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ANL/EVS-14/8

# An Update of the Analytical Groundwater Modeling to Assess Water Resource Impacts at the Dry Lake Valley North Solar Energy Zone

*Final Report*

**Environmental Science Division**

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# An Update of the Analytical Groundwater Modeling to Assess Water Resource Impacts at the Dry Lake Valley North Solar Energy Zone

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prepared for
The Bureau of Land Management
National Renewable Energy Coordination Office
U.S. Department of Interior
Washington, D.C.

May 2014

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## NOTATION

The following is a list of acronyms, initials, symbols, and abbreviations (including units of measure) used in this document.

### Acronyms, Initials, Symbols And Abbreviations

| | |
|---|---|
| BLM | Bureau of Land Management |
| b | aquifer thickness |
| DOE | U.S. Department of Energy |
| DOI | U.S. Department of the Interior |
| GIS | geographic information system |
| GMS | Groundwater Modeling System |
| GUI | graphical user interface |
| HA | Hydrologic Area |
| HUF | Hydrogeologic Unit Flow |
| K | hydraulic conductivity |
| MSL | mean sea level |
| NDWR | Nevada Department of Water Resources |
| PEIS | programmatic environmental impact statement |
| PV | photovoltaic |
| SNWA | Southern Nevada Water Authority |
| SEZ | solar energy zone |
| Sy | specific yield |
| T | transmissivity |
| USGS | U.S. Geological Survey |

### Units Of Measure

| | |
|---|---|
| ac-ft | acre-feet |
| d | day |
| ft | feet |
| kV | kilovolt |
| in | inch |
| km | kilometer |
| m | meter |
| $m^2$ | square meter |
| $m^3$ | cubic meter |
| yr | year |

Elevations are reported relative to mean sea level using the NAVD88 vertical datum.

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## ACKNOWLEDGMENTS

We would like to thank Larissa Ford, Lee Koss, Paul Summers, Daniel Netcher, Sarah Peterson, and Ray Brady of the Bureau of Land Management (BLM) for providing guidance and oversight for the groundwater modeling project associated with BLM's Solar Energy Program. The work was funded by the BLM, National Renewable Energy Coordination Office under interagency agreement, through U.S. Department of Energy contract DE-AC02-06CH11357.

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# AN UPDATE OF THE ANALYTICAL GROUNDWATER MODELING TO ASSESS WATER RESOURCE IMPACTS AT THE DRY LAKE VALLEY NORTH SOLAR ENERGY ZONE

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## 1 INTRODUCTION

The purpose of this study is to update a one-dimensional analytical groundwater flow model to examine the influence of potential groundwater withdrawal to support utility-scale solar energy development at the Dry Lake Valley North Solar Energy Zone (SEZ) as a part of the Bureau of Land Management's (BLM's) Solar Energy Program.

This report describes the modeling for assessing the drawdown associated with SEZ groundwater pumping rates for a 20-year duration considering three categories of water demands (high, medium, and low) based on technology-specific considerations. The 2012 modeling effort published in the *Final Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States* (Solar PEIS) has been refined based on additional information described below in an expanded hydrogeologic description.

### 1.1 The Bureau of Land Management's Solar Energy Program

In 2012, the BLM officially established its Solar Energy Program, which facilitates permitting of utility-scale solar energy development on BLM lands in six southwestern states (Arizona, California, Colorado, Nevada, New Mexico, and Utah) in an environmentally responsible manner (BLM 2012). As a part of the Solar Energy Program, the BLM established SEZs, which are areas that are well-suited for utility-scale production of solar energy where BLM will prioritize solar development. The BLM, together with the Department of Energy (DOE), analyzed the potential environmental impacts of the Solar Energy Program in the Solar PEIS, including impacts on water resources (BLM and DOE 2012). Groundwater is the primary water resource available for solar energy development in most of the SEZs, and impacts of groundwater withdrawals were investigated qualitatively and semi-quantitatively in the Solar PEIS to assess the range of potential effects. Impacts of reduced groundwater flow magnitude and timing of groundwater flows to streams, springs, seeps, and wetlands would depend upon the connectivity of surface water and groundwater in the region. These impacts include decreased water supply for downstream users; loss of wetland vegetation species; loss of habitat and forage for wildlife, wild horses, and livestock; and others.

As a part of the Solar PEIS analysis, water requirements for cooling and/or washing uses at solar energy facilities were examined for different technologies and varying levels of development and compared with basin-scale water budgets. In addition, one-dimensional groundwater modeling was performed to examine potential radial drawdown for different solar development scenarios.

As a follow-on to the work done for the PEIS, BLM identified a subset of SEZs, including the Dry Lake Valley North SEZ, for further analysis and groundwater modeling. The analyses are being used to examine potential groundwater impacts associated with future solar development of the SEZs, with a particular focus on examining groundwater drawdown and potential loss of connectivity to surface-water features, springs, and vegetation. In addition to these analyses, the developed numerical or analytical groundwater models are being made available through the Solar PEIS Web site (http://blmsolar.anl.gov) so that they can be used for project-scale review and for the development of long-term monitoring programs.

