**SOUTHERN NEVADA WATER AUTHORITY**
**100 CITY PARKWAY, SUITE 700**
**LAS VEGAS, NV 89106**

**PRELIMINARY DATA MEMO**

**June 28, 2011**

# WELL DEVELOPMENT AND AQUIFER TESTING RESULTS TEST WELL SPR7029M2 SPRING VALLEY, NV

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## Introduction

This memorandum presents preliminary data associated with the development and hydraulic testing at monitor well SPR7029M2 located in western Spring Valley, NV. The program was conducted between May 17 and 26, 2011 and consisted of development, a step-drawdown test and a 120-hr constant-rate aquifer test. This memorandum includes well construction, regional background information and test data including discharge rates, water levels, specific capacity, and field water chemistry data. The field data collected is presented in the form of summary tables and graphs in the appendices.

A comprehensive hydrologic analysis report will be prepared for this site, which will present hydrologic and water chemistry data, analysis, and results. Data is provisional and has not been processed through the quality control program review.

## Background Information

The following background information is provided to orient the reader to the location, well construction information, and water-level data for those wells measured as a part of the development and testing program. The site location section is specific to the test and observation wells, while the Regional Wells section is specific to the background wells monitored during the testing. The Well Construction section provides an overview of the well construction and completion information for all wells monitored.

### *Site Location*

Monitor well SPR7029M2, which was used as the pumping well during hydraulic testing, is located on the west side of Spring Valley in White Pine County, Nevada, near Cleve Creek (Figure A-1). It is located 12 miles north of the intersection of U.S. Highway 93 and State Route 893 in Section 25, T16N R66E. The approximate surface elevation at the well site is 5,883 feet above mean sea level (ft amsl). One associated observation well, identified as SPR7029M, is located 110 feet to the south of SPR7029M2. Regional and site plan maps depicting the wells and spatial orientation are presented in Figures A-1 and A-2. Coordinate locations and surface

and measuring point elevation data for the wells will be finalized in the near future after completion of a professional survey.

### *Regional Wells*

Regional background water levels were monitored continuously prior to, during, and after the development and testing period at three wells, SPR7030M, SPR7030M2, and 184 N15 E66 24CD 1. A shaded relief map with the site and background wells is presented in Figure A-1. Wells SPR7030M and SPR7030M2 are located on Cleveland Ranch property approximately 2.1 miles east-southeast from SPR7029M2. Well 184 N15 E66 24CD 1 is located approximately 5.0 miles south of SPR7029M2. Background water-levels were also monitored regularly throughout the testing period at well 391224114293601. These background wells are completed in the basin-fill aquifer.

Continuous water-level data at monitor wells SPR7030M and SPR7030M2 were logged with In-Situ Hermit 3000 data loggers attached to PXD-261 pressure transducers. Continuous water-level data at the well 184 N15 E66 24CD 1 was logged with an In-Situ Level TROLL 700 (30 pounds per square inch-gage [psig.]) integrated pressure transducer/data logger.

Wells SPR7030M and SPR7030M2 are clustered wells completed in separate boreholes at different depths as listed in Table 1 and are spatially located approximately 40 ft apart. These wells are both artesian with the water-levels rising above land surface based on pressure measurements taken at the wellhead. Based on the preliminary calculated water-levels at this site, there is an apparent upward hydraulic gradient, with the head level in the well completed in the deeper zone (SPR7030M2), approximately 40 ft above land surface, and the head level in the shallower zone well (SPR7030M) rising to approximately 30 ft above land surface. The wells have not been professionally surveyed and the approximate 10 ft difference in water level elevation is based upon a limited period of record and subject to verification.

Wells SPR7029M and SPR7029M2 are completed at different depths as indicated in Table 1. A professional survey has not yet been performed at the site. As a result, the vertical hydraulic gradient at the site has not been evaluated. The preliminary water-level data in the shallow zone (SPR7029M) indicated an approximate depth to water of 214.00 ft below the reference measuring point, and the water level in the deeper zone (SPR7029M2) is 215.71 ft below the reference measuring point. This data is very preliminary due to the limited period of record. The hydraulic gradient can be evaluated with greater certainty once a professional survey is performed and a longer period-of-record exists at these sites.

