Six-Month Pumping Test of Testing Well East (TW-E) at Owens Lake

REVISED TESTING PLAN

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LIST OF ACRONYMS AND ABBREVIATIONS

AQTESOLV	aquifer test solver
bgs	below ground surface
CEQA	California Environmental Quality Act
CSLC	California State Lands Commission
ft	feet
gpm	gallons per minute
HSLA	high strength, low alloy
ICWD	Inyo County Water Department
IMFZ	Inyo Mountain Fault Zone
LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LORP	Lower Owens River Project
mg/l	milligrams per liter
OLDMP	Owens Lake Dust Mitigation
OLGDP	Owens Lake Groundwater Development Program
OLGM	Owens Lake Groundwater Model
ORFZ	Owens River Fault Zone
OVFZ	Owens Valley Fault Zone
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RPPs	Resource Protection Protocols
SWRCB	State Water Resources Control Board
TM	Technical Memorandum
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-month pumping test of Testing Well East (TW-E), located at Owens Lake, CA. The purpose of the proposed six-month pumping test of TW-E is to:

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

To achieve these goals, the Los Angeles Department of Water and Power (LADWP) installed two (2) testing wells at the northern portion of Owens Lake in 2018, designated as Testing Well East (TW-E), and Testing Well West (TW-W), shown on **Figure 1**. Following well construction, the contractor conducted short duration (24 hours) pumping/flowing tests, which provided useful but insufficient information. Therefore, LADWP proposes to perform longer-term pumping tests.

As a conservative measure, LADWP plans to conduct the longer-term pumping test on only one of the testing wells at a time. TW-E was selected for the longer-term pumping test because the relatively lower pumping capacity at this location is more conservative. A duration of six (6) months for the longer pumping test is proposed 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 program (OLDMP).

The proposed six-month pumping test of TW-E is designed to allow for 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 on 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 faults zones, and
- 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 advance the cause of protecting sensitive resources.

Figure 1: Overview of the Owens Lake, Showing the Location of TW-E and Previous Pumping Test Wells

2.0 BACKGROUND

LADWP has been investigating the potential use of groundwater as a supplemental water source for OLDMP 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 OLDMP 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, 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 with low pumping rates and limited monitoring because they were intended for small-scale studies. The recent short-term test 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 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 each well (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, shallow monitoring wells associated with groundwater-dependent resources were not yet in place; meaning, the potential impact on sensitive resources could not be documented during the previous tests.

2.1.2 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 gallons per minute (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 of the TW-E wellbore itself, it did not provide larger-scale hydrogeological insight or data regarding fault characteristics.

2.1.3 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 the basin in the vicinity of the Owens River Fault Zone. TW-E was also intended to be utilized primarily for conducting pumping 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 has a total depth of 1,495 feet and is screened from 620 to 1,490 feet depth. The casing and screen are 12 inch in diameter and consist of high strength, low alloy (HSLA) steel material. **Figure 2** shows the geophysical log, lithological log, and as-built construction of the well.

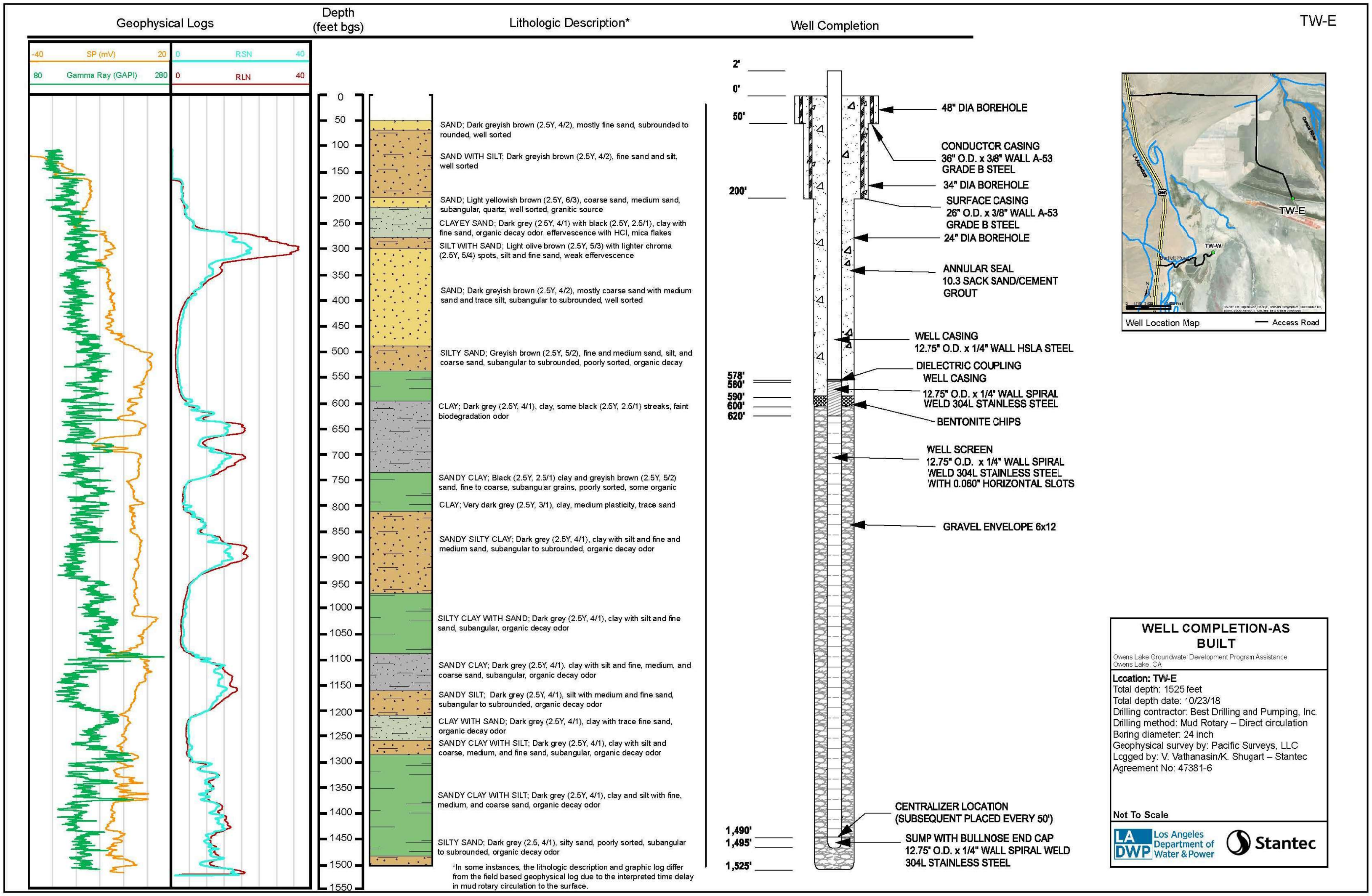


Figure 2: Geophysical log, Lithological Log, and As-Built of Testing Well TW-E

3.0 PROPOSED PUMPING TEST OF TW-E

To gather necessary hydrogeologic information, LADWP is proposing to pump TW-E continuously at an average rate of 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 create a detectable drawdown at some key monitoring points, but low enough such that the groundwater level in the well does not drop to near the level of the pump intake and cause cavitation in the pump.

The pump intake and pressure transducer will be installed in TW-E at depths of 580 and 560 feet below ground surface (bgs), respectively, to accommodate the expected drawdown inside the pumping well casing, having been simulated to produce approximately 400 feet of drawdown in the pumping well. The proposed duration will mimic the dust season under eventual 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 cause significant impacts to sensitive resources based on simulations using the OLGM, as described in the following section.

It is imperative to pump at a low enough rate and duration so as not cause harm to sensitive resources, such as groundwater-dependent ecosystems including habitat at springs and seeps 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 sensitive resources, two primary methods will be utilized:

1) Simulate pumping at TW-E of 1,350 gpm for 6 months using the OLGM and document the forecasted drawdown at sensitive locations; and
2) Perform extensive real-time monitoring of field conditions with a trigger mechanism that stops pumping before 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 and has been recently updated and improved in 2020. The model was utilized to simulate the effects of pumping TW-E at a rate of 1,350 gpm. This was accomplished by running the model for a period of six months beginning in October without simulation of pumping TW-E, then repeating the same simulation with TW-E pumping at a rate of 1,350 gpm. 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 1,350 gpm at TW-E was used as an aid in developing resource protection trigger levels discussed in Section 6.

4.0 MONITORING AND REPORTING PROGRAM

The monitoring program is focused on the area of potential influence of the Testing Well TW-E, located in the northern portion of Owens Lake. However, the current hydrologic monitoring throughout Owens Lake Basin will continue, and all data collected will be available to all parties.

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

Measurement data will be collected at a total of 169 monitoring locations (see **Figure 3** and **Figure 4**), including 140 monitoring wells, 26 flow measuring flumes, two (2) barometric pressure measurement sites, and the one (1) pumping well. It should be noted that monitoring at non-LADWP wells is subject to permission by the well owner. 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 is 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
- Water Quality Sampling and Monitoring

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

- Associated Field Efforts (Section 5)
- Protection of Groundwater-Dependent Resources (Section 6)
- Data analysis (Section 7)

Figure 3: Monitoring Well Locations during the Pumping Test of TW-E

Figure 4: Flumes and Barometric Pressure Stations Monitoring during the Pumping Test of TW-E

4.1 Data Collection Frequency

Figure 5 and **Table 1** illustrate the data collection frequency during the proposed six-month pumping test of TW-E, which is also described in the text below.

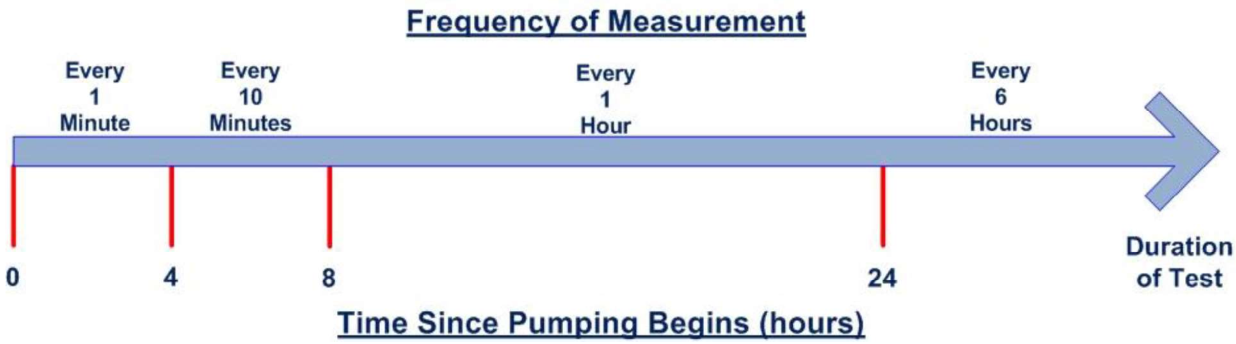


Figure 5: Data Collection Frequency at TW-E during the Six-Month Pumping Test

Pre-Test Monitoring. Approximately 30 days prior to commencement of the six-month pumping test in TW-E, LADWP will ensure that groundwater level data is recorded at a frequency of six(6) 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 to water and submergence depth will be correlated with a manual depth to water measurement using an electric water level sounder and recorded. This process 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.

Pumping Phase Monitoring. To capture the potential drawdown details in the pumping well, while limiting the total amount of data to be stored in the pressure transducers, during the first four (4) hours of the pumping 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 6-hour interval data collection through the end of the pumping test.

Flow Meter Monitoring. The pumping rate of TW-E during the six-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 pumping test followed by weekly measurements until the end of the test.

Post-Pumping Phase/Recovery Monitoring. During the recovery portion of the pumping test, groundwater levels will be recorded via the pressure transducer at intervals similar to the beginning of pumping, 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 four hours up to ten (10) days after conclusion of the pumping test. At the conclusion of the recovery portion of the pumping test, one manual groundwater level measurement will be performed, and the pressure at the transducer will be checked against manual measurement of water level.

Table 1: 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**
Transducer Data Collection Interval	6 hours	1 minute	10 minutes	Hourly	6 hours
During Recovery (10 days)	N/A	1 minute	10 minutes	Hourly	6 hours
Totalizer Data Collection	**First 4 Hours**	**First Week**			**After First Week**
	30 minutes	Daily			Weekly
MONITORING WELLS[2]	**1 Day Prior to Start**	**During Testing**			**10 Days After End**
Transducer Data Collection Interval	4-6 Hours	4-6 Hours			4-6 Hours
FLUMES[2]	**1 Day Prior to Start**	**During Testing**			**10 Days After End**
Transducer Data Collection Interval	Hourly	Hourly			4-6 Hours
BAROMETRIC PRESSURE	**1 Day Prior to Start**	**During Testing**			**10 Days After End**
Data Collection Interval	Hourly	Hourly			Hourly

Notes:
[1] Manual readings 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 1 day 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

Three (3) types of data will be collected during the proposed six-month pumping test of TW-E:

- Groundwater related monitoring
- Surface water related and barometric pressure monitoring
- Ground surface elevation 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 2** lists details on the 140 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.