## 1.2 The Dry Lake Valley North Solar Energy Zone

The Dry Lake Valley North SEZ covers approximately 25,000 acres (102 $km^2$) and is located in Lincoln County in southeastern Nevada (Figure 1). At its longest it extends about 11 mi (17.7 km) north to south and at its widest it extends about 6 mi (9.7 km) west to east. The SEZ has surface elevations that range between 4,498 ft (1,370 m) and 4,800 ft (1,463 m).

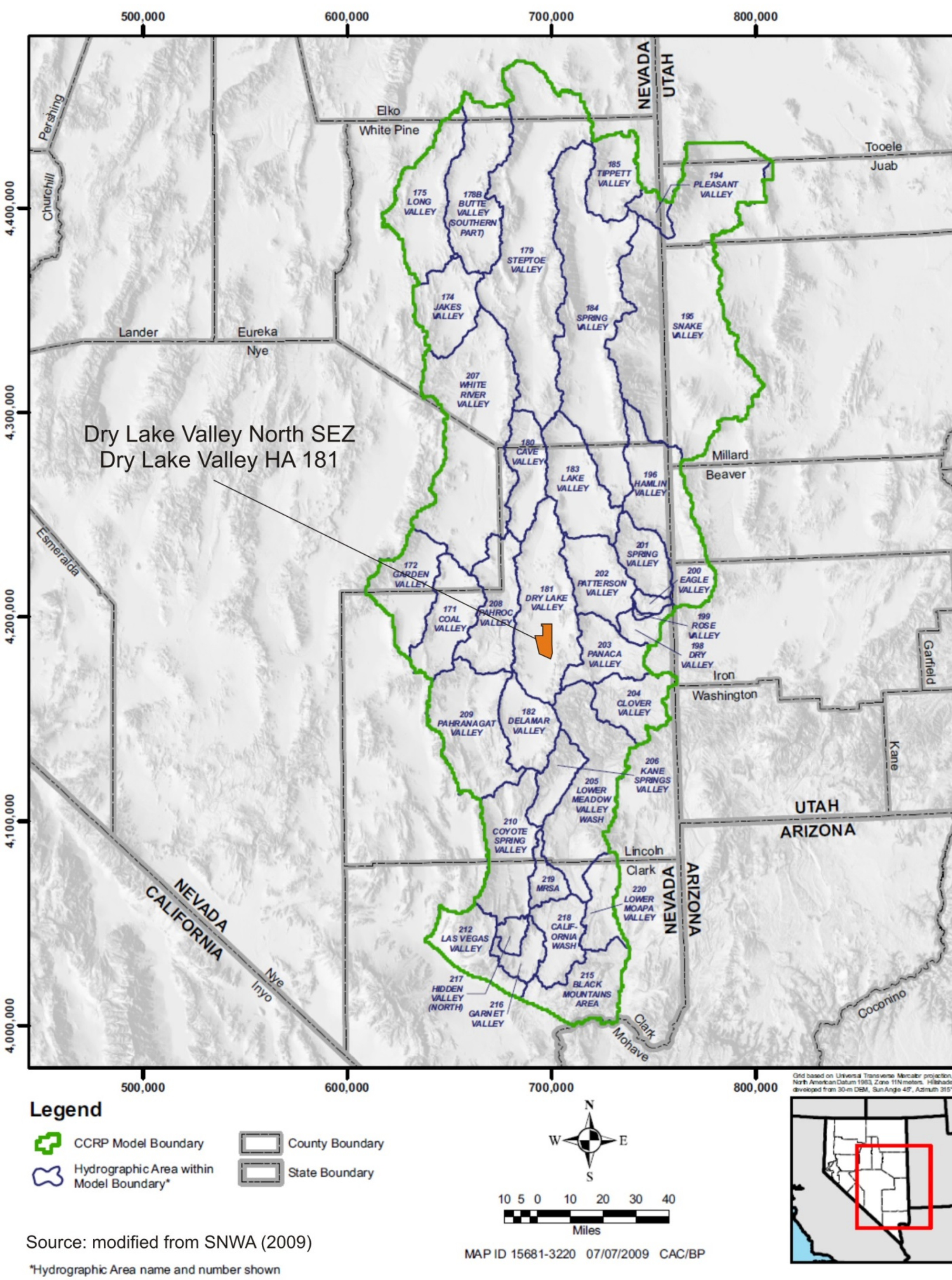


**Figure 1 Location of Dry Lake Valley North SEZ**

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# 2 HYDROGEOLOGIC SETTING AND MODEL INPUT PARAMETERS

Dry Lake Valley, the location of the Dry Lake Valley North SEZ, is an arid alluvial basin measuring approximately 60 mi (97 km) from north to south (Figure 1). The Nevada Department of Water Resources (NDWR) refers to it as Hydrologic Area (HA) 181. It is bounded on the west by a portion of the Shell Creek Range and on the east by the Pahroc, Fairview, Bristol, and Highland Peak ranges (SNWA 2008). Many small ephemeral channels are present that emanate from the mountains, and braided channels of alluvial outwash plains drain to a dry lake in the central-southern portion of the basin. None of the surface-water features are perennial.