### *Spring Monitoring*

Cleveland Ranch South Spring is located approximately 2.1 miles east-southeast from SPR7029M2 near SPR7030M and SPR7030M2. The spring was monitored continuously during testing at SPR7029M2. The manual measurements taken during development and testing indicate that the spring discharge rate remained unchanged. The provisional spring discharge rate during this period was 0.133 cfs or 59.7 gpm. Continuous data has not been processed at this time and will be included in the hydrologic data analysis report.

### *Well Construction*

Preliminary lithologic logs were prepared by SNWA and are attached in Appendix B for wells SPR7029M2 and SPR7029M as Figures B-1 and B-2, respectively. This information is preliminary and is subject to verification by SNWA Staff Geologists. The borehole and well statistics sheets for wells SPR7029M2 and SPR7029M are also attached in Figures B-3 and B-4, respectively. Well construction schematics for wells SPR7029M2 and SPR7029M are attached in Figures C-1 and C-2, respectively. A well construction schematic is not available for the Well 184 N15 E66 24CD. Abridged well completion information for the three background wells is listed in Table 1.

Geologic data analysis reports have been prepared for SPR7029M and SPR7029M2 as well as SPR7030M and SPR7030M2 documenting the drilling program including lithology, drilling parameters and well construction attributes (Mace, 2011a and b).

Table 1
Abridged Background Well Completion Information

| Background Well | Total Depth (ft bgs) | Completion Casing Diameter (in) | Open Interval (ft bgs) | Aquifer Type |
|---|---|---|---|---|
| SPR7029M2 | 440 | 12.75 | 360 - 430 | Basin Fill |
| SPR7029M | 275 | 4.5 | 213 – 262 | Basin Fill |
| SPR7030M | 98 | 4.5 | 54 - 98 | Basin Fill |
| SPR7030M2 | 240 | 4.5 | 174 – 237 | Basin Fill |
| 184 N15 E66 24CD 1 | -- | 12 | -- | Basin Fill |
| 391224114293601 | -- | 6 | -- | Basin Fill |

## Hydraulic Testing Information

The following test information provides a summary of the activities performed, an overview of the equipment used, and specific information related to the development and testing of well SPR7029M2. Procedural information as well as a summary of the results is provided for each test.

### *Site Activities*

Well development and hydraulic testing activities were performed from May 17 through 26, 2011. The summary of activities is presented below:

May 17 to 18: Developed SPR7029M2 using surging methods. Development was performed at sustainable rates ranging from 200 to 800 gallons per minute (gpm).

May 19: Performed a step-drawdown test at rates ranging from 200 gpm to 825 gpm.

May 21 to 26: Performed a 120-hour constant-rate test on well SPR7029M2 at 500 gpm.

May 22: Collected samples from SPR7029M2 at 08:00 for laboratory analysis for a limited suite of water chemistry parameters.

May 25: Collected samples from SPR7029M2 at 10:00 for laboratory analysis for an extensive suite of water chemistry parameters.

May 26: Started collection of recovery data for wells SPR7029M2 and SPR7029M.

### *Water Level and Field Chemistry Monitoring Overview*

Groundwater levels in the pumping and observation wells were recorded during the study period using multiple In-Situ Level TROLL 700 integrated transducer/data loggers. Barometric pressure at the site was recorded continuously using In-Situ BaroTROLL integrated transducer/data loggers. A Campbell Scientific CR1000 was used to record water-level data from the pumping and observation wells, as well as record barometric pressure, wellhead pressure, and continuous field chemistry parameters.

Groundwater levels at background wells SPR7030M and SPR7030M2 were recorded by In-Situ Hermit 3000 data loggers and PXD-261 pressure transducers. At well 184 N15 E66 24CD 1, an In-Situ Level TROLL 700 integrated transducer/data logger was used to record water-level data continuously. Well development and testing were performed in accordance with SNWA Field Procedure WRP-FOP-006 (SNWA, 2007a). Manual and continuous transducer data were collected throughout the test. Groundwater field chemistry samples were collected and analyzed for pH, conductivity, and turbidity regularly throughout the testing period from well SPR7029M2, manually in the form of grab samples, and continuously with a Hydrolab Quanta flow-through cell.

