Palen Solar Project
Water Supply Assessment

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1. Introduction

The objective of this report is to provide a Water Supply Assessment (WSA) pursuant to the requirements of California Senate Bill (SB) 610/221, for the Palen Solar Project. This project was previously proposed as a solar trough project, the Palen Solar Power Project, and later as a solar power tower project, the Palen Solar Electric Generating System.

SB 610, passed in 2002, amended the California Water Code to require detailed analysis of water supply availability for certain types of development projects, and to improve the link between information on water supply availability and certain land use decisions made by cities and counties. SB 610 requires detailed information regarding water availability to be provided to the city and county decision-makers prior to approval of specified large development projects. This information is to 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 companion measure to SB 610, SB 221, applies to residential subdivisions, and does not apply to the Palen Solar Project. Both measures recognize local control and decision making regarding the availability of water for projects and the approval of projects.

2. Project Location and Description

The Palen Solar Project would be located entirely on lands administered by the U.S. Department of the Interior, Bureau of Land Management (BLM), located in Riverside County, California approximately 10 miles east of the unincorporated community of Desert Center and north of Interstate 10. The project is within the jurisdiction of the BLM Palm Springs South Coast Field Office, and is within the Riverside East Solar Energy Zone (Riverside East SEZ) of BLM's Western Solar Plan. The project location is shown in Figure 1, Chuckwalla Valley Regional Groundwater Basins. All figures are included at the end of the document.

The Palen Solar Project would use a single-axis tracking system and may use various PV technologies, including, but not limited to Crystalline Silicon panels or Copper Indium Gallium Selenide panels. The output of the facility is proposed to be 500 MW (AC) and would produce approximately 1,598,683 MWh a year of renewable energy. Construction is scheduled to commence fall 2017, with completion 30 months later. The project would cover an area of 4,200 acres, and include the following components:

- a single solar field with two smaller adjacent solar fields for a total of 3 solar fields;
- two-hundred (200) power blocks of electrical generating capacity of 2.50 MW each for a combined capacity of 500 MW;
- one project electrical switchyard;
- common facilities area that would include an administrative and maintenance building;
- up to 10 groundwater wells;
- one temporary construction laydown area;
- a roadway system consisting of internal and perimeter roadways;

- a main access road from the I-10/Corn Springs Road interchange;
- a single circuit 230 kV generation tie-line electric transmission line extending from the project electricity switchyard to the Red Bluff Substation; and
- a redundant telecommunications cable installed beneath the roadway along the gen-tie route.

In order to estimate water usage for the Palen Solar Project, the project developer reviewed estimates for water usage provided by EPC Contractors on similar projects and publicly available information of actual water usage on a nearby project of similar size and technology. The summarized data from this review supported the estimated water usage for the Palen Solar Project. Total water use for the project's construction is estimated at 1,242 to 1,750 acre-feet, equating to 497 to 700 acre-feet per year (afy) during the anticipated 30-month construction period. Operational water use is estimated at 15 to 41 afy for panel washing and general maintenance activities. The applicant initially assumed water supply would be one of two planned scenarios:

> **Water Supply Scenario 1:** Over a 30-month period, up to 80% (560 afy) of construction water would be purchased from two wells operated by the Riverside County Service Area (CSA) 51 in Lake Tamarisk, at Desert Center, approximately 10 miles west of the project site. The water would be transported from Lake Tamarisk to the project site by truck. The remaining 20% or more of construction water would come from 2 onsite wells on the Palen Solar Project property. All operational water would be produced from the same on-site wells.
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> **Water Supply Scenario 2:** All construction and operational water would be supplied from up to 10 onsite wells. Water trucks would transport water from the onsite wells utilizing the internal roads within the project boundary.

Both scenarios would obtain water from the same source: the Chuckwalla Valley Groundwater Basin (CVGB), described in Section 4. This analysis therefore treats each scenario the same in terms of water balance for the CVGB. However, Water Supply Scenario 1 requires additional analysis as to the capacity of CSA 51 to serve project demands.

CSA 51 has two groundwater wells that pump at rates of 1,100 gallons per minute (gpm) and 1,200-1,500 gpm, respectively, with water stored temporarily in Lake Tamarisk. Both wells typically operate on a 10-hour workday, five days a week. The lower volume well can pump 660,000 gallons in a typical workday, and the higher volume well can pump 720,000-900,000 gallons in a typical workday, for a combined maximum of 1,560,000 gallons per working day.

In 2015, CSA 51 withdrew a total of 786 acre-feet to meet community needs, and sold no water outside the community. Based on the 10-hour workday and 5-day workweek described above, community demands in 2015 therefore required the two wells to pump a combined 985,000 gallons per day. Based on communications with CSA 51, community demands during the Palen 30-month construction period are anticipated to be roughly the same as they were in 2015. CSA 51 will not be selling to any other water users outside the community during this period.

Under Water Supply Scenario 1, the maximum possible project demand from CSA 51 is 80% of 700 afy, or 560 afy, during the 30-month construction period. Based on the 10-hour workday, 5-day workweek described above, the project could therefore demand up to 702,000 gallons per day from CSA 51 during that time. The sum of the estimated community demand and the maximum possible project demand is 1,687,000 gallons per day, which exceeds the two wells' daily combined maximum pumping capacity by about 127,000 gallons per day. Therefore, CSA 51 may not be able to supply the project's demands under Water Supply Scenario 1 without either compromising existing supply obligations to the community or extending the workday or workweek.

Based on these assumptions, pumping 1,687,000 gallons per day may exceed CSA pumping limitations and could result in a localized drawdown. However, CSA 51 has communicated that it has never had a problem continuing to pump despite some drawdown, even when pumping large volumes. Surrounding landowners recall that localized drawdown effects have always been minimal and have rebounded within a few months. Therefore, it is assumed that the impact of drawdown on CSA 51's capacity to supply the Palen Solar Project would be negligible.

Considering the above analysis of CSA 51's capacity to supply the project under the 80% scenario, the applicant intends to decrease its proposed purchase of CSA 51 water. Under **Revised Water Supply Scenario 1**, the applicant would purchase up to 30% of construction water from CSA 51, and obtain the remaining 70% or more from up to 7 onsite wells. At a maximum construction water use of 700 afy, 30% is 210 afy, which is approximately 263,000 gallons per day based on a 5-day workweek. The sum of estimated community demand and this revised maximum project demand is 1,248,000 gallons per day, which is under the minimum and maximum combined well output by approximately 132,000 and 312,000 gallons per day, respectively. CSA 51 therefore has capacity to serve project needs under this 30% scenario. Pumping 1,248,000 gallons per day over a 30-month period, based on the assumptions articulated above, would not compromise existing water users. Accordingly, the CSA 51 wells should be able to continue pumping at this rate throughout the construction period. Based on historical information provided by CSA, any local drawdown resulting from the temporary increase in pumping is expected to rebound after construction is complete.

Neither the Revised Water Supply Scenario 1 nor Water Supply Scenario 2 would require the construction of new or expanded water supply infrastructure aside from well improvements and distribution infrastructure that may need to be constructed as part of the project and within the project boundary by the project proponent. Revised Water Supply Scenario 1, which would rely in part on an existing water supplier, CSA 51, would require no new CSA 51 infrastructure. Water trucks serving the project during construction would be filled from existing infrastructure owned and operated by CSA 51.

3. SB 610 Overview and Applicability

SB 610 requires that a project be supported by a WSA if the project is subject to the California Environmental Quality Act, and would demand an amount of water equivalent to, or greater than, the amount of water required by a 500-dwelling unit project. According to SB 610 Guidelines, one dwelling unit typically consumes 0.3 to 0.5 afy, which would amount to 150 to 250 afy for 500 units. Projects must analyze whether the total projected water supplies determined to be available for the project during normal, single dry, and multiple dry water years during a 20-year projection, will meet the projected water demand associated with the proposed project, in addition to existing and planned future uses, including agricultural and manufacturing uses. Averaged over the 30-year project lifespan, the Palen Solar Project would use 84.6 acre feet per year.

Senate Bill 267 (SB 267), signed into law in 2011, amended California's Water Law to revise the definition of "project" specified in SB 610. Under SB 267, wind and photovoltaic projects which consume less than 75 afy of water are not considered to be a "project" under SB 610, in which case a WSA would not be required. The Project's average 30-year water use of 84.6 afy is above this threshold. It is therefore assumed that the Palen Solar Project is not exempted from SB 610 by SB 267.

4. Chuckwalla Valley Groundwater Basin

4.1 Basin Overview and Storage

All water for the Palen Solar Project will come from the CVGB. The CVGB covers an area of 940 square miles in eastern Riverside County, California. The basin underlies the Palen and Chuckwalla Valleys and is bounded by consolidated rocks of the Chuckwalla, Little Chuckwalla, and Mule Mountains on the south, of the Eagle Mountains on the west, and of the Mule and McCoy Mountains on the east. The Coxcomb, Granite, Palen, and Little Maria Mountains bound the valley on the north and extend ridges into the valley. There are no perennial streams in Chuckwalla Valley. Palen, Ford, and several smaller dry lakes are found in topographic low-points (CDWR, 2004). The surface watershed contributing to the area of the CVGB is 1,344 square miles (CEC, 2010), comprised of the Chuckwalla Valley (940 square miles) and the surrounding bedrock mountains (404 square miles).

Water-bearing units of the CVGB include Pliocene to Quaternary age continental deposits divided into Quaternary alluvium, the Pinto Formation, and the Bouse Formation. Figure 2a, Regional Geology, and Figure 2b, Regional Geology Legend, show the geology of the area. Bedrock is as deep as 5,000 feet below ground surface in the eastern portion of the CVGB (see Figure 3, Chuckwalla Valley Groundwater Basin Bedrock Topography). At the Palen Solar Project, wells extended to a depth of approximately 800 feet below the ground surface as shown in Figure 4, Chuckwalla Valley Groundwater Basin Cross Section A-A (See Figure 2a for the location of the cross section shown in Figure 4). The average specific yield of the upper 500 feet of unconsolidated sediments is estimated to be 10 percent (CDWR, 2004). Specific yield is a measure of the capacity of the aquifer to release water in terms of the volume of water per unit volume of aquifer that can be released by pumping. Total groundwater storage available to wells was originally estimated at 9,100,000 acre-feet (af), and more recently at 15,000,000 af (CDWR, 2004, CDWR, 1979). The estimate of 15,000,000 af was made by the CDWR based on multiplying specific yield times saturated thickness times basin size. Saturated thickness was obtained by subtracting the average depth to water from the average thickness of alluvial sediments, or 500 feet, whichever is smaller (CDWR, 1979). The 15,000,000 estimate, being the more recent, is used in this analysis.

The CVGB is located within the jurisdiction of the Colorado River Basin Regional Water Quality Control Board (RWQCB), and is subject to management direction of the Water Quality Control Plan (Basin Plan) for the Colorado River Basin (Region 7). The CVGB is bordered by the Orocopia Valley groundwater basin on the west, the Palo Verde Mesa Groundwater Basin on the east, the Cadiz Valley, Rice Valley and Ward Valley Groundwater Basins on the north, and the Pinto Valley Groundwater Basin on the northwest (Figure 1). The extent of hydrological connectivity between these basins and the CVGB is discussed in Sections 4.4 and 4.5 below.

Groundwater Management

The CVGB is an unadjudicated groundwater basin. Owners of property overlying the basin have the right to pump groundwater from the basin for reasonable and beneficial use, provided that the water rights were never severed or reserved. Groundwater production in the basin is not managed by an entity and no groundwater management plan has been submitted to the California Department of Water Resources (CDWR, 2016). There is no Urban Water Management Plan for the area, and there is no Integrated Regional Water Management Plan.

The Colorado River Water Use Plan by the Colorado River Board of California (CRBC, 2000), has studied a proposal for storing Colorado River water in the CVGB. According to the Colorado River Water Use Plan, the CVGB has the capacity to store up to 1.2 million acre feet of water in the northern portion of the valley. Stored water would be returned to the Colorado River Aqueduct. While the potential exists in this basin, further study would be necessary to determine the feasibility for developing a storage program. The effect that such a storage program would have on the project is discussed in section 5.3 below.

4.2 Climate

The climate in the area of the CVGB is arid with high summer temperatures and mild winter temperatures. At nearby Eagle Mountain, approximately 16 miles northwest of the Palen Solar Project, annual precipitation is 3.67 inches. Average annual precipitation in the project area, based on the gauging station at the nearby Blythe, California, airport, is 3.55 inches as reported by the Western Regional Climate Center (WRCC, 2016). Average summer maximum temperatures are above 100 degrees. Precipitation is seasonal. August is the wettest month due to summer thunderstorms. January is the second wettest month, due to winter rains. Snowfall is negligible (WRCC, 2016).

4.3 Groundwater Trends

Groundwater levels range from the ground surface to about 400 feet below ground surface (RWQCB, 2006). Groundwater contour data from 1979 shows that CVGB groundwater moves from the north and west toward the gap between the Mule and McCoy Mountains at the southeastern end of the valley. Groundwater levels were stable up to about 1963 (CDWR, 2004). The CDWR reported total groundwater extraction of 9,100 afy in 1966.

The direction of groundwater movement is not expected to have changed since 1979, but there have been changes in groundwater levels, especially localized around areas of significant extraction. For example, data from wells within the Desert Center area show a period of water level decline from the mid-1980s through the early 1990s during periods of expanded agricultural operations when combined pumping exceeded 20,000 afy, well above historic water usage for the western portion of the basin (AECOM 2011).

The National Park Service has noted that groundwater levels throughout the CVGB appear to have been trending downward for several decades (BLM, 2012). Most wells in the CVGB have not been used for monitoring data such as groundwater level trends since the 1980s; however, several wells have been used to collect groundwater data for the past 25 years, and these data show that groundwater level trends have been fairly stable in the eastern CVGB, and rising slowly back towards pre-agricultural pumping groundwater levels in the western CVGB, while dropping slowly but steadily only in the central CVGB. This is illustrated in Figure 5, Basin Wide Groundwater Hydrographs, which shows hydrographs for selected wells within the CVGB from 1958 to 2009.

Wells in the area of Desert Center (Wells 32M1 (548), 7P1 (598), 7M1 (604), and 12N1 (671)) generally show declines between about 1980 and the early 1990s, attributable to increased agricultural pumping. This pumping declined significantly after 1986, and local groundwater levels have recovered to approximately those of the early 1960s (AECOM, 2011). This is indicated in the recovery in the early 1990s for Wells 7P1 (598), 7M1 (604) and 12N1 (671) (Figure 5). The groundwater water level at and north of the area of the Palen Solar Project (see Wells 6C1 (500), 19Q1 (538) and 33N1 (592) in Figure 5) has been generally stable over the last 40 years with slight declines.

The well data is not continuous. For instance, the graph for Well 33N1 (592) (Figure 5) appears to show a slight but steady decline from about 1970 to 2009. However, there are no reference points between those dates, and it is possible that most or all of that decline occurred in response to the high agricultural extractions in the mid-1980s to the early 1990s. As the Desert Center wells show an upward trend after the agricultural extractions ended, it is possible that groundwater in the area of the Palen Solar Project will slowly recover.

Well 18H1 (493) in the eastern part of the basin shows a decrease in water level elevation between 1985 and 1990, likely due to increased water use at during the construction of the Chuckwalla Valley and Ironwood Prisons (CEC, 2010), while Well 14H1 (546), also in the eastern part of the basin, shows an increase in groundwater level between about 1985 and 2000.