## 2.1 Aquifer Characteristics

Mankinen et al. (2008) performed gravity geophysical surveying in the study area and estimated an average thickness of alluvial basin fill in Dry Lake Valley of about 3 mi (5 km), with a maximum depth of about 4 mi (6.5 km). The fill is underlain by sequences of carbonate rock aquifers.

In Dry Lake Valley, groundwater flow is to the south (Figure 2). Water levels in the basin fill are about 4,000 to 4,300 ft (1,200 to 1,300 m) above mean sea level (MSL) throughout much of the basin, where topographic elevations are roughly 4,600 to 4,900 ft (1,400 to 1,500 m) above MSL. Depth to water is therefore approximately 600 ft (180 m). For the Dry Lake Valley North vicinity, 19 well logs were obtained from a state database (NDWR 2012). Inspection of the database information indicated that wells in the basin have screens with bottom elevations of 3,000 to 3,300 ft (900 to 1,000 m) above MSL. Therefore, the estimated saturated thickness penetrated by wells in Dry Lake Valley is typically about 1,000 ft (300 m), although the saturated thickness extends much deeper than these wells.

SNWA (2009b) assembled the results of numerous prior studies of groundwater flow assessments in the region and acknowledged that different interpretations of groundwater exchange between adjacent basins are possible due to sparse data.

Conceptually, the bulk of the groundwater flow is expected to take place in permeable units within the basin fill and within the underlying carbonate aquifer, with interaction between the aquifer types as determined by local permeability relationships. The arrangement of permeable and impermeable material within basin fill is complex, as is the interconnectedness between permeable fill units and conduit flowpaths in the bedrock. Groundwater flow in the region is more active at shallower depths (Harrill and Prudic 1998). Deeper groundwater may be too uneconomical to pump (Eakin 1963) or of poor quality.

Basin fill is stratigraphically complex, and zonation of different types of alluvial materials aerially or vertically in the study area would be difficult to support because of the inherent depositional variability and the lack of details in drilling logs (i.e., “alluvium” does not give a strong indication of permeable vs. impermeable sediments). Rush (1968) generalized that the