A total of at least 3,883,100 gallons (gal) were pumped during development and testing at well SPR7029M2. The flow meter malfunctioned approximately three hours prior to the end of pump and surge development. It is estimated that 100,000 gal of water were discharged during that time. The volume pumped for surge development, was at least 94,300 gal (194,300 gal considering the unaccounted for volume). The volumes pumped for the step-drawdown and constant-rate tests were 251,600 and 3,537,200 gal, respectively.

### *Pump Equipment Description*

A Berkeley submersible turbine pump was utilized for the development and testing of well SPR7029M2. The pump consisted of 6x8-in bowls with an intake set at approximately 365 ft bgs. The pump motor was rated at 100 horsepower. The rating curve for the pump is attached in Figure B-5. Initially, a McCrometer Ultra Mag magnetic flow meter was used during development. The flow meter malfunctioned approximately three hours prior to the end of development. A McCrometer mechanical insertion flow meter was installed prior to performance of the step-drawdown test.

The test well transducer was set at approximately 275 ft bgs. An additional transducer was set in the test well prior to performance of the constant-rate test at approximately 340 ft bgs. Water was discharged through approximately 1,000 ft of 10-inch discharge line west-northwest of the

test well onto energy dissipation and erosion control material. The water was allowed to flow overland until infiltrating at least 100 ft past the discharge point.

### *Groundwater Levels*

Depth-to-groundwater measurements were obtained using marked reference points. The reference measuring point for the test well was temporary and will only be used for the test. The reference measuring points and static levels prior to the beginning of the step-drawdown and constant-rate tests are listed in Table 2. Data collected from observation wells SPR7030M, SPR7030M2, and 184 N15 E66 24CD 1 were used to obtain regional groundwater trends. Water-levels collected at 391224114293601 were used to quantify any impact from pumping at that site. Figures D-8, D-9, and D-10 depicts a plot of depth to water versus time for wells 184 N15 E66 24CD 1, SPR7030M, and SPR7030M2, respectively. Barometric pressure data collected during the test indicated variations during the constant-rate test as pressure fronts moved through the area. Effects from the pressure variations will be evaluated and corrected during the data analysis task. No other outside influences affecting water levels were identified during the test. Transducer data was compared to manual data collected throughout the test period. Preliminary evaluation indicated no significant variations outside of natural barometric fluctuations.

Table 2
Static Depth-to-Water Levels for Test and Background Wells

| Well | Measuring Point (ft above ground surface) | Static Prior to Development (ft bgs) | Static Prior to Step Test (ft bgs) | Static Prior to Constant-rate Test (ft bgs) |
|---|---|---|---|---|
| SPR7029M2 | 3.49 (temporary) | 215.41 | 215.10 | 215.05 |
| SPR7029M | 2.00 | 215.39 | 215.40 | 215.37 |
| SPR7030M | 4.03 | -29.46 | -29.46 | -29.52 |
| SPR7030M2 | 3.17 | -40.31 | -40.31 | -40.08 |
| 184 N15 E66 24CD 1 | 1.25 | 17.21 | 17.21 | 17.21 |
| 391224114293601 | 1.04 | 207.90 | 207.35 | 207.29 |

### *Well Development*

The well was initially developed after drilling using airlifting and dual-swab techniques. A dual swab was used prior to and after placement of the gravel pack.

Test well SPR7029M2 was developed using a pumping and surging technique as part of the development and testing program. The well was pumped at a constant-rate for a short period of time (one pumping period)—usually under an hour based upon time and turbidity—and then surged five times. Water level, sand content, turbidity, and flow rates were obtained during the pumping period. Specific capacity (discharge in gallons per minute/drawdown in feet) was determined at the end of each pumping period to evaluate well performance and the potential need for additional development. After review of the data, it was determined that development was complete after 10 hours of well development.

To quantify the effectiveness of development, the drawdown in the well 27 minutes into the 400 gpm pumping period production rate was matched to the drawdown in the well 30 minutes into the 400 gpm pumping period of the step-drawdown test. The specific capacity of the well increased from 20.09 to 26.94 gpm/ft. This improvement indicates that development was effective and increased the specific capacity of the well by 34%.

The turbidity improved from the highest measured value of 467 nephelometric turbidity units (NTU) to less than 3 NTU during development.

