public Hearing on Proposed Adoption of a Resolution to Update the District Groundwater Management Plan

   1.1 Board to Hear Public Testimony at This Time

2. Consider Resolution 14-04 Rescinding Resolution 14-01 Requesting that the San Bernardino County Board of Supervisors Authorize and Change the Election of Board Members to the Statewide Consolidated Election Cycle of a Polling Place Election Type, Extending the Present Board Member Terms by One Year to Reflect the Date Change and Rescinding Resolution 09-02

3. Consider Resolution 14-05 Declaring May 2014 Water Awareness Month and Encouraging Water Conservation During the Statewide Drought

4. Consent Calendar
   Matters under the Consent Calendar are to be considered routine and will be enacted in a single motion. There will be no separate discussion of these items unless the Board, staff or the public requests specific items be removed for separate discussion and action before the Board votes on the motion to adopt.

   - Minutes of the Regular Meeting held on March 26, 2014
   - Audit List

5. <u>Items Removed from the Consent Calendar for Discussion or Separate Action</u>

6. <u>Management Reports</u>

   6.1 Operations

   6.2 Finance

   6.3 General Manager

7. <u>Future Agenda Items and Staff Tasks/Directors' Comments and Reports</u>

8. <u>Adjournment</u>

The Board reserves the right to discuss only or take action on any item on the agenda.

Notice of agenda was posted on or before 3:00 p.m., April 18, 2014.

Tamara Alaniz

Tamara Alaniz, Board Secretary

Upon request, this Agenda will be made available in appropriate alternative formats to persons with disabilities, as required by Section 202 of the Americans with Disabilities Act of 1990. Any person with a disability who requires a modification or accommodation in order to participate in a meeting should direct such request to Cindy Fowlkes at (760) 367-7546 at least 48 hours before the meeting, if possible.

Pursuant to Government Code Section 54957.5, any writing that: (1) is a public record; (2) relates to an agenda item for an open session of a regular meeting of the Board of Directors; and (3) is distributed less than 72 hours prior to that meeting, will be made available for public inspection at the time the writing is distributed to the Board of Directors. Any such writing will be available for public inspection at the District offices located at 72401 Hatch Road, Twentynine Palms, CA 92277. In addition, any such writing may also be posted on the District's website.

MINUTES OF A REGULAR MEETING OF THE BOARD OF DIRECTORS OF THE TWENTYNINE PALMS WATER DISTRICT 72401 HATCH ROAD, TWENTYNINE PALMS, CA 92277

APRIL 23, 2014 / 6:00 P.M.

Call to Order and Roll Call

President Moore called the meeting to order at 6:00 p.m., 72401 Hatch Road, Twentynine Palms, California. Those responding to roll call were Directors Bo Bourikas, Chancey Chambers, Suzi Horn, Sam Moore, and Roger Shinaver. Also present were General Manager Tamara Alaniz, Operations Manager Ray Kolisz, Financial Consultant Cindy Byerrum, and District Secretary Cindy Fowlkes.

Pledge of Allegiance

Director Moore led the pledge.

Additions/Deletions to the Agenda

None

Public Comments

None

1. Public Hearing on Proposed Adoption of a Resolution to Update the District Groundwater Management Plan

   Two phone calls were received from the public for clarification. Both callers did not express their opinion for or against the plan.

   1.1 Board to Hear Public Testimony at This Time

   Director Shinaver moved to open the Public Hearing at 6: 03 p.m. , seconded by Director Chambers, and unanimously approved. There being no public testimony to be heard, Director Shinaver moved to close the public hearing at 6:03 p.m., seconded by Director Chambers and unanimously approved.

2. Consider Resolution 14-04 Rescinding Resolution 14-01 Requesting that the San Bernardino County Board of Supervisors Authorize and Change the Election of Board Members to the Statewide Consolidated Election Cycle of a Polling Place Election Type, Extending the Present Board Member Terms by One Year to Reflect the Date Change and Rescinding Resolution 09-02

   As the County Board of Supervisors denied the Board's request for reconsideration, staff recommends that the Board adopt Resolution 14-04 thereby rescinding Resolution 14-01 and reestablishing Resolution 09-02, implementing policies for District elections.

   After discussion, Director Chambers moved to adopt Resolution 14-04, seconded by Director Shinaver and approved by the following roll call vote.

   Ayes: Directors Bourikas, Chambers, Horn, Moore, and Shinaver

Noes:	None
Abstain:	None
Absent:	None

3. Consider Resolution 14-05 Declaring May 2014 Water Awareness Month and Encouraging Water Conservation During the Statewide Drought
Staff recommends the adoption of 14-05 to help educate the public on water conservation and the statewide drought.

Director Bourikas moved to approve Resolution 14-05 declaring May 2014 Water Awareness Month and encouraging water conservation during the statewide drought, seconded by Director Horn and approved by the following roll call vote.

Ayes:	Directors Bourikas, Chambers, Horn, Moore, and Shinaver
Noes:	None
Abstain:	None
Absent:	None

4. Consent Calendar
    - Minutes of the Regular Meeting held on March 26, 2014
    - Audit List

Director Chambers moved to approve the Consent Calendar, seconded by Director Shinaver and approved unanimously by Directors Bourikas, Chambers, Horn, Moore, and Shinaver.

5. Items Removed from the Consent Calendar for Discussion or Separate Action
None

6. Management Reports

6.1 Operations
Mr. Kolisz reported that the District responded to 57 Underground Service Alerts, 0 water main leaks, 2 blown meters, performed 3 leak audits, and had 1service line leak and 1 fire hydrant repair. The new valve exerciser arrived. The new emergency generator is expected to arrive in approximately10 weeks. Production continues to trend downward by 9% for the year. The proposed 10 part per billion standard for chromium VI has been forwarded to The Office of Administrative Law for approval. The Department of Health came out after a 10 year hiatus and inspected District wells resulting in an invoice for $25,000 for the mandatory Sanitary Survey.

6.2 Finance
Ms. Cindy Byerrum reported that Springbrook implementation and training is continuing. Water sales continue to decline by approximately $200,000 versus last year's sales. The 2014/2015 fiscal budget will include a possible rate study and in depth analysis to factor in costs for chromium 6 compliance.

6.3 General Manager

Ms. Alaniz clarified the procedure for payment plans. There were approximately 250 people who participated in the Water Education Day. The District will have a booth at the upcoming car show to discuss and promote healthy septic systems. Sprint/Nextel has vacated the cell site on Donnell Hill resulting in a $14,000 loss to the District. AT&T is asking for a reduction in their tower lease agreement.

7. Future Agenda Items and Staff Tasks/Directors' Comments and Reports

Director Shinaver would like staff to continue monitoring the adoption of the Chromium 6 standard.

Director Horn attended the USGS Aquifers 101 seminar.

Director Moore took a tour of CADIZ.

8. Adjournment

On motion by Director Shinaver seconded by Director Chambers and approved by the Board, the meeting was adjourned at 6:32 p.m.

