TECHNICAL MEMORANDUM

Title: Pumping Test Recommendations and Monitoring Plan

Project: Task Order 003 – Owens Lake Groundwater Development Program Assistance

Client: Los Angeles Department of Water and Power

Date: March 2019

Los Angeles Department of Water and Power

Technical Memorandum: Pumping Test Recommendations and Monitoring Plan

Owens Lake Groundwater Development
Program Assistance
Owens Lake, California

March 2019

Project No. 10509556

Victor Harris. C.HG. No. 848; CEG No. 1363
Project Manager

PROFESSIONAL GEOLOGIST
VICTOR E. HARRIS
No. 848
CERTIFIED
HYDROGEOLOGIST
STATE OF CALIFORNIA

Expires 5/31/19

MWH
300 N. Lake Ave., Suite 400
Pasadena, California 91101
T: 626-796-9141
F: 626-568-6101

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS / ABBREVIATIONS

bgs	below ground surface
CEQA	California Environmental Quality Act
DCM	Dust Control Measure
DDW	Division of Drinking Water
DTW	depth to water
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
fbgs	feet below ground surface
fmsl	feet above mean sea level
gpm	gallons per minute
K	Hydraulic Conductivity
LADWP	Los Angeles Department of Water and Power
MW	monitoring well
MWH	MWH Americas, Inc., now part of Stantec
NAD	North American Datum
OLGEP	Owens Lake Groundwater Evaluation Project
OVFZ	Owens Valley Fault Zone
S	Storativity
T	Transmissivity
TM	Technical Memorandum
TW	Test Well
UTM	Universal Transverse Mercator

1.0 INTRODUCTION

Preliminary groundwater modeling at Owens Lake has shown that groundwater development at Owens Lake may be environmentally sustainable, but aquifer testing is needed to fill critical data gaps. "Aquifer testing", also referred to as a pumping test, is a technique used by groundwater professionals using controlled pumping of a well or wells for a finite period of time. During this time, nearby monitoring/observation wells are monitored closely to measure groundwater level declines, or "drawdown" in the vicinity of the pumping well(s). In turn, collected data is used to evaluate the aquifer response to groundwater pumping and to calculate certain aquifer characteristics/parameters, including:

- **Hydraulic Conductivity** (K) – the ability of an aquifer to transmit water when subjected to a hydraulic gradient; rate of flow under a unit hydraulic gradient through a cross-sectional area of aquifer; unit [length/time]
- **Transmissivity** (T) - rate of flow moving through the entire saturated thickness of an aquifer one unit wide and under a unit hydraulic gradient; unit [$length^2$/time] or [$legth^3$/time/length]
- **Storativity** (S) - the volume of water released from storage per unit surface area of the aquifer or aquitard per unit decline in hydraulic head (from a confined aquifer [or aquitard])

Groundwater professionals utilize calculated aquifer parameters and their understanding of an aquifer system to develop groundwater models, which can then be used to simulate pumping conditions at different rates or time periods with greater accuracy. The combination of aquifer testing and groundwater modeling is recognized as the best method to predict the behavior of aquifers under variety of pumping scenarios.

1.1 Background and Rationale for Aquifer Test

Beginning in 2009, the Los Angeles Department of Water and Power (LADWP) initiated extensive studies in the Owens Lake area in order to investigate the potential and environmental sustainability of extracting groundwater from aquifers in the vicinity of Owens Lake for dust mitigation. This project was termed the Owens Lake Groundwater Evaluation Project (OLGEP). Use of groundwater for dust mitigation is anticipated to replace surface water that could instead be utilized for beneficial potable supply.

Groundwater modeling, completed in 2012, suggested that it may be possible to sustainably produce groundwater, but identified data gaps need to be filled to ensure protection of the environmental resources in the vicinity of Owens Lake, reduce the potential for impacts to non-LADWP production wells, and protect against land subsidence. To fill these data gaps, several actions were recommended:

- Install two new testing wells on Owens Lake for future aquifer testing
- Install two new monitoring wells designed to monitor groundwater levels before, during, and after aquifer testing
- Conduct baseline groundwater level monitoring and water quality sampling on selected wells in and around Owens Lake

- Perform aquifer testing

The overarching purpose of the pumping test is to determine the viability of each testing well to pumping at a high enough rate in order to conduct a long-term pumping test. Related goals include:

- Evaluate the overall aquifer response to pumping from deeper aquifers present below Owens Lake and the effect on non-LADWP pumping wells.
- Analyze the barrier effects of the Owens Valley Fault Zone (OVFZ). At Owens Lake, the role of the OVFZ as a barrier to groundwater flow is of key importance. Previous studies (MWH, 2012) recommended a pumping test at two testing wells as an aid in understanding the effects of pumping from deep aquifers at Owens Lake.
- Determine the degree to which the OVFZ influences effects on sensitive springs on the western side of Owens Lake associated with groundwater pumping.