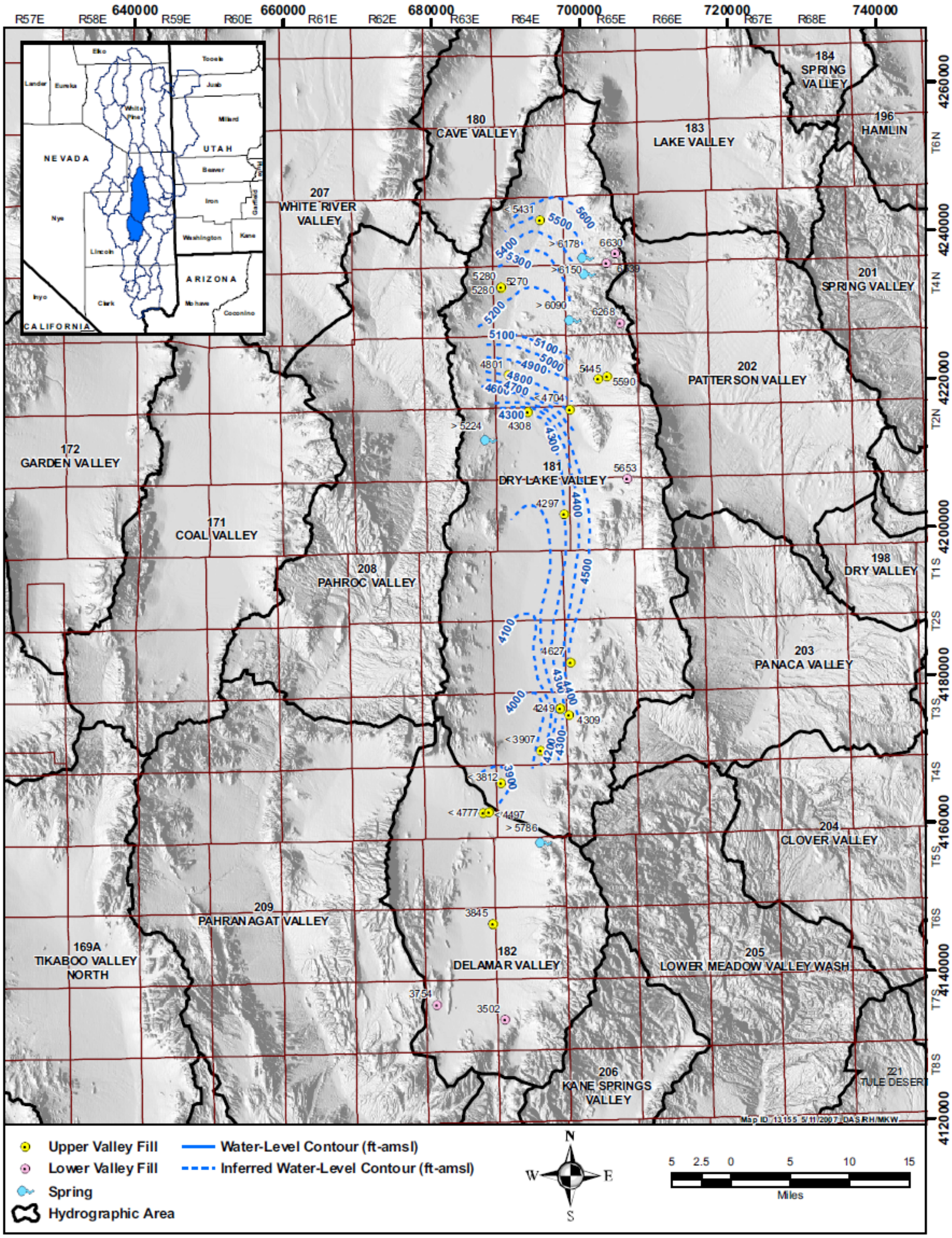


**Figure 2 Water Level Elevations in the Basin Fill Aquifer in Dry Lake Valley (HA 181) in Feet above MSL (Source: SNWA 2008a)**

deeper alluvial deposits have a range of permeability values based on sediment texture and cementation. Much of the deep alluvium is Muddy Creek Formation, which is a poor aquifer (Rush 1968). Younger alluvium, where thick and saturated, may be the best aquifer in the study area (Rush 1968).

The permeability of the carbonate aquifer may be affected locally or regionally by fracturing, solution enlargement, and fault plane barriers or preferential flowpaths. Because of the scale of the study and the lack of detailed information, the carbonate aquifer is assumed to function as a porous media in the numerical models.

## 2.3 Hydraulic Conductivity and Storage Properties

SNWA (2009a) identified the basin fill in Dry Lake Valley to be "upper valley fill." Upper valley fill hydraulic conductivity, based on 132 constant-rate tests in the region, has a mean of 12 ft/d (3.7 m/d), with a range of $2\times10^{-4}$ to 3,600 ft/d (0.006 cm/d to 1,100 m/d), and a 95% confidence interval range of 0.066 to 2,089 ft/d (2 cm/d to 637 m/d). For the upper valley fill, specific yield in the region (17 data points) ranges from 0.0004 to 0.2870, with a mean of 0.0424. Specific storage (36 data points) ranges from $1.72\times10^{-7}$ to $3.38\times10^{-3}$ $ft^{-1}$, with a mean of $1.21\times10^{-4}$ $ft^{-1}$. Dry Lake Valley, because of its great depth, also contains "lower valley fill." Based on 136 constant-rate tests in the SNWA study area, this material has an average hydraulic conductivity of 2 ft/d,(0.6 m) with a range of $2.4\times10^{-3}$ to 340 ft/d ($7.3\times10^{-4}$ to 104 m/d). Specific yield for this unit (3 data points) ranges from 0.0020 to 0.0030. Specific storage (10 data points) ranges from $6.75\times10^{-6}$ to $1.03\times10^{-7}$ $ft^{-1}$ ($2.06\times10^{-6}$ to $3.14\times10^{-8}$ $m^{-1}$).

SNWA (2009a) presents hydraulic conductivity values for the carbonate aquifer of Dry Lake Valley. Four measurements range from >0.025 to >250 ft/d (>0.76 cm/d to >76 m/d). For the overall eastern Nevada region, based on 89 constant-rate tests, SNWA gives a mean of 5.37 ft/d (1.64 m/d) for the carbonate aquifer, with a range of 0.027 to 3,200 ft/d (0.0082 to 980 m/d), and a 95% confidence interval range of 0.020 to 1,440 ft/d (0.006 to 439 m/d). For the carbonate aquifer, specific yield (2 data points) in the region ranges from 0.0012 to 0.0309, with a mean of 0.0160. Specific storage (3 data points) ranges from to $4.67\times10^{-7}$ to $1.24\times10^{-5}$ $ft^{-1}$, with a mean of $8.26\times10^{-6}$ $ft^{-1}$.

## 2.4 Water Budget Estimates and Water Rights

Recharge in the study area is expected to take place mainly through the infiltration of rainfall at higher elevations (SNWA 2009a). Little recharge is expected in the central basin areas. SNWA (2009a) relied on groundwater balance methods to estimate the recharge to basins throughout east-central Nevada. This approach relied on data on precipitation bands combined with recharge efficiencies. Recharge values of 16,208 ac-ft/yr ($2.0\times10^{7}$ $m^3$/yr) were determined for Dry Lake Valley. SNWA (2009a) summarized several other studies, which estimated a range of recharge values determined by various methods of 8,947 to 28,559 ac-ft/yr ($1.1\times10^{7}$ to $3.5\times10^{7}$ $m^3$/yr) for Dry Lake Valley. LVVWD (2001) estimated 13,254 ac-ft/yr ($1.6\times10^{7}$ $m^3$/yr) of recharge for Dry Lake Valley. Groundwater throughout the Dry Lake Valley North SEZ study area is too deep to be affected by evapotranspiration (Eakin 1963).

As discussed in the PEIS (BLM and DOE 2012), all waters in Nevada are public property, and the NDWR is the agency responsible for managing both surface and groundwater resources. The Dry Lake Valley groundwater basin is not a designated groundwater basin; thus there are no specific beneficial uses set by the NDWR. The NDWR sets the perennial yield for each groundwater basin, which is technically the amount of water available for water rights allocations.