Monitoring groundwater gradient is an important component of hydrologic monitoring program at Owens Lake. **Table 3** lists monitoring wells that will be utilized to monitor groundwater gradient toward springs and seeps around Owens Lake; these locations are shown on **Figure 6**. The monitoring wells associated with the calculation of horizontal and vertical groundwater flow gradient are part of current monitoring program at Owens Lake and will continue to be monitored throughout the proposed pumping test of TW-E. Hydrographs of key monitoring wells and their associated gradients is provided in **Appendix A.** Additional information on groundwater gradients is provided in the introductory portion of Section 6.

Table 2: Wells to be Monitoring Utilizing Transducers

No.	Well ID	Depth (ft)	Direction from TW-E	Distance from TW-E (miles)	Notes
1	TW-E	1,500	--	--	Pumping Well
2	TW-W	890	SW	2.5	Testing Well east of OVFZ
3	MW-2	295	W	3.65	On alluvial fan NW of Lake, horizontal gradient well
4	MW-3	265	W-NW	4.2	On alluvial fan west of Lake, horizontal gradient well
5	MW-4S	160	SW	2.8	On alluvial fan just west of ORFZ
6	MW-4D	590			
7	MW-5S	240		2.3	On Lakebed, just east of OVFZ, north of TW-W, trigger well
8	MW-5I	460			
9	MW-5D	660			
10	MW-6S	70	N-NW	3.8	Multi-completion well, northwest of Lubken Mainline Road
11	MW-6I	360			
12	MW-6D	440			
13	MW-7S	65	NW	3.8	Multi-completion well, northwest of Lubken Mainline Road
14	MW-7I	310			
15	MW-7D	495			
16	MW-8S	560	N-NW	3.1	Multi-completion well, northwest of Lubken Mainline Road
17	MW-8I	370			
18	MW-8D	65			
19	P1L	33	W	2.9	At Northwest Spring, vertical/horizontal gradient wells, trigger well
20	P1U	9			
21	P2L	33	S-SW	5.6	At Cottonwood Spring, vertical/horizontal gradient wells
22	P2U	8			
23	P3L	34	S	9.1	At Ash Creek Spring, vertical/horizontal gradient wells
24	P3U	8			
25	P4L	34		14.7	At Olancha Spring, vertical gradient wells
26	P4U	8			
27	P5aL	36	S-SE	9.9	At Trucksticker, vertical gradient wells
28	P5aU	8			
29	P5L	36	S	10.3	At Tubman spring, vertical/horizontal gradient wells
30	P5U	4			
31	P6L	34	SE	8.1	At Swedes Spring, vertical/horizontal gradient wells
32	P6U	5			
33	P7L	34		7.6	At Mill Spring, vertical gradient wells
34	P7U	4			

No.	Well ID	Depth (ft)	Direction from TW-E	Distance from TW-E (miles)	Notes
35	P8L	32	E-SE	4.7	At Horse Pasture Spring, vertical gradient wells
36	P8U	7			
37	T347	22	NW	3.8	Just north of Lakebed
38	T348	800		3.4	South of Lubken mainline Road
39	T349	40	N-NW	3.1	North of Lubken Mainline Road
40	T725	20	NW	3.8	Just north Lubken Mainline Road
41	T726	20			
42	T727	20			
43	T858	30	N-NW	6.5	Southeast of Hwys 136 and 395 intersection, trigger well
44	T890	1,500	N	5.3	Cluster monitoring wells, West margin of ORFZ
45	T891	540			
46	T892	390			
47	T893	1,530	N	3.0	Cluster monitoring well, In ORFZ
48	T894	1,270			
49	T895	960			
50	T896	1,601	N	0.6	Cluster monitoring wells, Between OVFZ and ORFZ
51	T897	880			
52	T898	340			
53	T899	1,003	SE	3.6	Cluster monitoring wells, West margin of IMFZ
54	T900	720			
55	T901	190			
56	T902	1,500	N-NW	3.0	Cluster monitoring wells, between OVFZ and ORFZ, trigger well
57	T903	800			
58	T904	380			
59	T905	1,500	S-SW	5.6	Cluster monitoring wells, West of OVFZ
60	T906	530			
61	T907	330			
62	T908	1,400	S-SW	12.7	Cluster monitoring wells, In OVFZ
63	T909	780			
64	T910	240			
65	T911	1,460	S	9.6	Cluster monitoring wells, south end of Lake, between OVFZ and ORFZ
66	T912	1,060			
67	T913	300			
68	T914	1,500	S-SE	7.1	Cluster monitoring wells, In ORFZ
69	T915	1,088			
70	T918	68	NW	3.8	At Dearborn Spring, in OVFZ, horizontal gradient well

No.	Well ID	Depth (ft)	Direction from TW-E	Distance from TW-E (miles)	Notes
71	T919	73	W	2.8	Near Northwest Spring, east margin of OVFZ, horizontal gradient well
72	T920	248	W-SW	3.9	In alluvial fan west of the Lake, west margin of OVFZ, horizontal gradient well, trigger well
73	T921	263	SW	5.6	In alluvial fan west of the Lake, west of OVFZ
74	T922	133	S-SW	9.5	At base of alluvial fan near Cottonwood, west of OVFZ, horizontal gradient well
75	T923	113		9.4	At base of alluvial fan near Ash Creed, west of OVFZ, horizontal gradient well
76	T924	178	SW	13.4	In alluvial fan west of the Lake, west of OVFZ
77	T925	78	S	14.7	South end of Lake
78	T927	68	S-SE	10.0	Near Trucksticker, in ORFZ, horizontal gradient well
79	T928	93	SE	7.5	Near Swedes Pasture, east margin of IMFZ, horizontal gradient well
80	T929	88	NE	3.4	Near Lizard tail, in IMFZ, trigger well
81	T930	68	NW	5.8	In alluvial fan, west of OVFZ
82	T931	62		3.7	In VDA 1, between OVFZ and ORFZ
83	DELTA W(3)	4	W-NW	1.7	Shallow monitoring wells on lakebed, between OVFZ and ORFZ
84	DELTA W(3)	10			
85	DELTA E(1)	4	N	2.1	
86	DELTA E(1)	10			
87	DELTA W(1)	4	N-NW	2.5	
88	DELTA W(1)	10			
89	River Site Lower	515	N	2.5	Monitoring wells at River Site just east of ORFZ
90	River Site Upper	230			
91	River Deep PW	555			Shallow and seep pumping well at River Site east of ORFZ
92	River Shallow PW	225			
93	FTS-T1	726	E-NE	3.4	East margin of IMFZ
94	FTS-T2U	154			
95	FTS-T2L	435			

No.	Well ID	Depth (ft)	Direction from TW-E	Distance from TW-E (miles)	Notes
96	FTS-T3	430			
97	FTS-T5	425			
98	FTS-T6	173			
99	Keeler-Swansea Lower	390	E	4.4	East of IMFZ and Keeler Fan Fault Zone
100	Keeler-Swansea Mid	190			
101	Keeler-Swansea Upper	135			
102	Star Trek	784	SE	5.8	On Lakebed, in IMFZ
103	SFIP PW	250	S	7.1	12" Dia., Test well, west margin of ORFZ
104	SFIP MW	250	S	7.1	5" Dia. Monitoring well, West margin of ORFZ
105	OL-92-2	1,059	S	8.6	USGS well on Lakebed, between OVFZ and ORFZ
106	C5(2)	4	N	2.3	Between ORFZ and IMFZ
107	C5(1)	10	NE		
108	6(1)	4		3.0	In IMFZ
109	D.5(1)	10	E	3.5	
110	Keeler(1)	10	E-SE	5.5	East margin of IMFZ
111	G9(1)	10		6.2	
112	I10(5)	4	SE	7.4	
113	J10(1)	10		8.5	
114	K10(2)	4			In IMFZ
115	L9(1)	10	S-SE	8.8	In ORFZ
116	M8(1)	10		9.4	
117	N7(3)	10		10.1	
118	P5(1)	4	S	11.4	East margin of OVFZ
119	S3(3)	10		12.3	In OVFZ
120	VDA1-1	25	N-NW	2.8	Vegetated Dune Area, proposed
121	VDA2-1	25	N-NE	3.0	Vegetated Dune Area, proposed
122	VDA3-1	25	NE	3.2	Vegetated Dune Area, proposed
123	VDA #3	20		3.1	Vegetated Dune Area
124	VDA8-1	25	E	5.2	Vegetated Dune Area, proposed
125	VDA #10	25	SW	6.7	Vegetated Dune Area
126	VDA #14	30	S	12.2	Vegetated Dune Area

No.	Well ID	Depth (ft)	Direction from TW-E	Distance from TW-E (miles)	Notes
127	VDA #15	30		12.9	Vegetated Dune Area
128	VSUMP	7	NW	3.2	Between lakebed and OVFZ
129	Mill site	130	SE	7.5	Nested monitoring wells
130		240			East margin of IMFZ
131		255			Production well
132	Down Valley N	1,038	N-NW	6.0	North of Lake, east margin of ORFZ
133		438			
134		592			
135		722			
136	Down Valley S	440		5.5	
137		598			
138		719			
139	O'Dell Well		W-NW	4.3	In alluvial fan, in OVFZ
140	Dearborn Spring Well	25		3.5	In Dearborn Spring, in OVFZ

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

Table 3: Monitoring Wells Utilized to Calculate Groundwater Flow Gradient to Springs and Seeps 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)	Southeast/Central
	T928	P6 (5)	East
	T929	Lizard tail	Northeast

Note: Locations shown on **Figure 6**.

Figure 6: Monitoring Well Locations Utilized for Groundwater Gradients

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 4** lists existing flow measurement sites, and locations are shown on **Figure 4**.

Flow measurements will continue throughout the pumping 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 pumping test to ensure monitoring is continuing. Data downloaded for the flumes during the pumping test will be according to the schedule shown in **Table 1**.

Barometric pressure will be monitored at existing LADWP weather stations at Owens Lake North and Owens Lake South sites, which are shown on **Figure 4**. Both stations record barometric pressure hourly.

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

4.2.3 Ground Elevation Monitoring

Land subsidence occurs when a large volume of groundwater is pumped for a long period of time from a groundwater basin. The proposed six-month pumping 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 water levels. However, ground surface elevation will be monitored as part of the monitoring program before, during, and after the pumping test of TW-E.

Table 5 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 six-month pumping test,
- three (3) months after commencement of the pumping test, and
- at the end of the pumping test (6 months).

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 4: Existing Flow Measuring Flumes to Continue Monitoring

Site Number	Location
1	Lizard Tail Seep
2	Dead Hawk
3	Black Sand
4	Horse Pasture 3" Flume
28	Horse Pasture 2" Flume
5	Keeler Flowing Well
6	Bonsai Mound
7	Sulfate Flowing Well
8	Carbide Dump
9	Mill Site Flowing Well
10	Swedes Pasture
11	Mambo
12	Indian Creek
13	L9 Ditch
14	Truck Sticker
15	Tubman Channel
16	Cement Pond
17	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

Table 5: 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 pumping test)
6371	West of OVFZ	Survey	Within 1 month prior, at 3 and 6 months during, and at 3 and 6 months after, the latter, if warranted
6372	West of 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**.

4.3 Reporting Interval

Once the pumping test is started, measurements collected from data loggers at key representative locations will be downloaded, and data from manual measurements will be compiled 1, 3, 7, 15, and 26 weeks after the start of the pumping test. Key representative monitoring locations are the same as trigger locations discussed in the next section. Within 10 business days of data collection, data will be made available to interested parties by either email or uploading to the OLGDP web page (www.ladwp.com/olg). Measurement data may be revised after quality assurance/quality control (QA/QC) of collected data.

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

4.4 Water Quality Sampling and Monitoring

The purpose of the planned water quality sampling and analysis is to document any potential change in water quality because of the pumping test. Water quality samples from select monitoring wells will be collected once just prior to the start of the pumping test and once prior to the conclusion of the test. In addition to field parameters (temperature, pH, and conductivity), samples will be collected for laboratory analysis of general chemistry and metals (**Table 6**). The locations where water quality samples will be collected are described in Section 6.0. Samples will be collected:

- one week prior to start of pumping,
- one week prior to the end of pumping.

Table 6: Water Quality Testing Plan

Category		Constituent
Field		Temperature
		pH
		Specific Conductance
		Dissolved Oxygen
		Turbidity
Lab	Non-Metals	Alkalinity
		Fluoride
		Nitrate
		Total Dissolved Solids
	Metals/ Metalloids	Aluminum
		Antimony
		Arsenic
		Barium
		Beryllium
		Boron
		Cadmium
		Chromium
		Copper
		Iron
		Lead
		Manganese
		Nickel
		Selenium
		Silver
		Thallium
		Uranium
		Vanadium
		Zinc

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 in situ the 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 inflow from various sections of the well screen and provides valuable information about the permeability of various aquifers outside the well screen.