Kerron E. Moore, President
Board of Directors

Attest:

Tamara Alaniz, Board Secretary
Twentynine Palms Water District

ORDINANCE NO. 95

AN ORDINANCE OF THE TWENTYNINE PALMS WATER DISTRICT ADOPTING A GROUNDWATER MANAGEMENT PLAN UPDATE PURSUANT TO WATER CODE SECTION 10750 ET SEQ. AND SUPERSEDING ORDINANCE 91

WHEREAS, the Board of Directors of the Twentynine Palms Water District ("District") has heretofore adopted Ordinance 82 on October 24, 2001, adopting a Groundwater Management Plan and establishing a Groundwater Management Program; and

WHEREAS, the District is a County Water District duly formed and operating pursuant to Section 31000 et seq. of the California Water Code and has the authority to provide water service to customers within its service area; and

WHEREAS, groundwater is a valuable resource within the State of California and particularly within the boundaries of the District and such groundwater must be monitored and evaluated; and

WHEREAS, in recognition of the value of groundwater as a resource, the California State Legislature enacted Water Code section 10750 et seq. ("AB 3030") which encourages local water purveying agencies to manage groundwater resources within their jurisdictions and to develop and implement groundwater management plans; and

WHEREAS, in keeping with the intent of AB 3030 to ensure the safe production, quality and storage of groundwater within its jurisdiction, the District has adopted and implemented a Groundwater Management Plan; and

WHEREAS, the District's Board of Directors has determined that it is prudent to update its Groundwater Management Plan; and

WHEREAS, as required by Water Code Section 10753.2(a) and Government Code Section 6066, notice of a public hearing was published in the Desert Trail September 19, 2013 and September 21, 2013 declaring the District's intent to amend its Groundwater Management Plan; and

WHEREAS, on September 25, 2013, the Board of Directors adopted Resolution No. 13-17 Declaring an Intent to Amend the District's Groundwater Management Plan and as required by Water Code Section 10753.3 and Government Code Section 6066, Resolution 13-17 was published in the Desert Trail on April 17, 2014 and April 24, 2014 and a Groundwater Management Plan Update was subsequently prepared; and

WHEREAS, as required by Water Code Section 10753.5 and Government Code Section 6066, notice of a second public hearing was published in the Desert Trail on April 17, 2014 and April 23, 2014 and a second public hearing was conducted on April 23, 2014 by the Board of Directors of the District in order to receive and consider any protests on whether or not to adopt the Groundwater Management Plan Update. Pursuant to Water Code Section 10753.6(c)(3), the Board of Directors has determined that a majority protest has not been filed and therefore, the Board wishes to take action to adopt the Groundwater Management Plan Update.

NOW, THEREFORE, BE IT ORDAINED by the Board of Directors of the Twentynine Palms Water District as follows:

1. Adoption of the Groundwater Management Plan Update. Pursuant to Water Code Sections 10753 and 10753.6, the District hereby adopts that certain Groundwater Management Plan Update set forth as Exhibit "A" attached hereto and incorporated herein by reference. Pursuant to the Groundwater Management Plan Update, the District hereby establishes a Groundwater Management Program as set forth in the Plan attached hereto as Exhibit "A."

2. Ordinance Shall be Superseding. All ordinances, resolutions, or administrative actions by the Board, or parts thereof that are inconsistent with any provision of this Ordinance are hereby superseded only to the extent of such inconsistency. As of the effective date of this Ordinance, Ordinance 91 shall be of no further force or effect.

3. Effective Date. This Ordinance shall be in full force and effect immediately upon adoption.

4. Publication of Ordinance. The Secretary of the District is hereby authorized and directed to publish this Ordinance in the Desert Trail within fifteen (15) days from the date of adoption. Upon written request, the Secretary shall also provide any interested persons with a copy of this Ordinance.

PASSED, APPROVED AND ADOPTED this 28th day of May 2014 by the following vote:

Ayes:	Directors Bourikas, Chambers, Horn, Moore, and Shinaver
Noes:	None
Abstain:	None
Absent:	None

Kerron E. Moore, President
Board of Directors

Attest:

Tamara Alaniz, Board Secretary
Twentynine Palms Water District

Appendix B

Monitoring Plan

Appendix B: Monitoring Plan

The appendix outlines the TPWD monitoring plan that includes components relating to the monitoring and management of groundwater levels, groundwater quality, and inelastic land surface subsidence. A map and description of monitoring sites indicating the type of data collected is provided.

B.1 Overview

The District currently has a groundwater monitoring program. The main purpose of this program is to provide long-term tracking of groundwater levels and quality, identify trends, and trigger management steps to protect groundwater quality and quantity.

TPWD collects groundwater data to evaluate changes in groundwater conditions in the area. The TPWD Groundwater Monitoring Program provides a systematic procedure for data collection to support the District in assessing the hydrologic conditions in the Twentynine Palms area. The data collected for the groundwater monitoring program are collected from multiple sources throughout the year. In general, these sources include:

- data collected by Twentynine Palms Water District;
- data compiled by other agencies (e.g., USGS); and,
- data for subsidence monitoring.

These data are compiled into the District's groundwater management database, and are summarized and presented in the District's Annual Groundwater Management Report. The Annual Report does not contain a comprehensive listing of the District's database, but the complete updated database is made available for download in PDF format directly from the TPWD website. The database can be accessed at the following web address: www.TPWD.org/index/District_Reports.

B.2 Data Collection by TPWD

The locations, type and frequency of the data collected have changed over time to meet the needs of the District. Therefore, the Groundwater Monitoring Program is reviewed and updated regularly as part of the annual groundwater management reporting process. The data collected under this program does not fall under any regulatory requirements. Therefore, the data collection recommendations will be adhered to a closely as possible; however, variations from the recommended frequency may occur due to scheduling, budgetary, access or other issues.

B.2.1 Groundwater Levels

The District currently operates nine production wells and 17 monitoring wells. Groundwater static levels and pumping levels are monitored on a monthly basis for all production wells. TPWD maintains records of historical groundwater elevations from the 1940s to the present. These have included the TPWD production wells and monitoring wells and are provided to the CASGEM reporting database.

Groundwater levels are measured at least monthly in all TPWD production wells. Water levels are measured in all production wells under both pumping (dynamic) and non-pumping (static) conditions. Production well water level measurements provide important information on: 1) drawdown in response to pumping; 2) water level recovery when pumping stops; and, 3) trends over time in static water levels. Therefore, continuation of monthly measurements in all production wells will continue. These wells are listed on Table B-1 and shown on Figure 6-1.

B.2.2 Groundwater Pumping

Tracking groundwater pumping from the TPWD groundwater production wells is an important component in assessing the water supply. The locations of TPWD production wells are shown on Figure 6-1. Groundwater pumping is metered by TPWD and recorded daily. For the Groundwater Management Summary, a monthly total is recorded in the database.

