Six-Month Operational Test of Testing Well
TW-E at Owens Lake

UPDATED TESTING PLAN

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LIST OF ACRONYMS AND ABBREVIATIONS

AQTESOLV	aquifer test analysis software
bgs	below ground surface
cfs	cubic feet per second
CEQA	California Environmental Quality Act
CSLC	California State Lands Commission
DTW	Depth to Groundwater
Eta	Evapotranspiration (actual)
ft	feet
GBUAPCD	Great Basin Unified Air Pollution Control District
GDEs	groundwater dependent ecosystems
gpm	gallons per minute
GPS	Global Positioning System
GWG	Groundwater Working Group
HRV	historical range of variability
HSLA	high strength, low alloy
HWG	Habitat Working Group
ICWD	Inyo County Water Department
IMFZ	Inyo Mountain Fault Zone
LAI	leaf area index
LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LORP	Lower Owens River Project
MCL	Maximum Contaminant Level

mg/l	milligrams per liter
MW	monitoring well
OLDM	Owens Lake Dust Mitigation
OLGDP	Owens Lake Groundwater Development Program
OLGEP	Owens Lake Groundwater Evaluation Project (2009-2012)
OLGM	Owens Lake Groundwater Model
ORFZ	Owens River Fault Zone
OVFZ	Owens Valley Fault Zone
PW	production well
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
SFIP	South Fault Investigation Project
RPC	Resource Protection Criteria
RP	Reference Point (for groundwater depth measurements)
RPPs	Resource Protection Protocols
RTK	Real-time kinematic positioning
SWRCB	State Water Resources Control Board
TAM	transmontane alkali meadow
TW-E	Testing Well East
TW-W	Testing Well West
USGS	U.S. Geological Survey
VDAs	Vegetated Dune Areas

1.0 INTRODUCTION AND PURPOSE

This document presents a proposed testing plan for a six (6)-month operational test of Testing Well East (TW-E), located at Owens Lake, California. Conducting the proposed operational test of TW-E is part of Owens Lake Groundwater Development Program (OLGDP), a component of Owens Lake Master Project. The Los Angeles Department of Water and Power (LADWP) convened the Owens Lake Master Project Advisory Committee (originally called the Owens Lake Planning Committee) to collaboratively work to develop a Master Project for Owens Lake. The goal of the Owens Lake Master Project is to control dust on the lake in a sustainable manner that maintains habitat, protects cultural resources, promotes public access and recreation, and reduces water use. The objective of OLGDP is to optimize groundwater management at Owens Lake by implementing groundwater banking in and around Owens Lake when excess Los Angeles Aqueduct (LAA) supply is available and utilize water beneath Owens Lake to provide a portion of water demand for dust mitigation in an environmentally sustainable manner. As has been noted throughout the development program, LADWP is utilizing an adaptive management strategy, meaning that the program will start at a small scale with extensive monitoring, and adjustments will be made to the program as more is learned about the hydrogeologic system through monitoring and modeling.

The purpose of the proposed 6-month operational test of TW-E in general is to:

- Resolve data gaps associated with the role of faults in groundwater flow at Owens Lake,
- Improve the understanding of the effects of pumping from deeper aquifers,
- Improve the Owens Lake hydrogeologic conceptual and numerical (computer) groundwater flow model (OLGM), and
- Assist in developing more robust measures to protect groundwater-dependent resources.

To achieve these goals, LADWP installed two (2) testing wells at the northern portion of Owens Lake in 2018, designated as TW-E, and Testing Well West (TW-W), shown on **Figure 1**. Following well construction, the contractor conducted 24-hour pumping/flowing tests, which provided useful but insufficient information. The tests were regarded as insufficient because the effect of pumping was very localized, meaning that the effect of longer-term pumping at diverse groundwater-dependent resource locations could not be adequately evaluated. Therefore, LADWP proposes to conduct longer-term operational tests.

As a conservative measure, LADWP plans to conduct the longer-term operational test on only one of the testing wells at a time. TW-E was selected for the longer-term operational test because the relatively lower pumping capacity at this location is more conservative and the groundwater quality is better at this location. A duration of six (6) months for the longer operational test is proposed. The test would begin in late September and be conducted within the dust season (mid-October through end of

June of the following year) to mimic conditions under which the well might eventually be operated to supply water for Owens Lake dust mitigation (OLDM).

The proposed 6-month operational test of TW-E is designed to allow for the collection of necessary data to:

- Improve the estimate of hydrogeologic characteristics of the aquifers in the northern portion of Owens Lake.
- Improve the understanding of how the Owens Valley and Owens River Fault Zones act as barriers of groundwater flow by collecting necessary data to estimate the horizontal conductivity in the vicinity of the faults.
- Measure the effect of pumping from TW-E on groundwater levels across the fault zones.
- Evaluate potential changes in shallow groundwater quality due to pumping deep aquifers.
- Utilize data collected to update and recalibrate the OLGM.
- The updated model would then be used to simulate various pumping scenarios to forecast the effect of pumping on groundwater-dependent resources in and around Owens Lake. Conducting the test will enhance the model's ability to replicate and predict field conditions, thereby greatly advancing the cause of protecting groundwater-dependent resources.

1.1 Document Version History

Originally published in January of 2020, a revised testing plan was distributed in May of 2020. An updated testing plan was published in October of 2020 along with responses to stakeholder comments. This updated testing plan for the Six-Month Operational Test of Testing Well TW-E at Owens Lake is dated February 2021. Compared with the previous October version, the February 2021 version incorporates minor clarifications and typographical corrections.

Figure 1: Overview of the Owens Lake, Showing the Location of TW-E and Previous Operational Test Wells Conducted by LADWP and Others

2.0 BACKGROUND

LADWP has been investigating the potential use of groundwater as a supplemental water source for OLDM since the late 1990s, and more recently since 2009. The effort has consisted of extensive data collection, field work, updating of the conceptual hydrogeologic model, and development of a numerical groundwater model for Owens Lake and surrounding area (Owens Lake Groundwater Model, or OLGM). LADWP has also been working with various regulatory entities, landowners, and stakeholders to establish guidelines for eventual utilization of groundwater for OLDM and the preparation of a monitoring and management framework under the California Environmental Quality Act (CEQA).

2.1 Previous Pumping Tests at Owens Lake

Several previous pumping tests have been conducted on TW-E and other wells at Owens Lake. While previous pumping tests at the SFIP, Fault Test, Mill, and River Site (see **Figure 1**) have improved the understanding of the Owens Lake hydrogeology on a localized scale, they had limitations in scope. As described in the following sections, these previous tests were conducted for a relatively short duration and/or with low pumping rates and limited monitoring because they were intended for evaluation of local aquifer properties. The recent short-term tests of TW-E and TW-W also had an insufficient pumping rate and duration, as well as relatively limited monitoring.

Because of these limitations, useful data for large-scale hydrogeologic and fault characterization could not be collected. Therefore, a longer-term test at a higher pumping rate is required at TW-E, and a greatly expanded monitoring program is proposed.

2.1.1 Pumping Test at Mill and River Sites (early 1990s)

In 1990 and 1991, aquifer tests were conducted at both the Mill and River sites (Jacobson et al., 1992).

The Mill site (**Figure 1**) consists of a production well screened from 110 to 255 feet depth with monitoring wells approximately 245 feet away screened at 110 to 130 feet and 220 to 240 feet depth. The well was pumped at an average rate of 1,500 gallons per minute (gpm) for a period of approximately three (3) months. During the test, a wetland monitoring program located just southwest of the site was conducted consisting of monitoring vegetation cover, density, biomass, and 12 shallow hand dug piezometers. Land surface elevation was also monitored for potential subsidence. Although the test yielded valuable data on the aquifer properties of the local shallow aquifer, impacts to wetlands were "basically undetectable", and there was "no measurable change in land surface" (Jacobson, et al., 1992).

The River site (**Figure 1**) consists of an upper production well screened from 155 to 225 feet depth, and a lower production well screened from 485 to 555 feet depth. Two monitoring wells are located approximately 340 feet from the upper production well, which was pumped at an average rate of 1,635 gpm for a period of approximately three (3) months. Similar to the Mill site, four (4) shallow hand dug piezometers were installed in a wetland area just west and south of the production well. Land subsidence was also monitored. Like the Mill site, although the test yielded valuable data on the aquifer properties of the local shallow aquifer, groundwater level variation in the wetland's piezometers "did not appear to be related to the drawdown due to the aquifer test" (Jacobson, et al., 1992).

A study evaluating impacts to wetlands over a 24-month period after both tests indicated no negative impacts to shallow groundwater levels, groundwater chemistry or vegetation in the wetlands due to the testing (Bair et al., 1995).

Although testing at both the Mill and River sites provided valuable information for estimation of local aquifer properties in the shallow aquifer in the vicinity of the sites, these sites are not correlative to testing of TW-E because they located east of the Owens River Fault Zone, and the pumped aquifer was in a different stratigraphic zone than the proposed for testing of TW-E. They do, however, indicate that pumping for an extended period (3 months) at rates higher than the proposed test at TW-E had no measurable impact on adjacent wetlands.

2.1.2 Pumping Test of Three Wells (SFIP, Fault Test, River Site)

In 2012, LADWP, in collaboration with Inyo County, performed two-month long pumping tests to evaluate local aquifer characteristics at three (3) wells (SFIP, Fault Test, and River Site [**Figure 1**]). The scope of those tests, however, was limited to the immediate vicinity of each well. Therefore, the data collected is not useful for the scope of the current evaluation. In addition, the previously tested wells were too far from the current study area near TW-E to characterize aquifer conditions. The River Site is located approximately 2.5 miles north of TW-E, while the Fault Test well is approximately 3.5 miles northeast of TW-E. Both wells are on the east side of the Owens River Fault Zone, meaning they are not representative of conditions where pumping for dust mitigation may occur on the west side of the Owens River Fault Zone. The SFIP well is located approximately 7.5 miles southeast of TW-E – too far away to aid in the current investigation. Monitoring during testing of SFIP, Fault Test, and River Site wells was also limited only to areas adjacent to the wells; therefore, widespread effects of pumping could not be documented. Additionally, some shallow monitoring wells associated with groundwater-dependent resources were not yet in place, meaning that the potential impact on resources could not be documented during the previous tests.

2.1.3 24-Hour Pumping Test of TW-E in 2019

Shortly after well construction, TW-E was pump tested for 24 hours in April 2019 at a rate of 800 gpm in accordance with the pumping rate and duration limits specified in LADWP's permit from the California State Lands Commission (CSLC). Due to the low pumping rate and duration of the test, aquifer response to the test was not observed in the majority of monitoring wells. Although the test provided data regarding the hydraulic characteristics near the TW-E wellbore itself, it did not provide larger-scale hydrogeological insight or data regarding fault characteristics.

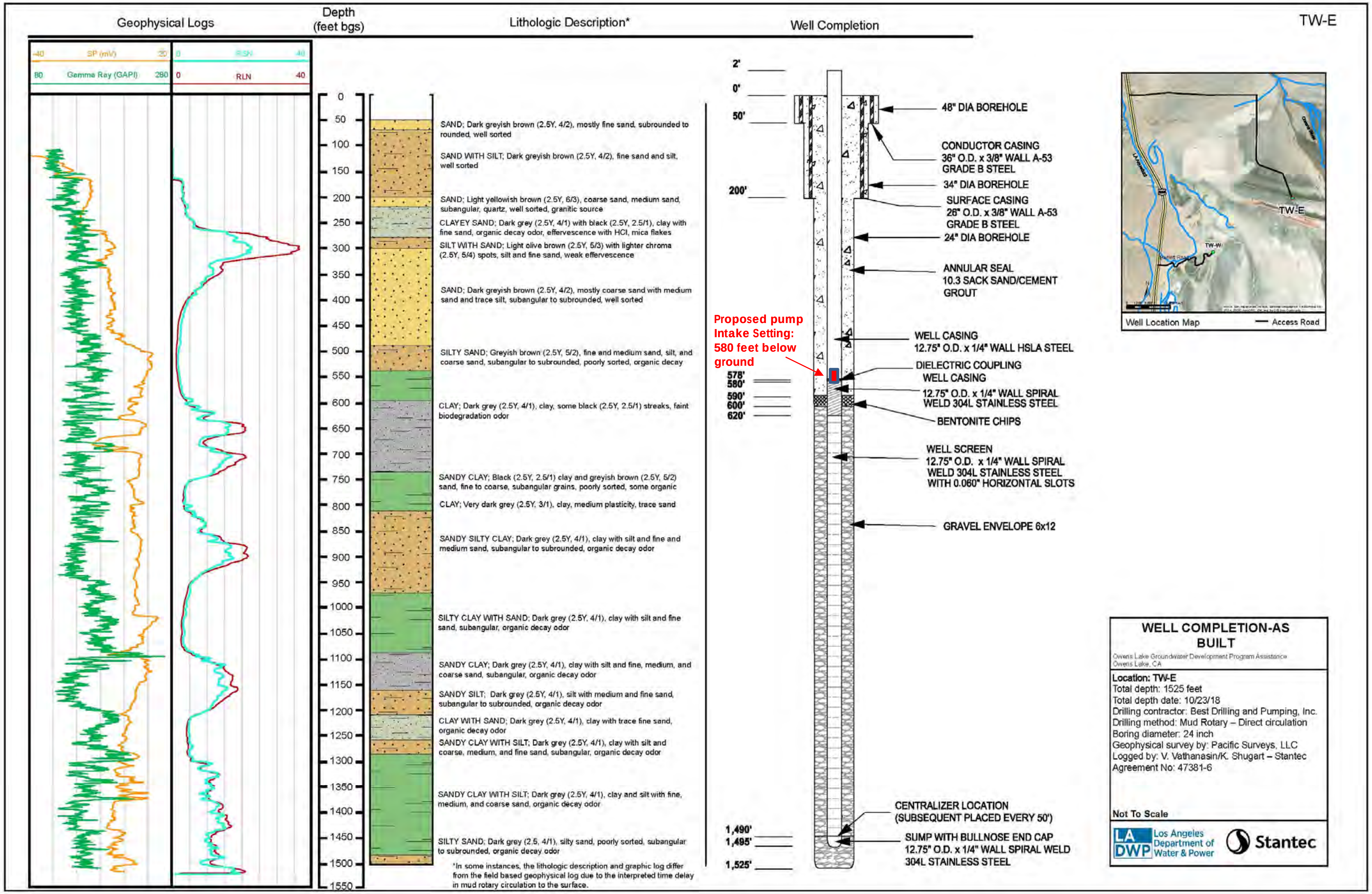
2.1.4 24-Hour Flowing Test of TW-W in 2019

Similar in construction but located approximately 2.5 miles southwest of TW-E, TW-W exhibits artesian flow of about 800 gpm. LADWP’s permit from CSLC for the pumping test limited the pumping rate to 800 gpm; therefore, a flowing test (in which the well is allowed to flow naturally without the assistance of a mechanical pump) was performed. Because the artesian discharge rate was insufficient to stress the aquifer, no response was observed in the observation wells. This test provided data characterizing the aquifer penetrated by TW-W but did not provide geographically widespread information that would assist in thorough hydrogeologic characterization beyond the vicinity of the pumping well.