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

5.1 Spinner Logging

The goal of spinner logging will be to determine the percentage of the pumped water that is extracted from each of the aquifers that contribute to flow in testing well 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 during the proposed pumping test via a 2-inch polyvinyl chloride (PVC) pipe extending below the pump intake to determine the source of groundwater during pumping 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 water supply to the pond is primarily water diverted from Los Angeles Aqueduct (LAA) or the Lower Owens River Project (LORP) Pump Back Station at the southern end of Lower Owens River Project. Pumped water from TW-E during the pumping test will be discharged into the dust mitigation ponds surrounding the well and will supplement the flow from 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 the high concentration of undesirable constituents in the soil floor of the ponds. None of the ponds surrounding TW-E are designated as habitat ponds. However, 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 7** shows the results of sampling collected in March 2020 from all seven (7) points.

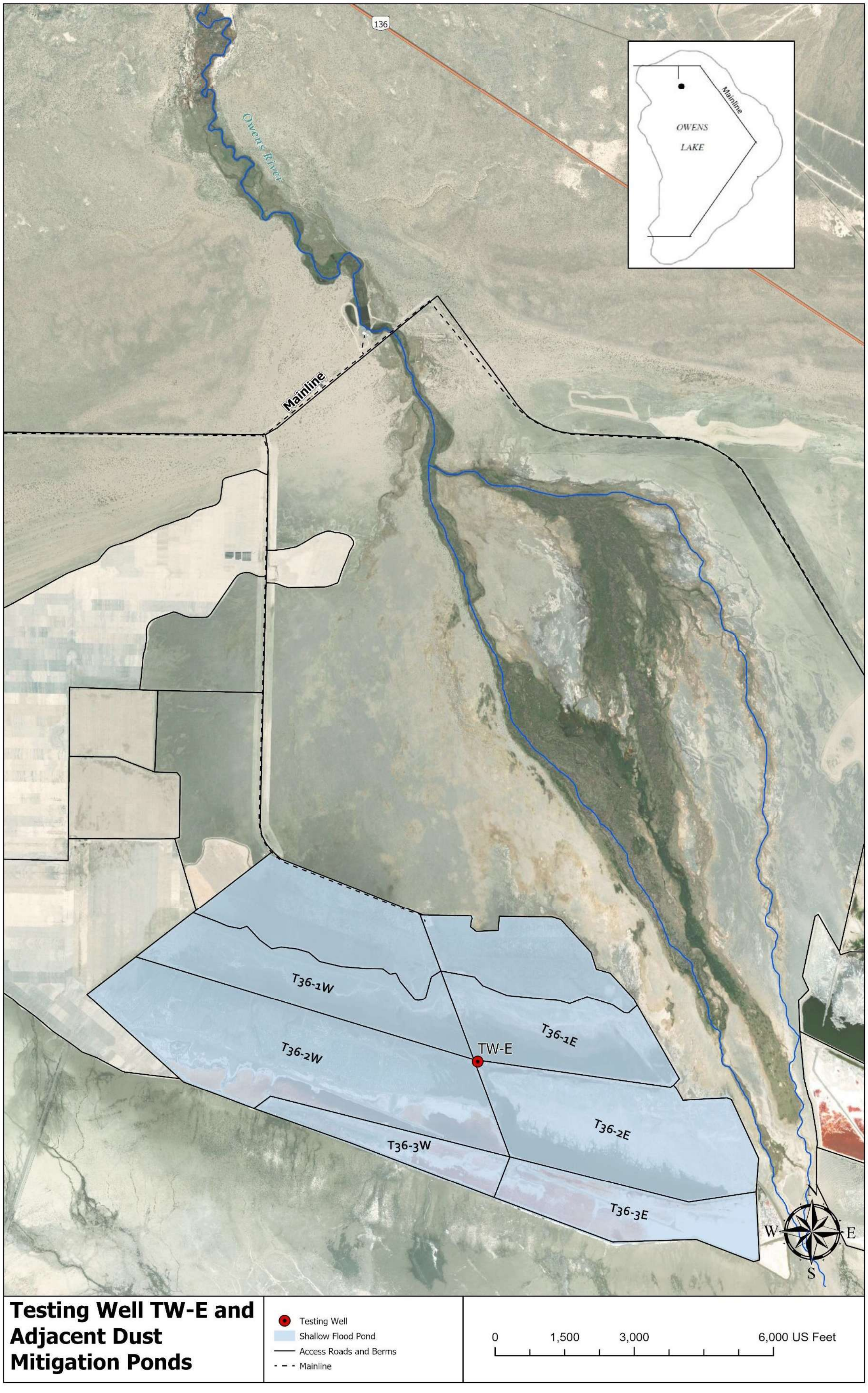


Figure 8: Location of Discharge Ponds in the Vicinity of TW-E

Table 7: 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 (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 (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

6.0 PROTECTION OF GROUNDWATER-DEPENDENT RESOURCES

Groundwater is water that exists underground in saturated zones beneath the land surface. The upper surface of the saturated zone is called the water table. Contrary to popular belief, groundwater does not form underground rivers in the Owens Valley. It fills the pores and fractures in underground materials such as sand, gravel, and other rock, much the same way that water fills a sponge. If groundwater flows naturally out of underground materials or if it can be removed by pumping (in useful amounts), then the subsurface materials are called aquifers. Groundwater moves slowly, typically at rates of 3-25 inches per day in an aquifer (U.S. Geological Survey [USGS], 2020).

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, 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 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 and seeps at the margin of the lake. This groundwater flow supports sensitive 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 3** 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 9**. 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**.

The location of resources to be protected and associated trigger wells is shown on **Figure 10**.

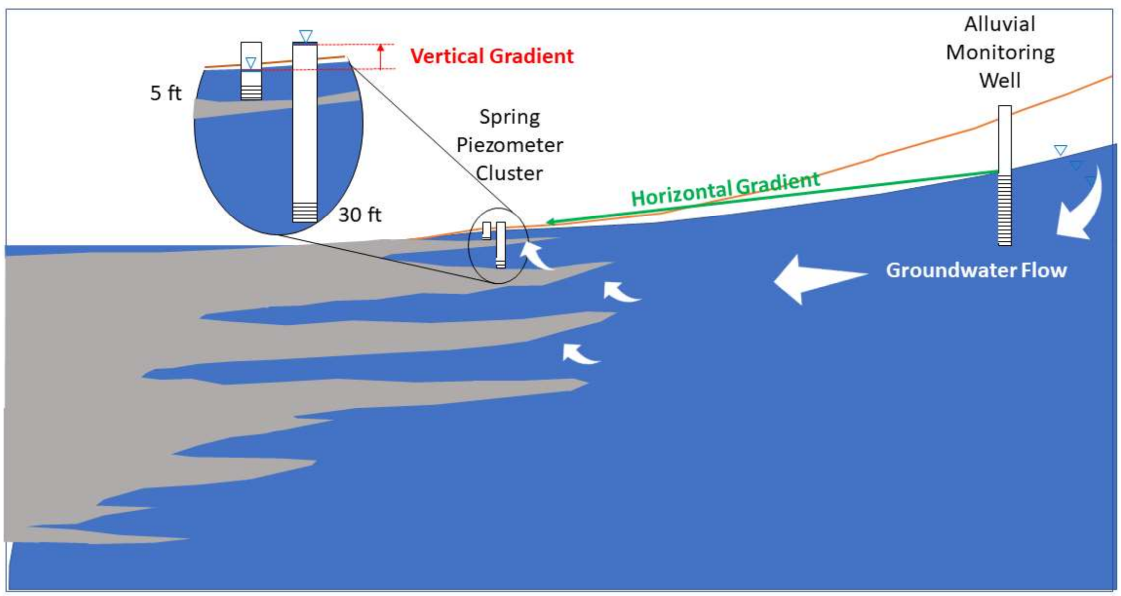


Figure 9: Illustration of Vertical and Horizontal Gradients

Figure 10: Location of Resources to be Protected and Associated Trigger Wells

6.1 Hydrogeologic Setting

Conducting a six-month pumping test of TW-E is important to collect necessary data to further understand the hydrogeology of Owens Lake. The test is designed such that while the necessary data will be collected, groundwater-dependent resources will not be impacted.

At Owens Lake, most of the groundwater-dependent resources utilize water from the shallow surficial aquifer. The surficial aquifer is separated from the active confined aquifers underneath by a thick layer of clay (aquitard) varying from approximately 100 feet to 200 feet as shown in schematic on **Figure 11**. Multiple aquitards underlie TW-E, with the shallowest at about 300 feet bgs. Aquitards have very low hydraulic conductivity and act as a relatively impermeable barrier between aquifers. Therefore, there is minimal to no direct connection of the near surface resources to the deeper active aquifers. 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 act as lateral groundwater barriers; therefore, the resources are protected by the faults from the effect of pumping in-between these faults.

The construction of testing well 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 active aquifers and not from the shallow surficial aquifer.

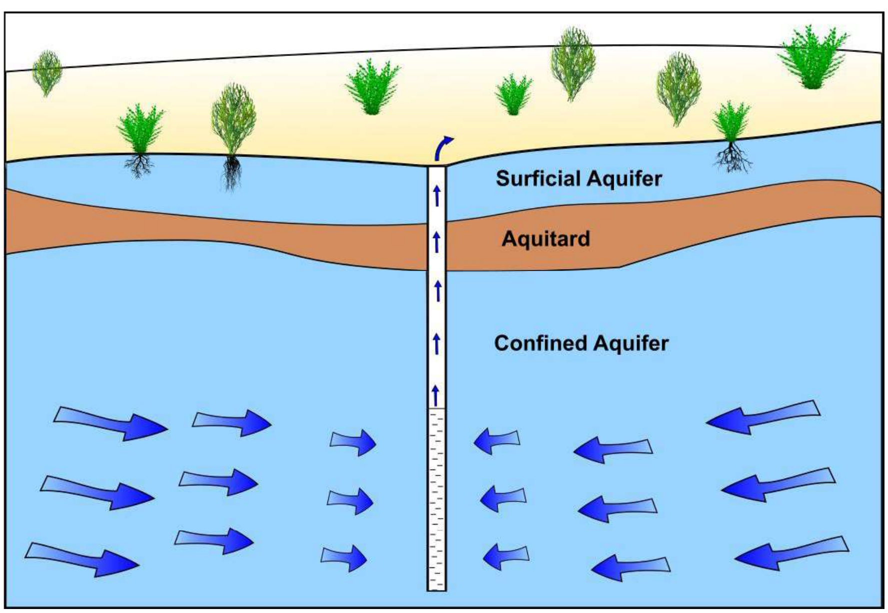


Figure 11: Schematic Showing General Cross Section Near Owens Lake Surface

6.2 Trigger Mechanism to Stop Pumping

The only mechanism by which the pumping of testing well TW-E can potentially affect nearby groundwater-dependent resources is if the pumping lowers the groundwater level directly beneath the resource, or reduce overland flow to the resource. Therefore, an extremely reliable method to protect groundwater-dependent resources is to set a limit ("trigger") on groundwater level beneath the resources and/or the gradient toward the resources. At the suggestion of reviewers of the initial version of the testing plan for the six-month pumping test of TW-E, a specific trigger mechanism will be utilized to manage the pumping portion of the proposed six-month pumping test of TW-E. While no impact is expected from the six-month pumping test of TW-E, triggers will be set 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 domestic wells. It is important to note that the triggers utilized in this test are anticipated to be much more conservative than those ultimately utilized during operational pumping and may not be realistic for long-term operation. However, 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 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 and seeps.

6.3 Model Simulation of the 6-Month Test

As noted in Section 3.1, the 2020 version of the OLGM (Stantec, 2020) was utilized to evaluate the shallow groundwater elevation decline (drawdown) due to pumping TW-E at 1,350 gpm for 6 months so that key locations can be identified as trigger locations to protect groundwater-dependent resources.

Given that TW-E produces water from deeper confined aquifers underlying thick sequences of silt and clay aquitards, the drawdown caused by pumping of TW-E will be highest in the deeper aquifers, but muted in shallow aquifers that support groundwater-dependent resources and non-LADWP wells. The maximum simulated drawdown occurring at any non-LADWP well is 0.24 feet at the O'Dell property northwest of TW-E. The maximum drawdown in any of the shallow piezometers surrounding the lake is 0.04 feet at P1 located west of TW-E, while the maximum drawdown at any VDAs site is 0.03 feet at VDA 5, located east of TW-E. These maximum simulated drawdown values are shown in **Figure 12,** 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. Simulated drawdown at specific trigger locations is described in the following section.