Aquifer testing will be conducted in order to plan for initial project operation. Planning for longer-term operational production will be conducted after review of the testing results. The testing will consist of a step-drawdown test and a 24-hour constant rate test.

The pumping tests will be used to determine the pumping capacity of the testing wells as part of project planning. If the testing wells produce enough water to make longer-term operation viable, then the monitoring data will help to plan the longer-term operation. In addition, data from the pumping test will be used to estimate aquifer characteristics in the vicinity of the testing wells.

It is anticipated that by using new testing and monitoring wells, along with aquifer testing data, the calculated aquifer parameters can then be used to improve the existing OLGEP groundwater model. This will enable simulation of pumping at different rates or time periods with greater accuracy. In addition, the combination of aquifer testing and refined groundwater modeling will be used for preparation of the California Environmental Quality Act (CEQA) documentation for the Master Project, which will enhance the design and effectiveness of Owens Lake dust control through a combination of water conservation, dust control, and habitat management. As part of the Owens Lake Groundwater Development Program (OLGDP), LADWP has developed resources protection criteria to provide early warning in order to protect sensitive environmental resources with dependence on groundwater.

1.2 Purpose of Technical Memorandum

The purpose of this Technical Memorandum (TM) is to present aquifer (or pumping) test recommendations and a monitoring plan on and near Owens Lake for aquifer testing of the two new testing wells. The recommended aquifer test will utilize two new testing wells (installed in 2018). A site location map is provided as **Figure 1**, showing well locations and pertinent study area features.

Document Path: \\us1300-f01\workgroup\1858\active\185865039\gis_MXDs\NW_OwensLake\Wells_PIA_LtrP_20190325.mxd

Test Well

Well Monitored by Transducer

LADWP Well Monitored Manually

Spring & Flowing Well

N

0 1 Miles

TITLE:

Figure 1 – Site Location Map

PROJECT: Task Order 003 – Owens Lake Groundwater Development Program Assistance 3

REFERENCE(S): Coordinate System: NAD 1983 UTM Zone 11N

Stantec

1.3 TM Organization

This TM contains the following information:

- Background information on new testing and monitoring wells
- Monitoring plan recommendations that address:
    - Wells to be pumped
    - Pumping rates and duration
    - Hydrologic monitoring, methods, and frequency
    - Water quality sampling
    - Anticipated post-test analysis methods

2.0 PURPOSE OF TESTING WELLS

This section reviews the purpose of the two new testing wells planned on Owens Lake. Locations are shown on **Figure 1**, and well details are summarized in **Table 1**.

The purpose of the two testing wells (TW-W and TW-E) is to evaluate:

1) The barrier effects of the OVFZ,
2) The degree to which the OVFZ influences effects of groundwater pumping on springs on the western side of Owens Lake as a result, and
3) The overall aquifer response to pumping from deeper aquifers present below Owens Lake.

Findings from a fault study of the northwestern Owens Lake area (MWH, 2016) suggest that the OVFZ is a barrier to groundwater flow. However, this finding cannot be confirmed without observation of groundwater levels on either side of the fault zone during aquifer testing and longer-term operation. Planning for longer-term operation will be based on the results of the testing described in this plan.

3.0 TESTING DESIGN AND RATIONALE

The two new testing wells were installed in order to evaluate data gaps related to the hydrologic characteristics of the OVFZ, pumping effects from deeper confined aquifers, and potential influence on non-LADWP pumping wells. It is anticipated that results of the testing will be used to update and re-calibrate the OLGEP groundwater model. The updated model will then be used to simulate project alternatives to support CEQA review and the preparation of an Environmental Impact Report (EIR) for the Master Project.

The testing described in this plan includes an 8-hour step-drawdown test to be conducted first, followed by a 24-hour constant rate pumping test at each testing well, and water quality samples be taken just prior to the conclusion of testing (if they were not collected previously). This work flow is shown on **Figure 2**. Water quality sampling (if not collected previously) will include selected field parameters.