B.2.3 Water Quality

TPWD monitors the active groundwater producing wells for a number of constituents with a frequency that complies with the Safe Drinking Water Act requirements as outlined in the California Code of Regulations, Title 22 requirements. Groundwater quality monitoring for fluoride and arsenic is conducted monthly and monitoring for other constituents occurs according to the requirements set by California Department of Public Health (DPH) Drinking Water Monitoring Schedule for all production wells. The Fluoride Removal Water Treatment Plant monitoring wells are also monitored on a monthly basis and various District-wide monitoring wells are monitored on a quarterly basis. These levels are collected on a timed schedule each month to ensure consistent data collection. All groundwater level records are kept at the District Office.

TPWD actively incorporates new constituents into the monitoring program as a result of new regulatory actions or trends in the water quality industry (e.g., hexavalent chromium was added to the monitoring list in 2013). All water quality results are reported to the CDPH Division of Drinking Water and Environmental Management.

TPWD's monitoring program consists of sampling both the raw and treated water from production wells, monitoring of shallow groundwater, and monitoring of surface water in the region. TPWD also collects and analyzes samples for general minerals, physical characteristics, select metals, and organic chemicals often associated with industrial or commercial sites.

B.3 Data Collected by Others

TPWD records are supplemented by data obtained from other agencies. These data are often available through internet sites that allow for the public access of these data. Several of these data sets have been incorporated into the TPWD Groundwater Monitoring Program. New data will be incorporated as it is made available.

The USGS currently collects groundwater level monitoring primarily associated with the Marine Base that includes several wells in the Twentynine Palms area. These are posted on the DWR Water Data Library web and can be downloaded from the following web link: http://www.water.ca.gov/waterdatalibrary/. These data are also posted on the CASGEM web site and can be downloaded from http://www.water.ca.gov/groundwater/casgem/.

Precipitation data are available from several sources in the area. The Desert Research Institute (DRI) Western Regional Climate Center (WRCC) publishes monthly average maximum and minimum temperatures for National Climate Data Center (NCDC) cooperative network stations in the area. Data for the Twentynine Palms Station (049099) is found at the web site http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9099. San Bernardino County (SBCO) maintains records from many stations within the county, with many more precipitation records than temperature records with over 30 stations in or near the management area.

Standard Monthly Average ETo determined from CIMIS Station No. 118 Cathedral City. These data serve as a reference for TPWD evapotranspiration data and are available online at www.cimis.water.ca.gov/cimis/welcome.jsp. The District will pursue the possibility of establishing a CIMIS station within its service area to generate more accurate ET data.

B.4 Data for Subsidence Monitoring

Land subsidence has not been identified as an issue within the Twentynine Palms area; however, playa lake deposits such as those found in the Mesquite Lake and Mainside Subbasins have been noted as sources of land subsidence in Antelope Valley and other similar areas. In the Indian Cove, Fortynine Palms and Eastern Subbasins, no compressible sediment layers are known to exist; therefore, there it is unlikely that subsidence would occur in these locations.

Therefore, the District will establish a baseline elevation assessment of historical US Geodetic Survey benchmark surveying data. Available benchmark data within and adjacent to the District was downloaded from the National Geodetic Survey website (http://www.ngs.noaa.gov/). It is recommended that the District have a competent land surveyor evaluate the historical benchmark data with respect to potential subsidence. Future assessments will be done periodically to verify whether land subsidence is occurring or not. Methods for future assessments will continue as benchmark surveying, but the District will evaluate other potential methods that may provide monitoring for land subsidence in a more cost-effective manner.

B.5 Review and Revision

The locations, type and frequency of the data collected have changed over time to meet the needs of the District. Therefore, the Groundwater Monitoring Program is reviewed and updated regularly as part of the ongoing groundwater management reporting process. An annual review of this Groundwater Level Monitoring Plan is recommended to confirm that:

- the data being collected by the Program is still meeting the groundwater management needs of TPWD;
- the wells and sampling locations included continue to provide reliable data and remain readily accessible to TPWD;
- clear protocols exist to ensure the accuracy of collected data; and,
- no unnecessary or extraneous data are collected.

TABLE B.1 – Groundwater Monitoring Program well locations and sampling frequencies.

Well	Type	Subbasin	Monitoring Frequency			
			Water Level	Fluoride	Nitrate	Title 22
WTP-1	Active	Mesquite Lake	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
1B	Monitoring	Eastern	Monthly	N/S	N/S	N/S
2	Monitoring	Eastern	Quarterly	N/S	N/S	N/S
4	Inactive	Fortynine Palms	Monthly	N/S	Annual	Per Drinking Water Monitoring Schedule
6	Inactive	Indian Cove	Monthly	N/S	N/S	Per Drinking Water Monitoring Schedule
7	Monitoring	Indian Cove	Monthly	N/S	N/S	N/S
9	Active	Indian Cove	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
10	Inactive	Indian Cove	Monthly	N/S	N/S	Per Drinking Water Monitoring Schedule
11	Active	Indian Cove	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
12	Active	Indian Cove	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
14	Active	Fortynine Palms	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
15	Active	Indian Cove	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
16	Active	Eastern	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
17	Active	Fortynine Palms	Monthly	Monthly	Annual	Per Drinking Water Monitoring Schedule
18	Monitoring	Mesquite Lake	Quarterly	N/S	N/S	N/S
M#1	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
M#2	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
M#3	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
M#4	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
M#5	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-1	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-2	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-3	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-4	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-5	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
N-6	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
S-1	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
S-2	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
S-3	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
S-4	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S
S-5	Monitoring	Mesquite Lake	Monthly	N/S	N/S	N/S

Appendix C

Hydrologic Water Balance

Appendix C: Hydrologic Water Balance

Appendix C provides a more detailed discussion of each of the components of the hydrologic water balance. This shows the level of understanding that is currently available for determining groundwater inflows and outflows.

C.1 Water Balance Summary

The water balance was performed for the groundwater basins underlying the District service area, including the portions of the Indian Cove, Fortynine Palms, Eastern, Mesquite Lake and Mainside Subbasins. The following discussion provides background information and assumptions used for quantifying each water balance component. Also described is the background on the various components of the water balance, including the sources of data and how each component was estimated. A more detailed description of the data sources can be also found in the Groundwater Study for the Mesquite Lake Subbasin (Kennedy/Jenks, 2010).

The water balance components were estimated based on various data sources, including the hydrogeologic knowledge of the basins from previous studies. Each component is evaluated based on the long-term average values over 30 years for the period from 1984 to 2013. The long-term average characterizes variations of the groundwater system over various hydrological years. The following discussion provides more detail of each of the water budget components.

C.2 Climate

Climatic factors including precipitation, temperature and evapotranspiration are the key controlling factors for the natural hydrologic water balance components. Table C-1 provides a climatic summary per month based on data from the National Weather Service and state agencies.