Dry Lake Valley has been identified as potential source for water to be developed for the Southern Nevada Water Authority Groundwater Project. In 1989 Las Vegas Water District submitted water right applications in Dry Lake Valley. There have been several rounds of hearings and court cases involved with these applications and this continues to this date. In March 2012 the Nevada State Engineer issued ruling 6166 which outlines that based on the Nevada State Engineer's understanding that the perennial yield of Dry Lake Valley is 15,000 ac-ft ($1.9\times10^7$ $m^3$) of water based on estimated annual recharge for the basin. The amount of committed groundwater is 807 ac-ft (995,000 $m^3$), and the Nevada State Engineer has reserved 50 ac-ft (60,000 $m^3$) of water for unforeseen future growth and development in the basin. The Nevada State Engineer issued the Southern Nevada Water Authority 11,584 ac-ft ($1.4\times10^7$ $m^3$) of water for development. This decision was appealed to the Nevada District Court, and in December 2013 the Nevada Seventh Judicial District Court remanded the decision back to the Nevada State Engineer.

## 2.5 Prior Dry Lake Valley North Modeling

As described above, in numerical modeling of a setting such as Dry Lake Valley North, incorporating numerous spatially and temporally varying data sets dealing with aquifer properties, the hydrogeologic framework, and boundary conditions is a challenge. A model created in a multi-year study by the Southern Nevada Water Authority (SNWA) (2009b) was therefore acquired to evaluate its use for assessing drawdown at associated with the Dry Lake Valley North SEZ. The evaluation included review of model input files, model documentation, and supporting documentation.

The SNWA (2009b) model is an 11-layer MODFLOW-2000 model that is highly complex in its three-dimensional framework and detailed input. It has a large extent that includes the SEZ (Figure 1). It relies on modified format Hydrogeologic Unit Flow (HUF) input files and a customized MODFLOW executable, and therefore cannot be opened entirely in a standard graphical user interface (GUI). In addition, the model relies on a nonstandard command line interface, and several scripts and support programs are needed to be run during a modeling run. The model file sets, which total 98 gigabytes, are a collection of 22 different models of various scenarios. Model documentation warns about very long run times. Because of these complications, the SNWA model was not used to assess drawdown at the SEZ. Instead, its reports were used as sources of background information, and hydrogeologic information and calibrated model values were reviewed for use as input to the Dry Lake Valley North SEZ analytical model.

The SNWA model's calibrated values for the hydraulic conductivity of valley fill ranged from 3 to 12 ft/d (0.9 to 3.7 m/d); for upper carbonate the range was 0.004 to 10 ft/d (0.12 cm/d to 3 m/d); and for lower carbonate the range was 0.04 to 90 ft/d (1.2 cm/d to 27 m/d). These units were spatially subdivided in the modeling effort, but the model documentation does not indicate what the calibrated values were in the vicinity of the two SEZs. Specific yield values used in the SNWA model included 0.11 for valley fill and 0.05 for upper or lower carbonate.

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# 3 METHODOLOGY

The analytical modeling approach relies on simplifying assumptions to generate a distance-drawdown relationship based on a combination of input parameters (pumping rate, hydraulic conductivity, aquifer thickness, duration, and aquifer storage). The analytical modeling method is also described in Appendix O of BLM and DOE (2012).

Drawdown of the potentiometric surface due to radial groundwater flow to a pumping well can be estimated using analytical equations and simplifying assumptions. For a confined aquifer, the Theis method can be applied. The Theis solution relates drawdown to an infinite-series term called the well function,

$$ho - h = \frac{Q}{4\pi T}\left[-0.5772 - \ln u + u - u^2/(2 \cdot 2!) + u^3/(3 \cdot 3!) - u^4/(4 \cdot 4!) + \cdots\right],$$

where the argument $u$ is

$$u = \frac{r^2 S}{4Tt}$$

and $Q$ = constant pumping rate [$L^3$/T]
$h$ = hydraulic head at time $t$ since pumping began [L]
$h_o$ = hydraulic head prior to pumping [L]
$r$ = radial distance from the pumping well to an observation well [L]
$T$ = aquifer transmissivity [$L^2$/T]
$S$ = aquifer storativity [unitless].

Transmissivity is the product of the aquifer's hydraulic conductivity, $K$ [L/T], and the aquifer's thickness, $b$ [L]. Storativity for a confined aquifer is the product of the specific storage and the aquifer thickness, and is usually small (<0.005).

Assumptions of the Theis method include a constant pumping rate, Darcian flow, and instant release of water from storage (Fetter 1988). The aquifer is assumed to be homogenous, isotropic, of a constant thickness, of negligible slope, and of infinite extent. The pumping well and observation wells are assumed to penetrate the aquifer fully, and the pumping well's diameter is infinitesimal.

For this study, the drawdown to be evaluated occurs as a result of long-term pumping. The Jacob method acknowledges that when $u$ of the Theis equation is very small (e.g., time $t$ is very large), the equation can be truncated after the first two terms (Fetter 1988). The equation becomes

$$h_o - h = \frac{2.3Q}{4\pi T}\, log_{10}\left(\frac{2.25Tt}{Sr^2}\right).$$

This step is valid when $u < 0.01$, and for most applications, is valid if $u < 0.1$ (Halford and Kuniansky 2002).