It is noteworthy that most of the long-term monitoring wells in the CVGB are situated within agricultural or prison operations, complicating extrapolation of any local drawdowns shown in those data to the 940 square mile CVGB as a whole due to the site-specificity of those wells' cones of depression (a "cone of depression" refers to drawdown which occurs in a well when it is pumped, causing a conical-shaped gradient in the surrounding aquifer that results from water flowing from areas of high to low pressure; when two or more cones of depression intersect each other, the effect on drawdown (increasing depth to groundwater) is combined and water table levels drop substantially) (BLM 2012).

In general, the data show a relatively stable groundwater surface, interrupted locally in the past mainly by agricultural pumping. Local groundwater levels show evidence of rising after the agriculture-related drawdown of the 1980s ended, indicating that local extraction rates have not exceeded recharge. Since groundwater levels were reported as stable in 1963 (CDWR, 2004), an extraction rate of roughly 9,100 afy may be a sustainable safe yield.

The groundwater level trends derived from the available data show a general trend toward stability, but the analysis is inconclusive because the data are not complete, there are gaps in the record, and well locations do not cover the entire CVGB. The monitoring wells that show the most prominent historic declines are in agricultural or prison areas where a local drawdown would occur from intense use, but would not necessarily be representative of the CVGB as a whole. For instance, Wells 546 and 500, which are outside the main areas of extraction, show a steady or rising water surface.

4.4 Groundwater Recharge

Recharge to the CVGB occurs from subsurface inflow from other groundwater basins, infiltration of precipitation, irrigation return flow, and wastewater return. Leakage from the Colorado River Aqueduct has also been identified as a possible source of inflow.

Subsurface Inflow

Groundwater in the CVGB generally flows west to east. Subsurface inflow originates from the Pinto Valley and Orocopia Valley groundwater basins, which are west of the CVGB. Although the California Department of Water Resources has hypothesized that underflow from the Cadiz Valley Groundwater Basin may enter the CVGB (CDWR, 2004), Cadiz Valley, Rice Valley and Ward Valley Groundwater Basins are not considered to contribute to the CVGB (BLM, 2011).

The amount of inflow from the Pinto Valley and Orocopia Valley Groundwater Basins is uncertain, and there have been a wide range of estimates from different experts. The results of several studies on CVGB recharge from subsurface inflow are shown in Table 1.

Table 1. Subsurface Inflow Recharge Estimates for the Chuckwalla Valley Groundwater Basin

Study	Recharge from Inflow from the Pinto Valley and Orocopia Valley Groundwater Basins (acre-feet per year)
Genesis Solar Project EIS[1]	3,500
Eagle Mountain Draft EIR[1]	6,700
Palen Solar Power Project EIS[1]	3,500
Eagle Mountain Draft EIS[1]	6,575
National Park Service (NPS)[1]	953–1,906
Argonne National Laboratory[2]	1,595

1 - Source: BLM, 2012
2 - Source: Argonne, 2013

The California Energy Commission (CEC, 2015) reported an estimated inflow of 3,173 afy from the Pinto Valley Groundwater Basin, and 1,700 afy from the Orocopia Groundwater Basin. CEC also reported that recent studies by GeoPentech estimated the inflow from the Orocopia Groundwater Basin as low as several hundred afy. The CEC therefore used 3,500 afy as an estimate for the total inflow into the CVGB in analyzing the Palen Solar Power Project. The NPS estimate was based on groundwater modeling by the U.S. Geological Survey (USGS) on the Warren, Joshua Tree, and Copper Mountain groundwater basins. These basins are not adjacent to the CVGB, and the groundwater model used is subject to a high level of uncertainty due to simplified assumptions and model inputs. Nevertheless, the NPS estimate compares well to the estimate reported by Argonne. The Eagle Mountain estimates were based on a 1996 report on environmental impacts of the Eagle Mountain Landfill.

Overall, there is substantial uncertainty regarding inflow from the adjacent groundwater basins. For purposes of this analysis, the groundwater budget uses the 3,500 afy used in the Palen Solar Power Project EIS. This estimate has been used for several projects in the past, and it is more recent than the Eagle Mountain Estimate. Additionally, it is approximately in the middle of the range of estimates given in Table 1. The analysis herein also applies the NPS low estimate of 953 afy to provide a probable range for the groundwater budget given the uncertainties involved.

Recharge from Precipitation

Infiltration recharge to the CVGB by precipitation is difficult to assess due to lack of reliable data and the aridity of the area. There has been a wide range of estimates by experts in support of other projects or agencies. The CDWR has not published an estimate.

Generally, precipitation recharge has been estimated as a percentage of total precipitation. The CVGB receives annually about 258,000 afy total rain (CEC, 2015). Most analysts note that studies published by the BLM indicate that 7 to 8 percent of the precipitation that falls on the bedrock mountain fronts ends up as groundwater recharge (BLM, 2012), while a smaller percentage of the valley floor precipitation makes it to the groundwater. For the CVGB, 7 to 8 percent of the precipitation that falls on the mountain fronts would be equivalent to 3 percent of the total precipitation that falls on the total CVGB watershed (BLM, 2012). The CEC, using estimates of 3, 5 and 7% of total incident precipitation ending up as groundwater recharge, and overlaying isohyetal precipitation maps over the entire CVGB watershed to estimate precipitation distribution and bedrock characteristics by sector, estimated precipitation-related recharge to be 8,588, 14,313, and 20,038 afy, respectively, and recommended using 8,588 afy (about 3% of total precipitation) for the groundwater budget analysis (CEC, 2015). These results are supported by the findings of a study presented in a USGS report on groundwater recharge in the arid and semiarid southwestern United States (USGS 2007), which gave a range of approximately 3 to 7 percent of total precipitation for the Mojave Desert, depending on the amount of precipitation received. In the 2007 study by the USGS, the lower (3 percent) estimate represented years with below-average precipitation, with the higher (7 percent) estimate for above-average precipitation. The percentage changes with the amount of precipitation because most recharge occurs from runoff, and runoff is generally higher in years with greater precipitation.

The results of several studies on CVGB recharge from precipitation are shown in Table 2.

Table 2. Precipitation Recharge Estimates for the Chuckwalla Valley Groundwater Basin

Study	Recharge from Precipitation (acre-feet per year)
Genesis Solar Project EIS[1]	9,448
Eagle Mountain Draft EIR[1]	5,500
Palen Solar Project EIS[1]	8,588
Eagle Mountain Draft EIS[1]	6,125
National Park Service (NPS)[1]	2,060–6,125
Argonne National Laboratory[2]	3,200

1 - Source: BLM, 2012
2 - Source: Argonne, 2013

The NPS study in Table 2 was based on groundwater modeling by the U.S. Geological Survey (USGS) on the Warren, Joshua Tree, and Copper Mountain groundwater basins described above. These results are subject to a high level of uncertainty due to simplified assumptions and model inputs, and the fact that the modeled basins are not adjacent to the CVGB. The results of the study were extrapolated to the CVGB, which was not studied directly (BLM, 2012).

The Palen Solar Project and Genesis Solar Project estimates were based on a percentage of precipitation entering groundwater after a study of groundwater basins in nearby desert basins which estimated recharge rates from 3 to 5 percent of total precipitation (CEC, 2015). The Argonne estimate is based on a reported recharge rate for the adjacent Palo Verde Mesa Groundwater Basin extrapolated to the CVGB.

GEI consultants, in a study conducted in response to NPS comments on the Eagle Mountain Pumped Storage Project (FERC, 2012) used the Maxey-Eakin method of modeling natural groundwater recharge rates, and a Metropolitan Water District (MWD) Review panel method. The Maxey-Eakin method predicted total recharge values from 600 to 3,100 afy, while the MWD Review Panel method predicted recharge ranging from 7,600 to 17,700 afy. GEI concluded that the MWD Review Panel method was the more reliable for the reason that the Maxey-Eakin method has been found to underestimate recharge rates.

As noted in the Desert Harvest WSA (BLM, 2012), the NPS contends the annual streamflow recharge rates simulated by the USGS may be two to ten times greater than the actual streamflow, suggesting that the USGS recharge rates may be as low as one tenth those given in Table 2, or only 206 to 612 afy. These estimates would be closer to those estimated by the Maxey-Eakin method. Recharge rates that low would mean that only about one tenth of one percent of total precipitation goes to groundwater recharge, well below the 3 to 7 percent published by the USGS (2007).

In summary, there is high uncertainty regarding the amount of precipitation-related recharge to the CVGB, and substantial disagreements among experts, with estimates presented herein ranging from 2,060 afy to 9,448 afy, and possibly even lower, or higher. For purposes of this analysis, the groundwater budget uses 8,588 afy. This is equivalent to 3 percent of the total average precipitation of 258,000 af, and is supported by the USGS 2007 study for which 3 percent would represent the estimated recharge for a below-average precipitation year. The analysis also applies the NPS low estimate of 2,060 afy, representing about (0.7 percent of average annual precipitation) to provide a probable range for the groundwater budget given the uncertainties involved.

Irrigation Return Recharge

Irrigation water applied to crops within the CVGB has the potential to infiltrate to groundwater depending on the amount and method of irrigation, soils, crop type, and climate. The CEC estimated irrigation return recharge as 10% of total irrigation volume as determined by a 2010 study (WorleyParsons, 2009), and determined that 800 afy would reach the CVGB (CEC, 2010). This was based on a total irrigation volume of 7,700 afy (6,400 afy for agriculture, 215 afy for aquaculture pumping, and 1,090 afy for Tamarisk Lake).

Wastewater Return Flow

Wastewater return flow within the CVGB originates from the Chuckwalla State Prison, the Ironwood State Prison, and the Lake Tamarisk development near Desert Center (CEC, 2010, WorleyParsons, 2009). The prisons use an unlined pond to dispose of treated wastewater, and it is estimated that 795 afy infiltrates to the CVGB (WorleyParsons, 2009). Another 36 afy is estimated to originate from Lake Tamarisk, for a total of 831 afy (WorleyParsons, 2009).

Colorado River Aqueduct

Leakage from the Colorado River Aqueduct, which runs across the western edge of the CVGB, has not been documented, but was hypothesized by the Argonne National Laboratory in a 2013 study of the Riverside East Solar Energy Zone (Argonne, 2013). Argonne estimated a 2,000 afy contribution to the CVGB from the aqueduct based on measured leakage rates from the Central Arizona Project in Arizona. Since this recharge component is not well documented, and if it does occur the use of it would require entitlement, it is not used in this analysis.

4.5 Groundwater Demand/Outflow

Outflow from the CVGB occurs from subsurface outflow to the Palo Verde Mesa Groundwater Basin, groundwater extraction for agriculture and other uses, and evapotranspiration from Palen Dry Lake. Outflow also occurs, or will occur, from the Palen Solar Project and other existing and proposed projects that are addressed in Section 5 of this document.

Subsurface Outflow

Subsurface outflow from the CVGB is to the Palo Verde Mesa Groundwater Basin, and has been variously estimated as ranging from 400 afy to 1,162 afy (CEC, 2015). Argonne (Argonne, 2013), in their 2013 study of the basin, assumed zero subsurface outflow, with no justification given. Using gravity data, Wilson and Owens-Joyce (1994) found that the area through which discharge occurs is significantly more limited than previously thought due to the presence of a buried bedrock ridge, though the discharge pathway was not indicated to be completely closed. Since this discovery was made after the 1,162 afy estimate was made (which was in 1990), the lower estimate of 400 afy outflow was adopted for this study.

Groundwater Extraction

Current and historical groundwater extraction in the CVGB includes agricultural water use, pumping for Chuckwalla and Ironwood State Prisons, pumping for the Tamarisk Lake development and golf course, domestic pumping, and a minor amount of pumping by Southern California Gas Company (CEC, 2010). The California Department of Water Resources, using data from 2005 to 2010, estimated the total amount of pumping at 4,700 afy for the entire CVGB (CDWR, 2015). Argonne (Argonne, 2013), also using California Department of Water Resources data, estimated 5,100 afy. Other recent studies have given higher estimates. Specifically, the Palen Solar Power Project EIS and CEC staff assessment for the Palen Solar Power Project, both used 10,361 afy (BLM, 2011, CEC, 2015). AECOM, in a previous WSA for the Palen Solar Power Project (AECOM, 2010) estimated 5,745 to 7,415 afy, with no source given. For purposes of this analysis, the most-recent estimate of 10,361 afy is used as a reasonable upper estimate of total extraction, as was used by the BLM and CEC.

The Genesis Solar Electric Plant and the First Solar Desert Sunlight Solar Farm have been recently completed in the area, and these projects will use 218 afy groundwater for operations (218 afy for

Genesis[1], and 0.3 afy for First Solar, with the total rounded to 218). Total baseline groundwater extraction is therefore 10,579 afy for purposes of this study.

Evapotranspiration at Palen Dry Lake

USGS mapping of groundwater flow and mapping in the area did not identify Palen Dry Lake as an area where groundwater discharges at the ground surface (CEC, 2015). Nevertheless, groundwater elevation contour mapping suggests that groundwater may occur near the ground surface beneath approximately the northwestern 25% of Palen Dry Lake. Groundwater levels in this well were reported to be approximately 20 to 25 feet below the ground surface between 1932 and 1984. Given that the surface elevation at Palen Dry Lake two miles to the south is approximately 460 feet msl, or 40 feet lower, it is possible that groundwater levels are very close to the ground surface beneath the northern portion of the playa (CEC, 2010). Data summarized by the CEC (CEC, 2010) suggest it is possible that part of the northern portion of Palen Dry Lake is discharging groundwater by evaporation as a wet playa.

The presence of groundwater-dependent vegetation along the margins of Palen Dry Lake is another indicator that groundwater may be lost through evapotranspiration. There are mesquite tree groves along the margins of Palen Dry Lake, woodland habitat along dry desert washes, stands of jackass clover, and desert/alkali sink scrub habitats along the margins of the dry lake (BLM, 2011a). The mesquites can be phreatophytes with deep roots that tap into groundwater, but do not necessarily require groundwater to survive. A groundwater depth of 20 to 25 feet would be well within the reach of mesquite tap roots. The presence of this vegetation is an indicator, but not necessarily proof, that evapotranspiration is occurring.

Worley-Parsons visited the Palen Dry Lake in December of 2009 and found intermittent salt deposits at the northwestern portion of the dry lake. The salt deposits were concluded to have been formed from evaporation surface water rather than from groundwater. In additional studies of aerial photographs by Worley-Parsons, a 700-acre salt pan was indicated at the northwest portion of the dry lake. The salt pan could be evidence of evaporation of groundwater. Review of historical imagery found that the occurrence of the salt pan was episodic, and apparently correlated with precipitation events, which could also be responsible for the formations (CEC, 2015).

In December 2009, Worley-Parsons, using hand-augur borings, found free groundwater at a depth of 8 feet below the ground surface at the Palen Dry Lake. This suggests that groundwater could be close enough to rise through capillary action and be lost through evaporation (CEC, 2015).

Salt accumulation at Palen Dry Lake is likely the result of the dissolution and recrystallization of surface salt deposits in response to surface accumulation by rains, although intermittent accumulation from evaporation may occur seasonally. This, plus the proximity of groundwater to the surface in some areas, and the presence of possible phreatophytes, indicates that groundwater loss through evapotranspiration may occur at least episodically and seasonally.