The Twentynine Palms area is quite dry, with average annual precipitation of less than 5 inches, most of which occurs during the winter months (Table C-1). Most of this precipitation is lost through evaporation; the total average monthly evapotranspiration (ETo) rate of a desert area is 57 inches per year (Table C-1). Precipitation follows a generally bimodal distribution, with most annual precipitation falling during the summer monsoon and the winter wet season. Summer storms are intense and of relatively short duration, and may lead to flash floods but are unlikely to contribute to recharge due in large part to the high potential evapotranspiration (ET) during the hot summer months and the lack of storm water retention. Winter storms are gentler and of longer duration, and are more likely to contribute to recharge.

Temperatures range from 20 to 60°F during the winter and from 80 to 110°F degrees during the summer. Throughout the area, high temperatures tend to decrease with increasing elevation, while low temperatures do not vary greatly with elevation.

TABLE C-1
CLIMATE DATA

Months	Standard Monthly Average ETo[(a)] (inches)	Average Rainfall[(b)] (inches)	Average Max. Temperature[(b)] (Fahrenheit)	Average Min. Temperature[(b)] (Fahrenheit)
January	1.6	0.5	63	36
February	2.2	0.4	68	39
March	3.7	0.4	74	43
April	5.1	0.1	82	49
May	6.8	0.1	91	57
June	7.8	0.0	101	65
July	8.7	0.5	105	72
August	7.8	0.7	103	70
September	5.7	0.4	98	64
October	4.0	0.3	86	53
November	2.1	0.3	72	42
December	1.6	0.5	63	35
Annual	57.1	4.2	84	52

Notes: (a) Standard Monthly Average ETo determined from CIMIS Station No. 118 Cathedral City.
(b) Twentynine Palms NWS Cooperative Network Station (049099).

C.3 Groundwater Inflows

Inflows replenish water to the aquifer system through various routes and processes. This section defines and discusses the different types of inflow. The total inflow is discussed below.

C.3.1 Direct Precipitation Recharge

Direct recharge accounts for recharge of precipitation that falls on the basin floor, percolates downward through the vadose (unsaturated) zone, and eventually reaches the water table. Because the Twentynine Palms area is very arid, potential evapotranspiration (ET_0) far outstrips the actual amount of precipitation; Nishikawa et al. (2004) noted that ET_0 is about 66.5 inches per year (in/yr) in the Joshua Tree area, while precipitation is about 4.8 in/yr (e.g. ET_0 is nearly 14 times precipitation).

Direct recharge has been estimated in several different studies. Nishikawa et al. (2004) used a variety of methods to try to constrain direct recharge in the Joshua Tree area to the west of the study area, including temperature, matric potential, soil water chemistry, and a watershed model. The results of their physical measurements indicated that recharge probably does not occur on the basin floor away from stream channels. Their watershed model produced recharge rates of 0 to 0.0001 in/yr on the basin floor away from the stream channels, and 0.0001 to 0.01 in/yr at the Coyote Lake playa.

Kennedy/Jenks (2010) used a modified Maxey-Eakin approach to estimate recharge throughout the study area. This analysis reached the same conclusion as did Nishikawa et al.: direct recharge on the basin floor is, for all intents and purposes, zero. However, the method used is a very coarse one, and sets recharge to zero wherever precipitation is less than 8 inches per year, an area that includes almost the entire region aside from the highest mountains. Li and Martin (2011) reached a similar conclusion to the above two studies regarding direct recharge, stating that the amount of precipitation that falls on the basin floor is too small to induce recharge. Kennedy/Jenks (2013) lumped basin floor recharge and mountain front recharge by using water budget numbers from the earlier Groundwater Study (Kennedy/Jenks, 2010). The amount contributed to recharge from precipitation on the basin floor is zero.

For this study, direct recharge was calculated based on the range in precipitation recharge typical of the basin floor according to the watershed model of Nishikawa et al. (2004), 0 to 0.0001 in/yr. The total area of basin floor in the five subbasins considered for this study is approximately 66,000 acres, so the range in basin floor recharge is 0 to 0.5 afy.

C.3.2 Irrigation Return Flows

Return flow from agricultural or landscape irrigation can be a significant contributor to the water budget of a basin. Within the study area, agriculture is not present, but there are a few sites with regular and significant irrigation (Luckie Park in the Mesquite Lake Subbasin, Knott Sky Park in the Fortynine Palms Subbasin, and the Desert Winds Combat Center Golf near the intersection of the Mesquite Lake, Mainside, and Deadman Subbasins). Return flows from these locations of irrigation have not been included in any of the models to date. Li and Martin (2011) note that ignoring these return flows is a limitation in their numerical model. They also note that, until around 2000, there was no indication that return flows had yet passed through the unsaturated zone and reached the water table in the regional aquifer, meaning that the return flows must be maintained for many years before they actually can pass through the thick unsaturated zones of the study area and lead to recharge to the water table. Irrigation return flow was assumed to be effectively zero.

C.3.3 Septic Return Flows

Some of the groundwater produced and delivered to customers, returns to the subbasins through infiltration and percolation of irrigation water and of septic tank discharges. As the majority of water use is from the residential development and the outdoor water use is generally small, residential indoor water use (and in turn residential wastewater) is a large contributor to septic systems. Total residential and non-residential septic return flow for the current conditions, based an assumption of an 80 percent water to sewer conversion, is estimated at 1,917 afy. Using the assumptions for the 2035 projected water use (Kennedy/Jenks, 2011); the estimated total septic return flow is 2,981 afy. Li and Martin (2011) and Kennedy/Jenks (2010) did not consider septic return flow in their models.

C.3.4 Surface Water

Surface water recharge is the recharge that occurs as infiltration of streamflow through streambeds cutting across the basin floor. There are no perennial streams within the study area, but there are several large dry streambeds that experience intermittent flows. Previous studies have taken different approaches to estimating this stream infiltration.

The stream channels are ephemerally flowing streams with runoff originating in the adjoining mountains in response to the largest storms. However, very little surface flow leaves this area (Troxell *et al*, 1954). Nishikawa *et al* (2004) evaluated stream gage data in the region including the Fortynine Palms Creek. Over the period of record, Fortynine Palms Creek had measurable flow on an average of 2.4 days per year, totaling 74.3 afy. These four gauges show streamflow to be highly intermittent, with the duration of surface flows limited to only 1 to 2 days in response to storms that primarily occurred in the summer months in response to monsoonal thunderstorms (Nishikawa *et al*, 2004).

Because Kennedy/Jenks (2010) used the modified Maxey-Eakin approach to estimate total recharge, there is no specific estimate available for streamflow infiltration. Theoretically, the Maxey-Eakin method includes streamflow infiltration in its total basin recharge, in addition to direct recharge, mountain front recharge, and mountain block recharge.