For unconfined aquifers, three phases of time-drawdown relationships occur during pumping (Fetter 1988). Initially, the aquifer contributes a small amount of water due to release from storage consistent with the Theis equation. Continued pumping causes a transition to decline of the water table due to gravity drainage. In the later stage, the situation transitions to a decreasing rate of drawdown, and time-distance data can again be modeled with the Theis equation (Kruseman and DeRidder 2000). Because this late-stage scenario is what is considered in the years-long Solar PEIS analyses, the above equation is appropriate. In this case, however, the storage term to be used is the specific yield, $S_y$. Values of $S_y$ for silts, sands, and gravels are generally in the range of 0.18 to 0.27 (Fetter 1988).

For this project, a spreadsheet tool was developed to evaluate the drawdown at various distances from a pumping well at long time duration using the Jacob method. The model relies on user input that is provided in consistent units for length and time to evaluate drawdown at various distances while also displaying $u$ values to check the validity of the approach. Depending on the hydrogeologic conditions, the storage term may be considered storativity (small values for a confined aquifer) or specific yield (large values for an unconfined aquifer). The spreadsheet includes a graphical view of the drawdown across a range of distances.

Because of the simplicity of the analytical approach, input values can be quickly and easily tested to estimate the effect of long-term pumping at various distances from a pumping well or pumping center. These estimates can be determined for best-guess and worst-case scenarios, based on the ranges of appropriate input values. The appropriateness of the simplifying assumptions, especially those related to the aquifer's spatial characteristics, must be considered carefully.

The operational water requirements for a proposed SEZ depend on the degree of buildout on the SEZ and the solar energy technology (BLM and DOE 2012). Some technologies require a cooling system, but all technologies require water for cleaning panels or mirrors. For the Dry Lake Valley North SEZ, the considered low, medium, and high groundwater pumping scenarios represent full buildout of the SEZ assuming photovoltaic (PV) panels, dry-cooled parabolic troughs, and wet-cooled parabolic troughs, respectively (BLM and DOE 2012). These water requirements are summarized in Table 1. In this assessment, all pumping is assigned to a single well; however, multiple wells may be installed for an operational SEZ.

Because of the great thickness of alluvial fill aquifer materials in Dry Lake Valley, the fill material was assumed to be the aquifer for supplying water for SEZ operations. This assumption is consistent with the aquifer currently supplying water to users in the valley. The saturated thickness of the fill has been shown to extend from 400 ft (122 m) to at least 1,305 ft (398 m) below ground surface at a well installed within or adjacent to the SEZ boundary (Ertec Western 1981). The initial value for saturated thickness assigned in the analytical model was 1,200 ft (366 m), and the sensitivity of the model to this value was evaluated. On the basis of the average values determined by SNWA (2009b), initial values for horizontal hydraulic conductivity (12 ft/d or 3.7 m/d) and specific yield of 0.0424 were assigned. The sensitivity of the model to these parameters was evaluated. The model duration was 7,305 days or 20 years. Pumping rates for low-, medium-, and high-demand scenarios (Table 1) were tested.

**Table 1  Low-, Medium-, and High-Demand SEZ Groundwater Pumping Requirements Assumed for Dry Lake Valley North SEZ**

| Description | Pumping Scenario | Assumed Pumping Requirements | | |
|---|---|---|---|---|
| | | ac-ft/yr | $m^3/d$ | $ft^3/d$ |
| Full buildout of PV | Low | 114 | 385 | 13,598 |
| Full buildout of dry-cooled parabolic trough | Medium | 2,864 | 9,675 | 341,618 |
| Full buildout of wet-cooled parabolic trough | High | 20,112 | 67,940 | 2,398,961 |

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# 4 RESULTS AND DISCUSSION

## 4.1 Dry Lake Valley North SEZ Analytical Modeling

The drawdown results are shown in Figure 3. Significant drawdown is indicated at 20 years of high-demand SEZ pumping, including nearly 200 ft (60 m) within 50 ft (15 m) of the pumping well and about 53 ft (15 m) at a distance of 2 mi (3.2 km). This amount of drawdown is attributed to the large amount of water required for full buildout of wet-cooled parabolic trough at this large SEZ.