The CEC (CEC, 2015) estimated groundwater discharge rates from the Palen Dry Lake using measured evaporation rates at Franklin Lake Playa in Death Valley, adjusted for differences in the

[1] The Genesis Solar Electric Plant originally proposed to use 1,644 afy groundwater for cooling; however, during the environmental analysis, the applicant revised the project to use dry cooling which required 218 afy. See Genesis Solar Energy Project Commission Decision (CEC-800-2010-011 CMF) pg. 5.

characteristics of the two dry lakes, as a reference. The result was 0.0583 feet of evapotranspiration per month, for three months of the year. Over the 2,000-acre area thought susceptible to groundwater evapotranspiration, this amounts to 350 afy (CEC, 2015).

The CEC estimate should be considered a rough approximation, as it was made based on a Death Valley dry lake with very different characteristics than the Palen Dry Lake. For instance (from CEC, 2015):

- Franklin Lake Playa is a terminal playa, which is the terminal discharge point of the local groundwater flow system; whereas, Palen Lake is a bypass playa, with most groundwater flowing laterally past the playa.
- Franklin Lake Playa includes extensive groundwater discharge features (e.g., saltpan, puffy ground and halophyte wetlands) that are generally less developed or lacking at Palen Lake, indicating less groundwater discharge would be expected at Palen Lake.
- Evapotranspiration rates at wet playas are temperature dependent, with maximum rates occurring during the summer months. Franklin Lake Playa occurs in Death Valley, where mean annual and summer high temperatures typically exceed those at Palen Lake.
- The available data suggest that groundwater discharge, if it is occurring at Palen Lake, is episodic or intermittent; whereas groundwater discharge at Franklin Lake Playa occurs throughout the year.

To compensate for these differences, the CEC used a groundwater discharge rate that was approximately half the Franklin Lake Playa rate. Additional analysis of the Palen Dry Lake would be needed to obtain a more-reliable estimate.

5. Groundwater Budget

The primary question to be answered in a WSA that is compliant with SB 610 requirements is:

> *Will the total projected water supply available during normal, single dry, and multiple dry water years during a 20-year projection meet the projected water demand of the proposed project, in addition to existing and planned future uses of the identified water supplies, including agricultural and manufacturing uses?*

In order to determine whether there are sufficient supplies to serve the project over the next twenty years, this section provides a baseline normal-year groundwater budget for the CVGB as a whole, based on the information provided in Section 4.5. This section also includes a normal-year groundwater budget assuming the Palen Solar Project is in place, and a normal-year groundwater budget assuming the Palen Solar Project and all known cumulative projects are in place. The same is repeated for single and multiple dry-year scenarios. The following is an explanation of water budget terms used in this document.

> A **Water Budget** is an identification, estimate, and comparison of the groundwater inputs and outputs that affect the overall trend of groundwater balance in the CVGB. Inputs such as recharge from precipitation, underflow from other groundwater basins, and other sources

are compared to outputs such as loss to other groundwater basins, extractions by humans, and evapotranspiration. Total inflow minus total outflow equals change in storage.

A **Safe Yield** is the amount of water that can be withdrawn from the groundwater basin for human use without depleting the groundwater resource. A safe yield occurs if the groundwater extractions, plus other natural outputs, do not exceed inputs. In this case, there would be no net depletion of the groundwater in storage. In this report, the safe yield is calculated for the basin as a whole.

An **Overdraft** occurs if extractions plus other outputs exceed total inputs, in which case there will be a net loss of groundwater storage over time. In this report, an overdraft, also referred to herein as a deficit, is estimated for the CVGB basin as a whole. Long-term overdraft conditions will result in a protracted diminishment of the groundwater resource that could have effects on the environment and the sustainability of the groundwater use.

The CVGB has a lack of long-term monitoring data for performing a detailed analysis. Wells have been in only a few areas of the basin, are not well documented, and the available data are incomplete and localized. It is known that extractions were 11 afy in 1952 (CDWR, 2004), rising to about 9,100 afy in 1966 (same source), and then peaking at around 20,000 afy for agriculture in the Desert Center area, as described above, resulting in local drawdowns that have since appeared to recover.

As a result of the scarcity of available data, there is substantial uncertainty regarding some of the primary inputs to a groundwater budget. Several studies in recent years for projects such as the Palen Solar Project have used the best available information do draw conclusions, summarized in Table 3. The conclusions herein are based on the same best available information and should be considered in the context of the overall uncertainty regarding the CVGB basin. Because of the uncertainties involved, the analysis uses two groundwater budgets. The first is a best estimate using data that has been widely reported and used in previous studies of this kind as described in Section 4. These adopted data are presented in Table 3. The second uses lower input estimates that have been made by U.S. Government agencies entrusted with management of natural resources in the area, also described in Section 4. Specifically, the second budget uses a recharge from precipitation estimate of 2,060 afy, and an underflow from Pinto Valley and Orocopia Valley Groundwater Basins of 953 afy as recommended by the NPS (BLM, 2012). All other inflow/outflow estimates are the same for both budgets. The two together provide insight into a range of potential outcomes related to groundwater use in the CVGB.

Table 3. CVGB Inflow/Outflow Summary

Inflow/Outflow Component	Range (afy)[1]	Adopted for this Study (afy)	Reason for Adoption/Source
Recharge from Precipitation	+206 to +20,038	+8,588	3 Percent of Total Precipitation USGS (2007), BLM, (2012)
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins	+953 to +6,575	+3,500	Used Previously for Palen and Genesis Projects
Irrigation Return Flow	+800	+800	WorleyParsons (2009)
Wastewater Return Flow	+831	+831	WorleyParsons (2009)

Table 3. CVGB Inflow/Outflow Summary

Inflow/Outflow Component	Range (afy)[1]	Adopted for this Study (afy)	Reason for Adoption/Source
Groundwater Extraction	–4,700 to –10,579	–10,579	Recent Estimate: -10,361 (CEC, 2015) + -218 (Genesis; WorleyParsons, 2009)
Underflow to Palo Verde Mesa Groundwater Basin	–400	–400	CEC (2015). Used lower estimate due to restricted discharge area (Wilson and Owens-Joyce, 1994)
Evapotranspiration at Palen Dry Lake	–350	–350	CEC (2015) estimate from Franklin Playa study.

1 – Inflow is depicted by a '+' sign; outflow is depicted by a '–' sign.
Source: See Section 4

5.1 Baseline Groundwater Budget

The baseline groundwater budget is the groundwater budget for the CVGB in the absence of the proposed project and all other known cumulative projects not already in place. For the purposes of this analysis, agricultural uses are considered as part of the baseline budget, as is the Prison Water Use, and the Genesis Solar Project. There are no manufacturing water uses in the area.

Normal (Average) Year

Table 4 provides a baseline normal groundwater budget for the CVGB based on the adopted information presented in Sections 4.4 and 4.5 and Table 3. This budget indicates a safe yield, which is the maximum quantity of water that can be continuously withdrawn from a groundwater basin without adverse effect. The baseline safe yield for the CVGB is estimated at 2,390 afy (total from Table 4), meaning the basin is currently close to capacity in terms of groundwater extraction. This budget would be for a normal (average) year, in terms of precipitation and water use.

Table 5 provides the same analysis using the lower NPS estimates of precipitation and underflow recharge described in Section 4. This baseline budget shows the CVGB to be in deficit, with a loss of approximately 6,685 afy in the groundwater resource, meaning groundwater levels would be expected to drop as the resource is depleted over the years.

Assuming a 2,390 afy average year surplus, the CVGB would have a surplus of approximately 71,700 af at the end of the 30-year period, meaning the groundwater basin would slowly recover from any deficits that may have been created by high agricultural pumping in the past. A 30-year period is used because that is the expected life of the project. With the NPS infiltration and underflow estimates (Table 5), at the end of the 30-year period the cumulative deficit would be 200,550 af. The basin would not recover losses during that period if the NPS estimates are correct. However, the amount of groundwater available in the CVGB is large, and this cumulative deficit after 30 years would amount to only about one percent of the total estimated storage.

Table 4. Estimated Baseline Groundwater Budget for the Chuckwalla Valley Groundwater Basin

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation[1]	8,588

Table 4. Estimated Baseline Groundwater Budget for the Chuckwalla Valley Groundwater Basin

Budget Components	Acre-Feet per Year
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins[2]	3,500
Irrigation Return Flow[3]	800
Wastewater Return Flow[4]	831
Total Inflow	13,719
Outflow	
Groundwater Extraction[5]	-10,579
Underflow to Palo Verde Mesa Groundwater Basin[6]	-400
Evapotranspiration at Palen Dry Lake[7]	-350
Total Outflow	-11,329
Budget Balance (Inflow – Outflow)	2,390 **(+ 0.02% of total storage)**

1 - BLM, 2012
2 - BLM, 2012
3 - CEC, 2015
4 - WorleyParsons, 2009
5 - Based on CEC, 2015 plus extractions of Genesis Solar Electric Plant (WorleyParsons, 2009)
6 - CEC, 2010
7 - CEC, 2010

Table 5. Estimated Baseline Groundwater Budget for the Chuckwalla Valley Groundwater Basin Using NPS Estimates of Precipitation and Subsurface Inflow.

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation[1]	2,060
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins[2]	953
Irrigation Return Flow[3]	800
Wastewater Return Flow[4]	831
Total Inflow	4,644
Outflow	
Groundwater Extraction[5]	–10,579
Underflow to Palo Verde Mesa Groundwater Basin[6]	–400
Evapotranspiration at Palen Dry Lake[7]	–350
Total Outflow	–11,329
Budget Balance (Inflow – Outflow)	–6,685 **(- 0.04% of total storage)**

1 - BLM, 2012
2 - BLM, 2012
3 - CEC, 2015
4 - WorleyParsons, 2009
5 - Based on CEC, 2015 plus extractions of Genesis Solar Electric Plant (WorleyParsons, 2009)
6 - CEC, 2010
7 - CEC, 2010

Dry Year

According to SB 610 guidelines, a dry year can be considered a year with a precipitation amount that is at 10 percent probability of occurrence, meaning 10 percent of the years would be drier. A critical dry year would be a year with 3 percent probability. The historic precipitation data at Blythe, California, approximately 35 miles east of the project and at a similar elevation with similar climate, was used as a reference. Historical precipitation data for Blythe, dating from 1893 to 2014, is available from the United States Historical Climatology Network (USHCN, 2016). The average of the annual precipitation from 1893 to 2014 at Blythe was 3.42 inches (Note that this is not the same as the WRCC (2016) estimate. However, this estimate is used only for calculating relative precipitation for dry years which is similar to the precipitation in the project area. The 10-percent probability dry year was estimated by ranking precipitation years from 1893 to 2014 from lowest to highest, and giving them ranking numbers 1 to 122 with the lowest precipitation year number 1 and the highest precipitation year number 122. Dividing the ranking number by the total (122) gives a relative probability of the precipitation in any given year being less than the corresponding precipitation for the ranking number. For instance, the precipitation for Year 2009 was 1.15 inches and ranked #13. Dividing 13 by 122 and converting to percent gives 10.7%. Consequently, 1.15 inches of rain, or about 34 percent of average annual precipitation at Blythe, was considered the 10 percent probability dry year. The critical dry year was estimated in the same way and found to be approximately 0.72 inches of precipitation, or 21 percent of average precipitation (reference precipitation year 2000, ranking #4 of 122 giving 3.3 percent relative probability).

This section provides a revised baseline groundwater budget based on dry year and critical dry year conditions. The following assumptions were used:

- Recharge from precipitation is the primary factor in determining the dry year groundwater budgets. Dry years are expected to produce less recharge from precipitation, due to the fact that less runoff would generally be expected to occur in dry years, resulting in less runoff leading to infiltration. This would depend, of course, on the pattern, intensity and distribution of precipitation in a dry year, which is difficult to predict for the future. There is some evidence (USGS, 2007) that lower precipitation years may in general give a lower percentage of precipitation ending up as recharge, but the evidence is apparently not consistent, and data presented by the USGS (USGS, 2007) provides no information below 3 percent, which is the percentage used as a basis for the infiltration rate used in this analysis. Therefore, for purposes of this analysis a simplifying assumption was made that the reduction in infiltration to groundwater is in direct proportion to the reduction in precipitation. A dry year recharge is therefore estimated as 8,588 afy multiplied by 0.34 (the ratio of dry year to average year precipitation). This calculation gives 2,920 afy precipitation recharge for a dry year, and 1,803 afy for a critical dry year.
- Underflow from the Pinto Valley and Orocopia Groundwater Basins is assumed to be unaffected. Some dry-year effect could occur, especially in the case of multiple dry years, but the timing of the effect would probably be delayed, and the magnitude of the effect much reduced due to the volume of existing groundwater already in these basins.

- Irrigation return flow is assumed to be unaffected. The area is naturally very arid, and it is assumed that natural precipitation, which in normal years is infrequent, is of minor or negligible consideration in the determination of the amount of irrigation water needed yearly.
- Wastewater return flow is assumed to be unaffected for similar reasons as for precipitation.
- Groundwater extraction is assumed to be unaffected by dry years for the same reasons the irrigation return flow and wastewater return flow were assumed to be unaffected.
- Underflow to Palo Verde Mesa Groundwater Basin was assumed to be unaffected for the same reasons the inflow from the Pinto Valley and Orocopia Groundwater Basins was assumed to be unaffected.
- Evapotranspiration at Palen Dry Lake was assumed to be unaffected for the reason that a single dry year, or critical dry year, would result in a reduction of a maximum of 6,782 acre feet of recharge. Given the size of the CVGB (940 square miles) a one-year reduction of this magnitude would only reduce the average groundwater level by about 0.14 inches. Evapotranspiration could be affected by a significant, long-term groundwater deficit, but for purposes of this analysis evapotranspiration was assumed to remain constant.

Tables 8 and 9 provide the assumed baseline groundwater budgets for a dry year and critical dry year. In both cases, a groundwater deficit is expected for the year, meaning groundwater withdrawals would exceed groundwater input. A dry year is expected to have a deficit of approximately 3,278 acre feet, increasing to 4,395 acre feet for a critical dry year.

Tables 8 and 9 provide the results of the same analysis using the NPS estimates of precipitation and underflow recharge. Each scenario, dry year and critical dry year, would have groundwater deficits, amounting to 8,045 afy and 8,312 afy, respectively.