Table 1
Summary of Well Design for New Test Wells

Well Name	Easting* (X)	Northing* (Y)	Approximate Elevation (fmsl)	Diameter (inches)	Screened Interval (fbgs)	Land Ownership
TW-W	409,511.2	4,038,469.6	3,559.3	12	440 to 840	California State Lands Commission
TW-E	412,675.9	4,040,565.7	3,565.0	12	620 to 1,490	California State Lands Commission

*Universal Transverse Mercator (UTM), North American Datum (NAD) 83, Zone 11N; fmsl – feet above mean sea level; fbgs – feet below ground surface)

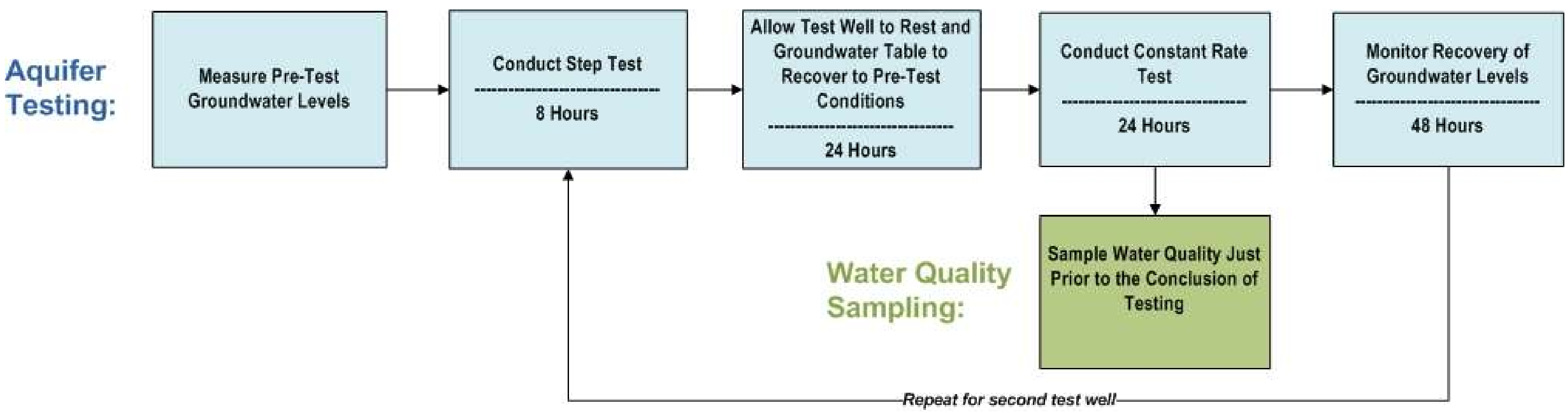

Figure 2
Work Flow Diagram for Each Test Well

The pumping tests will be conducted following well construction by the drilling contractor using contractor's temporary pump. After testing is complete, the wells will be resealed to prevent uncontrolled artesian flow.

3.1 Field Conditions

It is recognized that the artesian conditions at the two testing wells present challenges to pump testing, in that the two wells flow under non-pumping conditions, and installing a pump to obtain a constant pumping rate will be challenging, especially in the early portions of testing to avoid surface flooding. Although the goal will be to maintain constant pumping rates, this may not be practically possible in all cases.

In addition, it is recognized that due to the harsh conditions, long distances involved on Owens Lake, and potential problems with well access, it may not be feasible to install transducers and/or take manual measurements within the recommended time frame in all wells. In these cases, it is recommended that manual measurements be taken as often as practical in consideration of field conditions.

3.2 Pre-Test Monitoring

Before aquifer testing begins, pre-test monitoring should be performed in nearby wells to establish pre-test groundwater level trends. Groundwater levels, also referred to as depth to groundwater (DTW), will be measured at all recommended monitoring locations (as feasible) to characterize pre-test conditions. These locations are provided in **Appendix A**.

3.3 Eight-Hour Step-Drawdown Test

A step-drawdown test, or step test of a single well is designed to investigate the performance of a pumping well under controlled variable discharge conditions. In a step-drawdown test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping intervals (steps) of progressively higher constant rates.

Each step will have a duration of 2 to 3 hours to allow dissipation of wellbore storage effects. Up to four (4), 2 to 3-hour steps (or pumping rates) are anticipated, for a total step-test duration of approximately eight (8) hours. The pumping rate for the step drawdown test will be based upon observed drawdown in the pumping well during well development.