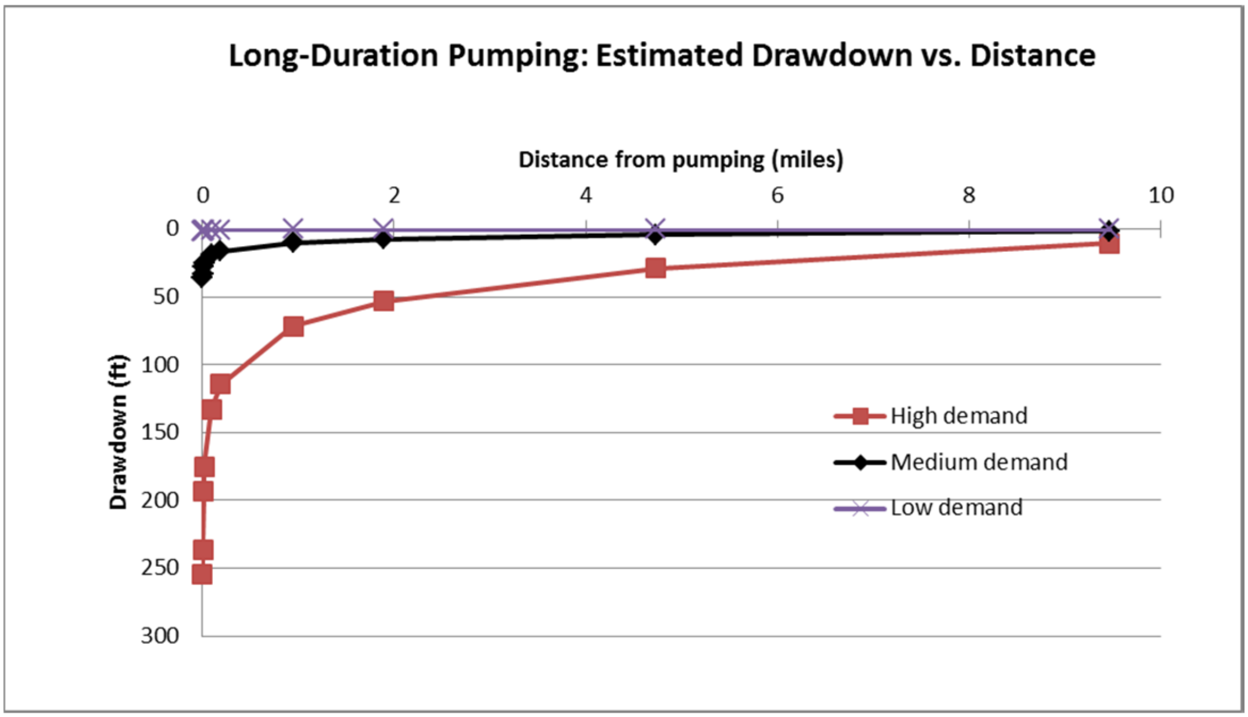


**Figure 3 Estimated Drawdown with Distance from a Single Pumping Well Supplying High, Medium, or Low SEZ Water Demands for a 20-year Period**

By applying the medium- and low-demand SEZ water requirements (Table 1), significantly smaller drawdowns are estimated (Figure 3). The medium-demand SEZ scenario produces about 28 ft (8.5 m) of drawdown within 50 ft (15 m) of the pumping well and about 8 ft (2.4 m) of drawdown at a distance of 2 mi (3.2 km), while the low-demand scenario produces about 1 ft (0.3 m) of drawdown within 50 ft (15 m) of the pumping well and 0.3 ft (0.09 m) of drawdown at a distance of 2 mi (3.2 km).

Note that multiple pumping centers might be located across this large SEZ. The pumping stresses would be distributed among these different locations. The pumping rate at any well would of course be a portion of the total in Table 1, and drawdown in the immediate vicinity of individual wells would therefore be decreased. At greater distances, however, the resulting drawdown should be similar to what would be caused by a single well pumping as modeled here.

Aquifer parameter values are expected to vary spatially. A means of assessing the effect of that variability on model output is to perform a sensitivity analysis on model input values. The parameters for hydraulic conductivity (K), specific yield (Sy), and aquifer thickness (b) were each adjusted by an increase or a decrease of 50% while holding the other parameters constant at the baseline level. In addition, order-of-magnitude increases and decreases in K were tested, and a larger Sy value of 0.2, corresponding to a coarse sand, was also tested. The tested values are consistent with the typical ranges for these parameters. For this modeling assessment, the medium-demand pumping case was analyzed because the high-demand case is less likely from a practical or water-rights perspective. The results are shown in Figure 4. Changes in K or b produced the same result, because they combine in the analytical model as the aquifer transmissivity (T) parameter. Conceptually, decreases in T (or K or b) are expected to produce a deep, localized cone of depression, whereas increases in T (or K or b) produce a shallower, broader cone of depression. Changes in Sy produce the inverse results. The order-of-magnitude increase in K produced significantly reduced drawdown. The order-of-magnitude decrease in K is not illustrated in Figure 4; this case produced unreasonably large drawdown, and a production well would not be screened across such a low-K zone.

The results in Figure 4 indicate fairly low sensitivity to drawdown at various distances across the ranges of parameters tested, with the exception of the greatly increased drawdown in close proximity to the pumping well when T (or K or b) is decreased.

### 4.2 Summary

The pumping associated with the high-demand water requirements (wet-cooled parabolic trough) yielded significant estimated drawdown at large distances from the SEZ. Determining whether water rights could be obtained to support such pumping requirements is beyond the scope of this study. However, the medium- and low-demand pumping requirements for the Dry Lake Valley North SEZ produce much less significant drawdown. These drawdown estimates may be useful in addressing concerns about water supply to other users in the basins and about ecological concerns related to spring flow or groundwater discharge to surface water bodies.

The SEZ pumping requirements can be compared to basin groundwater use in several ways. A summary sheet by NDWR (undated) lists the appropriations for Dry Lake Valley (HA 181) as 1,009 ac-ft/yr for irrigation, 18 ac-ft/yr for mining, and 38 ac-ft/yr for stock water (NDWR undated). Altogether, these uses are 1/19 of the requirement of high-demand SEZ pumping.