Li and Martin (2010) used the watershed model of Nishikawa et al. (2004) to estimate streamflow infiltration into the Mesquite Lake Subbasin; this area was included in the original model, but was not published in the 2004 report. Streamflow infiltration was estimated to be 165 afy within the Mesquite Lake Subbasin, mostly along the Mesquite Lake Wash and Twentynine Palms Channel. This study implies that recharge largely results from summer streamflow. Given the seasonal discrepancy described above for the watershed model, the bulk of the recharge occurring in the summer may be more realistic.

Stream gauge data are available for the Fortynine Palms Creek gauge (USGS #10253350) from October 1962 to September 1971. Measured flow occurred in 7 of the 9 water years with available data, with average annual flow of about 95 afy for those years. Flows varied from 7 to 155 afy. These data were compared to water-year precipitation totals from the National Climatic Data Center (NCDC) station #49099 at Twentynine Palms over the same period. The correlation between the two is not strong ($r^2 = 0.273$, $p = 0.15$), but it was believed to be useful as an initial tool for estimating streamflow over the period covered by the groundwater model. The correlation equation was applied to the available annual precipitation record, covering the period from 1936 to 2012; any estimated streamflow less than zero was set to zero. Average streamflow was estimated to be 81 afy, with a median streamflow of 66 afy, and varied from 0 to 314 afy (6 out of 77 years had no streamflow).

C.3.5 Mountain Front Recharge

Mountain front recharge (MFR) is recharge that occurs at the boundary between the alluvial basin sediments and the crystalline bedrock of the basin-bounding mountains. It must be noted that there are several different ways to define MFR, and the conceptual understanding of MFR for the purpose of this water balance is equivalent to MFR in Wilson and Guan (2004). Under this definition, MFR is made up of that water that runs off the mountains as surface runoff and enters the alluvium upon leaving the mountains.

Nishikawa et al. (2004) does not provide specific estimates of MFR from their numerical model, instead grouping it with the other recharge components. However, they do state that “simulated recharge rates between 0.1 and 0.5 in/yr occurs [sic] along the flanks of the Little San Bernardino Mountains.” They calculated recharge throughout the topographic contributing area to their groundwater model, demonstrating that higher recharge rates are present at the bedrock-alluvium interface than exist on either the exposed bedrock or basin floor. They speculate that any recharge that occurs outside of the numerical model domain (the main part of the groundwater basin) is eventually lost to evapotranspiration (ET) rather than reaching the groundwater basin, but there is no particular evidence presented for this.

As stated above, Kennedy/Jenks (2010) estimated recharge using a modified Maxey-Eakin method. The conceptual understanding of recharge for this analysis was that the recharge represents MFR as defined above. Calculated MFR varied from 0 to 54 afy in the Indian Cove Subbasin, 7 to 212 afy in the Fortynine Palms Subbasin, 2 to 190 afy in the Eastern Subbasin, 0 to 8 afy in the Mesquite Lake Subbasin, and 0 to 10 afy in the Mainside Subbasin, for a total of 9 to 474 afy for the subbasins.

Li and Martin (2011) do not directly address MFR because their groundwater model does not abut the major basin-bounding mountain ranges. However, they calculated that 510 afy of groundwater inflow passes from the Indian Cove, Fortynine Palms, and Eastern Subbasins into the Mesquite Lake Subbasin, and presumably this would mostly be made up of MFR. Kennedy/Jenks (2013) estimates a low recharge total of 8 afy based on the numerical groundwater model of Kennedy/Jenks (2010). As with the earlier study, this total can be assumed to represent MFR.

C.3.6 Mountain Block Recharge

Mountain block recharge (MBR) is that portion of recharge that occurs through the bedrock of the basin-bounding mountain ranges. It discharges from the bedrock itself into the basin alluvium, rather than flowing off the bedrock on or near the surface. For this report, MBR is conceptually similar to the definition of MBR in Wilson and Guan (2004). MBR has not been specifically considered in any of the previous reports discussed above. In fact, Nishikawa et al. (2004) speculated that the recharge they simulated to occur outside of the alluvial basins was largely lost to ET before it could discharge to the alluvium as MBR. However, some of this mountain block water must make its way to the alluvial basin.

Fugro West and Cleath (2002) used a Darcy’s Law approach to estimate groundwater inflow from the basin-bounding mountains surrounding the Paso Robles Groundwater Basin, which can be considered to be MBR under the definition used in this report. As a first approximation, we assume that the Little San Bernardino and Pinto Mountains can be considered hydraulically equivalent to the fractured granite bounding the Paso Robles Groundwater Basin, which Fugro West and Cleath (2002) give a hydraulic conductivity of 0.1 gallons per day per square foot (gpd/ft^2), a moderate value in their estimates. Their results indicated approximately 50 ft^3 of MBR per linear foot of mountain front length. Using this value, MBR into the three southern subbasins was calculated to be 56 afy into the Indian Cove Subbasin, 34 afy into the Fortynine Palms Subbasin, and 49 afy into the Eastern Subbasin, for a total of 139 afy.

C.3.7 Groundwater Inflow

Groundwater inflow represents water that enters a subbasin by flowing laterally within the saturated zone from another subbasin. Groundwater inflow in the study area is restricted somewhat by the presence of low-permeability faults and other barriers that help to compartmentalize the various subbasins.

Nishikawa et al. (2004) created a numerical model that included the Joshua Tree and Copper Mountain Subbasins, which border the Indian Cove and Mesquite Lake Subbasins, respectively, to the west. They allowed groundwater to leave their model along the eastern boundary of the Joshua Tree Subbasin and the far northern boundary of the Copper Mountain Subbasin. Their model indicated that 199 afy (207 under pre-development conditions) leaves the two subbasins as groundwater outflow, and that it all flows out the northern boundary of the Copper Mountain Subbasin. They state that this groundwater flows into the Surprise Spring Subbasin, but it is unclear whether or not this would actually occur, as the Transverse Arch is still present to the north of this point. The groundwater flow could also pass east through the space between Copper Mountain and the Transverse Arch into the Mesquite Lake Subbasin, although to do so it would have to cross the Copper Mountain Fault.

Kennedy/Jenks (2010) based their water budgets on all of the available USGS reports for the area. Conceptually, the Indian Cove Subbasin receives groundwater inflow from the Joshua Tree Subbasin to the west, while the Fortynine Palms and Eastern Subbasins do not receive inflow from other basins. The Mesquite Lake Subbasin receives inflow from the Indian Cove, Fortynine Palms, Eastern, Deadman Lake, Surprise Spring, and Copper Mountain Subbasins. Using a Darcy's Law approach, they estimated that the Indian Cove Subbasin receives about 36 afy of inflow from the Joshua Tree Subbasin, while the Mesquite Lake Subbasin receives a total of about 730 afy of inflow from the various surrounding subbasins.