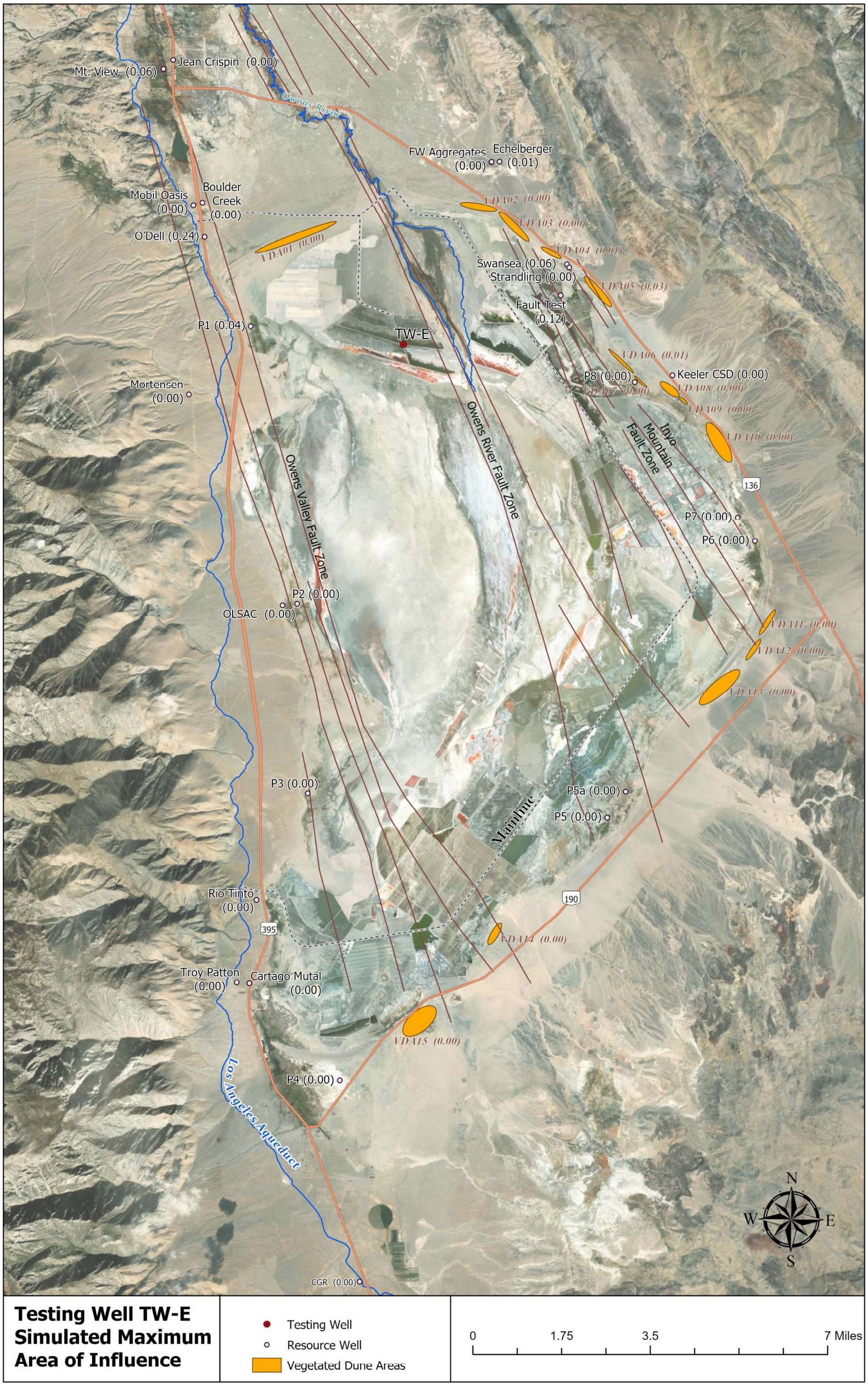


Figure 12: Simulated Maximum Shallow Aquifer Drawdown due to Pumping Test of Well TW-E

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 10** and listed in **Table 8**. Groundwater levels in 16 monitoring wells, designated as trigger wells, will be used to set specific trigger levels. These trigger wells are located either at the resources themselves or between TW-E and the resource to be protected. Anytime during the pumping phase of the test, should groundwater levels in any of the trigger wells fall below the preset trigger level for that monitoring well, pumping from TW-E will stop within 24 hours of the time that groundwater drop below trigger is detected, 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 noted prior to initiation of testing compared to the groundwater elevation during or at the completion of testing.

6.4.1 Groundwater Gradient Monitoring

Triggers associated with calculated groundwater gradients toward springs and seeps are listed in **Table 9.** This table lists both the horizontal gradient toward and vertical gradient at five groundwater dependent resources that could be affected by the six-month pumping test of TW-E, generally located in the northern half of Owens Lake.

Table 8: Groundwater-Dependent Resources and Associated Trigger Wells

Resource	Location	Trigger Well	Simulated Drawdown After Pumping for 6 Months at 1,350 gpm (feet)	Trigger Drawdown Due to Pumping (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	0.24	5
FW Aggregates Supply Well	east of the Owens River Fault and 4.5 mile E-NE of TW-E	T929	0.20	5
Mortensen Domestic Well	west of Owens Valley Fault, 3 miles west of TW-E	T920	0.0	5
VDA-1*	3 miles NW of TW-E	VDA-1	0.0	1
VDA-2*	3 miles NE of TW-E	VDA-2	0.0	1
VDA-3*	3 miles NE of TW-E, just SE of VDA-2	VDA-3	0.0	1
VDA-4	3 miles NE of TW-E, just SE of VDA-3	6(1)	0.01	1
VDA-5	3 miles NE of TW-E, just SE of VDA-4	D5 (2)	0.03	1
VDA-6	3 miles E of TW-E, just S of VDA-5	D5 (2)	0.01	1
VDA-7	3 miles E of TW-E, just S of VDA-6	P8 (30')	0.0	1
VDA-8	3 miles E of TW-E, just E of VDA-7	P8 (30')	0.0	1
Mt. View Trailer Park	4 miles NW of TW-E	T858	0.06	5
Fault Test Well (FTW)	2.7 miles east of TW-E	FTW	0.12	5
Keeler CSD	northeast of Keeler across Hwy 136	Keeler (1)	0.0	5

Note: * VDA's 1, 2, and 3 will be installed prior to the start of the test.

Table 9: Trigger Wells Associated with Groundwater Flow Gradient[1] toward Springs and Seeps around Owens Lake

Gradient Type	Up-Gradient Location	Down-Gradient Location	Location Notes	Pre-Pumping Gradient (feet)[2]	Simulated[3] Gradient After 6 month Pumping at 1,350 gpm (feet)	Trigger Gradient (feet)
Vertical	P1 (30)	P1 (5)	Northwest (Northwest Spring)	0.50	0.50	0.25
	P2 (30)	P2 (5)	West-Central (Cottonwood)	1.10	1.10	0.55
	P6 (30)	P6 (5)	East (Swedes Pasture)	16.30	16.29	8.15
	P7 (30)	P7 (5)	East (Mill Site)	6.10	6.10	3.05
	P8 (30)	P8 (5)	Northeast (Horse Pasture)	4.60	4.56	2.30
Horizontal	MW-3	T918	Northwest	174.26	173.77	87.13
	MW-2	P1(5)	Northwest	81.04	80.86	40.52
	T920	T919	Northwest	16.96	16.94	8.48
	T922	P2 (5)	West-Central	13.78	13.78	6.89
	T928	P6 (5)	East	17.32	17.31	8.66

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 model).

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 mile northwest of TW-E. 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, T904 will be utilized as the trigger well.
- **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 the trigger wells.
- **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.
- **Springs and Seeps located West of Owens Lake** - This specific spring and seep area include 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.
- **Vegetated Dune Areas** - The VDAs that are located north and northeast of Owens Lake and according to the OLGM those that could potentially be affected by the proposed six-month pumping test of TW-E are 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. While the surficial aquifer is separated from the active groundwater aquifers beneath Owens Lake, to add an additional layer of protection for these vegetated dunes and to ensure groundwater levels under the dunes are not significantly affected by the six-month pumping test of TW-E, groundwater level under each dune will be monitored during the pumping test.
- **Vertical and Horizontal Gradients** – The springs and seeps on both east and west sides of Owens Lake are fed by groundwater flowing lakeward both horizontally and vertically upward. Because in most cases, flow emanating from springs and seeps cannot be measured directly, measurement of flow gradients toward the springs and seeps serve as a mechanism to monitor flow from these areas.

6.5 Finalization of Triggers Prior to Commencement of Testing

LADWP will review the most recent hydrographs (**Appendix A**) one (1) week prior to the start of the pumping test to verify pre-pumping gradients (**Tables 8 and 9**). LADWP will prepare a memo to document the pre-pumping gradients and the trigger levels. The memo will be provided to the parties for review and comment.

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:

- relative groundwater levels prior to the start of pumping test,
- historic hydrograph for each trigger well, and
- typical depths of vegetation root zone in the area near each trigger well.

During the proposed pumping 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 relatively constant and not change operation of any nearby pumps. In addition to the trigger wells listed in **Table 8**, the groundwater gradient will also be monitored (**Table 9**) with associated trigger gradients to ensure the groundwater-dependent springs and seeps 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 140 monitoring wells, 26 flow measuring flumes, and two (2) barometric pressure stations for the duration the proposed pumping 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 pumping 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 six-month pumping 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 pumping test from monitoring locations throughout the Owens Lake Basin, 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.

8.0 REFERENCES

MWH, 2012. Owens Lake Groundwater Evaluation Project. Final Report. October.

MWH, 2016. Fault Investigation of Northwestern Owens Lake Area. April.

Questa Engineering, 2002. Analysis of Pump-Spinner Test and 48-Hour Pump Test in Well NC-EWDP-7SC, Near Yucca Mountain, Nevada. March.

Stantec, 2017. TM – Monitoring and Test Wells Basis of Design. February.

Stantec, 2018. Hydrologic Monitoring Management, and Mitigation Plan for the Owens Lake Master Project, prepared for: Owens Lake Master Project Advisory Committee. September.

Stantec, 2020. TM – Model Documentation Report for the Owens Lake Groundwater Model. May.

U.S. Geological Survey (U.S.G.S.), 2020. Frequently asked questions at https://www.usgs.gov/faqs/what-groundwater?qt-news_science_products=0#qt-news_science_products

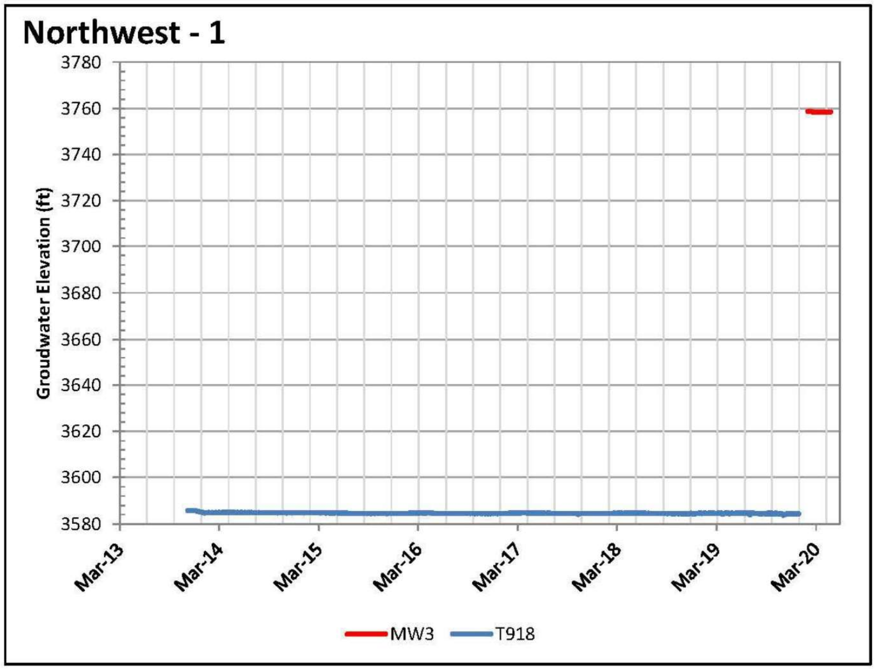
APPENDIX A

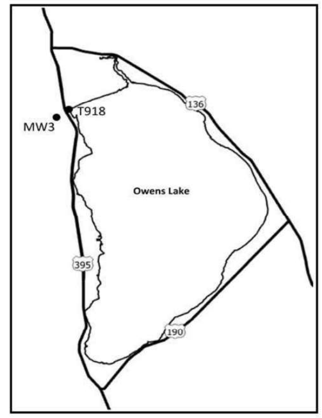
HYDROGRAPHS AND GROUNDWATER GRADIENTS (HORIZONTAL AND VERTICAL FOR KEY MONITORING WELLS