2.2 Description of Well TW-E

Testing well TW-E was installed in 2018 as part of the effort to improve the understanding of the Owens Lake area hydrogeology and to collect the data necessary to describe the lithology of the aquifer in the northern portion of Owens Lake in the vicinity of the Owens River Fault Zone. TW-E was also intended to be utilized primarily for conducting operational tests to improve the understanding of aquifer characteristics near the well and to evaluate the role of Owens Valley and Owens River fault zones as barriers to groundwater flow.

TW-E is 1,495 feet deep and is screened from 620 to 1,490 feet depth. The casing and screen are 12 inches in diameter, consisting of high strength, low alloy (HSLA) steel material. **Figure 2** shows the geophysical log, lithological log, and as-built construction of the well. TW-E is an artesian well with approximately 50 feet of head above ground level.



SAND; Dark greyish brown (2.5Y, 4/2), mostly fine sand, subrounded to rounded, well sorted

SAND WITH SILT; Dark greyish brown (2.5Y, 4/2), fine sand and silt, well sorted

SAND; Light yellowish brown (2.5Y, 6/3), coarse sand, medium sand, subangular, quartz, well sorted, granitic source

CLAYEY SAND; Dark grey (2.5Y, 4/1) with black (2.5Y, 2.5/1), clay with fine sand, organic decay odor, effervescence with HCl, mica flakes

SILT WITH SAND; Light olive brown (2.5Y, 5/3) with lighter chroma (2.5Y, 5/4) spots, silt and fine sand, weak effervescence

SAND; Dark greyish brown (2.5Y, 4/2), mostly coarse sand with medium sand and trace silt, subangular to subrounded, well sorted

SILTY SAND; Greyish brown (2.5Y, 5/2), fine and medium sand, silt, and coarse sand, subangular to subrounded, poorly sorted, organic decay

CLAY; Dark grey (2.5Y, 4/1), clay, some black (2.5Y, 2.5/1) streaks, faint biodegradation odor

SANDY CLAY; Black (2.5Y, 2.5/1) clay and greyish brown (2.5Y, 5/2) sand, fine to coarse, subangular grains, poorly sorted, some organic

CLAY; Very dark grey (2.5Y, 3/1), clay, medium plasticity, trace sand

SANDY SILTY CLAY; Dark grey (2.5Y, 4/1), clay with silt and fine and medium sand, subangular to subrounded, organic decay odor

SILTY CLAY WITH SAND; Dark grey (2.5Y, 4/1), clay with silt and fine sand, subangular, organic decay odor

SANDY CLAY; Dark grey (2.5Y, 4/1), clay with silt and fine, medium, and coarse sand, subangular, organic decay odor

SANDY SILT; Dark grey (2.5Y, 4/1), silt with medium and fine sand, subangular to subrounded, organic decay odor

CLAY WITH SAND; Dark grey (2.5Y, 4/1), clay with trace fine sand, organic decay odor

SANDY CLAY WITH SILT; Dark grey (2.5Y, 4/1), clay with silt and coarse, medium, and fine sand, subangular, organic decay odor

SANDY CLAY WITH SILT; Dark grey (2.5Y, 4/1), clay and silt with fine, medium, and coarse sand, organic decay odor

SILTY SAND; Dark grey (2.5, 4/1), silty sand, poorly sorted, subangular to subrounded, organic decay odor

*In some instances, the lithologic description and graphic log differ from the field based geophysical log due to the interpreted time delay in mud rotary circulation to the surface.

WELL COMPLETION-AS BUILT

Owens Lake Groundwater Development Program Assistance
Owens Lake, CA

Location: TW-E
Total depth: 1525 feet
Total depth date: 10/23/18
Drilling contractor: Best Drilling and Pumping, Inc.
Drilling method: Mud Rotary – Direct circulation
Boring diameter: 24 inch
Geophysical survey by: Pacific Surveys, LLC
Logged by: V. Vathanasin/K. Shugart – Stantec
Agreement No: 47381-6

Not To Scale

Figure 2: Geophysical log, Lithological Log, and As-Built of Testing Well TW-E

3.0 PROPOSED OPERATIONAL TEST OF TW-E

To gather necessary hydrogeologic information, LADWP is proposing to pump TW-E continuously at an average rate of three (3) cubic feet per second (cfs) (approximately 1,350 gpm) for a period of six (6) months. This rate and duration are based on the drawdown characteristics of the well and practicality of maintaining a constant pumping rate for a period of six (6) months. The rate must be high enough to produce a detectable drawdown at some key monitoring locations, but low enough that the groundwater level in the pumping well does not drop to near the level of the pump intake and cause cavitation in the pump.

The proposed test is intended to be an operational test as opposed to a short-term aquifer test or “step” test. An operational test implies operation at a constant rate for a similar duration and pumping rate as proposed potential future operation in order to understand the effects of pumping on the groundwater regime and groundwater-dependent resources. A variable rate test, or step test is typically conducted to design a permanent pump and/or to calculate the well efficiency. A short-term aquifer test is typically performed to calculate aquifer characteristics in the vicinity of the pumping well. A step test and short-term aquifer test have already been completed at TW-E.

The proposed duration of the test (6 months) was selected to mimic the duration that potential future pumping for dust mitigation would occur. The pumping rate of 3 cfs was selected in order to pump at a high enough rate to observe and document effects, but not to cause excessive drawdown in the pumping well such that it approaches the top of the well screen. Based on extrapolation of data from the short-term pump test, and the drawdown during the initial 24-hour pumping test, approximately 300 feet of drawdown is expected during the initial portion of the test. Given an initial groundwater elevation of approximately 50 feet above ground level, this equates to a depth to groundwater of 250 feet. With a pump intake setting at 580 feet depth, this will keep the groundwater level well above the pump intake. Should these estimations prove in error, or a boundary effect causes an increase rate of drawdown, then the pumping rate can be adjusted downward or the test can be terminated.

The pump intake and pressure transducer will be installed in TW-E at depths of 580 and 560 feet below ground surface (bgs), respectively. These depths were selected to accommodate the expected drawdown inside the pumping well casing, having been simulated to produce approximately up to 400 feet of drawdown in the pumping well after 6 months, or a depth to groundwater of 350 feet (because of the 50 foot of artesian pressure before the test). The proposed duration will mimic the eventual potential conditions when pumping for dust mitigation is expected occur. The pumping rate and duration were also selected such that testing the well does will not impact groundwater-dependent resources based on simulations using the OLGM, as described in following sections.

It is imperative to pump at a low enough rate and duration so as not to impact groundwater-dependent resources, such as groundwater-dependent ecosystems including habitat at springs and vegetated dune areas (VDAs). It is also imperative to not cause harm to non-LADWP wells or to cause subsidence that could damage infrastructure.

To avoid impacts to groundwater-dependent resources, two primary methods will be utilized:

1) Simulate pumping TW-E at 3 cfs for 6 months using the OLGM and document the forecasted aerial extent of potential drawdown at groundwater-dependent locations, and
2) Perform extensive real-time monitoring of field conditions and employ a trigger mechanism that stops pumping before potential significant impacts occur.

Model simulation methods are described briefly in this section, while the results of simulations are described in Section 6.0. The extensive proposed monitoring is described in the following section (Section 4.0).

The OLGM was originally created in 2012 as part of the Owens Lake Groundwater Evaluation Project (OLGEP). Development of the hydrogeologic conceptual model and the numerical computer model of groundwater flow at Owens Lake was overseen by an independent OLGEP Blue-Ribbon Panel comprised of diverse experts in groundwater modeling and ecology, with experience from the U.S. Geological Survey (USGS), International Groundwater Modeling Center, academia, and private industry. The Blue-Ribbon panel also included active participation from partner agencies of the Great Basin Unified Air Pollution Control District (GBUAPCD) and the Inyo County Water Department (ICWD), as summarized in **Table 1** (MWH, 2012).

Full documentation of the OLGM (including a description of the activities of the OLGEP Blue-Ribbon Panel) are available on LADWP’s web site (www.LADWP.com/olg).

The 2012 version of OLGM was updated in 2020 and utilized to simulate the effects of pumping TW-E at a rate of 3 cfs. This was accomplished in two steps: first by running the model for a period of 6 months beginning in October without simulation of pumping TW-E, then repeating the same simulation with TW-E pumping at a rate of 3 cfs. The groundwater elevation difference between the two simulations represents the simulated drawdown due to pumping TW-E for 6 months.

The results of the simulation of pumping 3 cfs at TW-E was used as an aid in developing resource protection trigger mechanisms discussed in Section 6 by using the model to estimate the maximum area of influence of pumping TW-E at a rate of 3 cfs for a period of six months and to evaluate if the test would cause adverse effects on groundwater-dependent resources. The model indicated no adverse effects on groundwater-dependent resources. However, as explained in Section 6, the trigger levels have been proposed to ensure protection of groundwater-dependent resources independent of model results.

Table 1: OLGEP Blue-Ribbon Panel

Blue-Ribbon Panel Member	Affiliation	Expertise
Dr. John Bredehoft	Hydrodynamics	Retired U.S.G.S senior research geologist, founder of the Hydrodynamics Group
Dr. Terry McLendon	KS2 Ecological Field Services	Basin and Range vegetation, ecological modeling, groundwater-plant interactions
Ed O’Borny	BioWest	Invertebrate biology, wetlands habitats
Dr. Melih Ozbilgin	Brown and Caldwell	Water resources planning, groundwater modeling
Dr. Eileen Poeter	Poeter Engineering	Retired head of the International Groundwater Modeling Center (Colorado School of Mines), founder of Poeter Engineering
Dr. Mark Trudell	Worley-Parsons	Groundwater modeling and hydrogeologic conceptual models
Dr. Grace Holder	Great Basin Unified Air Pollution Control District	Geology, dust emission, institutional knowledge of Owens Lake investigations
Dr. Robert Harrington	Inyo County Water District	Hydrology, groundwater modeling, Owens Valley groundwater resources

4.0 MONITORING AND REPORTING PROGRAM

The monitoring program is designed to collect necessary information to achieve the stated goals for the 6-month operational test of TW-E. The current extensive monitoring of groundwater elevations and surface flow at Owens Lake will continue throughout the test. Data collected by other entities such GBUAPCD and ICWD also will be requested and utilized as part of the analysis of the data from the operational test.

It is expected that data collected from monitoring locations closer to TW-E (generally in the northern half of Owens Lake) will show more effect of pumping and will be more useful for analysis. However, even lack of any response at a monitoring location will be useful in delineating the area of influence when TW-E is pumped at a rate of 3 cfs for 6 months. It is important to note that the current hydrologic monitoring throughout the Owens Lake Area will continue prior to, during, and after the proposed test, and all data collected will be available to all parties.

The proposed monitoring program consists of measuring the groundwater pumping rate at TW-E as well as monitoring groundwater levels, barometric pressure, precipitation, surface water flows, and vegetation. Each of these monitoring components is discussed in this document in terms of location, monitoring method, and frequency.

Hydrologic measurement data will be collected at a total of 181 monitoring locations (see **Figure 3** and **Figure 4**), including 142 monitoring wells (93 primary and 49 secondary), 26 flow measuring flumes, seven (7) meteorological sites, five (5) ground elevation monitoring sites, and the one (1) pumping well (TW-E).

It should be noted that monitoring at non-LADWP wells is subject to permission by the well owners. Several of the non-LADWP wells serving specific communities, such as Keeler Community Service District well or Cartago Mutual Water Company well, are monitored by the well owners, and the data are submitted to the State Water Resources Control Board (SWRCB) and made available to the public. A few of the private domestic non-LADWP wells, including O'Dell and Mortensen wells, are not equipped to allow groundwater level measurements. In these cases, nearby LADWP monitoring wells will be utilized.

The Monitoring and Reporting Program presented in this section is organized as follows:

- Data Collection Frequency
- Monitoring Locations
- Reporting Interval
- Groundwater Quality Sampling and Monitoring
- Vegetation Monitoring

Subsequent sections of the proposed testing plan described in this document include:

- Associated Field Activities (Section 5)
- Protection of Groundwater-Dependent Resources (Section 6)
- Data Analysis (Section 7)

Figure 3: Testing Well TW-E Operational Test Monitoring Wells

Figure 4: Surface Water and Meteorological Monitoring Locations for Operational Test of TW-E

4.1 Data Collection Frequency

Figure 5 and **Table 2** illustrate the data collection frequency during the proposed 6-month operational test of TW-E, which is also described in the text below.

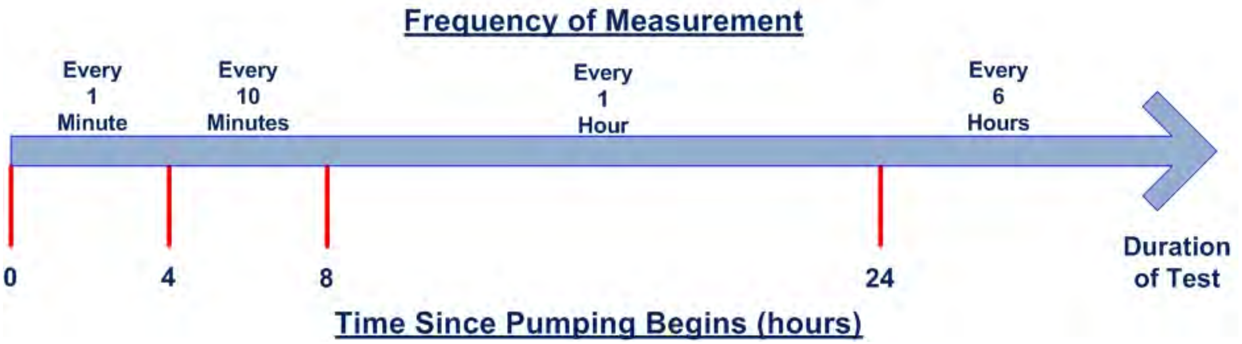


Figure 5: Data Collection Frequency at TW-E during the Six-Month Operational Test

Pre-Test Monitoring (minimum 30 days prior to the test) will be performed at TW-E, monitoring wells, flumes, meteorological stations, and land elevation stations as described below.