***Step-Drawdown Test***

A step-drawdown well performance test was completed on well SPR7029M2 using seven different pumping rate intervals ranging from 200 to 825 gpm. The pumping intervals were continuous and ranged from 60 to 90 minutes in duration. The final pumping rate used was 825 gpm. This was with the variable frequency drive (VFD) controller at a rate of 64 Hz (65 is maximum), and the gate valve fully opened. The final pumping rate started at approximately 840 gpm, then decreased slightly and was run at the rate of 825 gpm. The final specific capacity calculation at the completion of the 825 gpm pumping period was 11.94 gpm/ft. Figure D-4 depicts drawdown versus elapsed time during the course of the step-drawdown test. Figure D-5 depicts specific capacity versus drawdown. The specific capacity for each discharge rate was calculated at the end of each pumping interval.

Manual data supplemented the transducer data at the end of the step-drawdown test as depicted in Figure D-4. This was due to constrictions in the transducer access tube and wellbore, in that the transducer was only able initially to be set in at a depth of approximately 275 ft bgs. The pumping level during the last step at 825 gpm was approximately 287 ft bgs which was below the transducer.

***Constant-Rate Test***

A 120-hour constant-rate test was performed on well SPR7029M2 with a target discharge rate of 500 gpm. Log-log and semi-log plots of drawdown versus time derived from the transducer and manual data are presented in Figures D-1 and D-2 for SPR7029M2. A semi-log plot of drawdown versus time derived from the transducer and manual data for SPR7029M is presented in Figure D-3. The negative drawdown appears to be the result of natural increase in background water levels greater than drawdown induced by the pumping. Response at SPR7029M resulting from pumping SPR7029M2 appears to be minor or have no effect. Additional evaluation will be performed on the dataset.

During the first two minutes of the test, the flow rate was greater than 500 gpm. The initial high-flow rate is due to the absence of a check valve above the pump. Without the check valve it was impossible to control the flow rate until the discharge reached the surface where the flow meter and gate valve are located. It took approximately 1.5 minutes for the water to reach the surface where the flow rate was restricted and controlled at a constant 500 gpm. The flow rate was stable at 500 gpm, two minutes after startup. This resulted in excessive temporary drawdown in the test well as can be seen in Figures D-1 and D-2.

One flow rate adjustment was made during the test. This occurred approximately 38 minutes after beginning the constant-rate test. The discharge decreased during the initial 38 minutes of the test to 490 gpm. The flow was increased to 500 gpm by decreasing the wellhead pressure using the gate valve. The pressure was decreased from 34 to 32 psi. This change in production rate can be seen as a sudden increase in drawdown in the test well plot depicted in Figure D-1.

Totalizer readings indicated a total volume of 3,537,200 gallons was pumped during the 120-hour test of well SPR7029M2. This averages 491 gpm for the duration of the test.

Prior to the constant-rate test, water levels for wells SPR7029M2 and SPR7029M were approximately 215.05 and 215.37 ft bgs, respectively. At the end of the 120-hour constant-rate test prior to shutdown, the water level in SPR7029M2 had drawn down to 242.22 ft bgs. The water level in monitor well SPR7029M at the end of the constant-rate test was 215.42 ft bgs.

### *Recovery Test*

Well recovery data was collected at the test and observation wells after completion of the step-drawdown and the 120-hour constant-rate tests. For the constant-rate recovery test Level TROLL 700 data loggers were reset to collect data logarithmically. A plot of residual drawdown versus log t/t' (total pumping elapsed time/time since stoppage of pumping) for the test well is shown in Figure D-6.

A plot of residual drawdown (ft) versus recovery time (min) for SPR7029M2 is graphically displayed in Figure D-7.

As can be seen in this plot, there was a recharge pulse from the water in the pump column entering the test well. This resulted in temporary water level rise in the well of approximately 30 ft. This recharge pulse is not seen in the monitor well SPR7029M.