Table 6. Estimated Dry Year Groundwater Budget for the Chuckwalla Valley Groundwater Basin

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation	2,920
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins	3,500
Irrigation Return Flow	800
Wastewater Return Flow	831
Total Inflow	8,051
Outflow	
Groundwater Extraction	–10,579
Underflow to Palo Verde Mesa Groundwater Basin	–400
Evapotranspiration at Palen Dry Lake	–350
Total Outflow	–11,329
Budget Balance (Inflow – Outflow)	–3,278 **(- 0.02% of total storage)**

Table 7. Estimated Critical Dry Year Groundwater Budget for the Chuckwalla Valley Groundwater Basin

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation	1,803
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins	3,500
Irrigation Return Flow	800
Wastewater Return Flow	831
Total Inflow	6,934
Outflow	
Groundwater Extraction	–10,579
Underflow to Palo Verde Mesa Groundwater Basin	–400
Evapotranspiration at Palen Dry Lake	–350
Total Outflow	–11,329
Budget Balance (Inflow – Outflow)	–4,395 **(-0.02% of total storage)**

Table 8. Estimated Dry Year Groundwater Budget for the Chuckwalla Valley Groundwater Basin Using NPS Estimates of Precipitation and Subsurface Inflow

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation	700
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins	953
Irrigation Return Flow	800
Wastewater Return Flow	831
Total Inflow	3,284
Outflow	
Groundwater Extraction	–10,579
Underflow to Palo Verde Mesa Groundwater Basin	–400
Evapotranspiration at Palen Dry Lake	–350
Total Outflow	–11,329
Budget Balance (Inflow – Outflow)	–8,045 **(–0.05% of total storage)**

Table 9. Estimated Critical Dry Year Groundwater Budget for the Chuckwalla Valley Groundwater Basin Using NPS Estimates of Precipitation and Subsurface Inflow

Budget Components	Acre-Feet per Year
Inflow	
Recharge from Precipitation	433
Underflow from Pinto Valley and Orocopia Valley Groundwater Basins	953
Irrigation Return Flow	800
Wastewater Return Flow	831
Total Inflow	3,017
Outflow	
Groundwater Extraction	–10,579
Underflow to Palo Verde Mesa Groundwater Basin	–400

Table 9. Estimated Critical Dry Year Groundwater Budget for the Chuckwalla Valley Groundwater Basin Using NPS Estimates of Precipitation and Subsurface Inflow

Budget Components	Acre-Feet per Year
Evapotranspiration at Palen Dry Lake	–350
Total Outflow	–11,329
Budget Balance (Inflow – Outflow)	–8,312 **(–0.06% of total storage)**

Multiple Dry Years

The Blythe precipitation data shows that in the 122 years of record from 1893 to 2014, the longest consecutive series of dry (10 percent) years on record is two. There are no consecutive critical dry years on record. A two-year string of dry years would result in a baseline groundwater deficit of twice the amount given in Table 6, or 6,556 acre feet. A three-year string of dry years would result in a baseline groundwater deficit of 9,834 acre feet (0.07% of total storage). The longest consecutive series of years with below average precipitation on record at Blythe was 12 years, from 1893 to 1904. This period was considered to be representative of a series of multiple dry years for the purposes of this analysis.

Table 10 presents the results of an estimated 12-year groundwater budget assuming a repeat of the 1893-1904 drought at Blythe, assuming without-project conditions. The results show that at the end of the 12-year period, the cumulative groundwater deficit would be approximately 31,612 acre feet (0.2% of total storage). Table 11 shows the same analysis using NPS estimates of precipitation and subsurface recharge. In that scenario, at the end of the 12-year period the cumulative groundwater deficit would be more than 94,682 acre feet (0.6% of total storage).

Table 10. Baseline Multiple Dry Year Groundwater Budget in Acre Feet Using Adopted Estimates of Precipitation and Subsurface Inflow.

Year	1	2	3	4	5	6
Dry Year Reference Year	1893	1894	1895	1896	1897	1898
Precipitation, in Inches	1.75	2.16	1.84	1.29	2.84	1.30
Precipitation as Percentage of Average	51%	63%	54%	38%	83%	38%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588
Dry Year Adjusted Recharge from Precipitation	4,394	5,424	4,620	3,239	7,132	3,264
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	9,525	10,555	9,751	8,370	12,263	8,395
Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–1,804	–774	–1,578	–2,959	934	–2,934
Cumulative Budget Balance (Inflow - Outflow)	–1,804	–2,578	–4,155	–7,114	–6,180	–9,114
Year	**7**	**8**	**9**	**10**	**11**	**12**
Dry Year Reference Year	1899	1900	1901	1902	1903	1904
Precipitation, in Inches	0.75	0.56	1.21	1.12	0.88	1.33
Precipitation as Percentage of Average	22%	16%	35%	33%	26%	39%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588

Table 10. Baseline Multiple Dry Year Groundwater Budget in Acre Feet Using Adopted Estimates of Precipitation and Subsurface Inflow.

Dry Year Adjusted Recharge from Precipitation	1,883	1,406	3,038	2,812	2,210	3,340
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	7,014	6,537	8,169	7,943	7,341	8,471
Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–4,315	–4,792	–3,160	–3,386	–3,988	–2,858
Cumulative Budget Balance (Inflow - Outflow)	–13,428	–18,220	–21,380	–24,765	–28,754	–31,612

Table 11. Baseline Multiple Dry Year Groundwater Budget in Acre Feet Using NPS Estimates of Precipitation and Subsurface Inflow.

Year	1	2	3	4	5	6
Dry Year Reference Year	1893	1894	1895	1896	1897	1898
Precipitation, in Inches	1.75	2.16	1.84	1.29	2.84	1.30
Precipitation as Percentage of Average	51%	63%	54%	38%	83%	38%
Normal Recharge from Precipitation	2,060	2,060	2,060	2,060	2,060	2,060
Dry Year Adjusted Recharge from Precipitation	1,054	1,301	1,108	777	1,711	783
Other Groundwater Recharge (All Sources)	2,584	2,584	2,584	2,584	2,584	2,584
Total Groundwater Recharge	3,638	3,885	3,692	3,361	4,295	3,367
Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–7,691	–7,444	–7,637	–7,968	–7,034	–7,962
Cumulative Budget Balance (Inflow - Outflow)	–7,691	–15,135	–22,772	–30,740	–37,774	–45,736
Year	**7**	**8**	**9**	**10**	**11**	**12**
Dry Year Reference Year	1899	1900	1901	1902	1903	1904
Precipitation, in Inches	0.75	0.56	1.21	1.12	0.88	1.33
Precipitation as Percentage of Average	22%	16%	35%	33%	26%	39%
Normal Recharge from Precipitation	2,060	2,060	2,060	2,060	2,060	2,060
Dry Year Adjusted Recharge from Precipitation	452	337	729	675	530	801
Other Groundwater Recharge (All Sources)	2,584	2,584	2,584	2,584	2,584	2,584
Total Groundwater Recharge	3,036	2,921	3,313	3,259	3,114	3,385
Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–8,293	–8,408	–8,016	–8,070	–8,215	–7,944
Cumulative Budget Balance (Inflow - Outflow)	–54,029	–62,437	–70,453	–78,523	–86,738	–94,682

5.2 Groundwater Budget with Palen Solar and Cumulative Projects

Normal (Average) Year

Regardless of the water supply scenario as described in Section 2, all water for the project would be derived from the CVGB. Total water use by the Palen Solar Project will be up to 700 afy for the first 30 months of construction, and up to 41 afy for all subsequent years of operation. Based on the budget balance given in Table 4, the CVGB overall would have capacity to provide sufficient water for a 30-year period under average-year conditions, within the estimated annual recharge surplus, without inducing a groundwater deficit. Table 12 provides a summary of the projected groundwater budget with the project in place. For average precipitation years, the Palen Solar Project alone would use less water in 30 years than the total average year surplus for the CVGB, resulting in no loss of groundwater storage over the same time period. The CVGB would have 68,823 af more groundwater at the end of the 30-year period than at the beginning. This is compared to the baseline 30-year surplus of 71,700 af. The Palen Solar Project would reduce this without-project surplus by about 4 percent. By contrast, using the NPS recharge rates for precipitation and underflow, the with-project deficit at the end of 30 years would be 203,428 af (Table 13). This is compared to the baseline 30-year deficit of 200,550 af. The Palen Solar Project would contribute about one percent to this cumulative deficit.

Table 12. CVGB Groundwater 30-Year Budget in Acre Feet for Average Precipitation Year with Palen Solar Project in Place Using Adopted Estimates of Precipitation and Subsurface Inflow.

Year	1	2	3	4	5	6	7	8	9	10
Palen Solar Project (afy)	700	700	371	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	700	1,400	1,771	1,812	1,853	1,894	1,935	1,976	2,017	2,058
CVGB Baseline Average Year Surplus (afy)	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus Palen Solar Project (afy)	1,690	1,690	2,020	2,349	2,349	2,349	2,349	2,349	2,349	2,349
Cumulative CVGB Surplus (af)	1,690	3,380	5,400	7,749	10,098	12,447	14,796	17,145	19,494	21,843
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Palen Solar Project (afy)	41	41	41	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	2,099	2,140	2,181	2,222	2,263	2,304	2,345	2,386	2,427	2,468
CVGB Baseline Average Year Surplus (afy)	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus Palen Solar Project (afy)	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349
Cumulative CVGB Surplus (af)	24,192	26,541	28,890	31,239	33,588	35,937	38,286	40,635	42,984	45,333
Year	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Palen Solar Project (afy)	41	41	41	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	2,509	2,550	2,591	2,632	2,673	2,714	2,755	2,796	2,837	2,878
CVGB Baseline Average Year Surplus (afy)	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus Palen Solar Project (afy)	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349	2,349
Cumulative CVGB Surplus (af)	47,682	50,031	52,380	54,729	57,078	59,427	61,776	64,125	66,474	68,823

Table 13. CVGB Groundwater 30-Year Budget for Average Precipitation Year with Palen Solar Project in Place Using NPS Infiltration and Underflow Recharge Estimates

Year	1	2	3	4	5	6	7	8	9	10
Palen Solar Project (afy)	700	700	371	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	700	1,400	1,771	1,812	1,853	1,894	1,935	1,976	2,017	2,058
CVGB Baseline Average Year Deficit (afy)	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Surplus Minus Palen Solar Project (afy)	–7,385	–7,385	–7,056	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726
Cumulative CVGB Surplus (af)	–7,385	–14,770	–21,826	–28,552	–35,278	–42,004	–48,730	–55,456	–62,182	–68,908
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Palen Solar Project (afy)	41	41	41	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	2,099	2,140	2,181	2,222	2,263	2,304	2,345	2,386	2,427	2,468
CVGB Baseline Average Year Surplus (afy)	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Surplus Minus Palen Solar Project (afy)	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726
Cumulative CVGB Surplus (af)	–75,634	–82,360	–89,086	–95,812	–102,538	–109,264	–115,990	–122,716	–129,442	–136,168
Year	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Palen Solar Project (afy)	41	41	41	41	41	41	41	41	41	41
Total Cumulative Use by Palen Solar Project (afy)	2,509	2,550	2,591	2,632	2,673	2,714	2,755	2,796	2,837	2,878
CVGB Baseline Average Year Surplus (afy)	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Surplus Minus Palen Solar Project (afy)	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726	–6,726
Cumulative CVGB Surplus (af)	–142,894	–149,620	–156,346	–163,072	–169,798	–176,524	–183,250	–189,976	–196,702	–203,428

For a single dry year and single critical dry year with the Palen Solar Project in place, the worst-case scenario is for one of those years, dry or critical dry, to occur during the first year of construction. During the first year of construction the CVGB annual groundwater deficit if a dry year or critical dry year occurs would be 3,978 and 5,095 af, respectively. By comparison to Tables 6 and 7, the Palen Solar Project would increase the dry year deficit by 16 to 21 percent if a dry year or critical dry year occurs during the first year of construction. Assuming normal precipitation returns, this deficit would be completely recovered in the fourth year under both (dry or critical dry) scenarios. Using this same assumption for the rest of the 30-year lifespan, the cumulative groundwater surplus would be 66,032 af without the project and 62,454 af (5% reduction of surplus) if a dry year occurs during the first year of construction of the project. If a critical dry year occurs during the first year of the project the end-of-30-year without-project surplus would be 62,454 af and 61,338 af with-project (2% reduction of surplus).

Using NPS precipitation data, the single-year deficits depicted in Tables 8 and 9 are 8,053 afy for dry and 8,312 afy for critical dry years without the project. These deficits would increase to 8,753 and 9,012 afy for dry and critical dry years during the first year of construction (8% and 9% deficit increases, respectively), resulting in an increase of the overall single-year deficit from 0.05% of the total CVGB to 0.06%. Assuming normal precipitation returns after the dry year, this deficit would not be recovered during the project lifespan, with or without the project. Using the assumption of a single dry year at the beginning of the 30-year lifespan and normal precipitation afterward, the cumulative groundwater deficit would be 201,918 without the project and 204,796 af if a dry year occurs during the first year of construction (a 1.43% deficit increase) with the Palen Solar Project in place. This would result in an increase of the overall deficit from 1.35% of the total CVGB to 1.37%. The deficit would be 202,177 af in a critical dry year occurring in the first year of the 30-year period without the project and 205,055 af if a critical dry year occurs during the first year of construction (a 1.42% deficit increase). This would result in an increase of the overall deficit from 1.35% of the total CVGB to 1.37%. This is compared to a 200,550 af deficit after the same period assuming normal precipitation every year without the Palen Solar project, and an 203,428 afy deficit with the project (a 1.43% deficit increase). This would result in an increase in the overall deficit from 1.34% of the total CVGB to 1.36%.

Cumulative projects that are projected or already constructed are listed in Table 14, with their projected water use. Water used for agriculture is not anticipated to increase so was not included in the cumulative projects. Peak agriculture in the Desert Center region occurred in 1994 with an estimated 6,100 acres under cultivation. Since then, agriculture has continued to decline with an estimated 2,100 acres under cultivation in 2016.

Table 14. Cumulative Projects – Water Use Summary

Project Name	Construction Start (year)	Construction Duration (years)	Annual Construction Water Use (afy)	Annual Operational Water Use (afy)
Palen Solar Project	2018[1]	2.5	700	41
First Solar Desert Sunlight Solar Farm	Completed	2.2	600–650	0.3
Red Bluff Substation	Completed	2.2	150	0
Gen-tie line	Completed	1	6.25	0
Devers-Palo Verde 2 Transmission Line Project	Completed	3	4	0
Colorado River Substation Expansion	Completed	2	66–215	0
Blythe Energy Project Transmission Line	Completed	2	4	0
Desert Southwest Transmission Line	2018[1]	2	0.6	0
Eagle Crest Pumped Storage Project	2019[2]	4	4,456[4]	2,050[4]
Genesis Solar Energy Project	Completed	3	616–1,368	218[5]
Blythe Energy Transmission Line	Completed	-	2	0
Desert SW Transmission	2018[1]	-	0.3	0
Desert Harvest Solar PV Project	2017[3]	2	400-500	26-39
DC 50 Solar Project (450 acres) (50 MW)[6]	2019[9]	1	100	2.5
SunEdison Origination3, LLC (1,800 acres) (250 MW – calculated)[6]	2019[9]	2	275[7]	12.5
First Solar Development, LLC (3,500 acres) (500 MW – calculated)[6]	2019[9]	2.5	440[8]	25

Table 14. Cumulative Projects – Water Use Summary

Project Name	Construction Start (year)	Construction Duration (years)	Annual Construction Water Use (afy)	Annual Operational Water Use (afy)
SunPower Project (2,000 acres) (up to 400 MW ac)[6]	2019[9]	2 (between 2019 and 2021)	440	20

1 - Actual projected start November 2017. January 1, 2018 is used for this analysis.
2 - CEC, 2015
3 - EA, 2016
4 - BLM Estimate (FERC, 2014). Of this amount, 600 cfs is expected to seep back into the groundwater (ECEC, 2008), then pumped back out and reused..
5 - BLIM (2010). Genesis is a completed project. - This amount is included in the baseline analysis.
6 - The information provided to the BLM does not include the level of detail required for these four projects. Where necessary, MW have been calculated for the projects using the DRECP assumption of 7 acres per megawatt. Additionally, assumptions were made regarding water use for construction and operations, as well as the construction duration. The water use assumptions were taken from Sandia (2013). For California, this report calculated 2.2 acre-feet per megawatt for construction and 0.05 acre-feet per megawatt per year for operations.
7 - Using the assumptions stated above, a 250 MW project would require an estimated 550 af total for construction, assuming a 2-year construction timeframe, this would require 275 afy.
8 - Using the assumptions stated above, a 500 MW project would require an estimated 1,000 af total for construction. Assuming a 2.5-year construction timeframe, this would require 440 afy.
9 - The project has not provided a construction start date and 2019 is a conservative assumption of when this could occur as it provides time for the NEPA review but conservatively assumes some construction overlap with the Palen Solar Project.