Appendix A: Horizontal Groundwater Gradients

Owens Lake Groundwater Development Program

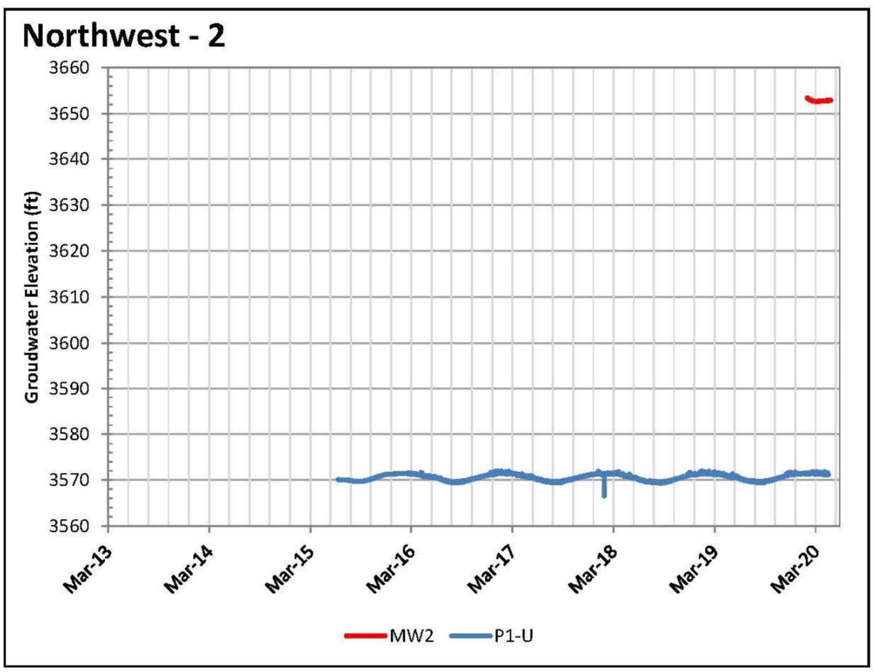
Horizontal Groundwater Gradient

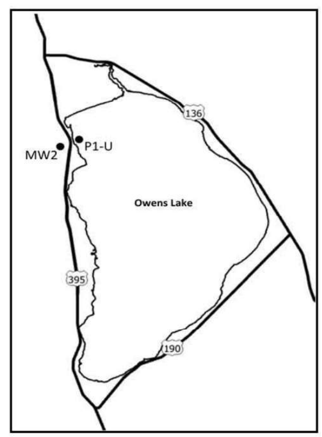




*Horizontal Gradient**

174.26 feet





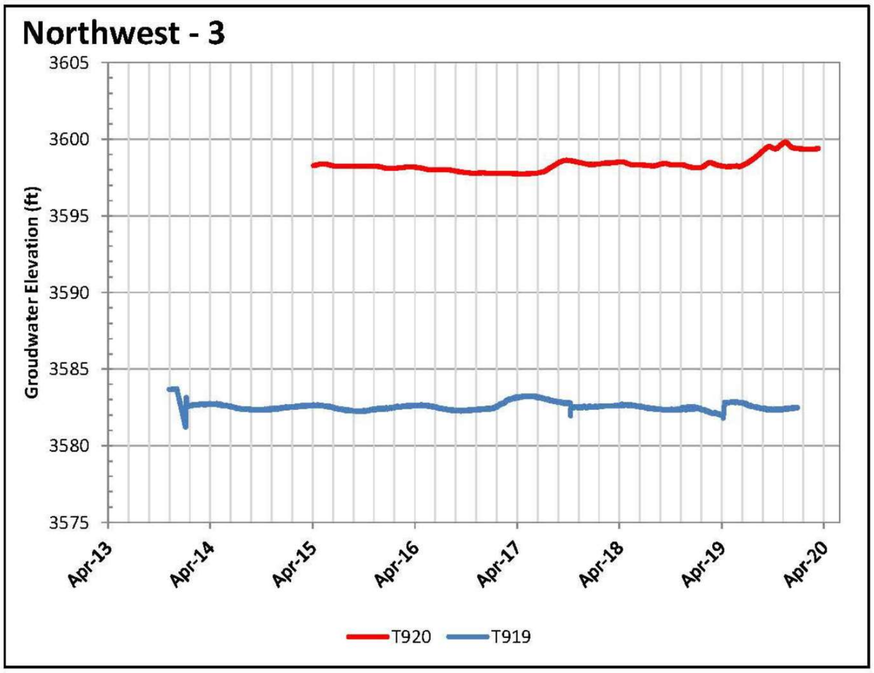
*Horizontal Gradient**

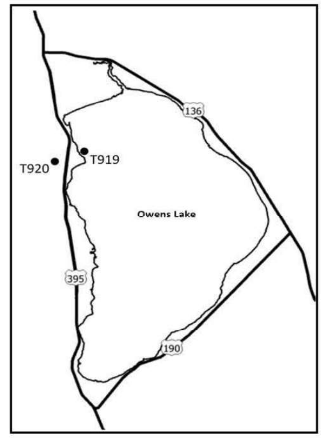
81.04 feet

*Horizontal groundwater gradient is groundwater level in aluvial minus lakebed monitoring well

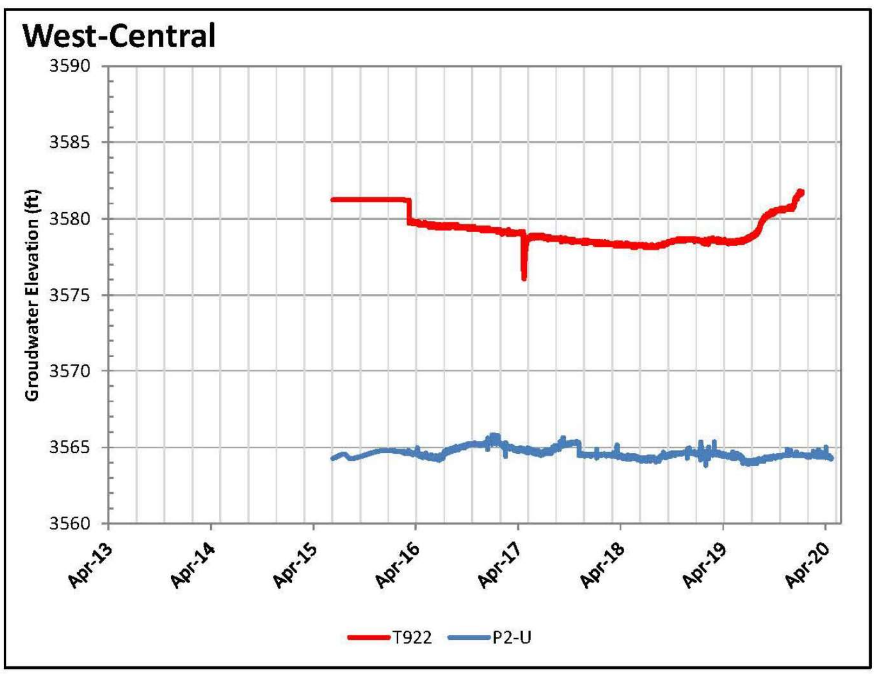
Owens Lake Groundwater Development Program

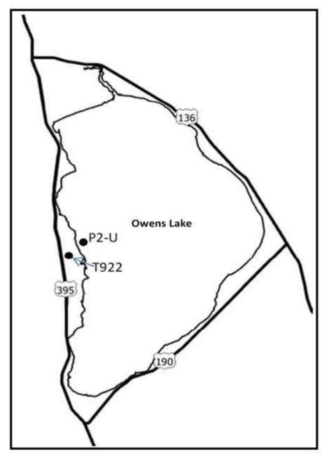
Horizontal Groundwater Gradient





*Horizontal Gradient**
16.96 feet



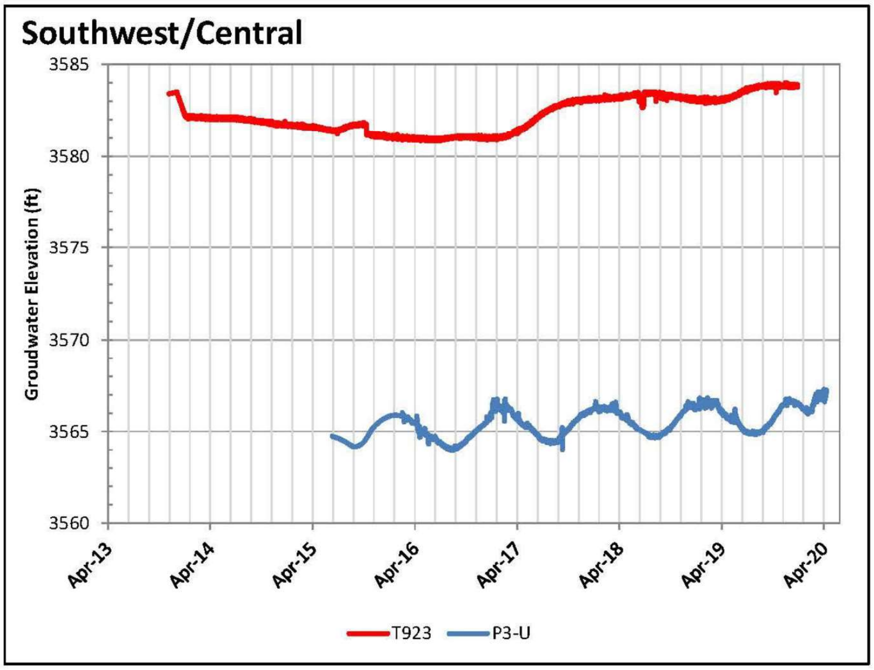


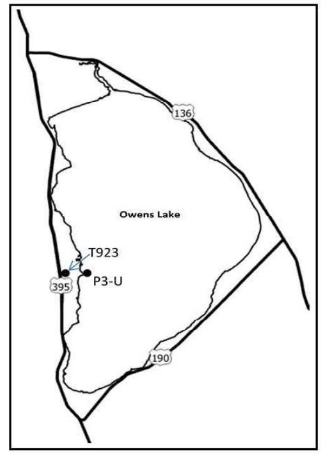
*Horizontal Gradient**
13.78 feet

*Horizontal groundwater gradient is groundwater level in aluvial minus lakebed monitoring well

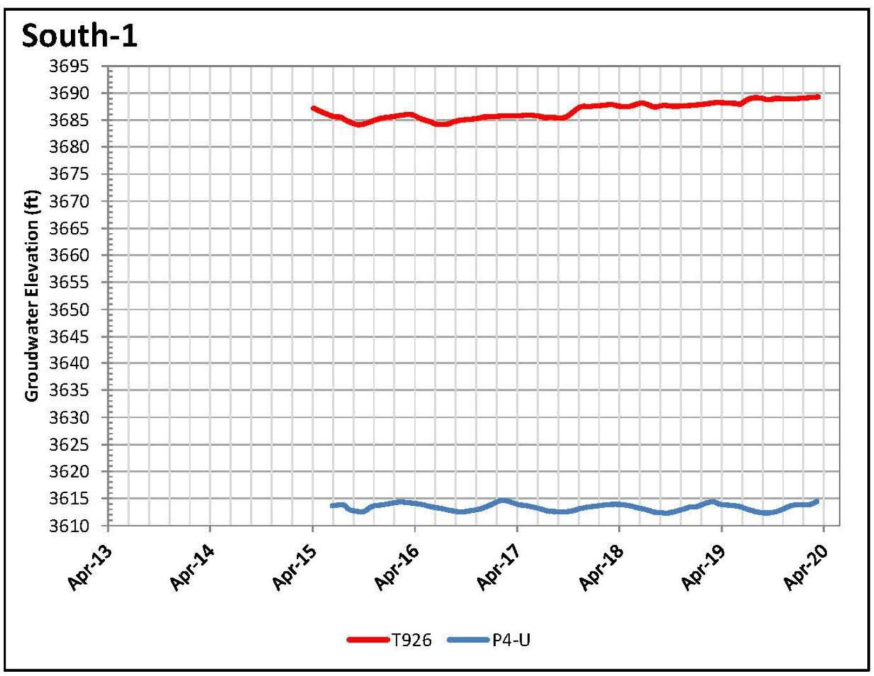
Owens Lake Groundwater Development Program