The goal of a step test is to evaluate well performance criteria such as well loss, well efficiency, wellbore skin factor and effective well radius. Results of the step test will form the basis for selection of a pumping rate for the 24-hour pumping test.

3.4 24-Hour Pumping Test

After the conclusion of the step test, groundwater levels will be allowed to stabilize (up to 24 hours) in a resting period to allow water levels to recover to pre-pumping conditions (as practical). A 24-hour pumping test will be conducted at each new testing well. A 24-hour constant rate pumping test is a routine test to gather data and calculate preliminary aquifer parameters and to plan for project implementation. The principle of the pumping test involves applying a stress to an aquifer immediately surrounding the well for a limited period of time, to be used for extrapolation to a longer period of time.

Twice a day for two days (48 hours) after completion of the 24-hour pumping test, groundwater levels will be measured at all recommended manual monitoring locations to monitor recovery of water levels. Wells with transducers will be monitored at the same frequency as during pumping for this two-day period and continue for a total of 10 days after the conclusion of testing at both wells.

Pumping tests at the two testing wells (TW-E and TW-W) will be separated by a recovery period of at least two days.

4.0 MONITORING PROGRAM

The monitoring program consists of groundwater level and water quality monitoring (if not already conducted), as well as surface water monitoring. Each of these monitoring components is discussed in terms of location, monitoring method, and frequency.

4.1 Monitoring Tables

Testing and monitoring well locations are shown in **Figure 1**. Monitoring tables are provided in **Appendix A** and **Appendix B** as follows:

<u>Groundwater Level</u>

- Table A-1 - Existing LADWP Wells Monitored by Utilizing Transducers
- Table A-2 - Existing LADWP Wells Monitored Manually
- Table A-3 - Existing LADWP and Non-LADWP Wells Monitored by Transducers

<u>Water Quality</u>

- Table B-1 – Water Quality Analyses

In order to accurately assess the effects of pumping wells TW-E and TW-W, groundwater level monitoring should be conducted by LADWP (as practical) at wells summarized in **Table A-1**, **Table A-2** and **Table A-3**.

Table A-1 (Wells to be monitored utilizing existing transducers) - Based on LADWP's existing monitoring program, a transducer is installed in wells listed in Table A-1. It is recommended that one day before the step test, a baseline manual measurement should be recorded, while the transducer is programmed. A minimum of a 5-minute measurement interval is recommended to capture the potential drawdown detail, while limiting the total amount of data to be stored in the transducer. Five (5) days after the constant rate testing is completed, a manual measurement should be recorded before downloading the transducer data.

Table A-2 (**Existing LADWP wells to monitor manually**) – Manual measurements should be recorded in wells listed in Table A-2. This data collection scheme includes a manual baseline measurement before step-testing; followed by manual measurements at 4-hour intervals during testing. Five (5) days after the constant rate test, one additional manual measurement should be taken. It is noted that during the pumping test and recovery stage, groundwater level measurements at any of these wells can be discontinued if the preceding three consecutive measurements indicate no change in groundwater level.

Table A-3 (**Existing flow measurement sites**) – It is recommended that flow measurements be taken at sites W3, W4, and Bartlett Well (W5) during the step and constant rate test. It is noted that during the pumping test and recovery stage, flow measurements at any of these locations can be discontinued if the preceding three consecutive measurements indicate no change in flow.

Testing Wells - In addition to monitoring existing wells, transducers should be installed in each testing well, with recordings set to monitor at 1- (one) minute intervals. Periodic field measurements using a manual electric probe to sound the depth to water in the well should be taken to confirm proper operation of the transducers.

A field form for recording manual measurements is provided in **Appendix C**.

Table B-1 (Water quality analyses) - Characterization of water quality will be conducted to establish a water quality baseline for the new testing wells (if not already conducted). This characterization will consist of general minerals (major cations and anions). **Table B-1** summarizes the recommended testing constituents and methods. New data will be merged with existing water quality data to create a more robust data set for the Owens Lake Area.

4.2 Testing Well Monitoring

Flow monitoring will be conducted at the testing wells during both the 8-hour step test and the 24-hour pumping test. Instantaneous flow measurements will be recorded at 30-minute intervals in order to maintain a constant flow. In addition, a flow totalizer will be installed to record the total amount of groundwater pumped during the test. These measurements should be recorded on the field log provided as **Appendix C**.