### *Ground Water Chemistry Results*

Two sets of groundwater chemistry samples were collected from well SPR7029M2 for comparison. The first was taken on May 22, 2011, at 08:00 during performance of the 120-hour constant-rate test after pumping 1,052,800 gal of water (including pumping during well development, step test, and the constant-rate test). The second was taken on May 25, 2011, at 10:00 during performance of the 120-hour constant-rate test after pumping 3,233,100 gal of water (including pumping during well development, step test, and the constant-rate test). Samples were collected in accordance with SNWA Field Procedure WRP-FOP-004 (SNWA, 2007b). Samples were collected for analyses of a large suite of parameters, including major solutes, minor trace constituents, radiological parameters, and organic compounds, for analysis by Southern Nevada Water System (SNWS). Additional samples were collected for isotope analysis. Results from those analyses have not been received at the time of this report. Results from SNWS are attached in Appendix E, noting that the sample labeled 'SPR7029M2(A)' is the early sample collected on May 22, 2011, and the sample labeled 'SPR7029M2' is the later sample taken on May 25, 2011. Geochemical evaluation of the water chemistry data will be performed during the data analysis task and included in the hydrologic analysis report.

## Summary and Conclusions

Development and testing at Well SPR7029M2 consisted of pump and surge development, a seven interval step-drawdown test, and a 120-hour 500 gpm constant-rate test. The pump and surge development occurred over the course of 10 hours and effectively increased the specific capacity by 34% to from 20.09 to 26.94 gpm/ft at 400 gpm. The step-drawdown test data will be analyzed during the hydrologic analysis task to provide well loss coefficients. The constant-rate test provided drawdown data that will be analyzed during the hydrologic analysis task, wherein estimates of aquifer parameters will be calculated. These parameters will include specific yield, transmissivity, and hydraulic conductivity. The development and testing was performed in compliance with Field Procedure WRP-FOP-006 (SNWA, 2007a). All data presented in this memo is considered provisional and may be revised prior to finalization after quality review.

Drawdown response at SPR7029M from pumping SPR7029M2 at 500 gpm for the duration of the constant-rate test appears to either be very minor or have no effect based upon preliminary test data. Analysis of background data and regional trends will be performed to evaluate the presence and magnitude of drawdown at the observation well. Drawdown in the pumping well was measured at approximately 27 feet at the end of the constant-rate test. This value includes well losses and does not differentiate or determine the proportion between drawdown caused by well and aquifer losses. Specific capacity at the end of the test was approximately 18.4 gpm/ft.

Preliminary simplified analysis of time drawdown data at SPR7029M2 using the Cooper-Jacob approximation (Cooper and Jacob, 1946) indicates an approximate transmissivity value of 16,000 $ft^2$/day. Using this value, a drawdown of approximately 2.5 ft would be expected at SPR7029M, a distance of 110 ft from SPR7029M2, at the end of the test if homogenous and isotropic conditions were present with horizontal flow using a simplified Theis forward solution analysis (Theis, 1935). The minimal drawdown, substantially less than 2.5 ft, observed at SPR7029M during the test may indicate limited or lack of significant connectivity between shallow groundwater and deeper zones penetrated by the pumping well, SPR7029M2. Additional testing of longer duration would be needed to further evaluate the relationship between SPR7029M and SPR7029M2, vertical flow, anisotropy values, and effect of partial penetration.

A comprehensive hydrologic analysis report will be prepared for this site, which will present hydrologic and water chemistry data, analysis, and results. Data is provisional and has not been processed through the quality control program review.

CSA/JP/

# *References*

Cooper, H.H., and Jacob, C.E., 1946, A generalized graphical method for evaluating formation constants and summarizing well field history: Am. Geophys. Union Trans., Vol. 27, p. 526-534.

Mace, J.T., 2011a, Well Completion and Geologic Data Analysis Report for Monitor Wells SPR7029M and SPR7029M2 in Spring Valley: Southern Nevada Water Authority, Las Vegas, Nevada, Doc. No. RDS-ED-0027.

Mace, J.T., 2011b, Well Completion and Geologic Data Analysis Report for Monitor Wells SPR7030M and SPR7030M2 in Spring Valley: Southern Nevada Water Authority, Las Vegas, Nevada, Doc. No. RDS-ED-0026.

Southern Nevada Water Authority, 2007a, Groundwater and Surface-Water Sampling and Measurement of Field Parameters: Southern Nevada Water Authority, Las Vegas, Nevada, Field Operating Procedure No. WRD-FOP-004, 22 p.