- At **TW-E**, groundwater levels will be collected using a transducer at intervals of 4 hours to document background trends, beginning approximately 30 days prior to beginning the operational test.
- Approximately 30 days prior to commencement of the 6-month operational test at TW-E, LADWP will ensure that groundwater level data in **monitoring wells** is recorded at a minimum frequency of every four (4) hours with a pressure transducer to document background variations in groundwater levels, where practical. At the time when pressure transducers are installed in monitoring wells, the transducer depth in the well and submergence depth will be correlated with a manual depth to water measurement using an electric water level sounder and recorded. This process of comparing transducer measured groundwater level with the manual measurement will be repeated every time transducer data is downloaded to ensure accuracy of data collected by transducer and corrected if there is a difference between manual and transducer collected data.
- Monitoring of surface waters using **flumes** with transducers will continue to be collected on an hourly frequency, beginning approximately 30 days prior to the start of testing.
- **Meteorological** data collection consisting of relative humidity, barometric pressure, temperature, precipitation, and evaporation will continue at an hourly frequency starting approximately 30 days before the test begins (meteorological stations are described later in the text in **Table 6**).

- **Ground elevation** monitoring will be performed within one month prior to commencement of the operational test.

Pumping Phase Monitoring during testing will be conducted at TW-E, monitoring wells, flumes, meteorological stations, and ground elevation stations as described below.

- To capture the potential drawdown details in the pumping well **TW-E** (while limiting the total amount of data to be stored in the pressure transducers) during the first four (4) hours of the operational test, pressure transducer data will be recorded every minute followed by four (4) hours at 10-minute intervals. Hourly data will be recorded after the first eight (8) hours of pumping until 24 hours, followed by regular maximum 6-hour interval data collection through the end of the operational test, as shown in **Figure 5**. The pumping rate of TW-E during the 6-month pumping test will be monitored using a totalizing flow meter. Instantaneous flow measurements and the total amount of groundwater pumped will be recorded manually every 30 minutes for the first 4 hours of testing to adjust discharge rate and maintain consistent discharge. Manual readings of totalizer data and groundwater elevation will also be recorded daily for the first week of the operational test followed by weekly measurements until the end of the test.
- Measurement and recording of groundwater levels at **monitoring wells** will continue at a frequency of 4 hours during the operational test.
- Monitoring of surface water flows using **flumes** with transducers will be collected on an hourly frequency during the pumping phase.
- **Meteorological** data collection consisting of relative humidity, barometric pressure, temperature, precipitation, and evaporation will continue at an hourly frequency during the operational test.
- **Ground elevation** monitoring will be performed 3 months after beginning the test, and at the end of the pumping phase.

Post-Pumping Phase/Recovery Monitoring will be conducted at TW-E, monitoring wells, flumes, meteorological stations, and ground elevation stations as described below.

- At **TW-E** during the recovery portion of the operational test, groundwater levels will be recorded via the pressure transducer at intervals similar to the beginning of pumping (**Figure 5**), that is one-minute intervals for the first 4 hours, followed by 10-minute intervals for 4 hours, then hourly for 24 hours, and finally every 4 hours up to a minimum of 180 days after conclusion of the operational test. At 180 days after termination of pumping phase, one manual groundwater level measurement will be performed, and the pressure at the transducer will be checked against manual measurement of groundwater level. From the 180 days on, data collection will continue as current monitoring program and data will made available on request.

- Monitoring at **monitoring wells** will continue at a frequency of 4 hours for a minimum of 180 days after the operational test. From the 180 days on, data collection will continue as current monitoring program and data will made available on request.
- Monitoring of surface waters using **flumes** with transducers will be collected at a frequency of 4 hours for a minimum of 180 days after the operational test.
- **Meteorological** data collection consisting of relative humidity, barometric pressure, temperature, precipitation, and evaporation will continue at an hourly frequency for a minimum of 180 days after the operational test.
- **Ground elevation** monitoring will be performed 3 months and 6 months after the test, if the surveying at the end of the pumping phase shows evidence of land subsidence.

Table 2: Groundwater Related Data Collection Frequency

TW-E[1]	30 Days Prior to Start	First 4 Hours	Second 4 Hours	8 to 24 Hours	After 24 Hours
Prior and during Pumping Phase	4 hours	1 minute	10 minutes	Hourly	4 hours
During Recovery (180 days)	N/A	1 minute	10 minutes	Hourly	4 hours
Totalizer Data Collection	**First 4 Hours**	**First Week**			**After First Week**
	30 minutes	Daily			Weekly

MONITORING WELLS[2]	30 Days Prior to Start	During Testing	180 Days After End
Transducer Data Collection Interval	4 Hours	4 Hours	4 Hours

FLUMES[2]	30 Days Prior to Start	During Testing	180 Days After End
Transducer Data Collection Interval	Hourly	Hourly	4 Hours

Meteorological data	30 Days Prior to Start	During Testing	180 Days After End
Data Collection Interval	Hourly	Hourly	Hourly

Notes:

[1] Manual measurement using an electric probe at TW-E will be taken and compared to the accompanying transducer readings at TW-E during installation and removal of the transducer, and during each transducer data download event.

[2] Manual readings at monitoring wells and flumes will be taken and compared to the accompanying transducer reading 30 days prior to the start of the test,10 days after the end of the test, and during each transducer data download event.

4.2 Monitoring Locations

Five (5) types of data will be collected before, during, and after the proposed 6-month operational test of TW-E:

- Groundwater-related monitoring
- Surface water monitoring
- Ground surface elevation monitoring
- Meteorological monitoring
- Vegetation monitoring

4.2.1 Groundwater Related Monitoring

The largest type of data collection effort will be the measurement of groundwater levels from monitoring wells. **Table 3** lists details on the 142 monitoring wells, including monitoring well number, depth, distance from the pumping well, and direction from TW-E, as well as specific comments related to each well. **Table 2** is organized by compass direction from TW-E, starting in the southwest and rotating clockwise.

Commenters on the initial version of this testing plan noted that a large number of monitoring locations are proposed, for some of which there is little possibility that drawdown would be noted. In response to this comment, **Table 3** has been subdivided into 91 “primary” locations (**Table 3A**) and 49 “secondary” locations (**Table 3B**). The subdivisions are based on modeling of the proposed test, whereby the effects of pumping are limited to the northern portion of the lake (which are designated primary locations in **Table 3**). Because all locations on **Table 3** are monitored by LADWP as part of an on-going monitoring program, the primary and secondary locations are undifferentiated in terms of monitoring frequency.

A subset of the primary wells will be used as trigger wells as discussed later in Section 6. These wells are shown in **bold font** in **Table 3A**.

Data collected from secondary monitoring locations shown in **Table 3B** will be extremely valuable to document whether there is any effect of pumping TW-E in the areas beyond the northern portion of Owens Lake.

Table 3: Wells to be Monitoring as part of Operational test of TW-E

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
	Table 3A – Primary Monitoring Locations **Note:** Trigger wells discussed in Section 6 are shown in **bold font**				
1	TW-E	1,500	--	--	Pumping Well
2	**T920**	**248**	**W-SW**	**3.9**	**In alluvial fan west of the Lake, west margin of OVFZ, horizontal gradient well**
3	**T919**	**73**	**W**	**2.8**	**Near Northwest Spring, east margin of OVFZ, horizontal gradient well**
4	MW-4S	160	SW	2.8	On alluvial fan just west of ORFZ
5	MW-4D	590			
6	TW-W	890	SW	2.5	Testing Well, east of OVFZ
7	MW-5S	240	SW	2.3	On Lakebed, just east of OVFZ, north of TW-W
8	MW-5I	460			
9	MW-5D	660			
10	**MW-2**	**295**	**W**	**3.65**	**On alluvial fan NW of Lake, horizontal gradient well**
11	**MW-3**	**265**	**W-NW**	**4.2**	**On alluvial fan west of Lake, horizontal gradient well**
12	**T918**	**68**	**NW**	**3.8**	**At Dearborn Spring, in OVFZ, horizontal gradient well**
13	Dearborn Spring Well	25	W-NW	3.5	In Dearborn Spring, west main splay of OVFZ
14	**P1L**	**33**	**W**	**2.9**	**At Northwest Spring, horizontal and vertical gradient, drawdown trigger well**
15	**P1U**	**5**			
16	**T858**	**30**	**N-NW**	**6.5**	**Southeast of Hwys 136 and 395 intersection, non-LADWP wells trigger well**
17	T930	68	NW	5.8	In alluvial fan, west of OVFZ
18	O’Dell Well	205	W-NW	4.3	In alluvial fan, west of main splay of OVFZ
19	T347	22	NW	3.8	Just north of Lakebed

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
20	Down Valley North	1,038	N-NW	6	North of Lake, east margin of ORFZ
21	Down Valley North	438			
22	Down Valley North	592			
23	Down Valley North	722			
24	Down Valley South	440	N-NW	5.5	North of Lake, east margin of ORFZ
25	Down Valley South	598			
26	Down Valley South	719			
27	T890	1,500	N	5.3	Cluster monitoring wells, West margin of ORFZ; DWP-1 site
28	T891	540			
29	T892	390			
30	MW-6S	70	N-NW	3.8	Multi-completion well, north of Lubken Mainline Road
31	MW-6I	360			
32	MW-6D	440			
33	MW-7S	65	NW	3.8	Multi-completion well, northwest of Lubken Mainline Road
34	MW-7I	310			
35	MW-7D	495			
36	T348	800	NW	3.4	South of Lubken mainline Road
37	T348S	24	NW	3.4	Shallow well just south of T348
38	**T931**	**62**	**NW**	**3.7**	**In VDA-1, between OVFZ and ORFZ**
39	VSUMP	7	NW	3.2	Between lakebed and OVFZ
40	VDA-1	17	N-NW	2.8	Vegetated Dune Area
41	**T902a**	**55**	N-NW	3	Cluster monitoring wells, between OVFZ and ORFZ, trigger well; DWP-10 site
42	T903	800			
43	T904	380			
44	Delta W(1)	4	**N-NW**	**2.5**	**Margin of lakebed, between OVFZ and ORFZ, south of VDA-1**
45	**Delta W(1)**	**10**			
46	Delta W(3)	10	W-NW	1.7	On lakebed, between OVFZ and ORFZ
47	MW-8S	560	N-NW	3.1	Multi-completion well, northeast of Lubken Mainline Road
48	MW-8I	370			
49	MW-8D	65			

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
50	T349	40	N-NW	3.1	North of Lubken Mainline Road
51	T893	1,530	N	3	Cluster monitoring wells, In ORFZ; Site DWP-2
52	T894	1,270			
53	T895	960			
54	River Site Lower	515	N	2.5	Monitoring wells at River Site just east of ORFZ
55	River Site Upper	230			
56	River Deep PW	555	N	2.5	Shallow and deep pumping well at River Site east of ORFZ
57	River Shallow PW	225			
58	Delta E(1)	4	N	2.1	Shallow monitoring wells on lakebed, between OVFZ and ORFZ
59	Delta E(1)	10			
60	T896	1,360	N	0.6	Cluster monitoring wells, Between OVFZ and ORFZ; Site DWP-9
61	T897	860			
62	T898	320			
63	**T929**	**88**	**NE**	**3.4**	**Near Lizard tail, in IMFZ, east of Hwy 136, trigger well**
64	**Lizard Tail**	**10**	**NE**	**3.0**	**Next to Lizard tail Mound,**
65	**VDA-3b**	**20**	**NE**	**3.1**	**Vegetated Dune Area**
66	**VDA-2-1**	**18**	**N-NE**	**3**	**Vegetated Dune Area**
67	VDA-2-2	25	NE	3.2	Vegetated Dune Area
68	C5(1)	10	NE	2.3	Between ORFZ and IMFZ
69	C5(2)	4	N	2.3	Between ORFZ and IMFZ
70	Swansea Domestic Well		**E-NE**	**4.1**	**In Swansea just east of Hwy 136**
71	**VDA-5**	**29**	**E**	**4**	**Vegetated Dune Area**
72	D.5(1)	10	E	4.1	In IMFZ
73	FTS-T1	726	E-NE	3.4	East margin of IMFZ
74	FTS-T2S	154			
75	FTS-T2D	435			
76	FTS-T3	430			
77	FTS-T5	425			
78	FTS-T6	173			
79	6(1)	4	NE	3	In IMFZ
80	**VDA 8-2**	**19**	**E-SE**	**5.7**	**Vegetated Dune Area**

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
81	**P8L**	**32**	**E-SE**	**4.7**	**At Horse Pasture Spring, vertical gradient wells**
82	**P8U**	**7**			
83	**Staging Area**	**24**	**E**	**4.1**	**East of TW-E, trigger well for VDA-6**
84	Keeler-Swansea Lower	390	E	4.4	East of IMFZ and Keeler Fan Fault Zone
85	Keeler-Swansea Mid	190			
86	Keeler-Swansea Upper	135			
87	Dead Hawk Spring	10	E	3.7	Located at Dead Hawk Wetland
88	T899	1,003	SE	3.6	Cluster monitoring wells, West margin of IMFZ; Site DWP-3
89	T900	720			
90	T901	190			
91	VDA-10	25	SW	6.8	Vegetated Dune Area
92	G9(1)	10	E-SE	6.2	East margin of IMFZ
93	Keeler (1)	10	E-SE	5.5	East margin of IMFZ
Table 3B – Secondary Monitoring Locations					
94	T928	93	SE	7.5	Near Swedes Pasture, east margin of IMFZ, horizontal gradient well
95	P6L	34	SE	7.9	At Swedes Spring, vertical/horizontal gradient wells
96	P6U	5			
97	Mill site	130	SE	7.5	Nested monitoring wells
98	Mill site	240			
99	Mill site	255			
100	P7L	34	SE	7.6	At Mill Spring, vertical gradient wells
101	P7U	4			
102	I10(5)	4	SE	7.4	East margin of IMFZ
103	Star Trek	784	SE	5.8	On Lakebed, in IMFZ
104	J10(1)	10	SE	8.5	East margin of IMFZ
105	K10(2)	4	SE	8.6	In IMFZ
106	L9(1)	10	S-SE	8.8	In ORFZ