Li and Martin (2011) also estimated groundwater inflow to the Mesquite Lake Subbasin. In contradiction to Nishikawa et al. (2004), they stated that 207 afy of groundwater leaves the Copper Mountain Subbasin and flows into the Mesquite Lake Subbasin between Copper Mountain and the Transverse Arch. They also give a groundwater inflow of 8 afy from the Deadman Lake Subbasin (and no inflow from the Surprise Spring Subbasin), much lower than the 577 afy estimated by Kennedy/Jenks (2010) for inflow from the Deadman Lake and Surprise Spring Subbasins. Groundwater inflow to the Mesquite Lake Subbasin from the three southern subbasins (Indian Cove, Fortynine Palms, and Eastern) was calculated to be about 510 afy based on their estimates of inflow from other subbasins (Copper Mountain and Deadman) and published estimates of total ET at Mesquite Lake, and is far higher than the estimates of Kennedy/Jenks (2010) from the same three subbasins (18 afy).

C.4 Groundwater Outflows

Outflows remove water from the aquifer system through various routes and processes. This section defines and discusses the different types of outflow individually. The outflow components are discussed below.

C.4.1 Pumping Wells

As development in the study area has continued, groundwater extraction by wells has become the chief outflow component in the aquifer water balance. This component should be the easiest to estimate, but much of the groundwater extraction in the study area is unmetered, and hence unknown. The District provides pumping volumes, but many other groundwater users exist in the study area, and do not measure or report their pumping.

Kennedy/Jenks (2010) used records and information from TPWD to estimate well pumping in the four subbasins covered by their report. Over their study period (1984 to 2008), they estimated average pumping at 1,286 afy in the Indian Cove Subbasin, 1,117 afy in the Fortynine Palms Subbasin, 366 afy in the Eastern Subbasin, and 774 afy in the Mesquite Lake Subbasin. TPWD did not produce drinking water from the Mesquite Lake Subbasin until 2003, so the average pumping does not accurately reflect current conditions (a steady production rate of 580 afy was assumed for the Roadrunner Dunes Golf Course and Luckie Park). In 2008, the last year included in the water balance, total pumping in the Mesquite Lake Subbasin was 1,530 acre-feet. In their water balance, domestic well pumping is ignored.

Li and Martin (2011) note the TPWD pumping in the Mesquite Lake Subbasin, but not any other pumping in the subbasin. They do mention that the Golf Course Well operated by the Marine Corps is located at the northern edge of the Mainside Subbasin, and has been pumping since the early 2000s. The Golf Course Well was estimated to have produced about 540 acre-feet in 2008. Kennedy/Jenks (2013) based groundwater pumping in their water balance on the earlier groundwater model (Kennedy/Jenks, 2010). The estimated pumping of 290 afy each for the Roadrunner Dunes Golf Course and Luckie Park are included, as is the estimated pumping of 540 afy in the Mainside Subbasin.

C.4.2 Evapotranspiration

Evapotranspiration (ET) is the transformation of liquid water to water vapor through either transpiration by plants or evaporation of standing or soil water. Where the water table is close to the land surface, ET can be supplied by the saturated zone of the aquifer; where the water table is out of reach of the root zone; ET is derived only from soil moisture, and has no bearing on the groundwater budget.

As noted above, water tables in the study area tend to be far beneath the land surface, so ET from the water table is limited. Kennedy/Jenks (2010) used existing reports to estimate ET within the study area. They determined that ET was about 550 afy at Mesquite Lake before development, and has likely decreased to around 340 afy due to lowering of the water table. ET at the Oasis of Mara was estimated to be up to about 75 afy, but there has been no rigorous estimate. Concentrations of phreatophytic vegetation (vegetation directly taps the water table to survive) at the Oasis of Mara and Mesquite Dry Lake (and Mesquite Springs) within the District (Riley and Worts, 1953).

Li and Martin (2011) used earlier estimates as the basis for their conceptual understanding of ET in the Mesquite Lake Subbasin, giving a total of 890 afy from transpiration and soil evaporation. This total was used to calibrate boundary conditions in their groundwater model, so the model cannot be used to provide an independent estimate. Kennedy/Jenks (2013) included ET in their water balance, and based it on the results of the groundwater model of Kennedy/Jenks (2010). This resulted in about 20 afy of ET in the Eastern Subbasin and 1,630 afy in the Mesquite Lake Subbasin. Based on these previous studies, ET varies from 20 to 75 afy at the Oasis of Mara and 340 to 1,630 afy at Mesquite Lake.

C.4.3 Groundwater Outflow

Groundwater exchanges between the southern subbasins and the Mesquite Lake Subbasin were discussed in the Groundwater Inflow section above (Section 6.4.1.6). This section only covers groundwater exchanges that leave the set of subbasins included in the study area.

Under the conceptual model of Kennedy/Jenks (2010), groundwater from the three southern subbasins flowed out to the Mesquite Lake Subbasin, and groundwater from this subbasin flows out into the Dale Basin to the east. Under their water balance approach, 114 afy flowed from the Mesquite Lake Subbasin to the Dale Basin. Their numerical model simulated a flow of 519 afy across this boundary. Note that the Mainside Subbasin is not included in either the water budget or the numerical model.

Under the conceptual model of Li and Martin (2011), groundwater flows from the Mesquite Lake Subbasin into the Mainside Subbasin, from where it may enter the Dale Basin. However, they state that only a minor amount of groundwater flows from the Mesquite Lake Subbasin to the Mainside Subbasin.

C.4.4 Springs

Springs are locations where the water table intersects the ground and groundwater is discharged to the surface. Once there, this water can re-infiltrate, be utilized as a water source, or be lost to ET. Because the study area is very dry, water tables are typically well below the ground surface, so springs are very rare within the alluvial basins. Prior to development, springflow occurred at the Oasis of Mara and Mesquite Springs, where faults force groundwater upward to the surface. However, there have been no rigorous estimates of flow at these springs. Because of lowered water tables, one can assume that there is no longer any flow occurring at these springs.

Appendix D

Groundwater Model Update

Appendix D: Groundwater Model Update

This section describes the changes that were made to the existing model of Kennedy/Jenks (2010) and discusses the updated model calibration.

D.1 Changes to the Existing Model

The existing groundwater model of Kennedy/Jenks (2010) was updated for this analysis to revise the components of the water budget and to include information from the USGS model of the Mesquite Lake Subbasin (Li and Martin, 2011). The sources used in updating these parameters include USGS numerical models that cover or abut parts of the study area (Nishikawa et al., 2004 and Li and Martin, 2011), the Mesquite Lake Groundwater Study (Kennedy/Jenks, 2010), and the Twentynine Palms Groundwater Protection Plan (Kennedy/Jenks, 2013); estimates of various water budget components from the numerous previous USGS studies in the area are collected in the Mesquite Lake Groundwater Study and the two USGS numerical model reports.

The primary change was to update the recharge coverage to combine five different components: direct recharge, mountain front recharge, mountain block recharge, streamflow infiltration, and septic return flow (see Appendix C for estimates of these components). A steady direct recharge rate of 0.5 in/yr was assumed everywhere. Mountain front recharge rates (varies over time) and mountain block recharge rates (steady over time) were applied to a narrow zone along the Little San Bernardino and Pinto Mountains in the Indian Cove, Fortynine Palms, and Eastern Subbasins. Streamflow infiltration (varies over time) is applied along the bed of Fortynine Palms Creek within the Mesquite Lake Subbasin. Septic return flow (steady over time) is based on land use maps and calculations to support the GPP.