Table 14 shows that the Eagle Crest Pumped Storage Project would use about 15 times more operational groundwater than all other future projects combined. The Palen Solar Project contributes about two percent of the total operational extractions, long-term. At the time of this report, the Eagle Crest Pumped Storage Project has not been approved. It is still under consideration, and was therefore included in the analysis below.

Table 15 provides a 30-year groundwater budget projection for average years with Palen Solar Project and all cumulative projects in place. Only those cumulative projects that would have an effect on groundwater during the assumed 2018 to 2046 period of analysis are included. Assuming an average precipitation year, there would be an initial groundwater overdraft of up to 11,106 af in the year 2022. The groundwater basin would then begin to recover. By the end of the 30-year period, the cumulative groundwater deficit would be approximately 6,114 acre feet, approximately 0.04% of total storage. Without the Palen Solar project, and all other cumulative projects in place, there would be a deficit of 3,236 acre feet at the end of the 30-year period. Without the Eagle Crest project, but assuming the Palen Solar project and all other cumulative projects are in place, the CVGB would have a growing surplus of groundwater for all 30 analysis years.

Table 16 represents the same analysis using NPS infiltration and underflow estimates, and shows a total cumulative deficit of about 278,364 af (2% of total storage), of which the Palen Solar project would contribute about 1 percent, or 2,878 af. Using these inflow estimates, the CVGB would not recover the overdraft within 30-years period, with or without the project.

Table 15. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using Adopted Precipitation and Underflow Recharge Estimates

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Palen Solar Project	700	700	371	41	41	41	41	41	41	41
First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 15. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using Adopted Precipitation and Underflow Recharge Estimates

Desert Southwest Transmission Line	0.6	0.6	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	0	4,456	4,456	4,456	4,456	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	500	39	39	39	39	39	39	39	39	39
DC 50 Solar Project	0	100	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3	0	275	275	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development	0	440	440	233	25	25	25	25	25	25
SunPower Project	0	440	440	20	20	20	20	20	20	20
Total Used	1,201	6,451	6,024	4,784	4,596	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Surplus	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus Total Use	1,189	–4,061	–3,634	–2,394	–2,206	200	200	200	200	200
Cumulative CVGB Surplus/Deficit	1,189	–2,872	–6,506	–8,900	–11,106	–10,907	–10,707	–10,507	–10,307	–10,108
Year	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Palen Solar Project	41	41	41	41	41	41	41	41	41	41
First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Desert Southwest Transmission Line	0	0	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	39	39	39	39	39	39	39	39	39	39
DC 50 Solar Project	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development	25	25	25	25	25	25	25	25	25	25
SunPower Project	20	20	20	20	20	20	20	20	20	20
Total Used	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Surplus	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus Total Use	200	200	200	200	200	200	200	200	200	200
Cumulative CVGB Surplus/Deficit	–9,908	–9,708	–9,509	–9,309	–9,109	–8,909	–8,710	–8,510	–8,310	–8,111
Year	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**
Palen Solar Project	41	41	41	41	41	41	41	41	41	41

Table 15. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using Adopted Precipitation and Underflow Recharge Estimates

First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Desert Southwest Transmission Line	0	0	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	39	39	39	39	39	39	39	39	39	39
DC 50 Solar Project	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development	25	25	25	25	25	25	25	25	25	25
SunPower Project	20	20	20	20	20	20	20	20	20	20
Total Used	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Surplus	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390	2,390
CVGB Surplus Minus total use	200	200	200	200	200	200	200	200	200	200
Cumulative CVGB Surplus/Deficit	–7,911	–7,711	–7,512	–7,312	–7,112	–6,912	–6,713	–6,513	–6,313	–6,114

Table 16. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using NPS Precipitation and Underflow Recharge Estimates.

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Palen Solar Project	700	700	371	41	41	41	41	41	41	41
First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Desert Southwest Transmission Line	0.6	0.6	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	0	4,456	4,456	4,456	4,456	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	500	39	39	39	39	39	39	39	39	39
DC 50 Solar Project		100	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3		275	275	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development		440	440	233	25	25	25	25	25	25
SunPower Project		440	440		20	20	20	20	20	20
Total Used	1,201	6,451	6,024	4,784	4,596	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Deficit	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Surplus Minus Total Use	–7,886	–13,136	–12,709	–11,469	–11,281	–8,875	–8,875	–8,875	–8,875	–8,875

Table 16. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using NPS Precipitation and Underflow Recharge Estimates.

Cumulative CVGB Surplus/Deficit	–7,886	–21,022	–33,731	–45,200	–56,481	–65,357	–74,232	–83,107	–91,982	–100,858
Year	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Palen Solar Project	41	41	41	41	41	41	41	41	41	41
First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Desert Southwest Transmission Line	0	0	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	39	39	39	39	39	39	39	39	39	39
DC 50 Solar Project	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development	25	25	25	25	25	25	25	25	25	25
SunPower Project	20	20	20	20	20	20	20	20	20	20
Total Used	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Deficit	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Deficit Minus total use	-8,875	-8,875	-8,875	–8,875	–8,875	–8,875	–8,875	–8,875	–8,875	–8,875
Cumulative CVGB Surplus/Deficit	-109,733	-118,608	-127,484	–136,359	–145,234	–154,110	–162,985	–171,860	–180,735	–189,611
Year	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**
Palen Solar Project	41	41	41	41	41	41	41	41	41	41
First Solar Desert Sunlight Solar Farm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Desert Southwest Transmission Line	0	0	0	0	0	0	0	0	0	0
Eagle Crest Pumped Storage Project	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Desert Harvest Solar PV Project	39	39	39	39	39	39	39	39	39	39
DC 50 Solar Project	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
SunEdison Origination 3	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
First Solar Development	25	25	25	25	25	25	25	25	25	25
SunPower Project	20	20	20	20	20	20	20	20	20	20
Total Used	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
CVGB Baseline Deficit	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685	–6,685
CVGB Deficit Minus Total use	-8,875	-8,875	-8,875	–8,875	–8,875	–8,875	–8,875	–8,875	–8,875	–8,875

Table 16. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Palen Solar Project Plus Cumulative Projects Using NPS Precipitation and Underflow Recharge Estimates.

Cumulative CVGB Surplus/Deficit	-198,486	-207,361	-216,237	–225,112	–233,987	–242,863	–251,738	–260,613	–269,488	–278,364

Dry Year

From the analysis in Table 15, the year with the highest groundwater deficit would be 2022. For that year, assuming dry year and critical dry year precipitation, the CVGB cumulative groundwater deficit would be 16,774 af (0.11% of total storage) and 17,891 af (0.12% of total storage) respectively, if all cumulative projects are in place and assuming adopted recharge inputs and four previous years of normal precipitation. Using NPS recharge estimates, the deficits would be 21,541 af and 21,808 af, respectively.

Multiple Dry Years

Table 17 provides a summary of the multiple dry year analysis using the same methods as described for Table 15, and assuming the Palen Solar Project plus all cumulative projects are in place. At the end of the 12-year period, the cumulative groundwater deficit would be approximately 70,000 acre feet (0.6% of total storage). Palen Solar Project would contribute 2,140 af to this deficit, or about three percent of the deficit. Table 18 provides the same analysis using the NPS estimates of recharge, showing a cumulative deficit of 133,070 af (0.9% of total storage). Palen Solar Project would cause about 1.6 percent of this deficit.

Table 17. Multiple Dry Year Groundwater Budget in Acre Feet with Palen Solar Project and All Cumulative Projects in Place

Year	1	2	3	4	5	6
Dry Precipitation Reference Year	1893	1894	1895	1896	1897	1898
Dry Year Adjusted Recharge from Precipitation (afy) (From Table 10)	4,394	5,424	4,620	3,239	7,132	3,264
Non-Precipitation Groundwater Recharge, All Sources (afy) (From Table 4)	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge (afy)	9,525	10,555	9,751	8,370	12,263	8,395
Non-Project Groundwater Loss, All Sources (afy) (From Table 4)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Extraction, All Projects) (afy) (From Table 15)	–1,201	–6,451	–6,024	–4,784	–4,596	–2,190
Total Groundwater Loss (afy)	–12,530	–17,780	–17,353	–16,113	–15,925	–13,519
Budget Balance (Recharge – Losses) (afy)	–3,004	–7,225	–7,601	–7,743	–3,663	–5,124
Cumulative Budget Balance (Recharge – Losses) (afy)	–3,004	–10,229	–17,831	–25,574	–29,236	–34,360
Year	**7**	**8**	**9**	**10**	**11**	**12**
Dry Precipitation Reference Year	1899	1900	1901	1902	1903	1904
Dry Year Adjusted Recharge from Precipitation (afy) (From Table 10)	1,883	1,406	3,038	2,812	2,210	3,340

Table 17. Multiple Dry Year Groundwater Budget in Acre Feet with Palen Solar Project and All Cumulative Projects in Place

Non-Precipitation Groundwater Recharge, All Sources (afy) (From Table 4)	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge (afy)	7,014	6,537	8,169	7,943	7,341	8,471
Non-Project Groundwater Loss, All Sources (afy) (From Table 4)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Extraction, All Projects) (afy) (From Table 15)	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190
Total Groundwater Loss (afy)	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519
Budget Balance (Recharge – Losses) (afy)	–6,505	–6,982	–5,350	–5,576	–6,179	–5,049
Cumulative Budget Balance (Recharge – Losses) (afy)	–40,865	–47,847	–53,197	–58,773	–64,952	–70,000

Table 18. Multiple Dry Year Groundwater Budget in Acre Feet with Palen Solar Project and All Cumulative Projects in Place Using NPS Estimates of Precipitation and Underflow Recharge

Year	1	2	3	4	5	6
Dry Precipitation Reference Year	1893	1894	1895	1896	1897	1898
Dry Year Adjusted Recharge from Precipitation (afy) (From Table 11)	1,054	1,301	1,108	777	1,711	783
Non-Precipitation Groundwater Recharge, All Sources (afy) (From Table 5~~7~~4)	2,584	2,584	2,584	2,584	2,584	2,584
Total Groundwater Recharge (afy)	3,638	3,885	3,692	3,361	4,295	3,367
Non-Project Groundwater Loss, All Sources (afy) (From Table 5)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Extraction, All Projects) (afy) (From Table 15)	–1,201	–6,451	–6,024	–4,784	–4,596	–2,190
Total Groundwater Loss (afy)	–12,530	–17,780	–17,353	–16,113	–15,925	–13,519
Budget Balance (Recharge - Losses) (afy)	–8,892	–13,895	–13,660	–12,752	–11,631	–10,152
Cumulative Budget Balance (Recharge - Losses) (afy)	–8,892	–22,787	–36,447	–49,199	–60,830	–70,982
Year	**7**	**8**	**9**	**10**	**11**	**12**
Dry Precipitation Reference Year	1899	1900	1901	1902	1903	1904
Dry Year Adjusted Recharge from Precipitation (afy) (From Table 11)	452	337	729	675	530	801
Non-Precipitation Groundwater Recharge, All Sources (afy) (From Table ~~7~~5)	2,584	2,584	2,584	2,584	2,584	2,584
Total Groundwater Recharge (afy)	3,036	2,921	3,313	3,259	3,114	3,385
Non-Project Groundwater Loss, All Sources (afy) (From Table 4)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Extraction, All Projects (afy) (From Table 15)	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190
Total Groundwater Loss (afy)	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519
Budget Balance (Recharge – Losses) (afy)	–10,484	–10,598	–10,206	–10,261	–10,405	–10,134
Cumulative Budget Balance (Recharge – Losses) (afy)	–81,466	–92,064	–102,270	–112,531	–122,936	–133,070

The rainfall record shows that a series of dry years has been followed by a series of years with above-average rainfall. To assess the probable effect of this over the 30-year life of the project, a 30-year running average analysis was made of the 121 years of record. This analysis, including the 30-year multiple-dry-year baseline calculation, is summarized in Tables 19 through 21.

It was found that the driest 30-year period was the period beginning in 1893 and ending in 1922. Average annual rainfall during this period was 3.05 inches, or about 89% of normal. Table 19 shows that if a repeat of this 30-year period occurs under current (no project) conditions, at the end of the 30-year period the CVGB would have a surplus of 43,601 af assuming adopted rainfall and infiltration conditions. The worst year of the drought-induced deficit in the CVGB would be year 12, in which the total deficit would be 31,612 af. Recovery would then begin with total recovery by year 21, and there would be a groundwater surplus of 43,601 af by the end of the 30 years. Using NPS recharge data, the same analysis results in a continually-increasing groundwater deficit ending at 207,290 af after 30 years.

Table 20 provides the same analysis with the Palen Solar project in place but no other cumulative project. The results are similar to the without-project condition, with total groundwater recovery occurring in year 22, and recovery to a surplus of 40,723 af at the end of 30 years. Using NPS recharge data, the same analysis, with the Palen Solar project in place, results in a continually-increasing groundwater deficit ending at 210,168 af after 30 years.

Table 21 provides the cumulative-project analysis. With all cumulative projects in place, the greatest CVGB deficit would occur in year 12, after which recovery would begin, but full recovery would not occur during the 30-year period. The CVGB would end the period with a 34,213-af deficit. Using NPS recharge data, the 30-year deficit would be 285,104 af.

Table 19. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Baseline (No Project) Conditions Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe.

Year	1	2	3	4	5	6	7	8	9	10
Precipitation Reference Year	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Rainfall, in Inches	1.75	2.16	1.84	1.29	2.84	1.3	0.75	0.56	1.21	1.12
Precipitation as Percentage of Average	51%	63%	54%	38%	83%	38%	22%	16%	35%	33%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	4,394	5,424	4,620	3,239	7,132	3,264	1,883	1,406	3,038	2,812
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	9,525	10,555	9,751	8,370	12,263	8,395	7,014	6,537	8,169	7,943

Table 19. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Baseline (No Project) Conditions Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe.

Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Total Groundwater Outflow	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–1,804	–774	–1,578	–2,959	934	–2,934	–4,315	–4,792	–3,160	–3,386
Cumulative Budget Balance (Inflow - Outflow)	–1,804	–2,578	–4,155	–7,114	–6,180	–9,114	–13,428	–18,220	–21,380	–24,765
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Precipitation Reference Year	**1903**	**1904**	**1905**	**1906**	**1907**	**1908**	**1909**	**1910**	**1911**	**1912**
Rainfall, in Inches	0.88	1.33	4.29	2.55	2.18	3.21	5.51	4.66	3.58	4.44
Precipitation as Percentage of Average	26%	39%	125%	75%	64%	94%	161%	136%	105%	130%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	2,210	3,340	10,773	6,403	5,474	8,061	13,836	11,702	8,990	11,149
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	7,341	8,471	15,904	11,534	10,605	13,192	18,967	16,833	14,121	16,280
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Total Groundwater Outflow	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	–3,988	–2,858	4,575	205	–724	1,863	7,638	5,504	2,792	4,951
Cumulative Budget Balance (Inflow - Outflow)	–28,754	–31,612	–27,037	–26,832	–27,556	–25,693	–18,055	–12,551	–9,759	–4,808
Year	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Precipitation Reference Year	**1913**	**1914**	**1915**	**1916**	**1917**	**1918**	**1919**	**1920**	**1921**	**1922**
Rainfall, in Inches	4.8	5.82	3.88	3.64	1.82	6.64	3.66	4.51	7.08	2.11
Precipitation as Percentage of Average	140%	170%	113%	106%	53%	194%	107%	132%	207%	62%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588

Table 19. 30-Year Projected CVGB Groundwater Budget in Acre Feet for Baseline (No Project) Conditions Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe.

Adjusted Recharge from Precipitation	12,053	14,615	9,743	9,140	4,570	16,674	9,191	11,325	17,779	5,298
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	17,184	19,746	14,874	14,271	9,701	21,805	14,322	16,456	22,910	10,429
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Total Groundwater Outflow	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Budget Balance (Inflow - Outflow)	5,855	8,417	3,545	2,942	–1,628	10,476	2,993	5,127	11,581	–900
Cumulative Budget Balance (Inflow - Outflow)	1,048	9,464	13,009	15,952	14,324	24,800	27,792	32,920	44,500	43,601

Table 20. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with the Palen Solar Project in Place.

Year	1	2	3	4	5	6	7	8	9	10
Precipitation Reference Year	**1893**	**1894**	**1895**	**1896**	**1897**	**1898**	**1899**	**1900**	**1901**	**1902**
Rainfall, in Inches	1.75	2.16	1.84	1.29	2.84	1.3	0.75	0.56	1.21	1.12
Precipitation as Percentage of Average	51%	63%	54%	38%	83%	38%	22%	16%	35%	33%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	4,394	5,424	4,620	3,239	7,132	3,264	1,883	1,406	3,038	2,812
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	9,525	10,555	9,751	8,370	12,263	8,395	7,014	6,537	8,169	7,943
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329

Table 20. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with the Palen Solar Project in Place.

Project Groundwater Outflow (Palen Solar Project only)	–700	–700	–371	–41	–41	–41	–41	–41	–41	–41
Total Groundwater Outflow	–12,029	–12,029	–11,700	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370
Budget Balance (Inflow - Outflow)	–2,504	–1,474	–1,949	–3,000	893	–2,975	–4,356	–4,833	–3,201	–3,427
Cumulative Budget Balance (Inflow - Outflow)	–2,504	–3,978	–5,926	–8,926	–8,033	–11,008	–15,363	–20,196	–23,397	–26,823
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Precipitation Reference Year	**1903**	**1904**	**1905**	**1906**	**1907**	**1908**	**1909**	**1910**	**1911**	**1912**
Rainfall, in Inches	0.88	1.33	4.29	2.55	2.18	3.21	5.51	4.66	3.58	4.44
Precipitation as Percentage of Average	26%	39%	125%	75%	64%	94%	161%	136%	105%	130%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	2,210	3,340	10,773	6,403	5,474	8,061	13,836	11,702	8,990	11,149
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	7,341	8,471	15,904	11,534	10,605	13,192	18,967	16,833	14,121	16,280
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Outflow (Palen Solar Project only)	–41	–41	–41	–41	–41	–41	–41	–41	–41	–41
Total Groundwater Outflow	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370
Budget Balance (Inflow - Outflow)	–4,029	–2,899	4,534	164	–765	1,822	7,597	5,463	2,751	4,910
Cumulative Budget Balance (Inflow - Outflow)	–30,853	–33,752	–29,218	–29,054	–29,819	–27,997	–20,400	–14,937	–12,186	–7,276
Year	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Precipitation Reference Year	**1913**	**1914**	**1915**	**1916**	**1917**	**1918**	**1919**	**1920**	**1921**	**1922**
Rainfall, in Inches	4.8	5.82	3.88	3.64	1.82	6.64	3.66	4.51	7.08	2.11

Table 20. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with the Palen Solar Project in Place.

Precipitation as Percentage of Average	140%	170%	113%	106%	53%	194%	107%	132%	207%	62%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	12,053	14,615	9,743	9,140	4,570	16,674	9,191	11,325	17,779	5,298
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	17,184	19,746	14,874	14,271	9,701	21,805	14,322	16,456	22,910	10,429
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Outflow (Palen Solar Project only)	–41	–41	–41	–41	–41	–41	–41	–41	–41	–41
Total Groundwater Outflow	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370	–11,370
Budget Balance (Inflow - Outflow)	5,814	8,376	3,504	2,901	–1,669	10,435	2,952	5,086	11,540	–941
Cumulative Budget Balance (Inflow - Outflow)	–1,461	6,914	10,418	13,320	11,651	22,086	25,037	30,124	41,663	40,723

Table 21. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with all Cumulative Projects in Place.

Year	1	2	3	4	5	6	7	8	9	10
Precipitation Reference Year	**1893**	**1894**	**1895**	**1896**	**1897**	**1898**	**1899**	**1900**	**1901**	**1902**
Rainfall, in Inches	1.75	2.16	1.84	1.29	2.84	1.3	0.75	0.56	1.21	1.12
Precipitation as Percentage of Average	51%	63%	54%	38%	83%	38%	22%	16%	35%	33%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	4,394	5,424	4,620	3,239	7,132	3,264	1,883	1,406	3,038	2,812
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131

Table 21. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with all Cumulative Projects in Place.

Total Groundwater Recharge	9,525	10,555	9,751	8,370	12,263	8,395	7,014	6,537	8,169	7,943
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Outflow (All Cumulative Projects)	–1,201	–6,451	–6,024	–4,784	–4,596	–2,190	–2,190	–2,190	–2,190	–2,190
Total Groundwater Outflow	–12,530	–17,780	–17,353	–16,113	–15,925	–13,519	–13,519	–13,519	–13,519	–13,519
Budget Balance (Inflow - Outflow)	–3,004	–7,225	–7,601	–7,743	–3,663	–5,124	–6,505	–6,982	–5,350	–5,576
Cumulative Budget Balance (Inflow - Outflow)	–3,004	–10,229	–17,831	–25,574	–29,236	–34,360	–40,865	–47,847	–53,197	–58,773
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Precipitation Reference Year	**1903**	**1904**	**1905**	**1906**	**1907**	**1908**	**1909**	**1910**	**1911**	**1912**
Rainfall, in Inches	0.88	1.33	4.29	2.55	2.18	3.21	5.51	4.66	3.58	4.44
Precipitation as Percentage of Average	26%	39%	125%	75%	64%	94%	161%	136%	105%	130%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	2,210	3,340	10,773	6,403	5,474	8,061	13,836	11,702	8,990	11,149
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	7,341	8,471	15,904	11,534	10,605	13,192	18,967	16,833	14,121	16,280
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Outflow (All Cumulative Projects)	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190
Total Groundwater Outflow	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519
Budget Balance (Inflow - Outflow)	–6,179	–5,049	2,384	–1,985	–2,914	–328	5,448	3,313	601	2,761
Cumulative Budget Balance (Inflow - Outflow)	–64,952	–70,000	–67,616	–69,601	–72,515	–72,842	–67,394	–64,081	–63,480	–60,718

Table 21. 30-Year Projected CVGB Groundwater Budget in Acre Feet Using Adopted Precipitation and Underflow Recharge Estimates and Assuming a Repeat of the Driest 30 Years on Record at Blythe, with all Cumulative Projects in Place.

Year	21	22	23	24	25	26	27	28	29	30
Precipitation Reference Year	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Rainfall, in Inches	4.8	5.82	3.88	3.64	1.82	6.64	3.66	4.51	7.08	2.11
Precipitation as Percentage of Average	140%	170%	113%	106%	53%	194%	107%	132%	207%	62%
Normal Recharge from Precipitation	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588	8,588
Adjusted Recharge from Precipitation	12,053	14,615	9,743	9,140	4,570	16,674	9,191	11,325	17,779	5,298
Other Groundwater Recharge (All Sources)	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Total Groundwater Recharge	17,184	19,746	14,874	14,271	9,701	21,805	14,322	16,456	22,910	10,429
Non-Project Groundwater Outflow (All Sources)	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329	–11,329
Project Groundwater Outflow (All Cumulative Projects)	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190	–2,190
Total Groundwater Outflow	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519	–13,519
Budget Balance (Inflow - Outflow)	3,665	6,226	1,355	752	–3,818	8,285	802	2,937	9,390	–3,090
Cumulative Budget Balance (Inflow - Outflow)	–57,053	–50,827	–49,472	–48,720	–52,538	–44,253	–43,450	–40,514	–31,123	–34,213

Analysis Summary

The following provides a summary of the results of the analysis presented above.

- Table 4 shows that under normal precipitation conditions, and using precipitation recharge and the adopted subsurface inflow recharge estimates, the CVGB would have a baseline surplus of approximately 2,390 afy, which means there could be a sustainable yield of groundwater extraction in that amount. Table 5, based on lower precipitation and subsurface inflow estimates (the NPS recharge estimates), shows that the CVGB could already be in an overdraft condition of 6,685 afy, and is and will continue to lose groundwater unless current pumping is curtailed. In this case, any additional extractions would increase the overdraft unless replaced by additional inflow.

- Tables 6 through 9 show that there will be a groundwater deficit in dry years and critical dry years (10 percent and 3 percent probability) under current conditions. The magnitude of the deficit depends on the recharge input assumptions.
- Tables 10 and 11 show that under current extraction conditions a repeat of the worst sustained drought on record at Blythe, 12 years of below-average precipitation, will likely result in cumulative groundwater overdrafts of 31,612 af to 94,682 af. Unless compensated by subsequent high-precipitation years, this would likely become a new baseline groundwater level. This cumulative overdraft would represent roughly 0.2 percent to 0.6 percent of the total groundwater in the basin.
- Table 12 shows that the addition of the Palen Solar Project alone to the existing condition would not create an overdraft in the CVGB, assuming adopted recharge estimates, and would have little effect on the cumulative surplus that is expected. Table 13 shows that using NPS recharge estimates, the Palen Solar Project would contribute about 1 percent to a 30-year projected overdraft.
- Table 15 shows that with all cumulative projects in place, and using adopted recharge estimates, the CVGB would suffer an initial overdraft of about 11,106 af in the fifth year, due to the higher use of water during project construction, and then begin to recover. In other words, after construction is complete, operation water use will be within the safe yield estimate of 2,390 afy. Long-term cumulative operational use is estimated at 2,190 afy, to which the Palen Solar Project would contribute about 1.9 percent. This Palen Solar Project contribution would have little effect on the rate of groundwater use or recovery. At the end of 30 years (the expected life of the Palen Solar Project), the total cumulative deficit would be about 6,114 af. Without the Eagle Crest Pumped Storage Project the cumulative groundwater balance at the end of 30 years would be a surplus of approximately 63,000 acre feet.
- Using NPS recharge estimates (Tables 15 and 16), the CVGB, now in overdraft, would be in more severe overdraft with cumulative projects in place, resulting in a cumulative 30-year overdraft of 278,364 af, to which the Palen Solar Project would contribute about one percent. Without the Eagle Crest Pumped Storage Project the cumulative groundwater overdraft would be only about 4 percent higher than the overdraft predicted with no cumulative projects at all.
- Table 17 shows that under a repeat of the multiple dry year scenario based on the 1893 to 1904 drought, cumulative projects would exacerbate the cumulative overdraft shown in Table 10. With projects in place and adopted recharge estimates, the cumulative overdraft would be 82,530 af to which the Palen Solar Project would contribute about 3 percent. Using NPS recharge estimates, there would be a cumulative overdraft of 145,600 af at the end of the drought, to which the Palen Solar Project would contribute about 1.5 percent.

5.3 Groundwater Budget Reliability Considerations

The groundwater budgets presented in this section are based on assumptions that could affect the reliability of the budget projections. These assumptions are based on the best available data from the sources cited in this document. The following is a discussion of these assumptions, and other considerations, and their implications on the groundwater budgets.

Recharge from precipitation is an important component of the groundwater budget, and alone can make a difference whether the groundwater basin is in a condition of surplus or overdraft as shown in the dry-year projections presented in Sections 5.1 and 5.2. The amount of recharge from precipitation is difficult to estimate. The estimate used in this analysis, 8,588 afy, represents 3% of the total average annual precipitation on the CVGB watershed, and is considered a reasonable estimate of the reported recharge range from previous studies. The overall groundwater budget is very sensitive to the precipitation input. For instance, if the recharge by precipitation is as low as 2.4% of total annual precipitation (6,198 afy), the baseline groundwater budget given in Table 4 would give a net budget balance of zero, and all project scenarios presented above would result in a groundwater deficit. If recharge from precipitation is as high as 6% of total rainfall, which is within the probable range of recharge estimated by the USGS (USGS, 2007) and CEC (CEC, 2015), there would be no groundwater deficit in any year under the cumulative scenario even assuming the lower subsurface inflow estimates of the NPS.

- The Colorado River Water Use Plan (CRBC, 2000), if implemented, could store up to 150,000 afy in the CVGB. This would be a significant increase in the annual water input to the basin, and considered alone would be sufficient to offset the normal year 30-year deficit projected in Table 16. However, this water would likely not be available except for return to the Colorado River Aqueduct, and is not considered in groundwater budget considerations.
- Precipitation reliability could be uncertain should there be shifts in the future climate of the area. The precipitation record at Blythe (USHCN, 2016) shows an overall increase in precipitation since 1893 (Figure 6, Annual Rainfall at Blythe, California), but the 5-year moving average since 1979 shows a downward trend. There was a similar downward trend from 1940 to 1955, and the low precipitation in the early 1900s implies an even more significant downward trend in the late 1880s. Nevertheless, should the current trend continue, recharge from precipitation could decline, resulting in greater groundwater deficits than those estimated here.
- All other groundwater budget input parameters are best estimates subject to uncertainty. The cumulative project list includes projects that are still under consideration and which could be altered or cancelled in the future. Other projects could be proposed, and projects could use other water sources than the CVGB. Changes in future projects could have substantial effects on the groundwater budget.

6. Summary and Conclusions

It is determined that the Palen Solar Project, as a stand-alone project, can draw all of its anticipated water needs from the CVGB without resulting in an overdraft of the groundwater basin under normal (average precipitation) conditions using adopted inflow rates. As shown in Section 5, the normal-year baseline groundwater budget for the CVGB shows a surplus of 2,390 acre feet (Table 4), which is more than the total yearly need for construction by the PV project, and far more than the annual operating water needs. The total 30-year projected water use of the Palen Solar Project is less than the annual baseline water surplus for the CVGB.

During a dry year, and critical dry year (Tables 6 through 9), the baseline groundwater budget for the CVGB shows a groundwater deficit, to which the Palen Solar project would contribute, increasing the overall deficit from 0.05% to 0.06% of the entire CVGB. The same is true for the multiple dry year analysis.