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
107	M8(1)	10	S-SE	9.4	In ORFZ
108	T927	68	S-SE	10	Near Trucksticker, in ORFZ
109	P5aL	36	S-SE	9.9	At Trucksticker, vertical gradient wells
110	P5aU	8			
111	P5L	36	S	10.3	At Tubman spring, vertical/horizontal gradient wells
112	P5U	4			
113	N7(3)	10	S-SE	10.1	In ORFZ
114	SFIP PW	250	S	7.1	12” Dia., Test well, west margin of ORFZ
115	SFIP MW	250			5” Dia. Monitoring well, West margin of ORFZ
116	T914	1,500	S-SE	7.1	Cluster monitoring wells, In ORFZ; Site DWP-5
117	T915	1,088			
118	VDA-14	30	S	12.2	Vegetated Dune Area
119	P5(1)	4	S	11.4	East margin of OVFZ
120	T911	1,460	S	9.6	Cluster monitoring wells, south end of Lake, between OVFZ and ORFZ; Site DWP-6
121	T912	1,060			
122	T913	300			
123	VDA-15	30	S	12.9	Vegetated Dune Area
124	S3(3)	10	S	12.3	In OVFZ
125	T925	78	S	14.7	South end of Lake
126	P4L	34	S	14.7	At Olancha Spring, vertical gradient wells
127	P4U	8			
128	T908	1,400	S-SW	12.7	Cluster monitoring wells, In OVFZ; Site DWP-7
129	T909	780			
130	T910	240			
131	T924	178	SW	13.4	In alluvial fan west of the Lake, west of OVFZ
132	T923	113	S-SW	9.4	At base of alluvial fan near Ash Creed, west of OVFZ, horizontal gradient well
133	P3L	34	S	9.1	At Ash Creek Spring, vertical/horizontal gradient wells
134	P3U	8	S	9.1	
135	OL-92-2	1,059	S	8.6	USGS well on Lakebed, between OVFZ and ORFZ
136	T905	1,500	S-SW	5.6	Cluster monitoring wells, West of OVFZ; Site DWP-8
137	T906	530			
138	T907	330			

No.	Well ID	Depth (feet)	Direction from TW-E	Distance from TW-E (miles)	Notes
139	T922	133	S-SW	9.5	At base of alluvial fan near Cottonwood, west of OVFZ, horizontal gradient well
140	T921	263	SW	5.6	In alluvial fan west of the Lake, west of OVFZ
141	P2L	33	S-SW	5.6	At Cottonwood Spring, vertical/horizontal gradient wells
142	P2U	8			

Notes: OVFZ – Owens Valley Fault Zone, ORFZ – Owens River Fault Zone, IMFZ – Inyo Mountain Fault Zone

Monitoring groundwater gradient is an important component of hydrologic monitoring program at Owens Lake. **Table 4** lists monitoring wells that will be utilized to monitor groundwater gradient toward springs around Owens Lake; these locations are shown on **Figure 6**. The monitoring wells associated with the calculation of horizontal and vertical groundwater gradients are part of current monitoring program at Owens Lake and will continue to be monitored throughout the proposed operational test of TW-E. Hydrographs of key monitoring wells and their associated groundwater gradients are provided in **Appendix A.** Additional information on groundwater gradients is provided in the introductory portion of Section 6.

Table 4: Monitoring Wells Utilized to Calculate Groundwater Gradient to Springs around Owens Lake

Gradient Type	Up-Gradient Location	Down-Gradient Location	General Location on the Margins of Owens Lake
Vertical	P1 (30)	P1 (5)	Northwest (Northwest Spring)
	P2 (30)	P2 (5)	West-Central (Cottonwood)
	P3 (30)	P3 (5)	Southwest/Central (Ash Creek)
	P4 (30)	P4 (5)	South (Olancha)
	P5 (30)	P5 (5)	Southeast/Central (Tubman)
	P5a (30)	P5a (5)	East (Trucksticker)
	P6 (30)	P6 (5)	East (Swedes Pasture)
	P7 (30)	P7 (5)	East (Mill Site)
	P8 (30)	P8 (5)	Northeast (Horse Pasture)
Horizontal	MW-3	T918	Northwest
	MW-2	P1 (5)	Northwest
	T920	T919	Northwest
	T922	P2 (5)	West-Central
	T923	P3 (5)	Southwest/Central
	T926	P4(5)	South
	T927	P5a (5)	South/Southeast
	T928	P6 (5)	Southeast
	T929	Lizard tail	Northeast

Note: Locations are shown on **Figure 6**. Numbers in parentheses indicate the depth of the piezometer (U for "Upper" [5 feet], and L for "Lower" [30 feet]) on **Figure 6**.

Figure 6: Monitoring Well Locations Utilized for Groundwater Gradient Calculations

4.2.2 Surface Water Monitoring

The second type of monitoring is surface water flow measurements at all existing sites where flow can be measured. **Table 5** lists existing flow measurement sites, and locations are shown on **Figure 4**.

Table 5: Existing Flow Measuring Flumes to Continue Monitoring

Number	Location
1	Lizard Tail Seep
2	Dead Hawk
3	Black Sand
4	Horse Pasture 3" Flume
5	Horse Pasture 2" Flume
6	Keeler Flowing Well
7	Bonsai Mound
8	Sulfate Flowing Well
9	Carbide Dump
10	Mill Site Flowing Well
11	Swedes Pasture
12	Mambo
13	Indian Creek
14	L9 Ditch
15	Truck Sticker
16	Tubman Channel
17	Cement Pond
18	Whiskey Springs
19	Wahoo
20	Georgia O'Keefe
21	Kaiser Permanente
22	Cottonwood Spring (W3)
23	PPG Flowing well (W4)
24	Bartlett Flowing well (W5)
25	Northwest Spring
26	Rio Tinto

Flow measurements will continue throughout the operational test. Current flow measurement frequency is on an hourly basis, which is recorded using data loggers. LADWP will download flow measurement data from these sites approximately 10 days prior to the start of the operational test to ensure monitoring is continuing. Data downloaded from the flumes during the operational test will be according to the schedule shown in **Table 2**.

All other existing surface water flow measuring flumes throughout the Owens Lake area will continue to be monitored during the operational test of TW-E.

4.2.3 Meteorological Monitoring

Meteorological parameters will be monitored at seven (7) existing LADWP and GBUAPCD weather sites during the operational test as shown on **Figure 4**. The meteorological parameters to be recorded at the stations are listed in **Table 6**.

Table 6: Parameters to be Monitored at Meteorological Sites at Owens Lakes

Station Name	Relative Humidity	Barometric Pressure	Temperature	Precipitation	Evaporation
A-Tower	**Yes**	No	**Yes**	**Yes**	No
1552	No	No	No	**Yes**	No
OL North	**Yes**	No	**Yes**	**Yes**	**Yes**
Cottonwood	No	No	**Yes**	**Yes**	No
Mill	**Yes**	No	**Yes**	**Yes**	No
Olancha	**Yes**	**Yes**	**Yes**	No	No
T7	**Yes**	**Yes**	**Yes**	No	No

4.2.4 Ground Elevation Monitoring

Land subsidence occurs when a large volume of groundwater is pumped for a long period of time from a groundwater aquifer. As observed earlier in testing of the Mill and River sites, the proposed 6-month operational test is not expected to be long enough or pumping at a high enough rate to cause subsidence. In addition, the recovery cycle after the 6-month test allows for recovery of groundwater levels. However, ground surface elevation will be monitored as part of the monitoring program before, during, and after the operational test of TW-E.

Table 7 lists existing LADWP ground surface monitoring locations on Owens Lake; locations are shown on **Figure 7.** Five (5) sites are selected to be the ground elevation monitoring locations owing to their close proximity to TW-E (i.e., 7012) and to assess potential subsidence impacts on the east side of the Owens River Fault (i.e., 6527 and 6532) and the west side of the Owens Valley Fault Zone (OVFZ - i.e., 6371 and 6372).

Ground elevation will be monitored:

- one (1) time within one (1) month prior to commencement of the 6-month operational test,
- three (3) months after commencement of the operational test, and
- at the end of the operational test (6 months).

Ground elevation surveys will be completed using a Trimble RTK system consisting of a Trimble R8 global positioning system (GPS) receiver for a base unit, and a Trimble R10 GPS receiver for the rover unit. The base unit sets on a control point and broadcasts the correction to the receiver using an ultra-high frequency radio transmitter which is received by the R10 rover unit. The data is processed and gathered using a Trimble TSC3 control unit.

Real-time kinematic positioning (RTK) is a satellite navigation technique used to enhance the precision of the position data from the satellite-based positioning system. It uses measurements of the phase of the signal's carrier wave in addition to the information content of the signal and relies on a single reference station to provide real-time corrections, providing up to centimeter-level accuracy.

As previously noted, no change in ground elevation is expected; however, if it does occur, it will provide valuable knowledge of the relationship between pumping deeper aquifers and effects at the surface and the potential for elastic rebound of the aquifers. This knowledge will greatly enhance development of future pumping plans and the adaptive management process.

Table 7: Existing LADWP Ground Elevation Monitoring Locations, Method, and Frequency

Subsidence Monitoring Location ID*	General Location	Measurement Method	Frequency (prior to, during and after long-term operational test)
6371	Within the OVFZ	Survey	Within 1 month prior, at 3 and 6 months during, and at 3 and 6 months after, the latter, if warranted
6372	Within the OVFZ	Survey	
6527	East of Owens River Fault	Survey	
6532	East of Owens River Fault	Survey	
7012	Southwest of TW-E	Survey	

Note: * Locations shown on **Figure 7**.

Figure 7: Locations of Ground Elevation Monitoring Sites during Operational Test of TW-E

4.2.5 Vegetation Monitoring

Vegetation monitoring will be conducted during the operational test to 1) document any potential changes in vegetation activity as a result of the operational test and 2) inform future development of monitoring protocols. Vegetation monitoring will occur before and after the operational test because the operational test is anticipated to occur during the winter months when vegetation is dormant. Vegetation monitoring is focused on two specific resource areas: springs and associated alkali meadow and VDAs. Each is described below.

- **Springs and Associated Alkali Meadows.** From 2014 through 2018, LADWP worked with the Habitat Work Group (HWG) and the Groundwater Work Group (GWG) to develop the "*Resource Protection Protocol for Springs and Associated Alkali Meadows at and around Owens Lake (RPP)*" (Owens Lake Habitat Work Group, 2018). The RPP identifies criteria, protocols, and management actions to prevent significant impacts to springs and associated alkali meadow resources due to groundwater pumping. Appendix A of the RPP (Technical Approach) details the rational, methods, and data analysis techniques used to monitor and identify changes in vegetation productivity (i.e., Leaf Area Index or LAI) and acreage. Identified changes are then statistically compared to the historical range of variability (HRV) and used to trigger tiered management actions. Vegetation monitoring during the operational test will be consistent with the methods outlined in Appendix A of the RPP.
- **Vegetated Dune Areas.** LADWP, in collaboration with the HWG and the GWG, is currently developing an RPP to protect VDAs from potential impacts due to groundwater pumping. In February 2020, a Workplan was developed for VDA RPP that describes data collection and analysis methods to 1) quantify baseline conditions to inform development of Resource Protection Criteria (RPC), 2) identify monitoring protocols to achieve the RPC, and 3) develop triggers for further resource evaluation or management actions. Given the complex nature of the vegetated dune system around the playa, the VDA RPP Workplan is being implemented in a phased approach.
    - Phase 1 includes historical baseline data analysis of vegetative cover, evapotranspiration (ETa), and LAI on all VDAs, as well as detailed data collection, characterization, and monitoring on four VDAs. Additional characterization will be conducted on three VDAs on the southeast shore of Owens Lake playa. These datasets will be used to develop a generalized conceptual model, identifying (to the extent possible) the major drivers influencing changes in vegetative cover within the VDAs. This includes vulnerability to changes in groundwater levels that could occur as a result of groundwater pumping.
    - Phase 2 will use the information from Phase 1 to develop appropriate RPCs and monitoring protocols, which will then be scaled to all VDAs.

Implementation of the VDA RPP Workplan is anticipated to be complete prior to the operational test. Vegetation monitoring is anticipated to include remote sensing-based methods for estimating leaf area index (LAI) and actual evapotranspiration (ETa). Monitoring methods may be further refined based on results of workplan implementation.

4.3 Reporting Interval

All of the data collected during the proposed operational test of TW-E will be made available to any interested stakeholder in a timely manner. Measurement data may be revised after quality assurance/quality control (QA/QC) of collected data. The following a description of data reporting for different types of data collected.

Groundwater level data collected from monitoring locations list in **Table 3B**, surface water data listed in Table 5 and meteorological data listed in **Table 7** are generally downloaded once every two months and after QA/QC will be available to stakeholders.

Data collected from monitoring wells list in **Table 3A** will be downloaded at 1, 3, 5, 8, 11, 14, 17, 20, 23, and 26 weeks after start of the pumping phase of the test. All data will undergo a QA/QC process.

Once the operational test is started, measurements collected from data loggers at trigger wells will be downloaded, and data from manual measurements will be compiled 24 hours, 72 hours, and then weekly thereafter during the pumping phase. After completion of the QA/QC process, data will be made available to any interested stakeholder. Trigger locations are discussed in more detail in Section 6. Within 10 business days of data downloading, data will be made available to interested parties by either email or the OLGDP web page (www.ladwp.com/olg). Measurement data may be revised after further QA/QC of collected data. Adverse trends which appear to be leading toward a trigger value within the 6-month period will be reported when they are observed. If these adverse trends are noted in any trigger well, groundwater levels for that well will be downloaded every weekday and made available to any interested stakeholder. Management actions based on adverse trends will include increasing the monitoring frequency, and/or decreasing the pumping rate at TW-E.

4.4 Groundwater Quality Sampling and Monitoring

The purpose of the planned groundwater quality sampling and analysis is to document any potential change in groundwater quality as a result of the operational test. The groundwater quality testing is focused on LADWP monitoring wells located near non-LADWP wells, spring and seep locations, and VDA locations. Groundwater quality samples from select monitoring wells will be collected once just prior to the start of the operational test and once prior to the conclusion of the test. In addition to field parameters (temperature, pH, dissolved oxygen, and specific conductance), samples will be collected for laboratory analysis of major ions, indicator constituents, stable isotopes, and nutrients (for VDA samples) as listed in **Table 8**. Indicator constituents are those constituents that have been shown in previous sampling to be close to, or above the Maximum Contaminant Level (MCL) as noted during baseline sampling (LADWP, 2020). Water quality samples will be collected:

- one week prior to start of pumping, and
- one week prior to the end of pumping (or when pumping stops, if test is stopped before 6 months of pumping).

4.4.1 Groundwater Quality Sampling Constituents

As part of water quality monitoring, groundwater quality will be sampled and analyzed for the constituents noted in **Table 8**.