The Mesquite Dry Lake was updated to simulate evapotranspiration in the area of the using both the evapotranspiration package and groundwater discharge due to evaporation using a drain (DRN) boundary condition. This type of boundary condition allows for the setting of a drain stage elevation and conductance value. In the case of the drain boundaries added to the updated model, the stage was set to an elevation near the ground surface, and the conductance was set to a sufficiently large value (5,000 square feet per day, ft^2/d) that groundwater was allowed to flow freely out of the aquifer and into the drain. The DRN package does not allow for water to be routed; instead, it is simply removed from the model. This approach was also taken in the Mesquite Dry Lake area by Li and Martin (2011).

With respect to physical changes to the model, the far northwestern section of the Mesquite Lake Subbasin (west of the Surprise Spring Fault) was deactivated in the updated model. This was done because much of this area was simulated as being dry, and it was difficult to introduce groundwater flowing from the Copper Mountain Subbasin to the Mesquite Lake Subbasin, as cells were widely inactive. This groundwater flow was instead introduced further into the Mesquite Lake Subbasin, east of the Surprise Spring Fault and west of the Elkins fault.

Groundwater inflow to the model was simulated using specified flux boundaries, assuming the estimates given in Appendix C. These boundaries were introduced along the interface between the Joshua Tree and Indian Cove Subbasins, between the Copper Mountain and Mesquite Lake Subbasins, and between the Deadman and Mesquite Lake Subbasins.

D.2 Groundwater Model Setup

Aquifer parameters (horizontal and vertical hydraulic conductivity, specific yield, and storage coefficient) for the Indian Cove, Fortynine Palms, and Eastern Subbasins were updated to those of the Joshua Tree Subbasin to the west in the groundwater model of Nishikawa et al. (2004). Those for the Mesquite Lake Subbasin used the parameters of the Li and Martin (2011) model (Table D-1).

TABLE D-1
GROUNDWATER MODEL AQUIFER PARAMETER SUMMARY

Subbasin	Model Layer	K_h (ft/d)	K_z (ft/d)	S_y (-)	S_s (ft^{-1})
Indian Cove	1	60	0.60	0.25	3×10^{-6}
	2	5	0.05	0.16	1×10^{-6}
	3	0.5	0.005	0.05	1×10^{-6}
Fortynine Palms	1	60	0.60	0.25	3×10^{-6}
	2	5	0.05	0.16	1×10^{-6}
	3	--	--	--	--
Eastern	1	60	0.60	0.25	3×10^{-6}
	2	5	0.05	0.16	1×10^{-6}
	3	--	--	--	--
Mesquite Lake	1	44	0.44	0.25	3×10^{-6}
	2	24	0.24	0.16	3×10^{-6}
	3	0.2	0.002	0.05	1×10^{-6}

Notes:
Kh = Horizontal hydraulic conductivity
Kz = Vertical hydraulic conductivity
Sy = Specific yield
Ss = Specific storage
-- = Layer not active in this subbasin

The alluvial fan deposits are the principal water-bearing unit in the region. Li and Martin (2011) divide the upper alluvial fan deposits into two units based on their characteristics. The lower unit (QTf1) consists of silty sand and gravel, which are interbedded with moderate amounts of silt and clay that were deposited on the lower slopes of the alluvial fans. The lower unit is irregularly cemented with calcium carbonate and is moderately consolidated. The upper unit (QTf2) consists of unconsolidated pebbly sand, pebble-cobble gravel, and minor silt and clay that were mainly stream deposits. In general, QTf2 is more permeable than QTf1 because of the predominance of the coarser-grained deposits and the lack of cementation. The thickness of the upper alluvial fan deposits reaches about 400 feet in the Joshua Tree Subbasin, with a saturated thickness of 300 feet. K for this unit varies from 5 to 60 ft/d, and T varies from 600 to 56,000 ft^2/d. S_y varies from 0.08 to 0.23.

The thickness of the lower Quaternary alluvium varies from zero along the basin margins to a maximum of 400 feet in the western Indian Cove and eastern Mesquite Lake Subbasins and throughout much of the Joshua Tree Subbasin. K for this unit varies from 0.5 to 60 ft/d, and T varies from about 200 to 36,000 ft^2/d. S_y of these sediments varies from 0.12 to 0.14, while S_s is about 1 × 10-6 ft^{-1}.

The maximum saturated thickness of the Tertiary alluvium in the Twentynine Palms area is about 1,700 feet along the western edge of the Indian Cove Subbasin and reaches up to 3,000 feet, according to Nishikawa *et al.* (2004). Sediments that have become deeply buried tend to be more consolidated, compacted, and cemented with depth. Therefore, the deepest sediments tend to be less transmissive of water than the upper sediments. The hydraulic conductivity, *K*, is around 0.5 to

1 feet per day (ft/d), while the transmissivity, *T*, is on the order of 750 square feet per day (ft^2/d). The specific yield (S_y) of this unit is 0.05, while the specific storage (S_s) is estimated to be 1×10^{-6} ft^{-1}. Because of the low transmissivity and specific storage of this unit, it is generally considered fairly unimportant as a source of water (Londquist and Martin, 1991).

D.3 Historical Model Calibration Summary

The updated model was re-calibrated with the updated boundary conditions and parameter estimates noted above. Calibration was achieved largely by varying the conductance of horizontal flow barriers (i.e. faults) within the model. The calibration was performed using a statistical analysis to compare the difference or residual between measured and simulated groundwater elevations. A summary of this analysis includes:

- The correlation coefficient to simulate groundwater elevations is 0.9623 based on 554 groundwater elevation measurements over the 25-year base period from 50 different wells. The correlation coefficient ranges from 0 to 1 and a correlation of 1 is a perfect correlation. The correlation coefficient of 0.9623 indicates a very strong correlation between simulated and observed groundwater elevations.

- The residual mean is computed by dividing the sum of the residuals by the number of residual data values. The closer this value is to zero, the better the calibration. The residual mean for the model is 3.0 feet.

- The residual standard deviation evaluates the scatter of the data. A lower standard deviation indicates a closer fit between the simulated and observed data. The standard deviation for the calibrated model is 35 feet.

- The absolute residual mean is a measure of the overall error in the model. The absolute residual mean is computed by taking the square root of the square of the residuals and dividing that by the number of measurements. The absolute residual mean for the model is 27 feet.

- Another statistical measure of calibration is the ratio of the standard deviation of the mean error divided by the range of observed groundwater elevations. This ratio shows how the model error relates to the overall hydraulic gradient across the model. Typically, a calibration is considered good when this ratio is below 0.15 (ESI 2001). The ratio for the Paso Robles Groundwater Model is 0.05, which is well below the threshold.