In the event of a pump failure interrupting the test, the test will be repeated after a 24-hr resting period.

As previously described, transducers should be installed in each testing well, with recordings set to monitor at 1- (one) minute intervals. Periodic field measurements of DTW using a manual electric probe should be taken to confirm proper operation of the transducers.

4.3 Groundwater Levels

In cases where transducers are installed in existing monitoring wells, they will be programed to record at the intervals denoted on the monitoring tables. **Table A-1** presents a list of existing LADWP monitoring wells where transducers have been installed and should be monitored during the testing described in this plan.

In addition to the monitoring wells with transducers, existing LADWP wells summarized in **Table A-2** have been selected for monitoring water levels manually. Monitoring should be conducted at the frequency shown in the table to the extent practical and feasible.

4.4 Water Quality

Characterization of water quality should be conducted to establish a water quality baseline for the new testing wells. Water quality samples near the end of the 24-hour pumping test may be collected for general mineral analysis (major cations and anions). **Table B-1** summarizes the recommended testing constituents. The parameters listed on Table B-1 were selected to be consistent with previous geochemical studies near the lake (MWH, 2012). New data will be merged with existing water quality data to create a more robust data set for the Owens Lake area and to create baseline data for future comparison.

5.0 DATA ANALYSIS METHODS

Aquifer test analysis software (AQTESOLV, 2017) will be used to calculate aquifer parameters (i.e., hydraulic conductivity, transmissivity, and storativity) and assess well performance. Information learned from the pumping test will be incorporated into the long-term aquifer testing plan to be developed for longer-term operation. The general pattern of drawdown as a result of 24-hour constant rate pumping test will also be recorded for future groundwater model modification.

The results of the pumping test will also be utilized to determine the optimal pumping rate and duration for planned initial production from of each of the testing wells, as well as key monitoring locations that could potentially be affected by groundwater pumping.

6.0 REFERENCES

AQTESOV software (http://www.aqtesolv.com), 2017.

MWH, 2012. Owens Lake Isotope Study. Final Technical Memorandum. September.

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

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

Stantec, 2017. Technical Memorandum Monitoring and Test Wells Basis of Design. February.

Appendix A – Monitoring Tables

Table A-1
Existing LADWP Wells Monitored by Utilizing Transducers

Well ID	Ground Surface Elevation (fmsl)	Well Depth (ft)	Top of Screen (fbgs)	Bottom of Screen (fbgs)	Baseline (1 day before the step test)	Test Period	Frequency	Recovery (5 days after constant test)
T896	3,572.10	1,601	1,280	1,360	1 manual	Transducer	5 minutes	1 manual
T897	3,572.39	880	780	860	1 manual	Transducer	5 minutes	1 manual
T898	3,572.22	340	240	320	1 manual	Transducer	5 minutes	1 manual
T893	3,599.49	1,530	1,430	1,510	1 manual	Transducer	5 minutes	1 manual
T894	3,599.72	1,270	1,170	1,250	1 manual	Transducer	5 minutes	1 manual
T895	3,600.07	960	860	940	1 manual	Transducer	5 minutes	1 manual
T902	3,631.19	1,500	1,290	1,350	1 manual	Transducer	5 minutes	1 manual
T903	3,631.30	800	720	780	1 manual	Transducer	5 minutes	1 manual
T904	3,631.46	380	300	360	1 manual	Transducer	5 minutes	1 manual
T931	3,616.90	62.3	27	57	1 manual	Transducer	5 minutes	1 manual
T348	3,643.00	20.2	N/A	N/A	1 manual	Transducer	5 minutes	1 manual

Well ID	Ground Surface Elevation (fmsl)	Well Depth (ft)	Top of Screen (fbgs)	Bottom of Screen (fbgs)	Baseline (1 day before the step test)	Test Period	Frequency	Recovery (5 days after constant test)
D.5(7)-4 ft	3,571.91	4	3	4	1 manual	Transducer	5 minutes	1 manual
D.5(7)-10 ft	3,572.68	10	9	10	1 manual	Transducer	5 minutes	1 manual
DELTA W(3)-4 ft	3,567.19	4	3	4	1 manual	Transducer	5 minutes	1 manual
DELTA W(3)-10 ft	3,567.26	10	9	10	1 manual	Transducer	5 minutes	1 manual
River Monitoring Well	3587.81	585	155	255	1 manual	Transducer	5 minutes	1 manual
River Deep Production Well	3587.81	555	485	505	1 manual	Transducer	5 minutes	1 manual
MW-5 (Deep Casing)	N/A	900	600	655	1 manual	Transducer	5 minutes	1 manual
MW-4 (Deep Casing)	N/A	530	590	595	1 manual	Transducer	5 minutes	1 manual