Table 8: Groundwater Quality Sampling Constituents

Category		Constituent
Field		Temperature (T)
		pH
		Specific Conductance (SC)
		Dissolved Oxygen (DO)
Laboratory	Major Cations	Calcium (Ca)
		Magnesium (Mg)
		Sodium (Na)
		Potassium (K)
	Major Anions	Bicarbonate (HCO_3)
		Chloride (Cl)
		Sulfate (SO_4)
		Nitrate (NO_3)
		Carbonate (CO_3)
	Indicator Constituents	Arsenic (As)
		Boron (B)
		Fluoride (F)
		Total Uranium (U)
		Total Dissolved Solids (TDS)
	Stable Isotopes	Deuterium (^2H)
		Oxygen 18 (^{18}O)
	Nutrients*	Nitrate Nitrogen (NO_3-N)
		Phosphate-P (PO_4-P)

Note: *VDA locations only

4.4.2 Groundwater Sampling Locations

Groundwater sampling will be performed at specific resource areas using monitoring wells as shown in **Table 9**.

Table 9: Groundwater Quality Sampling Locations

Type of Resource	Resource	Location of Resource	Monitoring Well to Be Sampled
Non-LADWP Well	Boulder Creek RV Park, O'Dell Well, and Nearby Domestic Supply Wells	west of Owens River Fault and 4.5 miles NE of TW-E	T931
	FW Aggregates Supply Well	east of the Owens River Fault and 4.5 miles E-NE of TW-E	T929
	Mortensen Domestic Well	west of Owens Valley Fault, 3 miles west of TW-E	T920
	Mt. View Trailer Park	4 miles NW of TW-E	T858
	Fault Test Well (FTW)	2.7 miles east of TW-E	FTW
	Keeler CSD	northeast of Keeler across Hwy 136	P8 (30)
Vegetated Dune Areas	VDA-1	3 miles NW of TW-E	VDA-1
	VDA-2	3 miles NE of TW-E	VDA-2-1
	VDA-3	3 miles NE of TW-E	VDA-3b
	VDA-5	3 miles NE of TW-E	VDA-5
	VDA-6	3 miles E of TW-E	Staging Area Monitoring Well
	VDA-7	3 miles E of TW-E	P8 (30)
	VDA-8	3 miles E of TW-E	VDA-8-2
Spring	Northwest Spring	2.9 miles NW of TW-E	P1(5)
	Horse Pasture	4.7 miles E-SE of TW-E	P8(5)

5.0 ASSOCIATED FIELD ACTIVITIES

This section describes planned downhole flow measurements during pumping of TW-E called “spinner logging”. Spinner logging consists of lowering a device for measuring the in-situ velocity of fluid flow in a production well based on the speed of rotation of an impeller, or “spinner”. A spinner log allows for measurement of flow from the aquifers to various sections of the well screen and provides valuable information about the relative permeability of various aquifers outside the screened portion of the well.

This section also describes the disposal of the water produced during testing of TW-E.

5.1 Spinner Logging

Spinner logging will be performed, if possible, depending on the available annular space around the pump column. The goal of spinner logging is to calculate the percentage of the pumped water that is extracted from each of the aquifers that contribute to pumping in TW-E. Spinner logging involves lowering a tool consisting of a small impeller at the end of a rod into the well, moving vertically at a constant rate. The impeller rotation measures fluid velocity from which aquifer properties (hydraulic conductivity), interflow between different aquifers, and contribution of each aquifer to the total well production can be calculated.

The continuous TW-E screen is 870 feet long, penetrating a generally silty sand formation with varying silt proportion and occasional thin clay/clayey intervals. Therefore, it cannot be determined with certainty whether the aquifer TW-E is extracting from is a continuous confined aquifer or multiple confined aquifers contributing in varying proportions to the total well production.

A spinner log was performed on TW-E after well construction under non-pumping conditions. Results from the initial log showed over 50% of the artesian flow is from the upper portion of the screen (around 700 feet bgs). Depths beyond 900 feet bgs provided negligible flow.

A spinner log will be performed (if possible, based on pump design) during the proposed operational test via a 2-inch polyvinyl chloride (PVC) pipe extending below the pump intake (but above the well screen) to determine the source of groundwater during testing and further characterize the pumped aquifer(s). The measurements from the spinner log will determine the percentage of the pumped water that is extracted each of the aquifers. The rate of extracted water from the individual aquifers will be utilized when aquifer parameters are being estimated using the specialized aquifer test solver (AQTESOLV) software. This approach should significantly improve the estimate of hydrologic parameters for each of the aquifers in the vicinity of TW-E, and it will also provide important information to improve the OLGM.

5.2 Discharge of Pumped Water

TW-E is located in the center of the dust control area T-36. **Figure 8** shows a map of the area in the vicinity of TW-E. The ponds around TW-E are interconnected and the slope of the area is generally from north to south toward the Brine Pool. Water will be discharged to T36-1W and/or T36-1E and then can flow to other adjacent ponds. The current water supply to the ponds is primarily water diverted from the LAA or the Lower Owens River Project (LORP) Pump Back Station at the southern end of LORP. Pumped water from TW-E during the operational test will be discharged into the dust mitigation ponds surrounding the well and will supplement the flow from the LAA.

While the water diverted from the LAA to Owens Lake for dust mitigation is of high quality, the quality degrades considerably once discharged into the ponds due to evaporation and the high concentration of undesirable constituents in the soil floor of the ponds. To evaluate compatibility of the pumped water from TW-E with water in these ponds, LADWP collected and analyzed water quality samples from TW-E and surrounding ponds in March 2020, then compared the results with samples taken between 2010 and 2019. **Table 10** shows the results of sampling collected in March 2020 from all seven (7) points.

The purpose of this sampling is to demonstrate that disposal of pumped groundwater from TW-E will not degrade surface waters in the ponds. This data indicates there will be no adverse effects of disposal of groundwater from TW-E on water quality of the designated ponds.

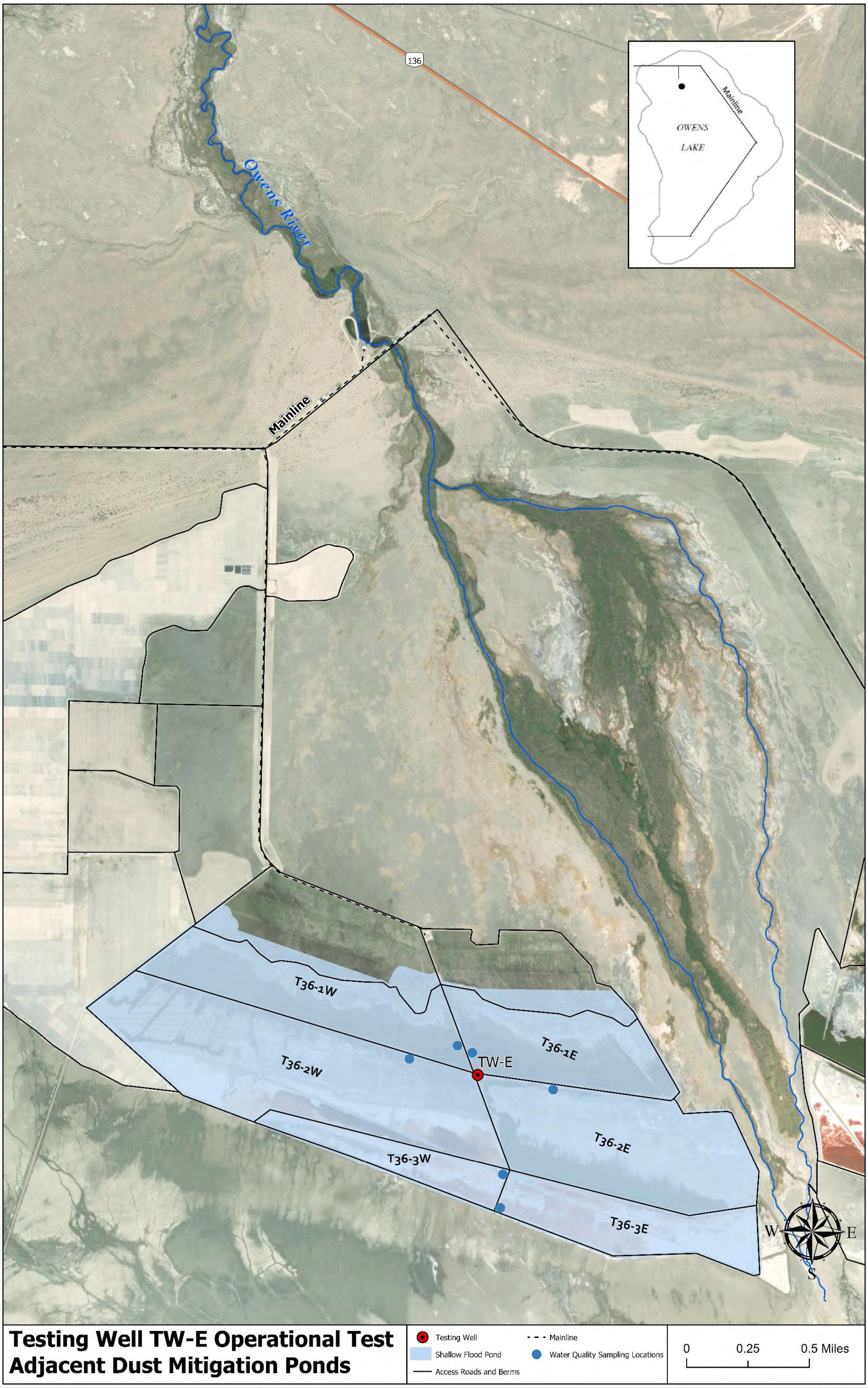


Figure 8: Location of Discharge Ponds Adjacent to TW-E

Table 10: Water Quality Testing Results (March 2020)

Constituent	T36-3W	T36-1W	T36-2W	TW-E	T36-2E	T36-1E	T36-3E
Temperature (°C)	17.4	38.1	26.7	21.3	34.4	36.5	25.4
Specific Conductivity (µs/cm)	164,100	18,11	14,930	2.7	15,020	1,770	166,700
pH	9.6	8.8	10	7.9	10	8.9	9.8
Turbidity	78	66	43	6.6	60	70	80
Dissolved Oxygen[1] (mg/L)	1.77	13.87	16.2	5.6	25.52	17.7	5.37
Total Dissolved Solids (mg/L)	346,400	2,200	9,600	1,920	11,200	2,100	338,700
Aluminum[1] (mg/L)	N/A	ND	1.54	0.57	1.54	ND	N/A
Arsenic (mg/L)	74.3	0.16	1.78	0.0516	1.73	0.16	75
Barium (mg/L)	0.23	0.027	0.056	0.475	0.051	0.026	0.228
Boron (mg/L)	N/A	11.3	1.1	8.19	1.1	11.3	N/A
Lead (mg/L)	0.042	0.0059	0.014	0.013	0.014	0.0073	0.033

Notes: ND – Non-detect; N/A – Not tested; mg/L – milligrams per liter

[1] Values reported for Dissolved Oxygen and Aluminum are from 2018 sampling.

6.0 PROTECTION OF GROUNDWATER-DEPENDENT RESOURCES

As used in this document, the term “groundwater-dependent resources” has a relatively broad meaning to describe things that depend on, or are influenced by groundwater, including the land surface (which depends in part on groundwater pore pressure), non-LADWP wells (which depend on the groundwater level), springs (which depend on upwelling groundwater to the surface), and vegetated dune areas (which may depend to some degree on the depth to groundwater). The term “groundwater-dependent ecosystems” refers to a subset of groundwater-dependent resources that includes ecosystems at springs that depend on groundwater. Although the vegetation on dunes could be considered a groundwater-dependent ecosystem, the protection mechanism is slightly different because the vegetation on the dunes is dependent to some degree on the depth to groundwater, as opposed to the springs in which groundwater is essentially at the surface, and it is the upwelling groundwater which supports the ecosystem.

The only mechanism by which the pumping of TW-E can potentially affect nearby groundwater-dependent resources is if the pumping lowers the groundwater level directly beneath the resource or reduces overland flow to the resource. This in turn could potentially change the water quality in the shallow aquifer near the resources. Because of a relatively thick clay layer between the surficial aquifer and the aquifer where TW-E is screened, no significant impact is expected from the 6-month operational test of TW-E. This has been further confirmed by groundwater modeling.

An easily measurable method to protect groundwater-dependent resources is to set limits (“triggers”) on groundwater level beneath the resources and/or the gradient toward the resources. At the suggestion of reviewers on the initial version of the testing plan for the 6-month operational test of TW-E, a specific trigger mechanism will be utilized to manage the pumping phase of the proposed 6-month operational test of TW-E. Setting triggers will be out of an abundance of caution to provide an additional layer of protection from potential impacts of pumping on nearby groundwater-dependent resources, including groundwater-dependent ecosystems and/or nearby non-LADWP wells.

Triggers (such as the depth to water under VDAs) utilized in this operational test are anticipated to be much more conservative than those ultimately utilized during operational pumping and may not be realistic for long-term operation. This test is expected to provide valuable information regarding how conservative the trigger levels identified in this document are, and based on that, more realistic triggers for the long-term operation can be developed.

If a trigger level in any monitoring well is reached anytime and for any reason during the test, then LADWP will cease the pumping of TW-E for the test, start recovery data collection, and report to parties within 24 hours of such determination and action. The same is true of the trigger gradients toward springs.

6.1 Hydrogeologic Setting

Conducting a 6-month operational test of TW-E is important to collect necessary data to further understand the hydrogeology of Owens Lake. The test is designed to collect the necessary data but ensuring that groundwater-dependent resources will not be impacted.

Generally, groundwater-dependent resources of concern at Owens Lake utilize water from the shallow surficial aquifer. The surficial aquifer is separated from the confined aquifers underneath by a thick layer of clay (aquitard) varying from approximately 100 feet to 200 feet as shown in schematically on **Figure 9**. Multiple aquitards underlie TW-E. Aquitards have very low hydraulic conductivity and act as a relatively low-permeability barrier between aquifers. Therefore, there is minimal to no direct connection of the near surface resources to the deeper aquifers proposed to be pumped. Additionally, most of the groundwater-dependent resources are located to the east of Owens River Fault or to the west of Owens Valley Fault. Previous studies have shown these faults most probably act as lateral groundwater barriers; therefore, the resources are protected to some degree by the faults from the effect of pumping in-between these faults (MWH, 2012, 2016). More recent groundwater level and water quality data from wells located across faults confirm this finding.