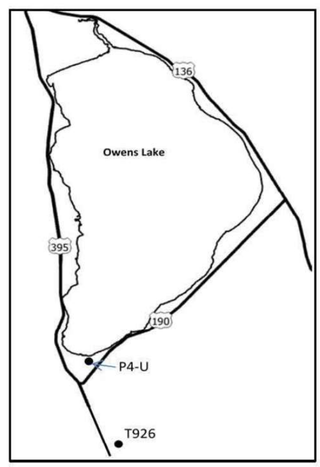
Horizontal Groundwater Gradient





*Horizontal Gradient**
17.92 feet



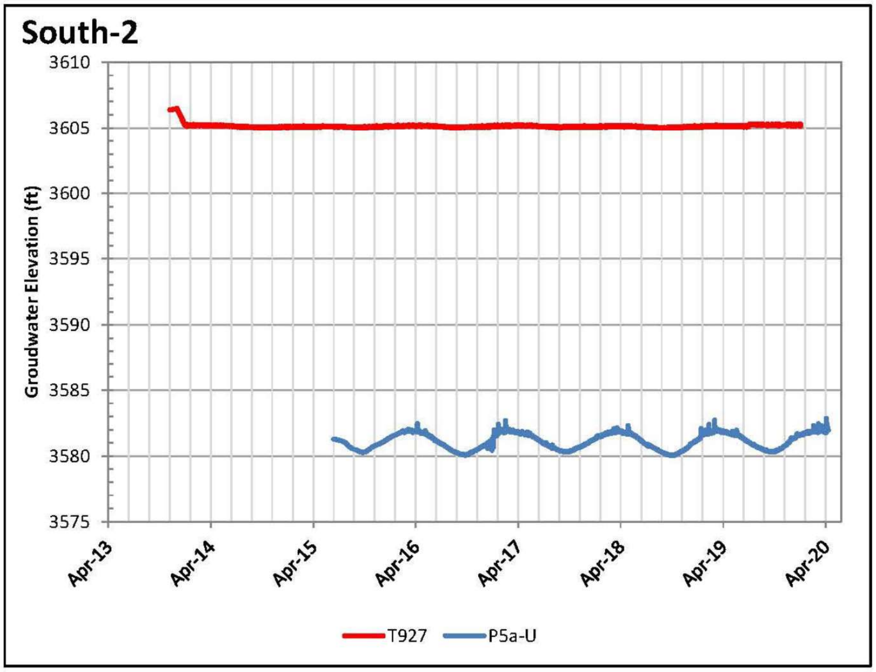


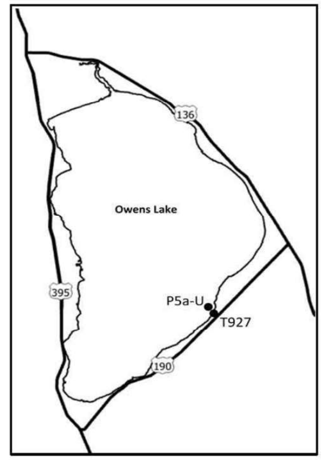
*Horizontal Gradient**
74.81 feet

*Horizontal groundwater gradient is groundwater level in aluvial minus lakebed monitoring well

Owens Lake Groundwater Development Program

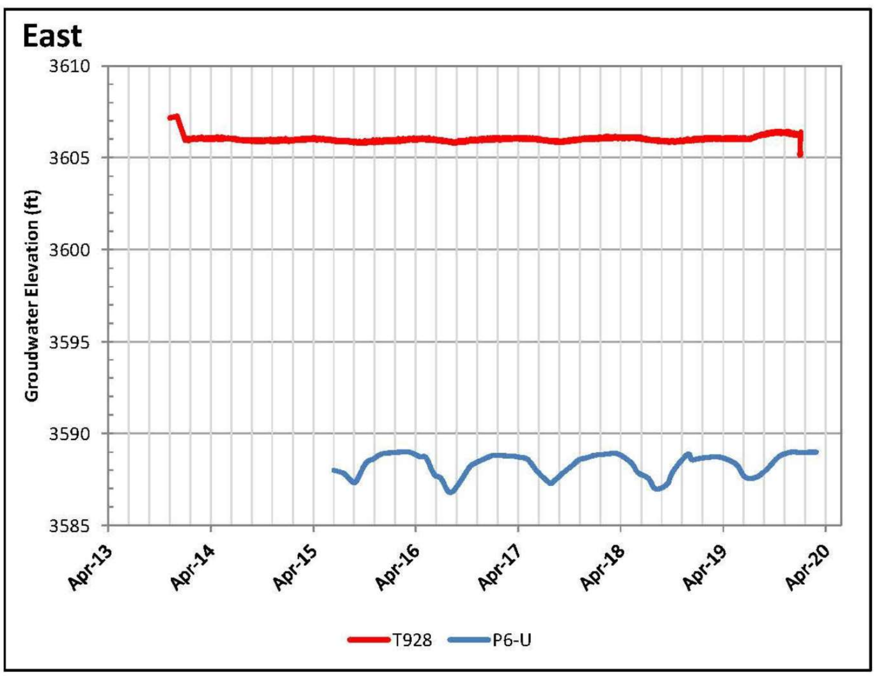
Horizontal Groundwater Gradient

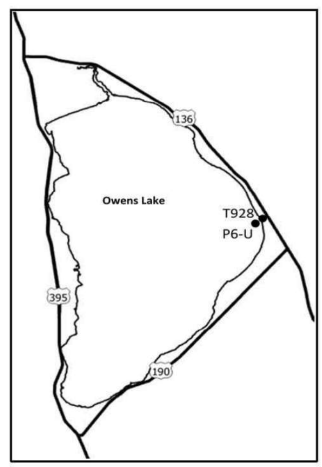




*Horizontal Gradient**

23.34 feet





*Horizontal Gradient**

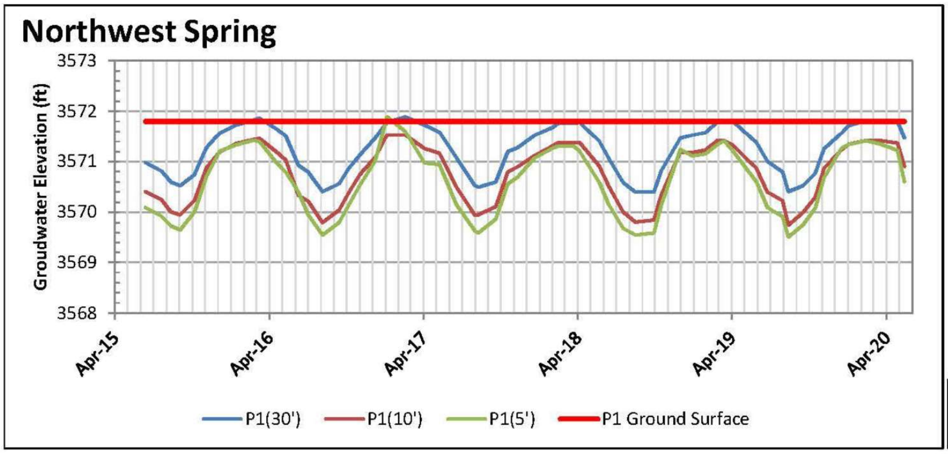
17.32feet

*Horizontal groundwater gradient is groundwater level in aluvial minus lakebed monitoring well

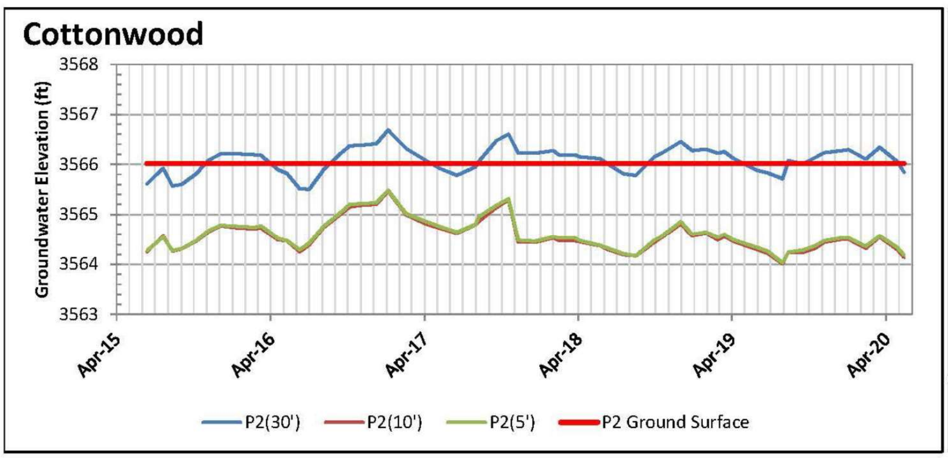
Appendix A: Vertical Groundwater Gradients

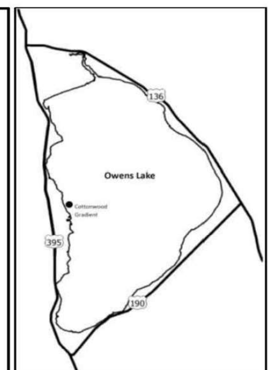
Owens Lake Groundwater Development Program

<u>Vertical Groundwater Gradient</u>

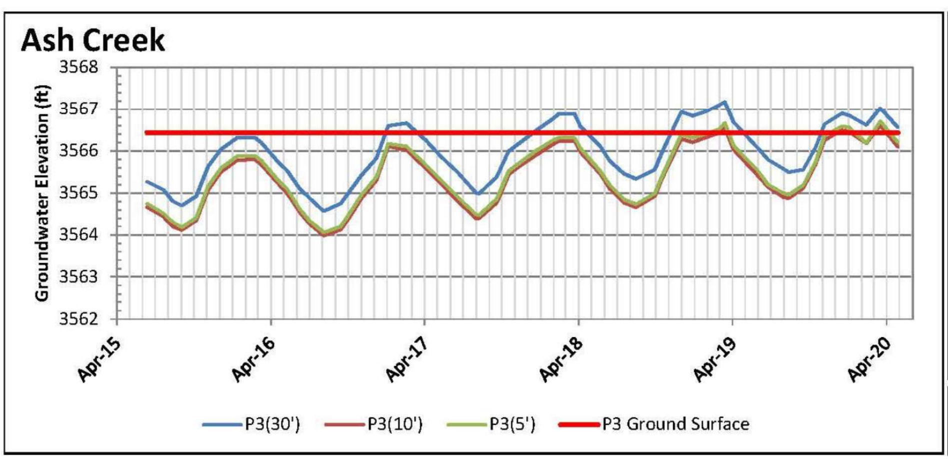


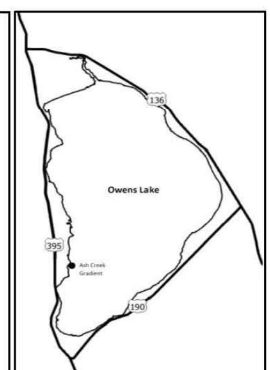
*Upward Gradient**
0.50 feet





*Upward Gradient**
1.10 feet



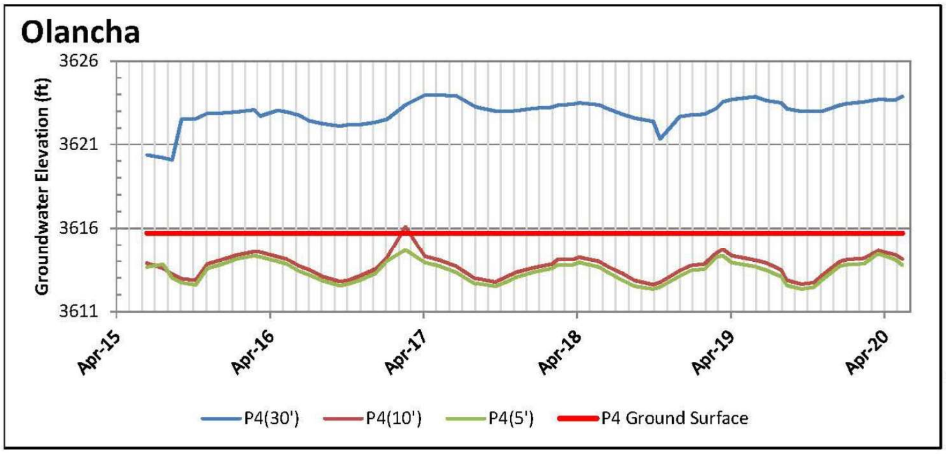


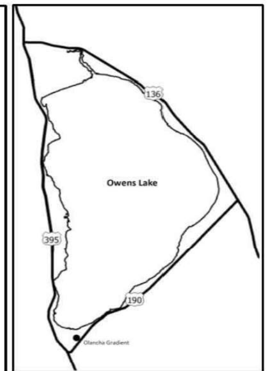
*Upward Gradient**
0.52 feet

*Vertical groundwater gradient is groundwater level in 30' deep minus 5' deep monitoring well

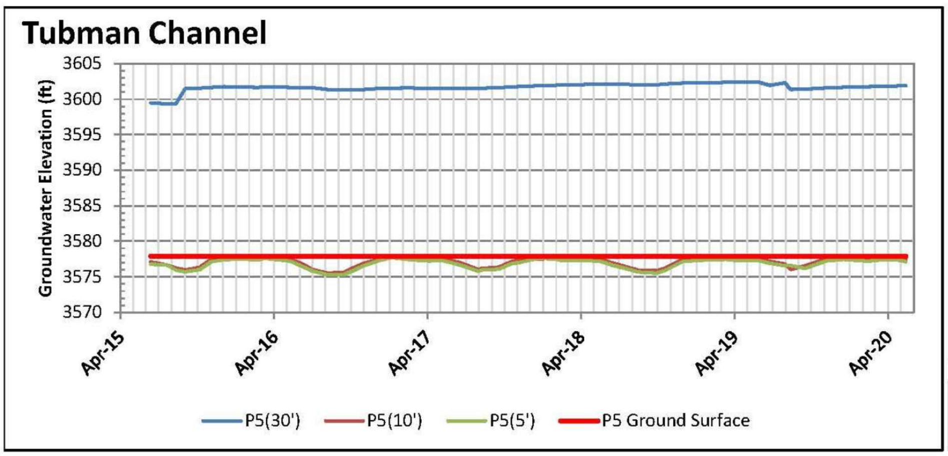
Owens Lake Groundwater Development Program