fmsl – feet above mean sea level
ft – feet
fbgs – feet below ground surface

Table A-2
Existing LADWP Wells Monitored Manually

Well ID	Surface Elevation (fmsl)	Well Depth (ft)	Top of Screen (fbgs)	Bottom of Screen (fbgs)	Baseline (1 day before the step test)	Method	Frequency	Recovery (5 days after constant test)
T347	3,635	22	N/A	N/A	1 manual	Manual	Every 4 hours[1]	1 manual
T349	3,637	38.26	N/A	N/A	1 manual	Manual	Every 4 hours[1]	1 manual
T725	3,667	20	10	20	1 manual	Manual	Every 4 hours[1]	1 manual
T726	3,667	20	10	20	1 manual	Manual	Every 4 hours[1]	1 manual
T727	3,667	20	10	20	1 manual	Manual	Every 4 hours[1]	1 manual
T890	3,667	1,500	1,150	1,230	1 manual	Manual	Every 4 hours[1]	1 manual
T891	3,667	540	480	520	1 manual	Manual	Every 4 hours[1]	1 manual
T892	3,667	390	290	370	1 manual	Manual	Every 4 hours[1]	1 manual
T914	3,566	1,500	1,360	1,400	1 manual	Manual	Every 4 hours[1]	1 manual
T918	3,605	68	33	63	1 manual	Manual	Every 4 hours[1]	1 manual
T919	3,600	73.3	38	68	1 manual	Manual	Every 4 hours[1]	1 manual
T920	3,811	253	218	248	1 manual	Manual	Every 4 hours[1]	1 manual
River Shallow Production Well	3,588	225	170	190	1 manual	Manual	Every 4 hours[1]	1 manual
T921	3,811	263	228	258	1 manual	Manual	Every 4 hours[1]	1 manual
T922	3,670	133	98	128	1 manual	Manual	Every 4 hours[1]	1 manual

Well ID	Surface Elevation (fmsl)	Well Depth (ft)	Top of Screen (fbgs)	Bottom of Screen (fbgs)	Baseline (1 day before the step test)	Method	Frequency	Recovery (5 days after constant test)
MW-4 Shallow Casing	N/A	140	160	165	1 manual	Manual	Every 4 hours[1]	1 manual
MW-5 Shallow Casing	N/A	200 400	240 455	900	1 manual	Manual	Every 4 hours[1]	1 manual

[1] This is a monitoring goal but may not be feasible. As a minimum, one reading should be taken before the step and 24-hour test, one during the 24-hour test, and 1 immediately prior to ending the 24-hour test.

fmsl – feet above mean sea level
ft – feet
fbgs – feet below ground surface

Table A-3
Existing Flow Measurement Sites

ID	Flow Monitoring Method	Baseline (1 day before the step test)	Frequency	Recovery (10 days after constant test)	Note
W3	Flume	1 manual	daily	1 manual	Site # 22, Transducer installed
W4	Stopwatch/grad. Cylinder, uncontrolled flowing well	1 manual	daily	1 manual	Site # 23
Bartlett	Flume with transducer	1-hour intervals	1 hour	1 hour	Site # 24

Appendix B – Groundwater Quality Monitoring Table

Table B-1
Groundwater Quality Analyses

Field Parameters (using portable water quality meter)	**Laboratory Parameters**
Temperature pH Electrical Conductivity Dissolved Oxygen	Chloride Sulfate Carbonate Bicarbonate Sodium Calcium Magnesium Potassium Total Dissolved Solids Total Alkalinity Specific Conductivity (laboratory)

Appendix C – Field Forms

Pages______________________________ **Test Well**______________________ **Date**____________________________

Test Type__________________________ **Static Level**_____________________ **Operator**________________________

Time	RPM	GPM	Pumpin Level	Drawdown	Specific Yield	Sand PPM	Notes	Totalizer

Total Hours This Day_________________________________ **Total Hours To Date**____

WELL__________________________ **PAGES**_______________________

DATE	TIME	DTW (FT)	NOTE	BY