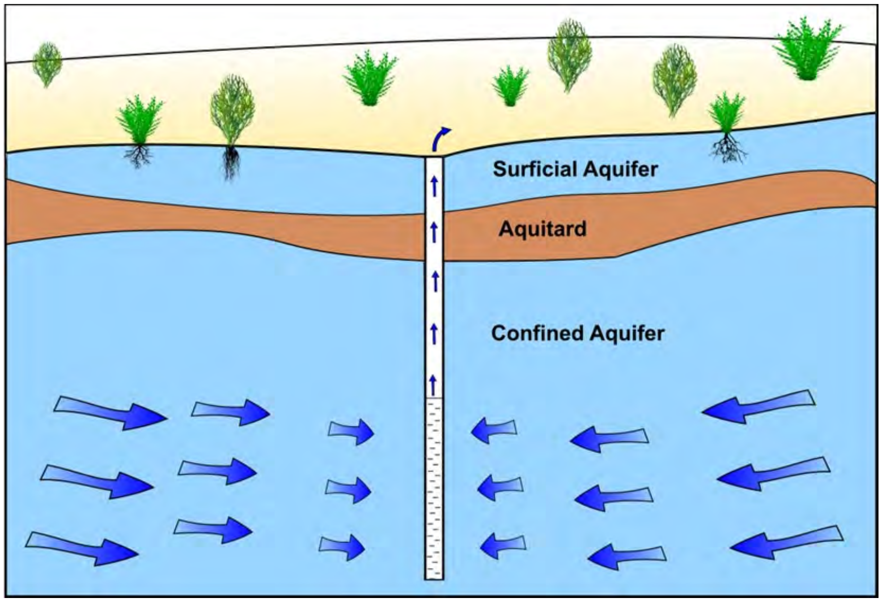


Figure 9: Schematic Showing General Cross Section Near Owens Lake Surface

The construction of TW-E consists of solid casing from ground surface to 620 feet depth and screen from 620 feet to 1,490 feet bgs (**Figure 2**). Due to the depth interval of the screen, TW-E extracts water from the deeper confined aquifers and not from the shallow surficial aquifer.

The groundwater gradient, also referred to as hydraulic gradient, is the slope of the water table or potentiometric surface, that is, the change in water level per unit of distance along the direction of groundwater flow. It is determined by measuring the water level in two or more wells. The water level in a well is usually expressed as feet above sea level. The groundwater (or hydraulic) gradient is the driving force that causes groundwater to move in the direction from high elevation to low elevation, much like surface water. Gradient is generally expressed in consistent units, such as feet per foot. For example, if the difference in water level in two wells 1,000 feet apart is 2 feet, then the gradient is 2/1,000 or 0.002.

In the unique case of routine or periodic monitoring of the gradient using the exact same two monitoring locations over time, the change in gradient can be simplified. This is because the distance between the two wells does not change; only the groundwater elevation in one or both of the wells may change. In these cases, the relative gradient can be expressed as a length, that is, the elevation difference between the two wells.

In the example above, the relative change in gradient could be expressed as the change in the 2 feet difference. If the difference at a later date is 1 foot, the gradient has been reduced by 50 percent. At Owens Lake, the pre-pumping gradient (expressed as a length) can be compared to concurrent pumping or post-pumping gradient and is expressed as a change in either feet or percent, as in the example above.

This testing plan calls for two types of gradient monitoring using well pairs: horizontal gradients and vertical gradients.

- **Horizontal gradients** refer to monitoring of the gradient between a monitoring well located upgradient of Owens Lake (generally on the adjacent alluvial fans) and a paired shallow piezometer or monitoring well near the margins of the lakebed. This is an indirect measurement of groundwater flow toward the springs at the margin of the lake. This groundwater flow supports habitat surrounding the lake.
- **Vertical gradients** are measured between two piezometers (which are essentially shallow monitoring wells with short screens) located in the same borehole or next to each other but screened at different depths. The LADWP has installed several monitoring sites surrounding Owens Lake in which there is a deeper piezometer (generally 30 feet deep), and a co-located shallow piezometer (generally 5 feet deep), termed a piezometer cluster. These are designated as “P” sites (as listed on **Table 4** and shown on **Figure 6**). There is also typically a 10-foot piezometer at the same location (which is not used in the gradient calculation). Groundwater level measurements at these piezometers at different depths are used to

calculate the vertical gradient (upward or downward). Similar to the horizontal gradients described above, monitoring change in vertical gradients can be simplified by monitoring the change in the difference between the groundwater levels in a deep and shallow piezometer at the same location. The shallow piezometers and alluvial monitoring wells are illustrated schematically in **Figure 10**. Both the vertical and horizontal gradients have remained relatively constant since monitoring has begun, so a single "pre-pumping" gradient can be expressed in units of feet as listed on the hydrographs in **Appendix A**.

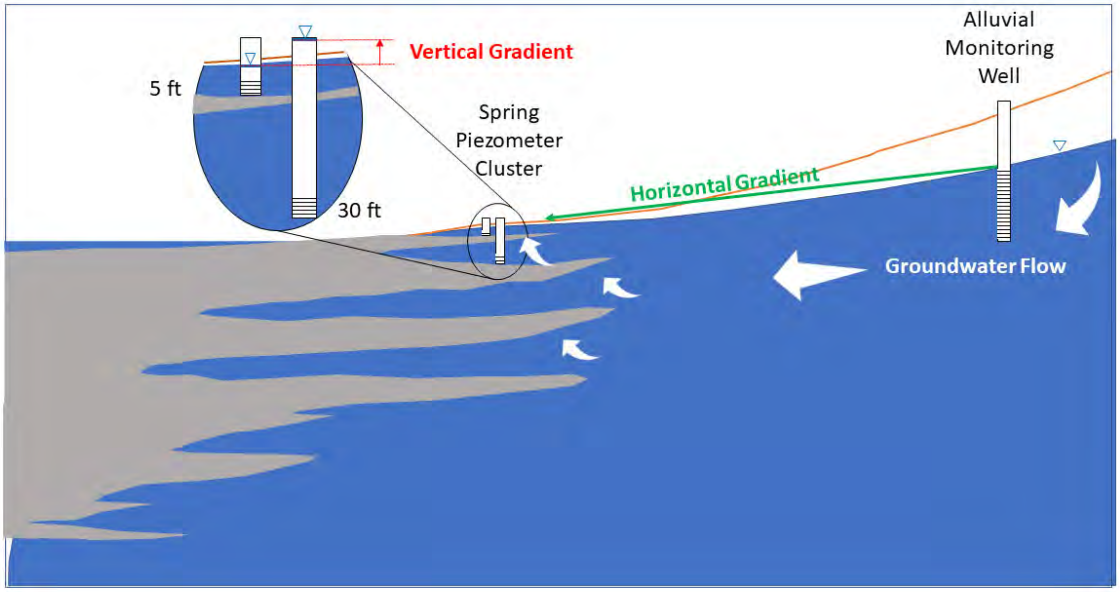


Figure 10: Illustration of Vertical and Horizontal Groundwater Gradients

6.2 Resources to be Protected, Methods, and Rationale for Triggers

As shown on **Figure 11**, key resources to be protected during the proposed operational test utilizing conservative triggers include:

- Groundwater-dependent ecosystems (GDEs), including:
    - Habitat at springs around Owens Lake
    - Vegetated dune areas (VDAs)
- Production capability of non-LADWP wells (generally private wells)

Along with identification of these resources to be protected, methods to monitor each of these resources have been developed, as described below.

Figure 11: Location of Resources and Associated Trigger Wells for the 6-month Operational Test of TW-E

6.2.1 Methods of Monitoring Groundwater-Dependent Resources

Each type of groundwater-dependent resource has a specific monitoring method designed to protect that resource, as described below.

Groundwater-Dependent Ecosystems primarily consist of springs and associated alkali meadows that surround the lake. These areas are supported by horizontal and vertical groundwater flow that seeps in wide areas around the lakeshore and flows toward the brine pool as described in the previous section. VDAs could also be considered GDEs but are handled separately because they are not dependent on upwelling groundwater, but instead potentially shallow groundwater as discussed below.

Due to the dispersed nature of upwelling groundwater, flow in many of the springs cannot be measured accurately with typical surface water monitoring techniques such as flumes or weirs. However, groundwater modeling of the Owens Lake area has shown that flows at the springs correlate to the vertical and horizontal groundwater gradient toward the springs (MWH, 2012). For this reason, LADWP has installed monitoring wells and piezometers specifically to monitor the flow toward springs as a surrogate for direct measurement of spring flow. These include the monitoring wells located on the alluvial fans upgradient of the springs, as well as multi-depth piezometers located at the springs. Measurement of the gradient has been conducted beginning at various locations during the 2013 to 2015 period. Hydrographs of these monitoring locations are included in **Appendix A**.

In addition to monitoring groundwater levels and gradients around springs, an entirely independent method of monitoring the GDEs has been developed utilizing remote sensing of vegetation productivity, cover, and extent of alkali meadow vegetation. The historical range of variation of these areas was calculated based on data gathered from over 30 years.

Production Capability of non-LADWP wells is monitored using the static groundwater elevation in the wells relative to the top of the screen in the non-LADWP well. Although it would be preferable to monitor pumping water level in the well, this data is generally not available due to access constraints for non-LADWP wells. In cases where the water level in the non-LADWP well cannot be measured directly, a nearby LADWP monitoring well is utilized.

Vegetated Dune Areas are monitored by the shallow groundwater elevation under, or close to the dune areas. While some dune areas may be technically considered GDEs, the approach to monitoring differs from the spring and seep areas because although the VDAs may be sensitive to groundwater depth, they are not fed by groundwater upwelling to the surface and flowing overland.

6.2.2 Rationale for Triggers

A “trigger” level for each resource listed above is designed to provide early warning of a potential adverse condition during the operational test, so that the test can be stopped before an adverse condition for that particular resource arises. There are two important aspects of triggers (as used in this plan) that are particularly important:

- Triggers are not transferrable from one type of resource to another. As an example, triggers to protect production capability in non-LADWP wells are not appropriate (or designed) to protect GDEs or VDAs. This is because GDEs and VDAs may be much more sensitive to groundwater level changes than a production well.
- All trigger levels work independently, such that reaching any one of the trigger levels will result in the termination of the pumping to protect the given resource.

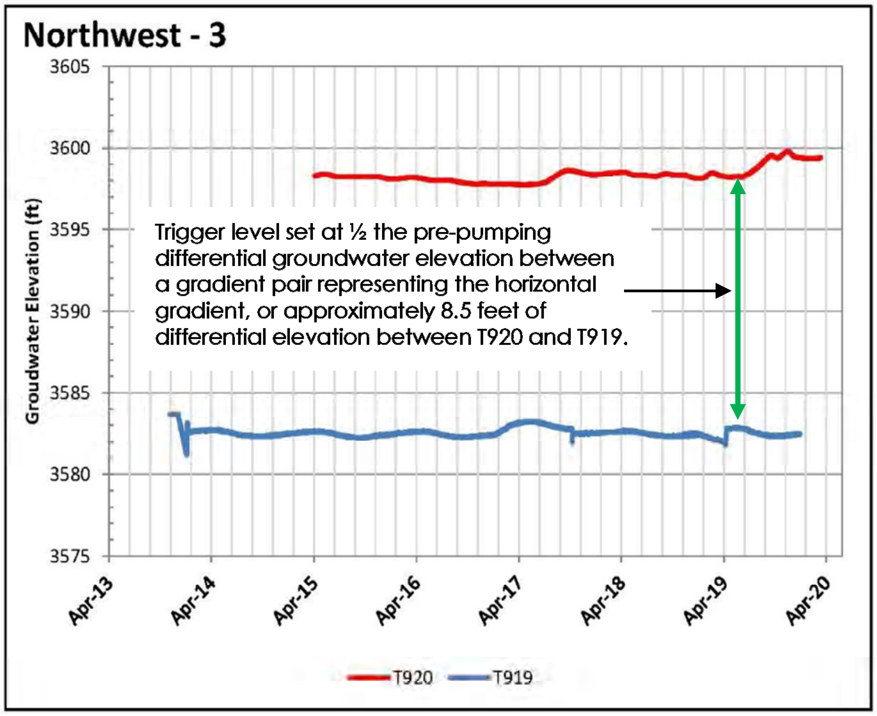
The rationale for triggers is summarized in **Table 11** and described in more detail below.

The **rationale for trigger levels for GDEs** is based both on monitoring of horizontal and vertical gradients, as well as an absolute value for drawdown in the vicinity of springs. The rationale for the trigger level for horizontal and vertical gradients is to ensure that positive gradients are maintained, and flow continues to the springs. The proposed trigger level for horizontal and vertical gradients is to maintain at least 50 percent of the pre-pumping flow to the springs. This ensures that water is available to the root zones of the vegetation at the springs. Gradient monitoring locations surrounding the lake are summarized in **Table 4**. The locations with triggers are limited to the northern portion of the lake. Trigger values are specific to each gradient pair, as illustrated in an example at the northwest portion off the lake (**Figure 12**) and compiled for other locations in **Appendix A.**

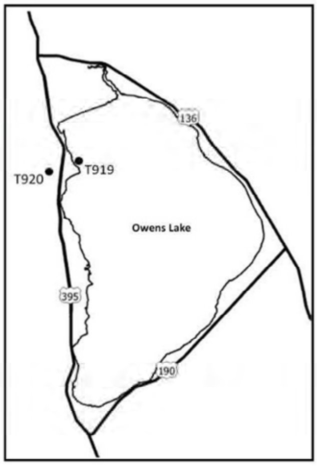
Table 11: Summary of Rationale for Triggers

Resource	Rationale for Triggers
GDEs	The rationale for protection of GDEs is monitoring of flow toward the springs as represented by groundwater gradients with the understanding that some reduction in flow is permissible, as long as a positive gradient toward ground surface is maintained. An absolute value of depth to groundwater at the shallowest piezometer near the springs is also utilized at the request of reviewers. This absolute value will be set at the seasonally adjusted historical range of variation. In addition, the seasonally adjusted LAI and size of transmontane alkali meadow (TAM) area will be documented before and after the test utilizing remote sensing techniques.
Production Capability at non-LADWP Wells	The rationale for protection of production capability at non-LADWP wells is based on the depth of the top of the screen in all non-LADWP wells in the northern portion of the lake relative to the static water level. With the recognition that a certain amount of drawdown will not affect production capability, as long is the pumping water level is above the well screen. The trigger for all non-LADWP wells is based on the shallowest, or most sensitive non-LADWP well in the northern portion of the lake (i.e. where the distance between the static water level and the top of the well screen is the shortest).
VDAs	The trigger level for VDAs is based on the review of literature observations that the type of vegetation on the dunes is capable of sustaining certain level of groundwater elevation decline temporarily without adverse effects (see following text and **Appendix B**).