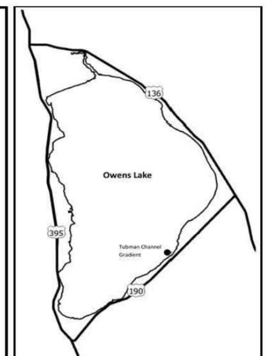
Vertical Groundwater Gradient



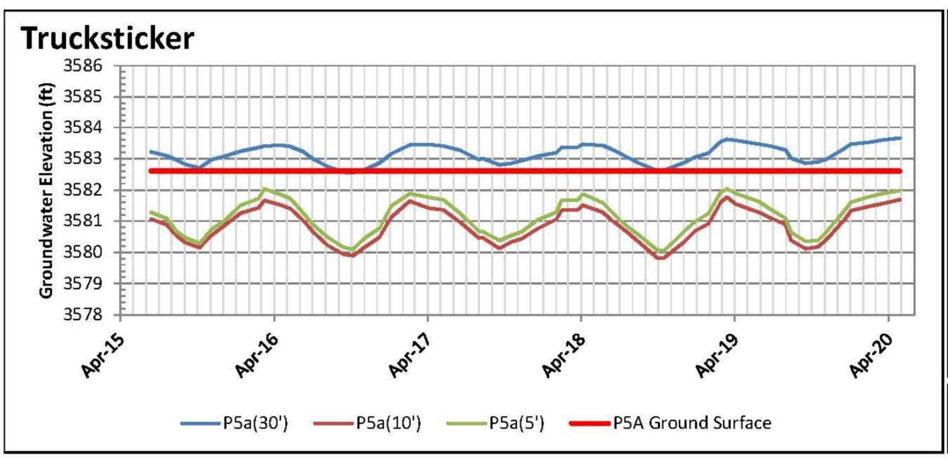


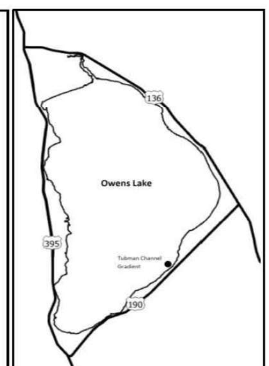
*Upward Gradient**
9.20 feet





*Upward Gradient**
24.10 feet



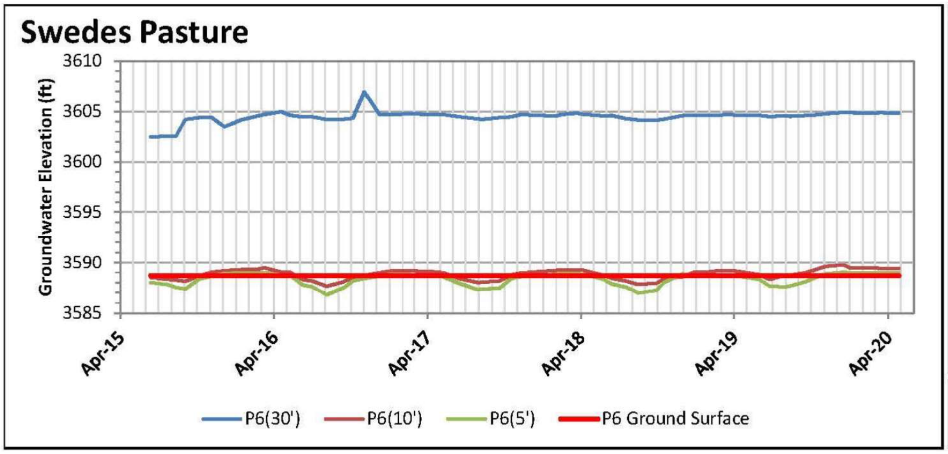


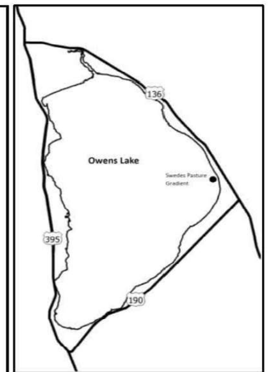
*Upward Gradient**
1.56 feet

*Vertical groundwater gradient is groundwater level in 30' deep minus 5' deep monitoring well

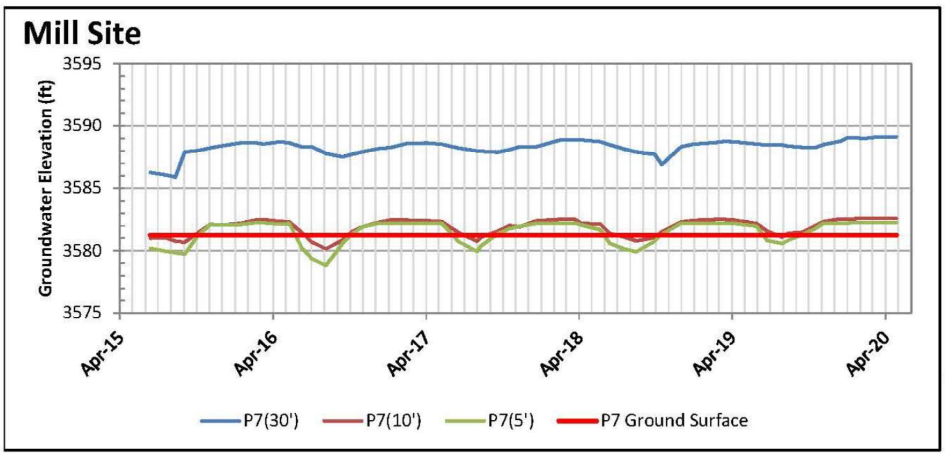
Owens Lake Groundwater Development Program

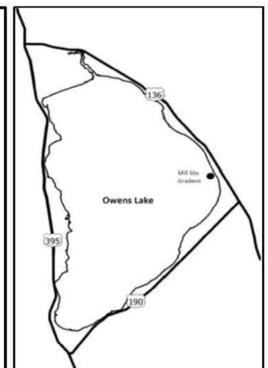
Vertical Groundwater Gradient



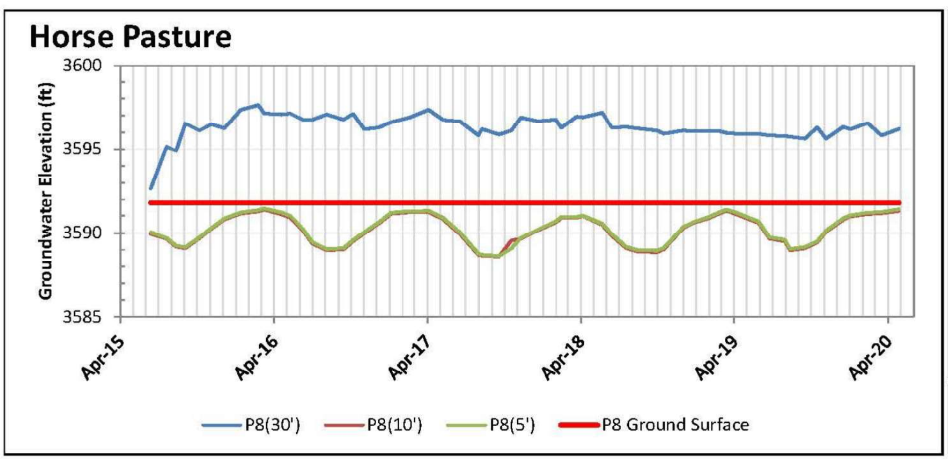


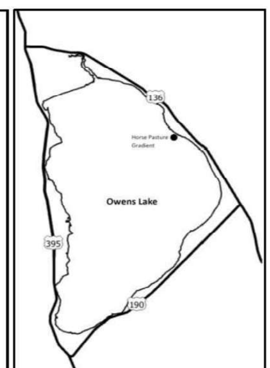
*Upward Gradient**
16.30 feet





*Upward Gradient**
6.10 feet



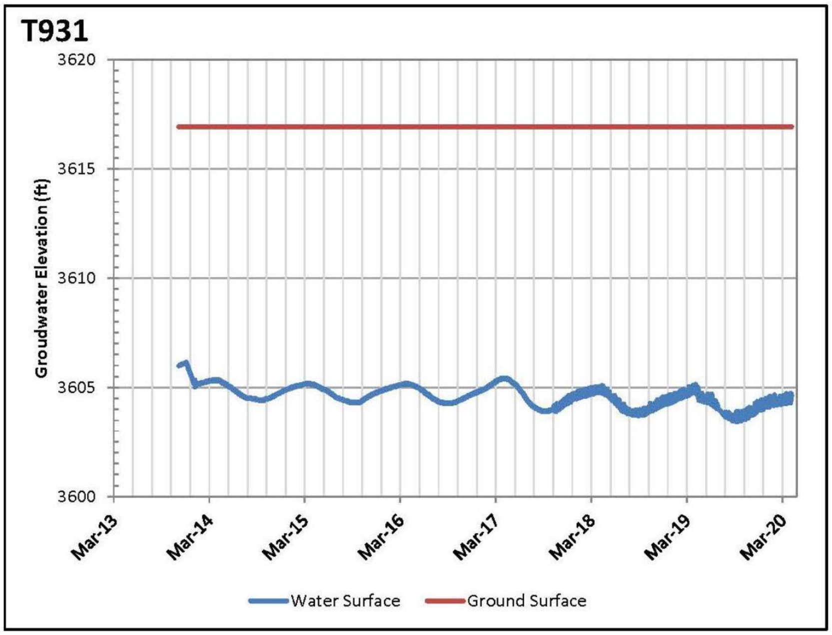


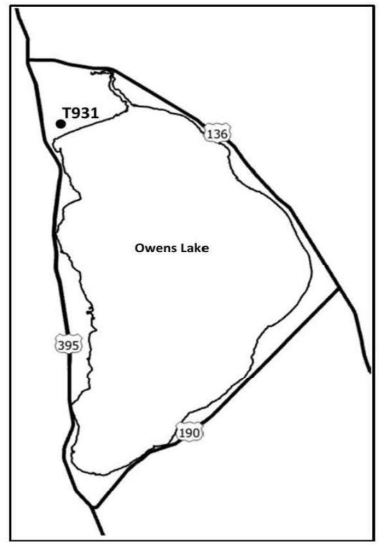
*Upward Gradient**
4.60 feet

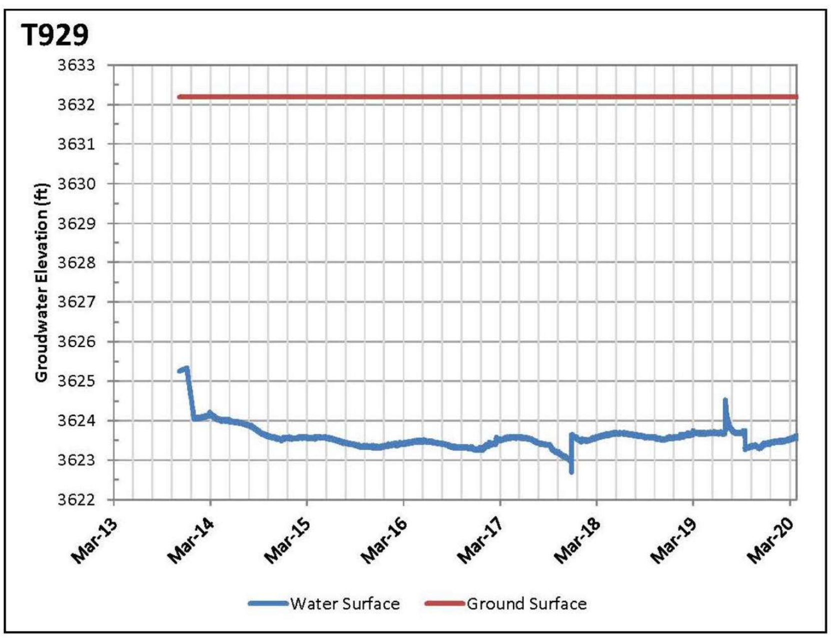
*Vertical groundwater gradient is groundwater level in 30' deep minus 5' deep monitoring well