SNWA (2009a) provides an estimated groundwater flow out of Dry Lake Valley of 18,208 ac-ft/yr. This is less than the high-demand SEZ pumping of 20,112 ac-ft/yr. These comparisons do not consider water rights or other users in the basins.

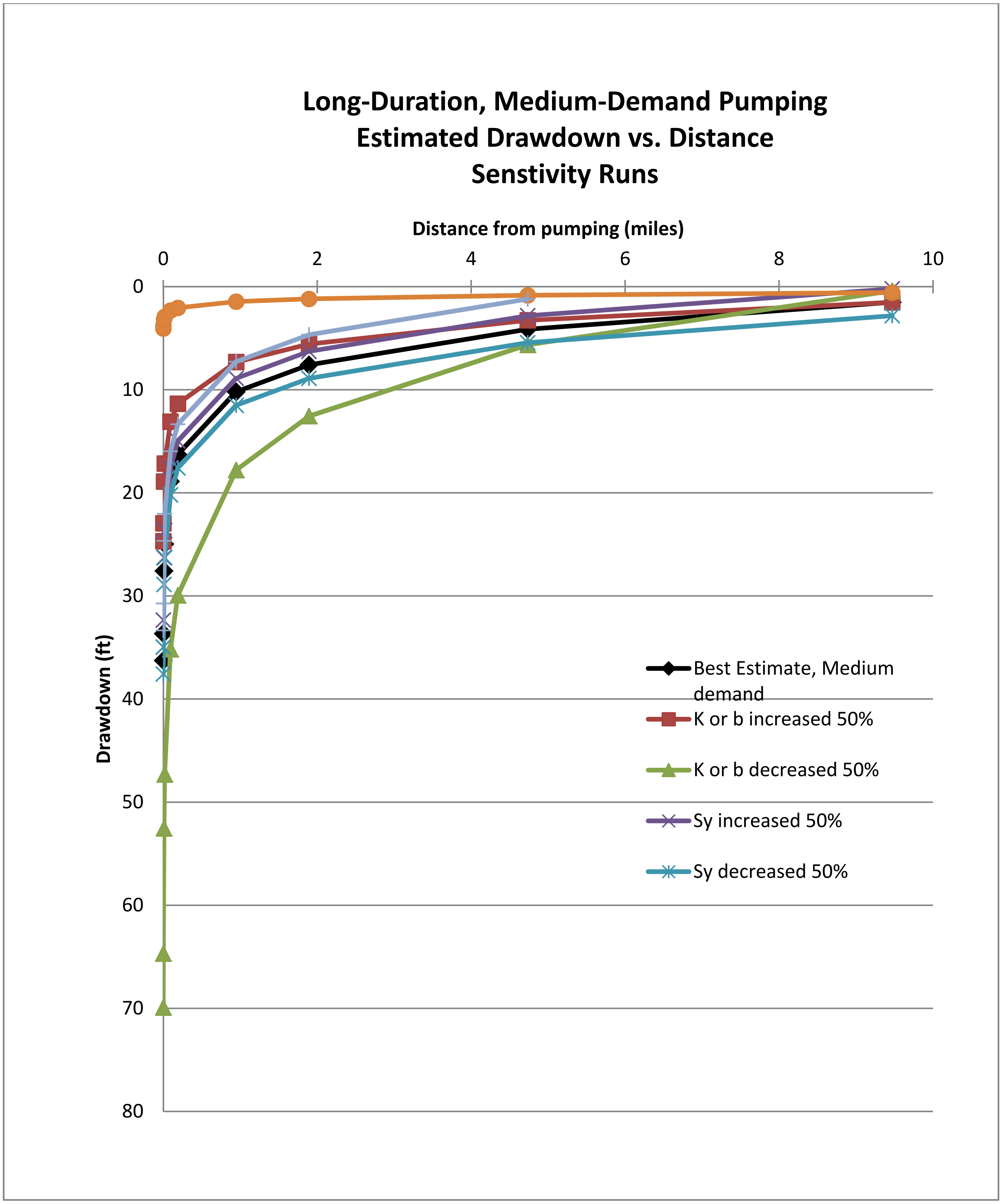


**Figure 4  Aquifer Parameter Sensitivity Analysis for the Medium-Demand Case of 2,864 ac-ft per year during a 20-year Period**

Development of groundwater resources is expected to remove water from aquifer storage, resulting in a long-term decline in water levels. Replenishment would occur at a slow rate if pumping ceased (Burbey 1997).

### 4.3 Implications for Future Model Development

Improvements in the current model could be made with the discovery or collection of new data regarding the hydrogeological framework and aquifer parameter values. Drilling for production or monitoring wells, for example, could generate high-quality drill logs that could refine the hydrogeologic framework and aquifer parameter values in the local vicinity of the SEZ. New wells could also provide water level data, and aquifer tests could provide aquifer parameter refinements. The nature of the alluvium is that it is highly variable spatially. Site-specific data would improve the design and accuracy where such improvements are most needed for assessing drawdown impacts.

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