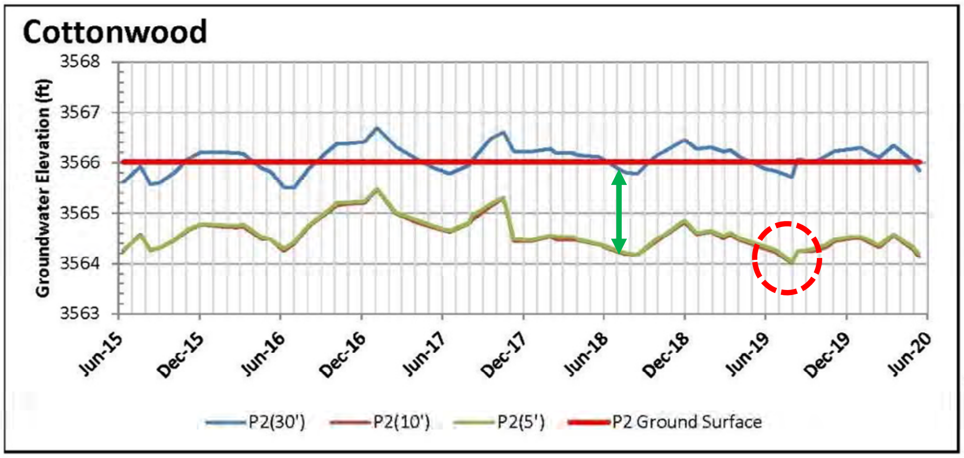
Horizontal Groundwater Gradient



Trigger level set at ½ the pre-pumping differential groundwater elevation between a gradient pair representing the horizontal gradient, or approximately 8.5 feet of differential elevation between T920 and T919.



*Horizontal Gradient**
16.96 feet



*Upward Gradient**
1.10 feet

Trigger level set at ½ the pre-pumping differential groundwater elevation between a gradient pair representing the vertical gradient, or approximately 0.5 feet of differential elevation between P2(30') and P2(5') (green arrow). In addition, a groundwater elevation trigger in the P2(5') equal to the historical recorded low will also act as a trigger (red dashed circle).

Figure 12: Example of Horizontal (Top) and Vertical (Bottom) Gradient Triggers

The rationale for trigger levels for non-LADWP wells is based on maintaining an adequate water column above the top of the well screen in non-LADWP wells. To develop a threshold level for non-LADWP wells in the northern portion of the lake, a review of the length of the water column above the well screen in the shallowest non-LADWP wells within a cluster of adjacent wells was performed, as summarized in **Table 12**.

Table 12: Non-LADWP Wells to be Protected

Well Name	Top of Screen (depth-ft)	Static Water Level (depth-ft)	Water Column Above Top of Screen (ft)	Threshold Level Based on Each Well (drawdown, ft)[1]
Jean Crispin #2	60	12	48	24
Don Odell	145	37	108	54
Don Echelberger	100	50	50	25
Stradling	43	0	43	21
Mortensen	300	275 (estimated)[2]	25	12
Keeler CSD	51	41	10	5

Notes:

[1] The well-specific threshold is a measure of drawdown, which is set at ½ the distance between the static water level and the top of the well screen for the most sensitive well in a cluster of non-LADWP wells (i.e., Keeler CSD above).

[2] The water level in the Mortensen well cannot be measured due to obstructions by pumping equipment. Therefore, the static water level was estimated based on nearby wells.

The non-LADWP wells around Owens Lake are located either west of the Owens Valley Fault or east of the Owens River Fault and are protected by the barrier effect of the faults. Water level in non-LADWP wells cannot be measured directly because of access limitations. Instead, trigger wells are selected at a location between the TW-E and each non-LADWP well or group of wells. **Figure 13** shows the general spatial relationship between the TW-E, trigger wells, and the non-LADWP wells. For the protection of non-LADWP wells, a drawdown of five (5) feet from the pre-pumping groundwater level in the trigger wells corresponds to a much smaller drawdown at non-LADWP wells and therefore is considered very conservative. The rationale for the five (5) feet of drawdown is based on the most sensitive non-LADWP well in the northern portion of the lake (Keeler CSD Well) but has been applied to all non-LADWP monitoring locations to apply a conservative level of protection and for simplicity.

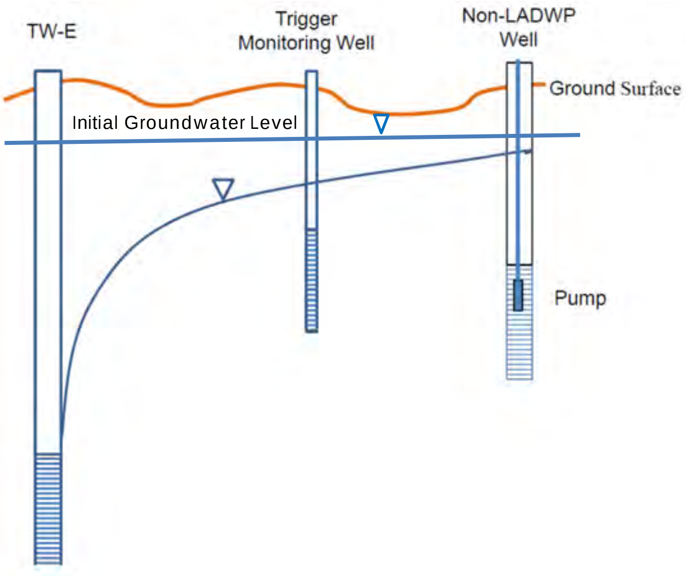


Figure 13: Spatial Relationship of Groundwater Levels in TW-E, Trigger Monitoring Wells, and Non-LADWP Wells

The rationale for **trigger levels for VDAs** is based on a literature review of *Sarcobatus* response to variations in groundwater depth. The literature review to support the conservative nature of these trigger levels is briefly summarized in the bullets below and in **Appendix B**:

- **Daily Oscillations in Depth to Water**. A number of detailed studies of *Sarcobatus* have documented daily oscillations of 1-5 cm in the depth to water with minima in late afternoon/evening and overnight recovery during the growing season (See **Appendix B**: Robinson, 1970; Devitt et al., 2011; Devitt and Bird, 2016; T931 hydrograph data). The oscillations are not present after leaf senescence (Devitt and Bird, 2016). These oscillations are direct evidence of groundwater use and their magnitude is related to transpiration, leaf area index, atmospheric demand, root depth distribution, and specific yield of the aquifer (Steinwand et al., 2006; Devitt and Bird, 2016). The magnitude of these oscillations, or even their presence, however, can be affected by the texture and specific yield of the aquifer being tapped by *Sarcobatus* roots. In the Devitt and Bird (2016) study, oscillations that were initially present, disappeared for 2,225 days while groundwater declined from 9.33 m to 10.71 m below ground surface, but reappeared coincident with the level crossing a textural boundary at 10.67 m.

  At Owens Lake, similar daily oscillations of groundwater depth have been documented at well T931 where there is dense shrub vegetation with *Sarcobatus* and other species. At the end of April 2019, daily oscillations of up to 4.3 cm (0.14 ft) were observed when groundwater was at 3.58 m (11.76 ft) depth. Together, these results show that *Sarcobatus* can adjust to changes in groundwater depth of up to 1.38 m (4.5 ft) over several years (average 0.75 ft / yr) and continue to utilize groundwater to depths of at least 10.71 m (35 ft).

- **Seasonal Fluctuation in Depth to Water.** Another line of evidence that *Sarcobatus* root systems can adjust to changes in groundwater depth with no adverse impacts on cover or vigor comes from assessment of seasonal variation in depth and historical variation in cover. *Sarcobatus* naturally experiences and tolerates these seasonal variations with no detectable effect on the health of the plant community, which remains essentially stable through these variations (Great Basin Report, 2019; Pilot Study Results, 2019). Decrease in groundwater level under *Sarcobatus* communities during the growing season has a surprisingly small range considering the diversity of sites studied and the range of years covered (**Appendix B**). Based on the data summarized in **Appendix B**, the typical growing season decline in groundwater depth ranges from 20.0 – 35.1 cm (0.66 – 1.15 ft) (Robinson, 1970; Nichols, 1994; Devitt et al., 2011; Devitt and Bird, 2016; Steinwand et al., 2006; T931 hydrograph data; Keeler Landfill Monitoring Well hydrograph data). In addition to these typical values over different years and study locations, single year maximal declines of 64 cm (2.10 ft), 55.2 cm (1.81 ft) (Keeler Landfill Monitoring Well near VDA08 in 2005, 2017) and 54.9 cm (1.80 ft) (T931 well near VDA01 in 2017) have been observed. These seasonal fluctuations have occurred during the period where our historical analyses of cover (Pilot Study Results 2019) shows fluctuations but no trend in cover change (i.e. stable cover). The flexibility of *Sarcobatus* root systems is such that it can tolerate changes up to these magnitudes without any detrimental effect on the vegetation community.

  Furthermore, measurements of plant stress as xylem water potential show no end of season differences for *Sarcobatus* following wet and dry precipitation years with a one-year decline in groundwater up to 1.3 m (Trent et al., 1987). Devitt et al. (2011) also found that differences in groundwater depth from 4.6-9.3 m among sites did not cause differences in *Sarcobatus* stress levels. Its root system was able to adjust to these differences and access capillary fringe water resources.

  Setting a target trigger within the range of these seasonal fluctuations or year-year declines for cessation of groundwater pumping is conservative in the sense that these are the normal variations experienced and tolerated by *Sarcobatus*. Even seasonal declines of up to 2.1 ft are not unusual in the long history of these communities, and yearly declines of approximately one meter are not more stressful than usual for *Sarcobatus*.

- **Multiple Year Responses to Groundwater Decline**. Based on Fig 7b of Elmore et al. (2003), a decline of 1.1 m in groundwater level over multiple years would be required to produce a detectable change in the live cover of *Sarcobatus* communities. Smaller changes in groundwater depth, even over multiple years, are unlikely to cause any detectible change in cover of groundwater dependent shrubs. The plasticity of *Sarcobatus* root systems to access different water sources was demonstrated by Wagner et al. (2018) and supports the

> conclusion from Devitt and Bird (2016) that the root zone of greasewood is very deep (up to 10.75 m depth) and the "findings, including the groundwater oscillations, deep unsaturated zone extraction and shifts in soil water in storage based on precipitation support a very flexible and dynamic utilization of multiple water sources by greasewood." In a rabbitbrush and *Sarcobatus* community on dunes at Mono Lake, growth reduction and mortality were not initiated until much more than 1 m of groundwater decline over multiple years (Toft, 1995). Large plants of rabbitbrush were largely unaffected by a 2.1 m decline in groundwater level over multiple years and recovered to initial size after long-term drought (Toft and Frazier, 2003). There was no mortality among the large rabbitbrush plants in this community and they flowered every year of the 17-year study. Although *Sarcobatus* was not studied in this location because of the difficulty of determining genetic individuals, large established *Sarcobatus* survived and recovered after the long-term drought and groundwater decline (Toft, pers. comm.).

All of these studies and data from hydrographs at Owens Lake (**Appendix B**), support the conclusion that *Sarcobatus* can easily withstand seasonal or multiple year declines in groundwater of up to approximately one meter because of their flexible, extensive root systems that can adjust to changes in groundwater depth and also access multiple water sources (vadose zone soil moisture, perched saturated zones and capillary fringe water). The 1-foot trigger is a conservative threshold for this operational test.

6.3 Simulation of the 6-Month Operational Test

As noted in Section 3.0, the current version of the OLGM (Stantec, 2020) was utilized to evaluate the potential shallow groundwater elevation decline (drawdown) due to pumping TW-E at 3 cfs for 6 months so that key locations can be identified as trigger locations to protect groundwater-dependent resources. Due to sequences of silt and clay aquitards, the drawdown caused by pumping of TW-E will be greatest in the deeper aquifers, but muted in shallow surficial aquifers that support groundwater-dependent resources and non-LADWP wells. Simulated drawdown at specific trigger locations is described in the following section.

6.3.1 Simulated Area of Influence

The largest simulated drawdown occurring at any non-LADWP well is 0.53 feet at the O'Dell well northwest of TW-E. The highest simulated drawdown in any of the shallow piezometers surrounding the lake is 0.04 feet at P1 located west of TW-E, while the highest simulated drawdown at any VDAs site is 0.03 feet at VDA05, located east of TW-E. These simulated drawdown values are shown in **Figure 14,** which has been utilized to focus trigger locations where deep pumping may affect shallow groundwater levels and groundwater-dependent resources. Note that simulated drawdown due to the proposed pumping is limited to the northern portion of Owens Lake and the area immediately north of Owens Lake.

Figure 14: Simulated Shallow Aquifer Drawdown (ft) at Groundwater-Dependent Resources due to Operational Test of TW-E

6.3.2 Use of the Model to Determine Trigger Levels

The OLGM was utilized in preparing the proposed monitoring plan for the 6-month testing two ways:

1) To provide an initial estimate of the expected drawdown in the shallow aquifer in the vicinity of groundwater-dependent resources to provide confidence that the proposed testing of TW-E will not cause significant impact to groundwater-dependent resources.
2) To evaluate the geographic extent of area of potential drawdown from pumping of TW-E.

The level of expected drawdown in the shallow aquifer (where measurable based on the groundwater model) is described in Section 6.3.1. The modeling results indicate that drawdown in the shallow aquifer is very minor, and in many cases may not be measurable. It also indicates that drawdown near groundwater-dependent resources is limited to the northern portion of Owens Lake, which is why monitoring is focused (but not exclusive) to the northern portion of the lake.

The modeling results may raise the question: *"Why not set trigger values at or near the simulated model results?"* The answer to this question is that the trigger values are designed to be conservative protective values for the specific resource to be protected, *and not* the modeling results. If the model results are used as trigger values, then the test will be terminated unreasonably early, partially negating the purpose of the test, which is to evaluate the impact of pumping at groundwater-dependent resources. This concept is illustrated schematically in **Figure 15**, whereby the trigger level is set conservatively to protect the resource, and not on modeling results.