Based on the statistical analysis, the model is well calibrated and slightly better than was achieved in the original model. The variation is primarily due to the large area of the basin and overall limited groundwater elevation data and uncertainty on key natural recharge and discharge components. These results are similar to those achieved for basins similar to Twentynine Palms.

D.4 Future Groundwater Model Scenarios

Four future groundwater model scenarios were simulated using the historical groundwater model. These model scenarios are designed to demonstrate the effect of continued growth of demand on the aquifer system and the transition of septic systems to sewerage. The duration of each of these scenarios was 25 years.

Initial head conditions for the future scenarios are taken from the end of the historical simulation, i.e., the end of calendar year 2008. The only differences between the historical model and the future scenarios is the treatment of pumping and septic recharge (see the individual scenario descriptions below). The same time series of MFR and streamflow infiltration were used; this assumes that the 25-year period of the historical model can be considered to be reasonably representative of average conditions for the future scenarios. MBR was not varied over time, and used the same average rates assumed for the historical model.

D.4.1 Baseline with Constant 2010 Water Demand

Scenario 1 simulated baseline conditions, with water demand not changing from 2010 conditions. The baseline scenario assumes that pumping does not change over time, nor does septic recharge (which is assumed to depend directly on pumping). This is not expected to be representative of actual conditions, but instead provides a set of conditions against which the other scenarios can be compared.

D.4.2 Scenario 1 – 2035 Water Demand with Current Distribution of Pumping to Subbasins

Scenario 1 uses a linear growth rate of 2.58 percent per year (not compounding; that is, growth is 2.58 percent of the 2010 total every year) to predict pumping and septic recharge over the 25-year simulation duration. In this case, the increased pumping is distributed to the existing wells exactly proportional to their pumping in 2010. That is, if a well provided 5 percent of total demand in 2010, it would also experience 5% of the increased demand every year. Similarly, the septic recharge in all land use types increased by 2.58% per year over 2010 rates.

Table D-2 summarizes the relative change in the hydrologic budget relative to the Baseline Scenario. Storage continues to decline over time. Groundwater pumping increases by 1,370 acre-feet in Year 25, resulting in an average increase in pumping of 685 afy over the 25 years simulation period. The resulting increase in septic tank return flows of 548 afy is based on the assumption of 80 percent of the additional pumping is included in the scenario. The scenario results show a decrease in groundwater storage of 283 afy and increase in groundwater discharge at Mesquite Lake of 145 afy. The groundwater inflow and outflows balance reflects changes in flow between the subbasins across the Oasis Fault.

TABLE D-2
HYDROLOGIC BUDGET SUMMARY

	Groundwater Inflow (AFY)			Groundwater Outflow (AFY)			(AFY)
Subbasin	**Septic Return Flow**	**GW Inflow**	**Natural Recharge)**	**Wells)**	**Natural Discharge**	**GW Outflow**	**Change in Storage**
Indian Cove	60	0	0	274	0	-27	-186
Fortynine Palms	57	26	0	240	0	-111	-46
Eastern	43	-15	0	103	0	-28	-47
Mesquite Lake	387	-128	0	69	145	49	-4
Total	**548**	**-117**	**0**	**685**	**145**	**-117**	**-283**

D.4.3 Scenario 2 – 2035 Water Demand with Management Strategy

Scenario 2 uses the same linear growth rate in groundwater pumping that was used in Scenario 2. The only difference between Scenarios 2 and 3 is that Scenario 2 assumes that all of the increased pumping over time occurs in the Mesquite Lake Subbasin. Pumping in WTP-1 was held uniform over the simulation duration at its 2010 rate (about 940 afy). A single new well was added at the start of the simulation to provide all of the increased demand. When the pumping rate for this new well surpassed 450 afy (simulation year 9), another new well was added and the increased demand was divided evenly between the two wells. The same approach was used to add a third well in simulation year 17 and a fourth in simulation year 25.

Table D-3 summarizes the relative change in the hydrologic budget relative to the Baseline Scenario. Although storage continues to decline over time, it does so at a lower rate than Scenario 1. This is because the Indian Cove, Fortynine Palms and Eastern Subbasins show a slight increase in storage over the period. The increased pumping in the Mesquite Lake Subbasin does not all come out of storage. Instead, a portion is from capturing of groundwater that would have ultimately discharged at Mesquite Lake. The wells capture water upgradient of the lake so as not to involve the migration of saline water from the area of the playa. Rather, it reduces the hydraulic gradient towards the lake resulting in lower discharge at the lake. As with Scenario 1, the groundwater inflow and outflows balance reflects changes in flow between the subbasins across the Oasis Fault.

TABLE D-3
HYDROLOGIC BUDGET SUMMARY

	Groundwater Inflow (AFY)			Groundwater Outflow (AFY)			
Subbasin	**Septic Return Flow**	**GW Inflow**	**Natural Recharge)**	**Wells)**	**Natural Discharge**	**GW Outflow**	**Change in Storage**
Indian Cove	60	-1	0	0	0	-2	61
Fortynine Palms	57	-5	0	0	0	38	14
Eastern	43	19	0	0	0	18	44
Mesquite Lake	387	39	0	685	-82	-3	-174
Total	**548**	**51**	**0**	**685**	**-82**	**51**	**-55**

D.4.4 Scenario 3 – 2035 Water Demand Without Septic Return Flow

Scenario 3 uses the same pumping assumptions as Scenario 2, but septic return flow is eliminated immediately and totally at the beginning of the simulation. This represents the assumption that the septic systems present in the basin are converted to sewerage. This scenario was run to illustrate that simply removing the septic tanks and not considering the impact of the return flow may have consequences on groundwater levels in the basin. The result is that there is a substantial decrease in groundwater storage that would result in large decreases in groundwater levels. In several areas, groundwater levels drop so that the model makes the area inactive which had some impact on the scenario. This could be addressed by applying more sophisticated modeling techniques, but for this application, the primary objective of the scenario was to evaluate the impact of removing return flows on the basin, and the result is that those changes would be significant. This result is also based on the assumption that 80 percent of the overall water demand makes it back to groundwater. Further investigations are proposed in the GPP that would look to obtain site specific data on the percent of return flows that do make it to groundwater.

TABLE D-4
HYDROLOGIC BUDGET SUMMARY

Subbasin	Groundwater Inflow (AFY) Septic Return Flow	GW Inflow	Natural Recharge)	Groundwater Outflow (AFY) Wells)	Natural Discharge	GW Outflow	Change in Storage
Indian Cove	-193	4	0	0	0	14	-203
Fortynine Palms	-204	38	0	0	0	-68	-99
Eastern	-201	-32	0	0	0	-17	-216
Mesquite Lake	-1,294	-59	0	685	-773	21	-1,286
Total	**-1,892**	**-50**	**0**	**685**	**-773**	**-50**	**-1,804**

Kennedy/Jenks Consultants

Enduring relationships

Trusted expertise

Promises delivered