Cumulative projects, including the Palen Solar Project, would use groundwater ranging from 1,201 afy to 6,451 afy, depending on whether these projects are under construction or in operation (long-term cumulative operation use, not including existing uses, is 2,050 afy). This groundwater use would be more than the estimated CVGB baseline surplus during construction, resulting in a short-term net reduction in groundwater reserves assuming normal precipitation years and adopted recharge estimates, with increased reductions for dry, critical dry, and multiple dry years (Section 5, Table 17). Long-term operational use is less than the safe yield, resulting in near recovery of the CVGB at the end of 30 years.

Dry years will result in a groundwater overdraft. Assuming adopted recharge inputs and long-term cumulative project operational water use, the CVGB would be expected to recover from a single dry year in 16 or 17 years, and from a critical dry year in 21 to 22 years. If cumulative project water use ends after a 30-year project lifespan the recovery time would be much less. It would take about 13 years to recover from the same drought if no new projects are in place and assuming normal precipitation. It should be noted that past precipitation amounts have been episodic. For instance, shortly after the 1893 to 1904 drought there was a period of 13 years with precipitation well above average, except for one year. High precipitation years, especially repeated in this way, would significantly shorten the recovery time from a drought. Simulation from the entire rainfall record at Blythe shows that after a repeat of the 1893 to 1904 drought beginning at the start of construction, with all cumulative projects in place, total recovery of the CVGB would occur approximately 50 years after the start of construction. Further, as described under the dry year analysis above, the dry year and multiple dry year deficits are a small percentage of the total CVGB volume.

Because of the uncertainties involved in the CVGB groundwater basin, the analysis includes a budget that assumes lower recharge rates that have been supported by studies of nearby, but separate, groundwater basins. Under these recharge assumptions, the CVGB is already in overdraft condition due to existing withdrawals. Any additional projects that use groundwater would contribute to this overdraft. Although the 30-year projected overdraft assuming these recharge rates and cumulative projects would amount to approximately 263,361 af, this amount is relatively small compared to the total volume of the CVGB, representing about 1.7 percent of the total volume available. Calculated evenly over the entire CVGB area, an overdraft of this magnitude could drop overall groundwater surface elevations about 4.3 feet. Much greater drops would be expected within the cone of groundwater depression around each well, possibly reducing well yields in the vicinity.

The overdraft conditions projected from the analysis using the NPS recharge estimates would occur with or without the Palen Solar project. Projected cumulative long-term water extractions by other projects, plus existing extractions, are 315 times operational extractions proposed by the Palen Solar project. The Palen Solar wells, expected to extract about 41 afy long term, would likely have small effect on the overall resource or locally.

In conclusion, depending on recharge assumptions, a sustainable water supply sufficient to meet the water demand of the Palen Solar Project and existing and planned future uses is available in the CVGB assuming normal precipitation during a 30-year period. Temporary overdrafts during cumulative project construction would be recovered by 2036. The Palen Solar Project alone will not produce an overdraft in any year. If groundwater inflow rates are lower than those adopted herein, the basin may already be in overdraft. If in overdraft, the CVGB has ample storage to supply the Palen Solar Project for 30 years without significantly diminishing the resource because application of the most conservative models under cumulative conditions result in an estimated overdraft of less than 2 percent of the resource, with or without the project.

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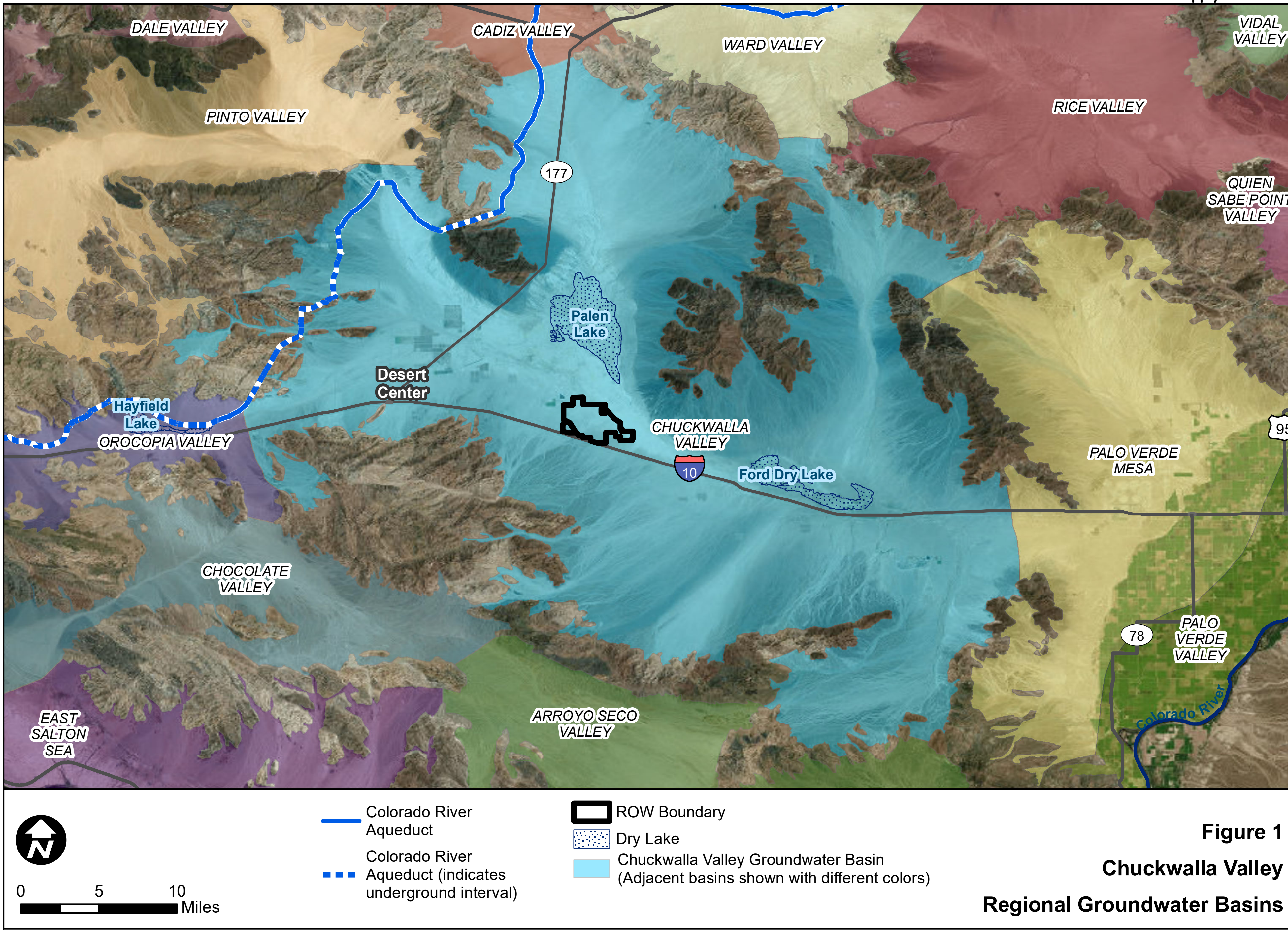
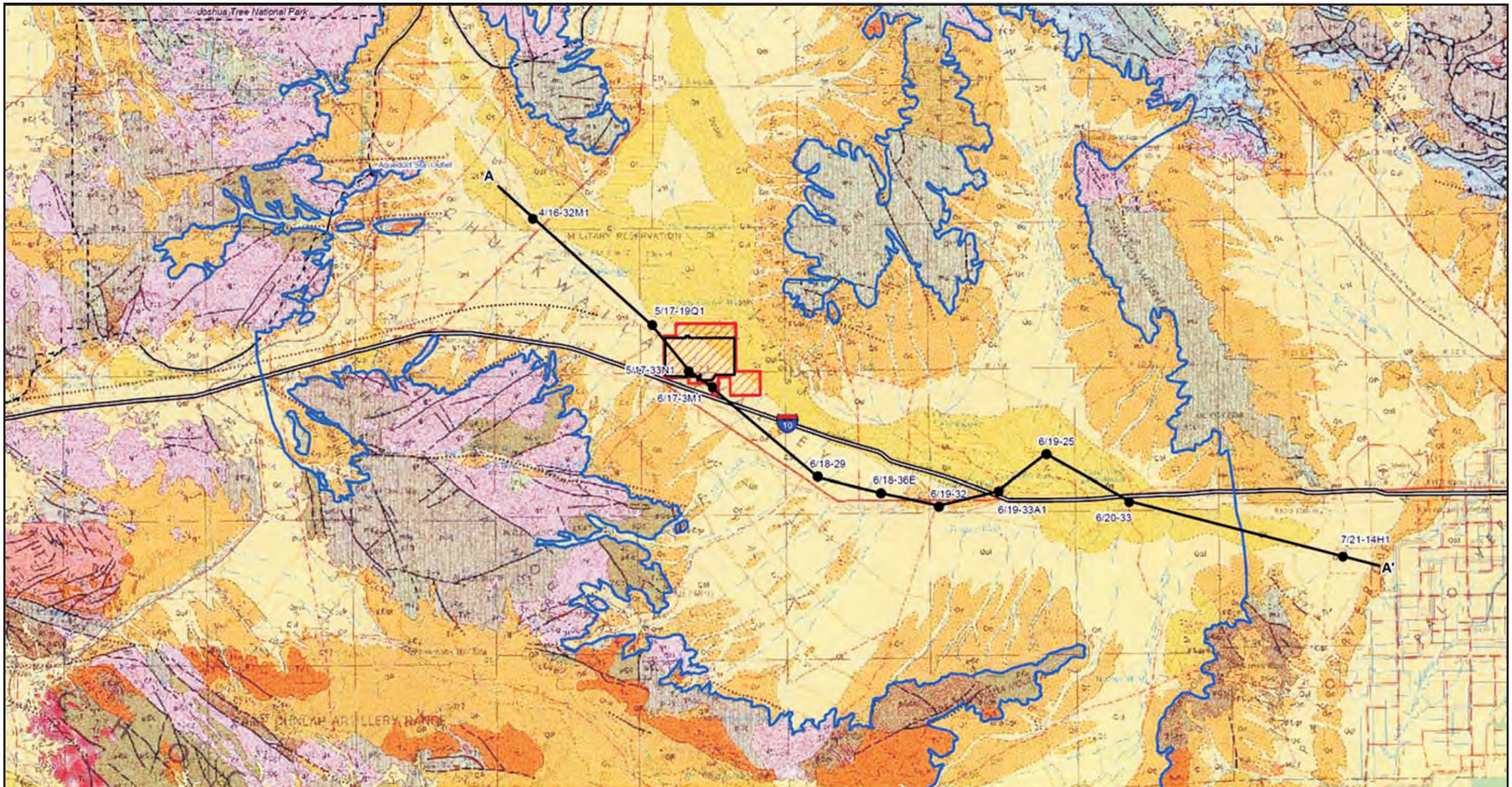


Figure 1
Chuckwalla Valley
Regional Groundwater Basins



Map Location

0 4 8 Miles

ROW Boundary

Colorado River Aqueduct

Colorado River Aqueduct
(Dash showing underground interval)

Groundwater Well

Chuckwalla Valley Groundwater Basin Boundary

Cross-Section Line

Freeway

Source: CEC, 2010.