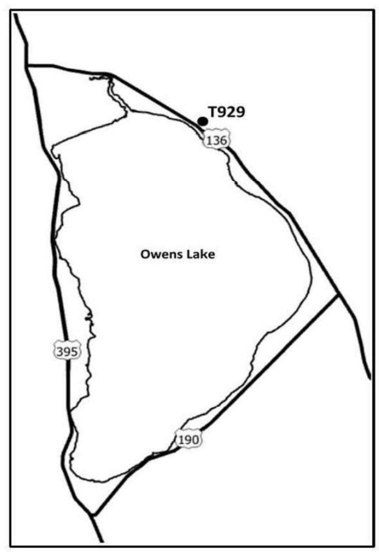
Appendix A: Trigger Wells

Owens Lake Groundwater Development Program
non-LADWP Wells



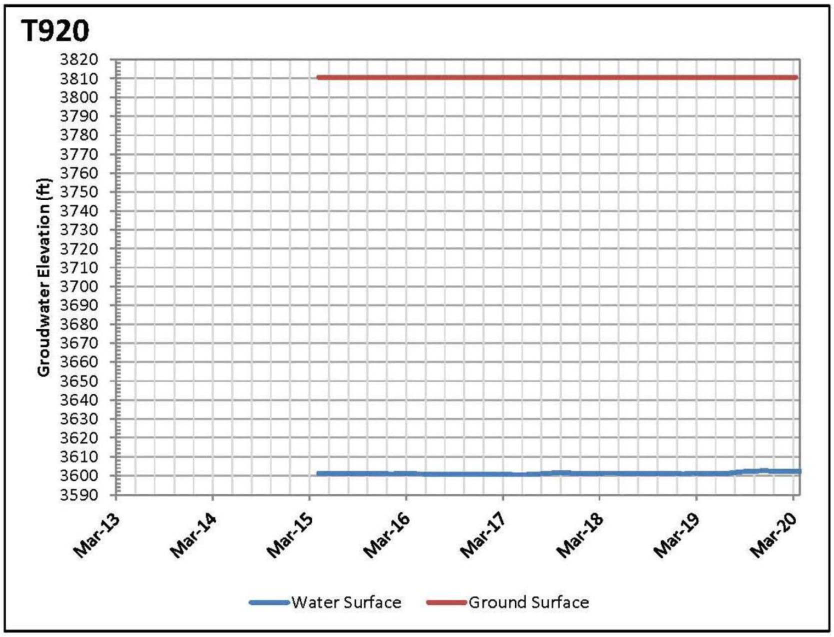


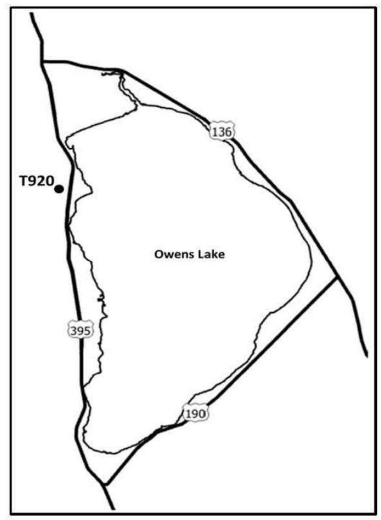


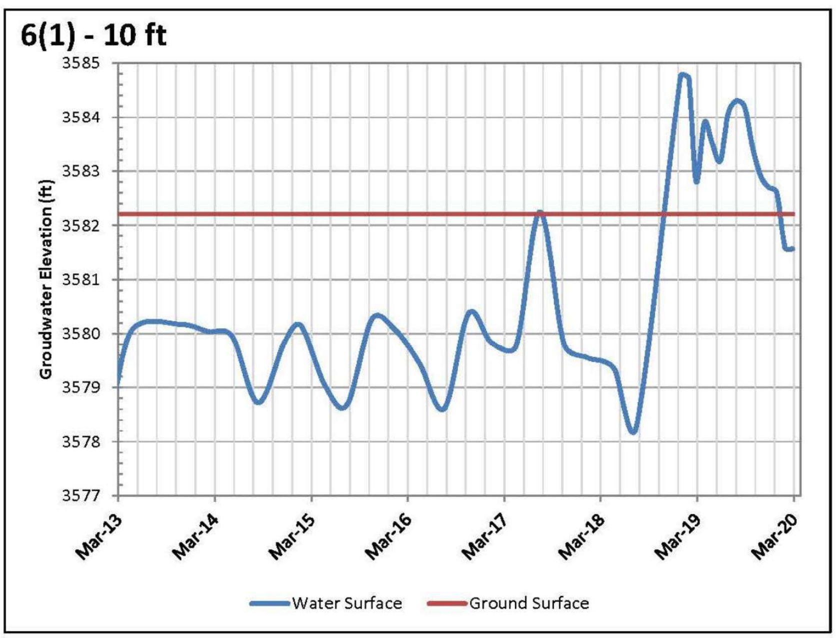


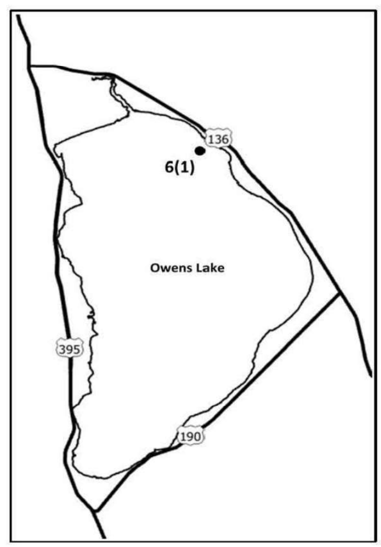
Owens Lake Groundwater Development Program

non-LADWP Wells



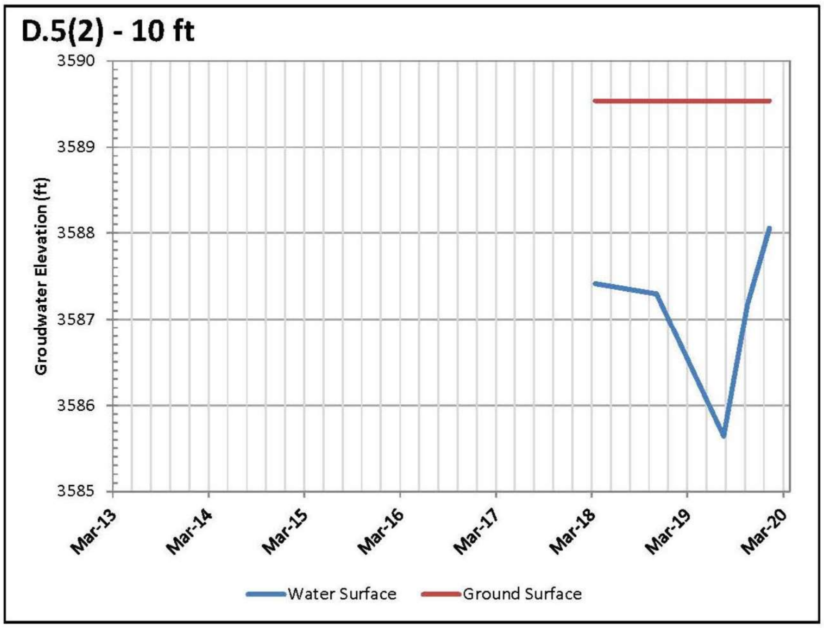


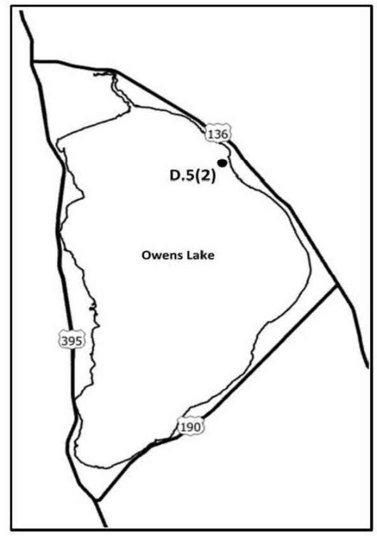


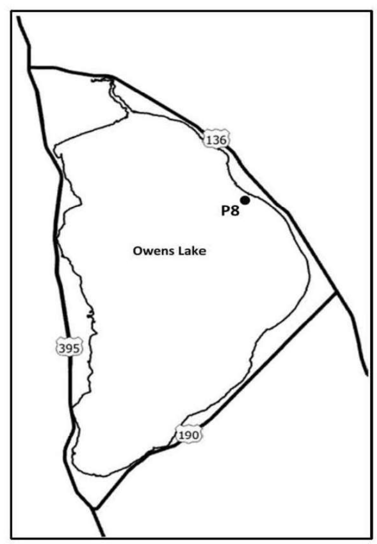


Owens Lake Groundwater Development Program

non-LADWP Wells

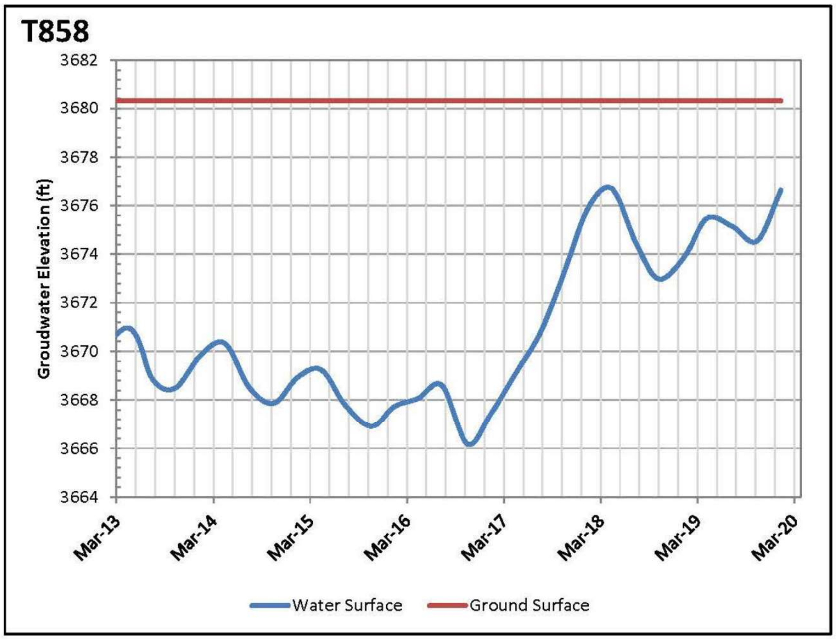


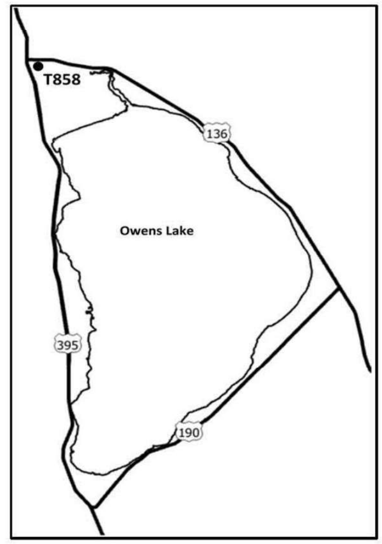


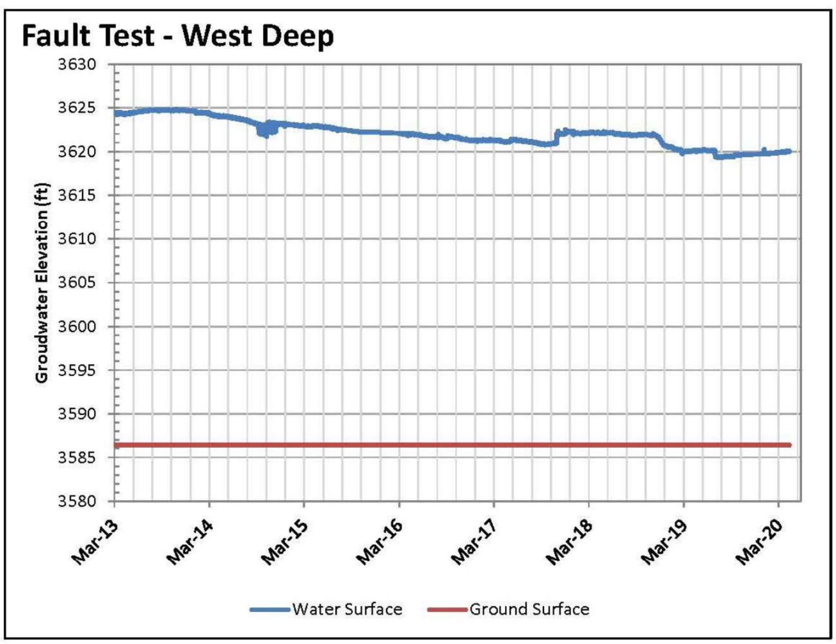


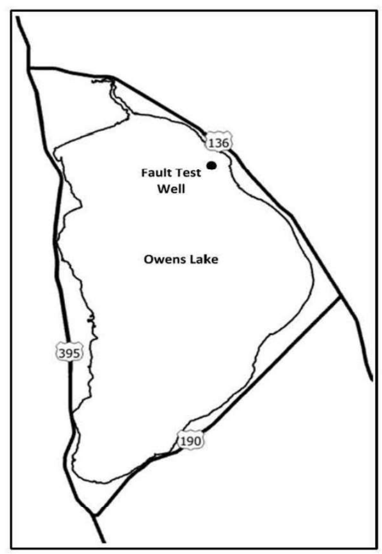
Owens Lake Groundwater Development Program

non-LADWP Wells









Owens Lake Groundwater Development Program

non-LADWP Wells