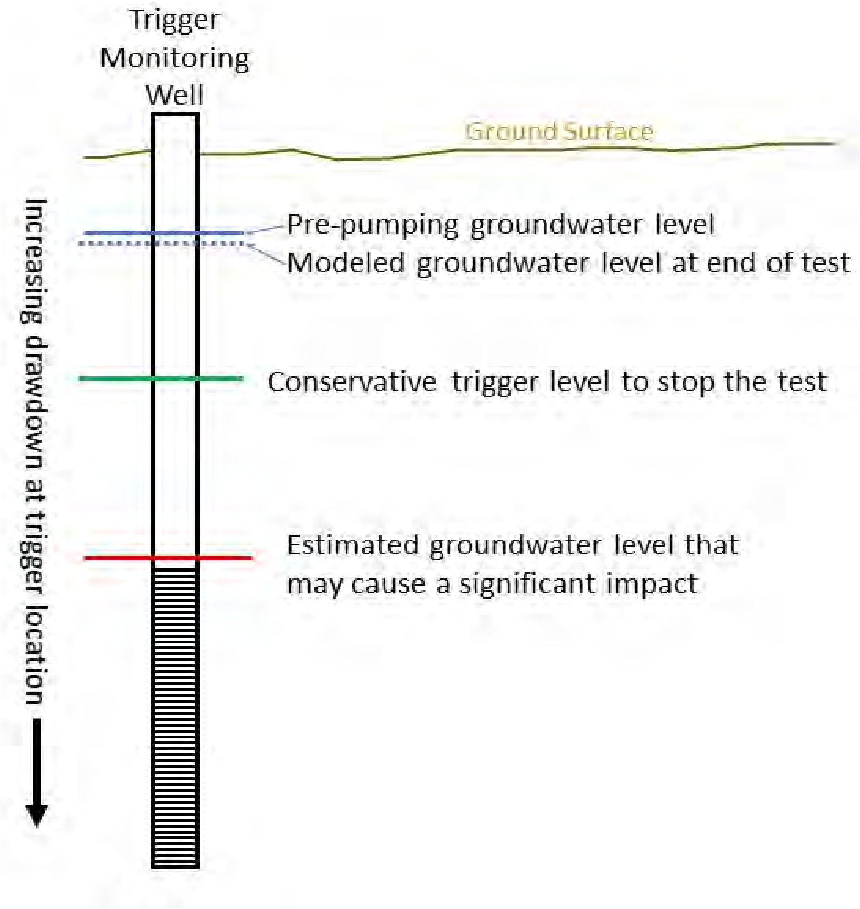


Figure 15: Schematic Relationship between Model Scenarios and Trigger Levels

An associated question may also be: *"If the modeled changes in groundwater levels are so minor, then why not run the test at a much higher pumping rate, or a longer duration so that a reaction at monitoring locations is assured?"* This is a reasonable conclusion based on the modeling results, but it is not in keeping with the overall philosophy of groundwater development at Owens Lake, which is adaptive management - start very slowly and conservatively, using only one testing well. It is also true that a negative result (no impact) is partially instructive in increasing the knowledge of how the groundwater regime reacts to pumping at various rates.

And finally, another reasonable question may be: *"What if the groundwater model simulations are grossly wrong?"* Because of the years of work in building an accurate conceptual and calibrated numerical model which has been vetted by independent experts (**Table 1**), this outcome is considered unlikely. However, if it does occur, it can be considered a positive outcome, in that the model can be updated and calibrated based on the field results, and ultimately become a much more robust tool in protection of resources and the adaptive management process. The trigger levels are set independently of the model results to protect resources, and not by outcomes predicted by groundwater model results. Therefore, in the unlikely event that modeled predictions are grossly wrong, groundwater dependent resources will still be protected.

6.4 Proposed Trigger Locations and Preliminary Trigger Values

Trigger values are proposed not only for groundwater elevations, but also for groundwater gradients toward groundwater-dependent resources within the estimated area of influence of pumping at TW-E, as described below.

6.4.1 Groundwater Elevation Monitoring

Specific groundwater-dependent resources and their associated trigger wells are shown on **Figure 11** and listed in **Tables 13** through **16**. These trigger wells are located either at the resources themselves or between TW-E and the resource to be protected. If during the pumping phase of the test, groundwater levels below a trigger value are detected in any of the trigger wells, pumping from TW-E will stop within 24 hours. In this situation, recovery data collection will start, and parties will be notified of the situation and the action taken. Trigger levels are described in terms of drawdown, or the change in groundwater elevation measured prior to initiation of testing compared to the groundwater elevation during testing.

6.4.2 Groundwater Gradient Monitoring

Triggers associated with calculated groundwater gradients toward springs are listed in **Table 15.** This table lists both the horizontal gradient toward and vertical gradient at five (5) groundwater dependent resources that could be affected by the 6-month operational test of TW-E, generally located in the northern half of Owens Lake.

To address reviewers' requests for absolute drawdown triggers at spring sites, a drawdown trigger of 2.3 and 3.2 feet at the shallowest piezometer near Northwest and Horse Pasture springs would also be used respectively and listed in **Table 16**.

Table 13: Non-LADWP Wells and Associated Trigger Wells

Resource	Location	Trigger Well	Simulated Drawdown After Testing for 6 Months at 3 cfs (feet)	Proposed Trigger Drawdown (feet)	Trigger DTW from RP (feet)
Boulder Creek RV Park, O'Dell Well, and Nearby Domestic Supply Wells	west of Owens River Fault and 4.5 miles NE of TW-E	T931 T902a	0.24 0.73	5 5	TBD
FW Aggregates Supply Well	east of the Owens River Fault and 4.5 miles E-NE of TW-E	T929	0.20	5	TBD
Mortensen Domestic Well	west of Owens Valley Fault, 3 miles west of TW-E	T920	0.0	5	TBD
Mt. View Trailer Park	4 miles NW of TW-E	T858	0.06	5	TBD
Keeler CSD	northeast of Keeler across Hwy 136	P8 (30)	0.0	5	TBD

Note: A trigger level of 5 feet in the trigger well corresponds to less than 5 feet in the non-LADWP well (**Figures 13 and 15**).
DTW = Depth to Groundwater RP = Reference Point
The Trigger DTW from RP will be set prior to the start of the test based on the latest field measurements

Table 14: VDA Wells and Associated Groundwater Drawdown Triggers

Resource	Location	Trigger Well	Simulated Drawdown After Testing for 6 Months at 3 cfs (feet)	Proposed Trigger Drawdown (feet)	Trigger DTW from RP (feet)
VDA-1	3 miles NW of TW-E	Delta W(1)	0.0	1	TBD
VDA-2	3 miles NE of TW-E	VDA-2-1	0.0	1	TBD
VDA-3	3 miles NE of TW-E, just SE of VDA-2	VDA-3b	0.0	1	TBD
VDA-4	3 miles NE of TW-E, just SE of VDA-3	VDA-5	0.01	1	TBD
VDA-5	3 miles NE of TW-E, just SE of VDA-4	VDA-5	0.03	1	TBD
VDA-6	3 miles E of TW-E, just S of VDA-5	Staging Area Monitoring Well	0.01	1	TBD
VDA-7	3 miles E of TW-E, just S of VDA-6	P8 (30)	0.0	1	TBD
VDA-8	3 miles E of TW-E, just E of VDA-7	VDA-8-2	0.0	1	TBD

Note: The Trigger DTW from RP will be set prior to the start of the test based on the latest field measurements.
DTW = Depth to Groundwater
RP= Reference Point

Table 15: Trigger Wells Associated with Groundwater Gradient[1] toward Springs around Owens Lake

Gradient Type	Up-Gradient Location	Down-Gradient Location	Location Notes	Pre-Pumping Gradient (feet)[2]	Simulated[3] Gradient After 6-month Testing at 3 cfs (feet)	Trigger Gradient (feet)[4]
Vertical	P1 (30)	P1 (5)	Northwest (Northwest Spring)	0.5	0.5	N/A[5]
	P8 (30)	P8 (5)	Northeast (Horse Pasture)	4.6	4.6	2.3
Horizontal	MW-3	T918	Northwest	174.3	173.8	87.1
	MW-2	P1(5)	Northwest	81.0	80.9	40.5
	T920	T919	Northwest	17.0	17.0	8.5
	T929	Lizard Tail	Northeast	33.0	32.8	16.5

Notes:

[1] See Section 6.0 for explanation of how gradients are recorded.

[2] Pre-pumping gradients are shown in **Appendix A** hydrographs.

[3] Simulated gradients after pumping are very close, or the same as pre-pumping conditions (i.e. little effect is predicted by the numerical groundwater model).

[4] Trigger levels will also be set for a specific depth to groundwater at each 5-foot piezometer based on the seasonally adjusted historic range of variation (**Figure 12**).

[5] Water levels in the shallowest piezometer at this site has been unreliable. An absolute value in the 5-foot piezometer based on the historical range of variation will be used as a trigger (**Table 16**).

Table 16: Groundwater Trigger Drawdown for the Shallow Aquifer at Springs

Location	Trigger Well	Trigger Drawdown (feet)[1]	Trigger DTW from RP (feet)[2]
Northwest (Northwest Spring)	P1 (5)	2.3	TBD[3]
Northeast (Horse Pasture)	P8 (5)	3.2	TBD

Notes:

[1] Based on the historical range of variation (**Figure 12 and Appendix A**)

[2] DTW=Depth to Water RP=Reference Point

[3] Trigger DTW from RP will be set prior to the start of the test based on the latest field measurements.

Groundwater-dependent resources and their trigger mechanisms are grouped and discussed below:

- **Supply well for Boulder Creek RV Park located northeast of Highway 395 and Lubken Mainline Road and several nearby domestic wells** – All of these wells are located west of Owens Valley Fault and approximately 4.5 miles northwest of TW-E (MWH, 2016). Comparison of groundwater measurement from these wells and the monitoring wells located east of Owens Valley Fault show the clear effect of the fault zone, which would protect these wells from potential effect pumping TW-E. As an additional protection measure, T902a will be utilized as the trigger well (**Table 13**).
- **Domestic well at Mortenson Property**– Located three (3) miles directly west of TW-E, and west of Owens Valley Fault, this well is protected by the Owens Valley Fault Zone, which may be a barrier to groundwater flow. As an additional protection of this resource, T920 will be used as a trigger well (**Table 13**).
- **Supply wells for the FW Aggregates Mining Operation located east of Highway 136** - These wells are located on the east side of Owens River Fault and approximately 4.5 mile east and northeast of TW-E. As a result of the barrier effect of the Owens River Fault, these well would be protected from the effect of pumping TW-E. Monitoring well T929 will be utilized as the trigger well for these domestic wells (**Table 13**).
- **Springs located West of Owens Lake** - This specific spring area includes Northwest Spring and associated vegetated area. This area is approximately 2.5 miles west of TW-E. Similar to the domestic wells to the north, these areas are protected from any effect of pumping TW-E by the barrier effect Owens Valley Fault. The trigger wells assigned for the additional protection of these areas are P1(5’), and P1(30’) for calculating groundwater gradient (**Table 15**), as well as an absolute value for the 5 feet deep monitoring well (**Table 16**).

- **Vegetated Dune Areas** – Based on groundwater modeling using the OLGM, the VDAs that are located north and northeast of Owens Lake are those that could potentially be affected by the proposed 6-month operational test of TW-E (VDA-1through VDA-8). It is assumed that the vegetation on VDAs that keep these dunes stable is partially dependent on surficial aquifers under the dunes. The surficial aquifer is separated from the deeper groundwater aquifers beneath Owens Lake. However, to ensure no significant impacts would occur to these vegetated dunes, groundwater levels under or adjacent to each dune will be monitored during the 6-month operational test of TW-E (**Table 14**).
- **Vertical and Horizontal Gradients** – The springs on both east and west sides of Owens Lake are fed by groundwater flowing lakeward both horizontally and vertically upward. Because flow emanating from springs cannot be measured directly, measurement of groundwater gradients toward the springs serve as a mechanism to monitor flow from these areas (**Table 15**).

6.5 Finalization of Triggers Levels Prior to Commencement of Testing

LADWP and responsible agencies will meet and review the most recent hydrographs for the trigger wells (**Appendix A**) about three (3) weeks prior to the start of the operational test to verify pre-pumping groundwater levels for the trigger wells (**Tables 13 through 16**). LADWP will prepare a memo to document the pre-pumping trigger levels. Triggers will be identified in terms of depth to groundwater (DTW) from the reference point (RP) of trigger monitoring wells. The reference point is a location on the well casing that has been surveyed and is used each time to measure the depth to water by LADWP hydrographers. The memo will be provided to the parties for review and comment before being finalized.

It is understood that numerous factors affect groundwater levels in each trigger well, including flows in the nearby surface water features, surface water applied to the nearby area, precipitation, evapotranspiration, change in barometric pressure, and pumping from other nearby wells. Some or all of these factors contribute to a variable, non-periodic historic hydrograph in most monitoring wells in the area, and a “typical” seasonal background water table trend cannot be readily identified. Therefore, the final trigger level in each trigger well will be set considering:

1) groundwater levels prior to the start of operational test,
2) historic hydrograph for each trigger well, where available, and
3) typical plant seasonal water demand by GDEs.

During the proposed operational test, LADWP will attempt to minimize fluctuations in groundwater levels due to controllable factors by providing consistent operational management. For example, during the test, LADWP will attempt to keep flows in the Lower Owens River and discharge to Owens River delta relatively constant and not change operation of any nearby pumps. In addition to the trigger wells listed in **Tables 13, 14, and 16,** the groundwater gradient will also be monitored (**Table 15**) with associated trigger gradients to ensure the groundwater- dependent springs located on the margins of the lake are not impacted by the test.

7.0 DATA ANALYSIS

Data analysis will include graphical analysis, calculation of aquifer parameters, and model calibration as described below. This data analysis will follow the test, not to be confused with routine reporting during the test itself.

Graphical Analysis - Groundwater levels and surface water flow measurements will continue to be collected from monitoring wells, flow measuring flumes, and meteorological stations described in Section 4 for the duration the proposed operational test of TW-E. The planned graphical analysis includes preparation of hydrographs using data from all monitoring locations. Additionally, changes in groundwater level from the pre-pumping condition in every monitoring well will be calculated, and hydrographs will be prepared. Using the calculated drawdowns, contour maps of drawdown will be prepared to visually present the spatial effect of the operational test, as well as the effects in various aquifers to the extent that available data allows. This type of graphical analysis will help identify areas that can potentially be affected by pumping TW-E on a longer-term basis and help identify sources pumped water. Of particular interest will be the groundwater level changes across the Owens Valley and Owens River fault zones to determine the effect of fault zones on groundwater movements.

Aquifer Parameters Calculations - Groundwater level and discharge rate data collected at testing well TW-E and groundwater level data collected at monitoring wells will be analyzed using AQTESOLV, a specialized software developed by HydroSOLVE, Inc. of Reston, Virginia, to calculate specific aquifer hydraulic parameters, such as transmissivity, storativity, and hydraulic conductivity at testing well TW-E and the wells monitored during the 6-month operational test, to the extent possible. Based on the spinner log results, pumped water can be proportioned to specific aquifers allowing for more accurate calculation of aquifer characteristics, and as a result improved model calibration.

Model Calibration - Using the data collected during the operational test from monitoring locations throughout the Owens Lake area, hydrogeologic parameters of various aquifers in between and across fault zones will be adjusted in the Owens Lake groundwater flow model to achieve model calibration, which will improve the estimated hydraulic characteristics of the Owens Valley and Owens River fault zones. Similarly, aquifer parameters in the vicinity of TW-E will be adjusted to achieve optimal model calibration for the area. These model improvements will result in increased model reliability and accuracy in forecasting the effect of various potential future groundwater management scenarios.

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