Figure 2a

Regional Geology

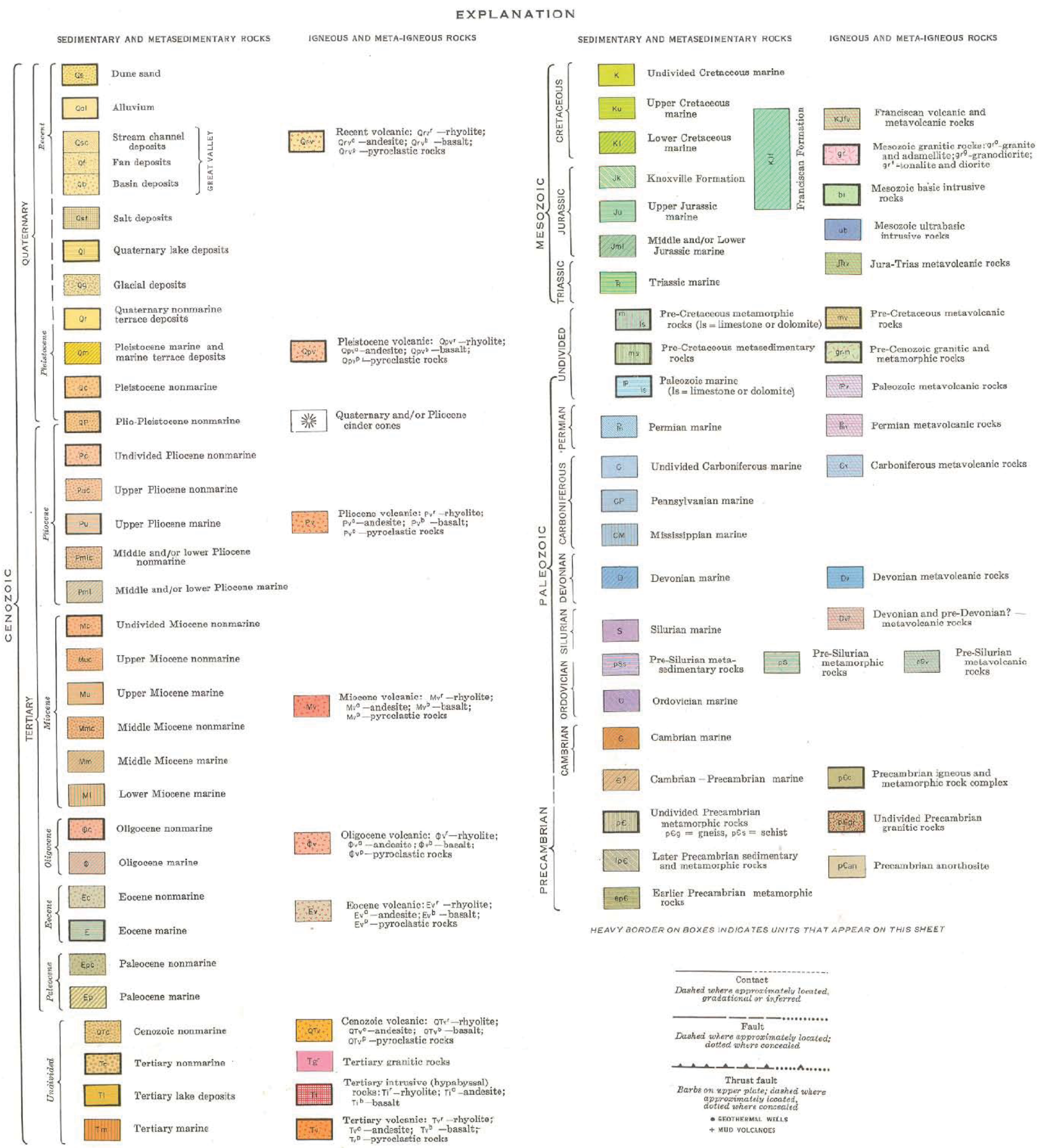


Figure 2b

Regional Gology Legend

Source: CEC, 2010

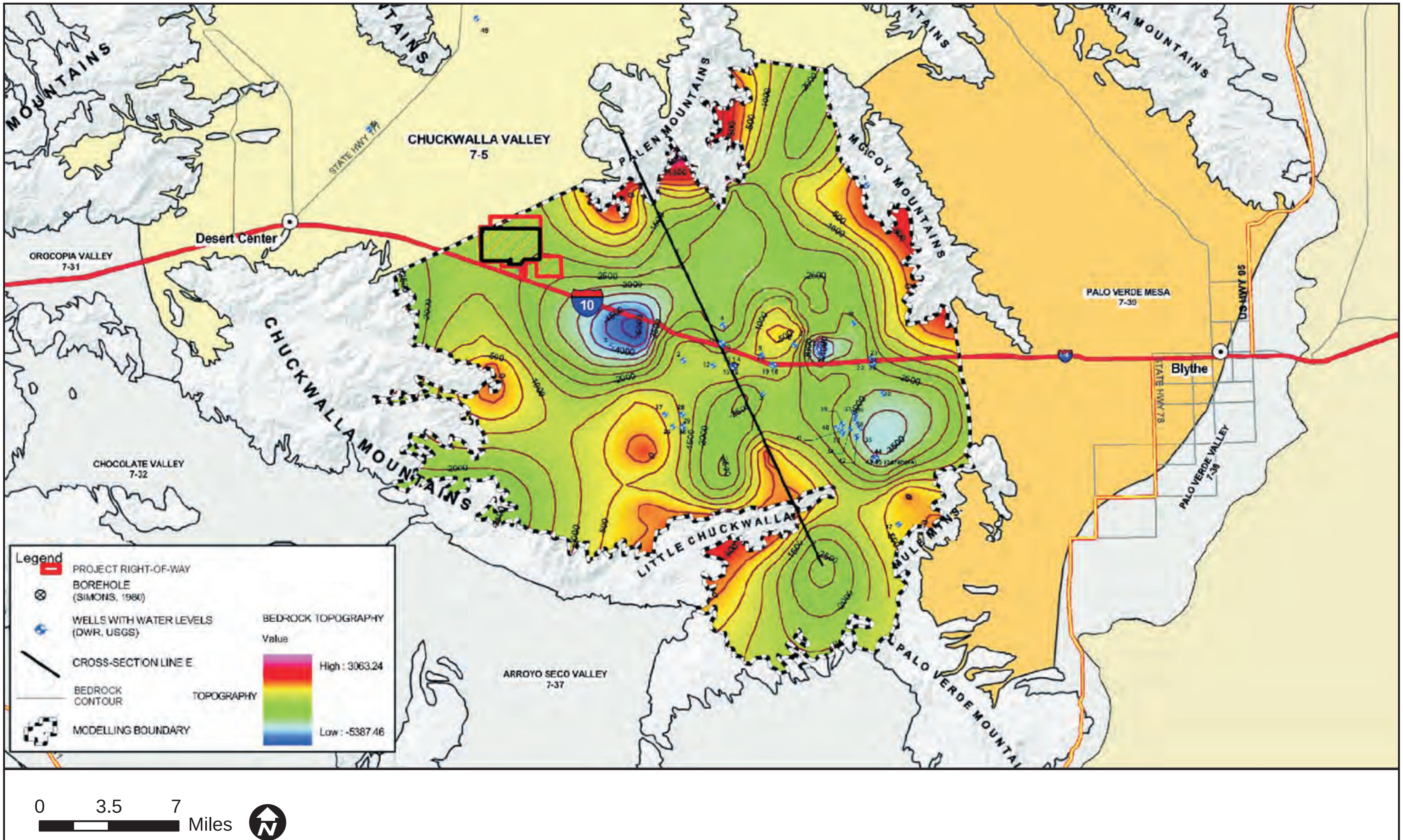


Figure 3

Chuckwalla Valley Groundwater Basin Bedrock Topography

Source: CEC, 2010.

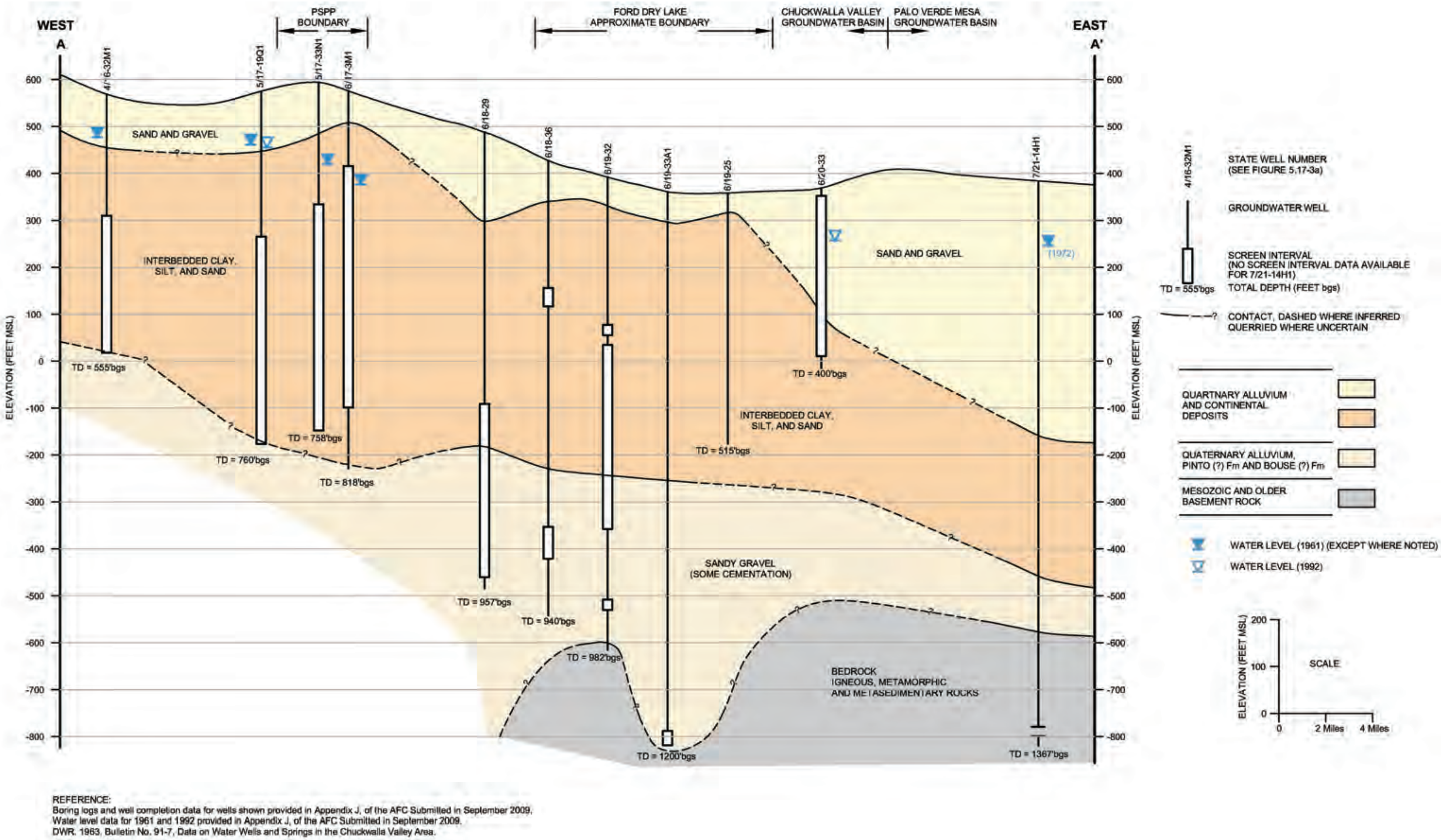


Figure 4

Chuckwalla Valley Groundwater Basin Cross Section A-A

Source: AECOM, 2010.

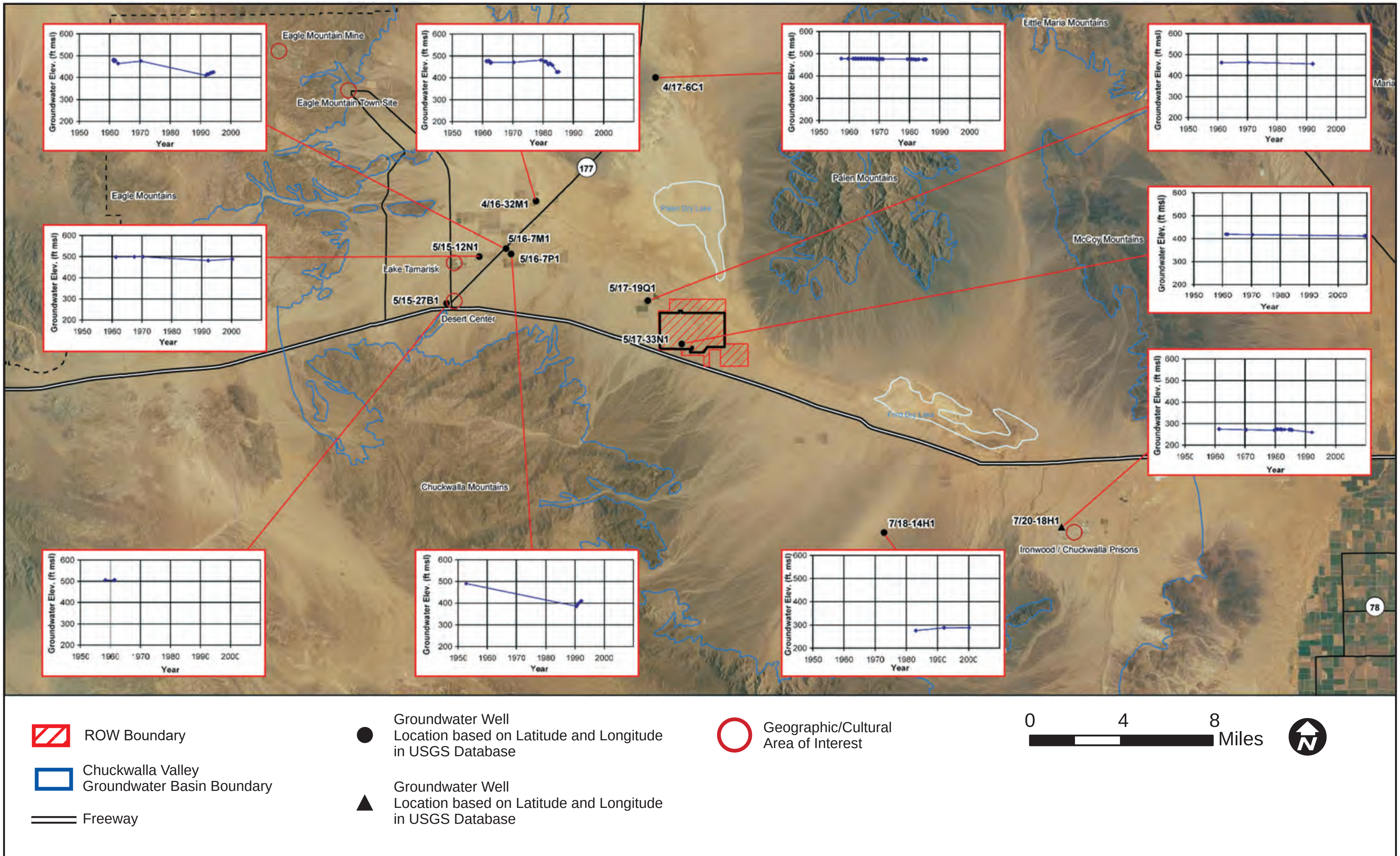


Figure 5

Basin Wide Groundwater Hydrographs

Source: AECOM, 2010.

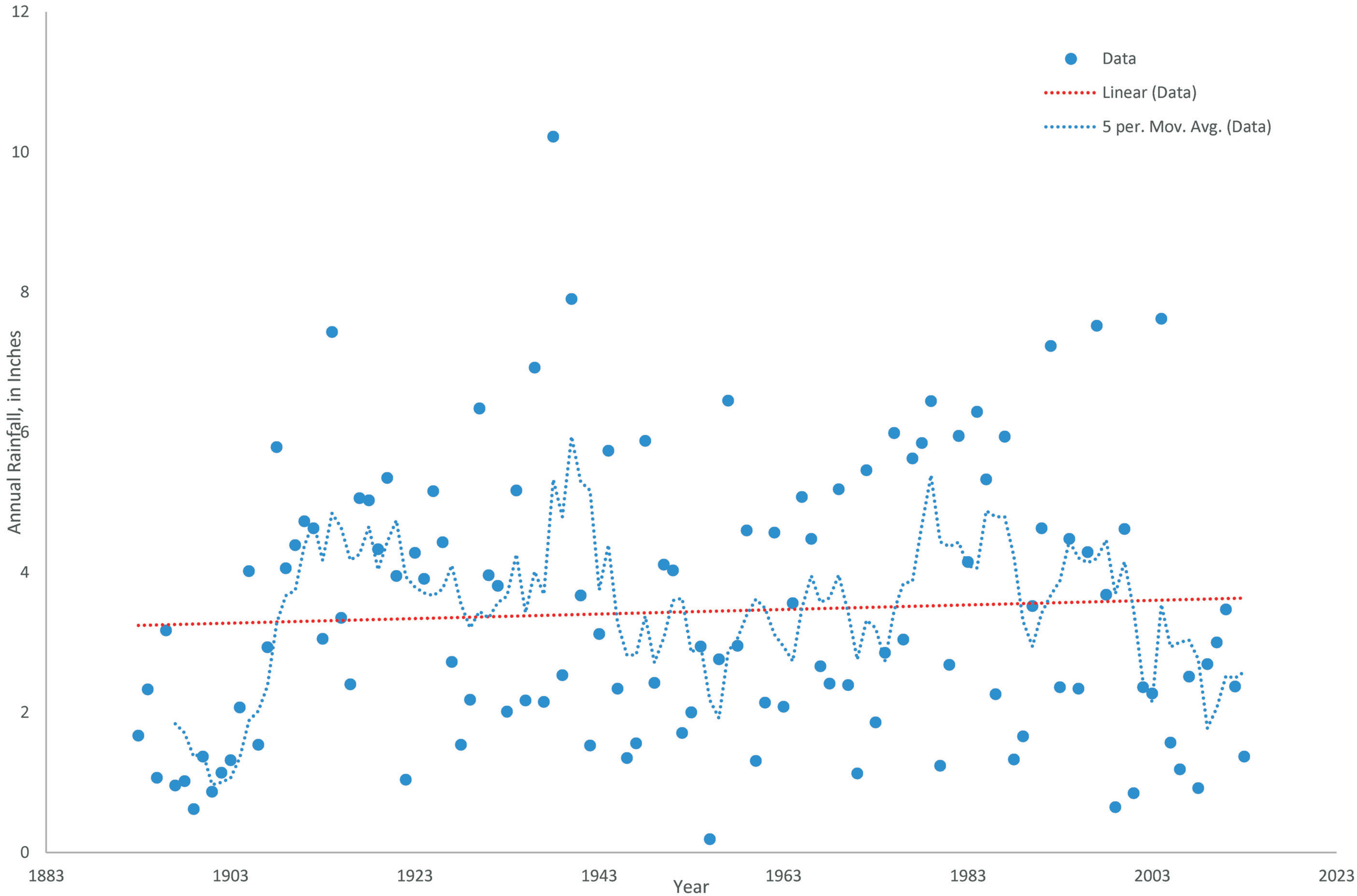


Figure 6

Annual Rainfall at Blythe, California