Southern Nevada Water Authority, 2007b, Well Development and Aquifer Testing: Southern Nevada Water Authority, Las Vegas, Nevada, Field Operating Procedure No. WRD-FOP-006, 29 p.

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: Am. Geophys. Union Trans., Vol. 16, p. 519-524.

# Appendix A
# SITE LOCATION MAP
# & SITE LAYOUT MAP

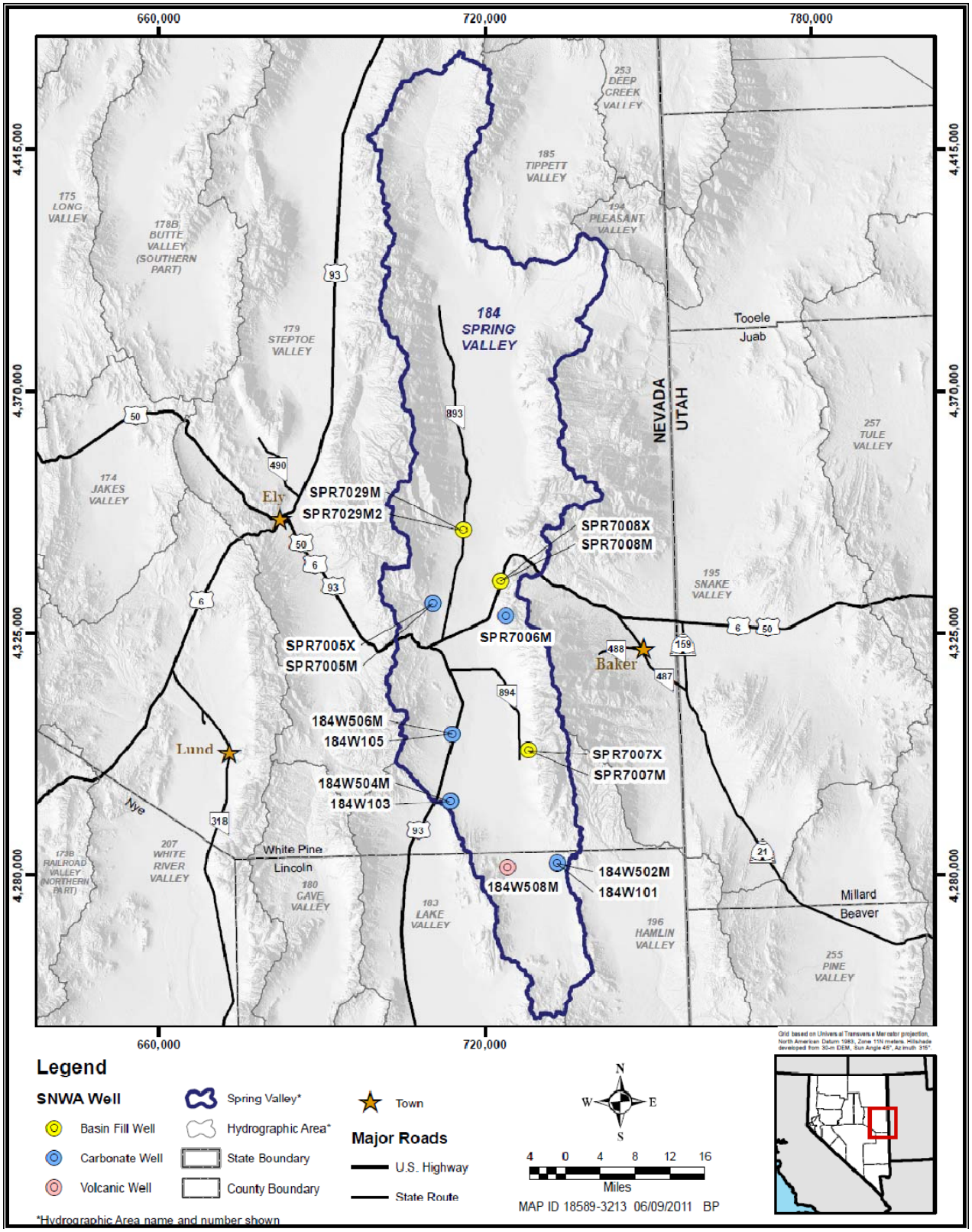


**Figure A- 1**
**SNWA Exploratory and Test Wells as of June, 2011**

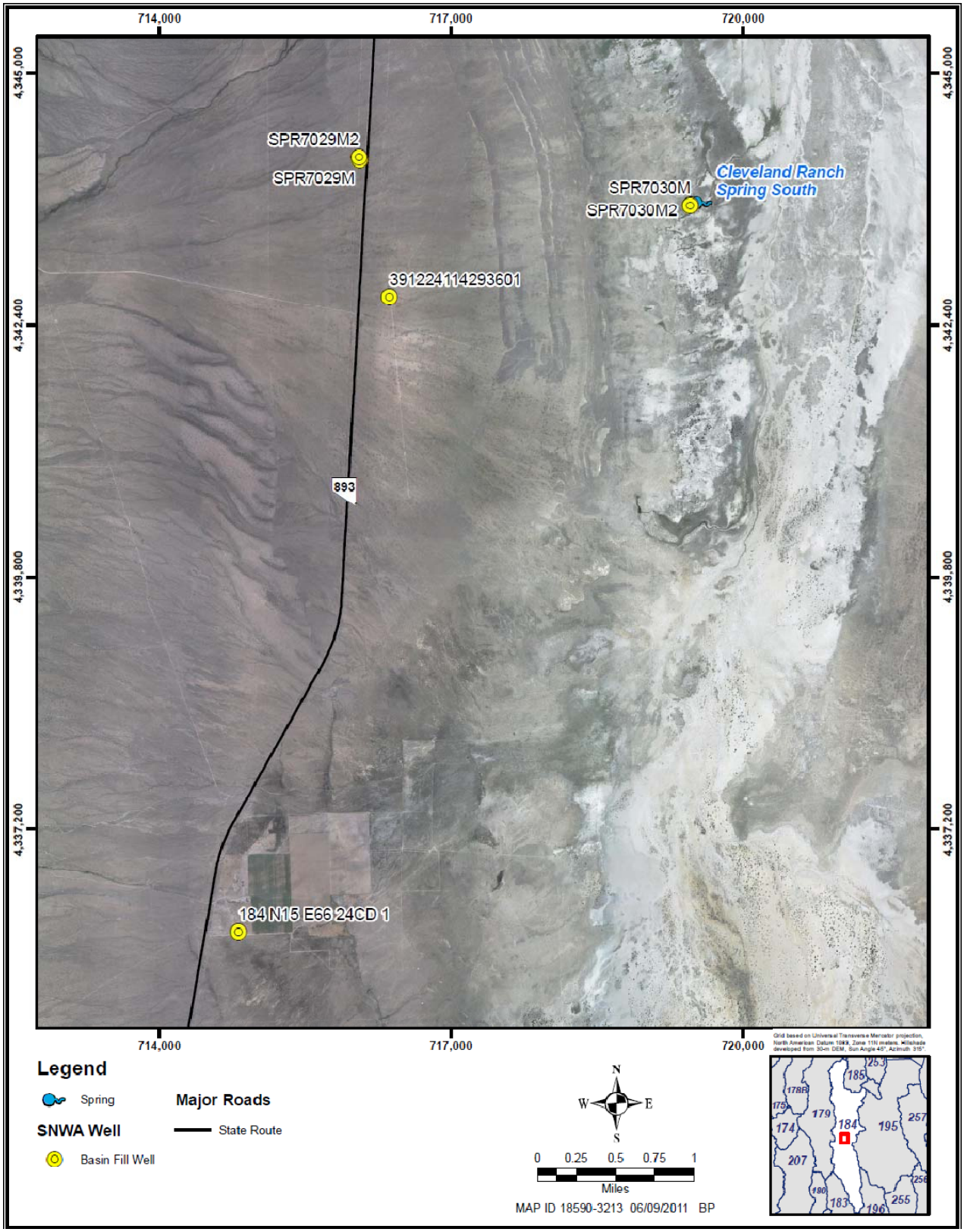


**Figure A- 2**
**Locations of Wells Included in the Hydraulic Testing Program**

# Appendix B
# BOREHOLE, WELL, AND PUMP STATISTICS

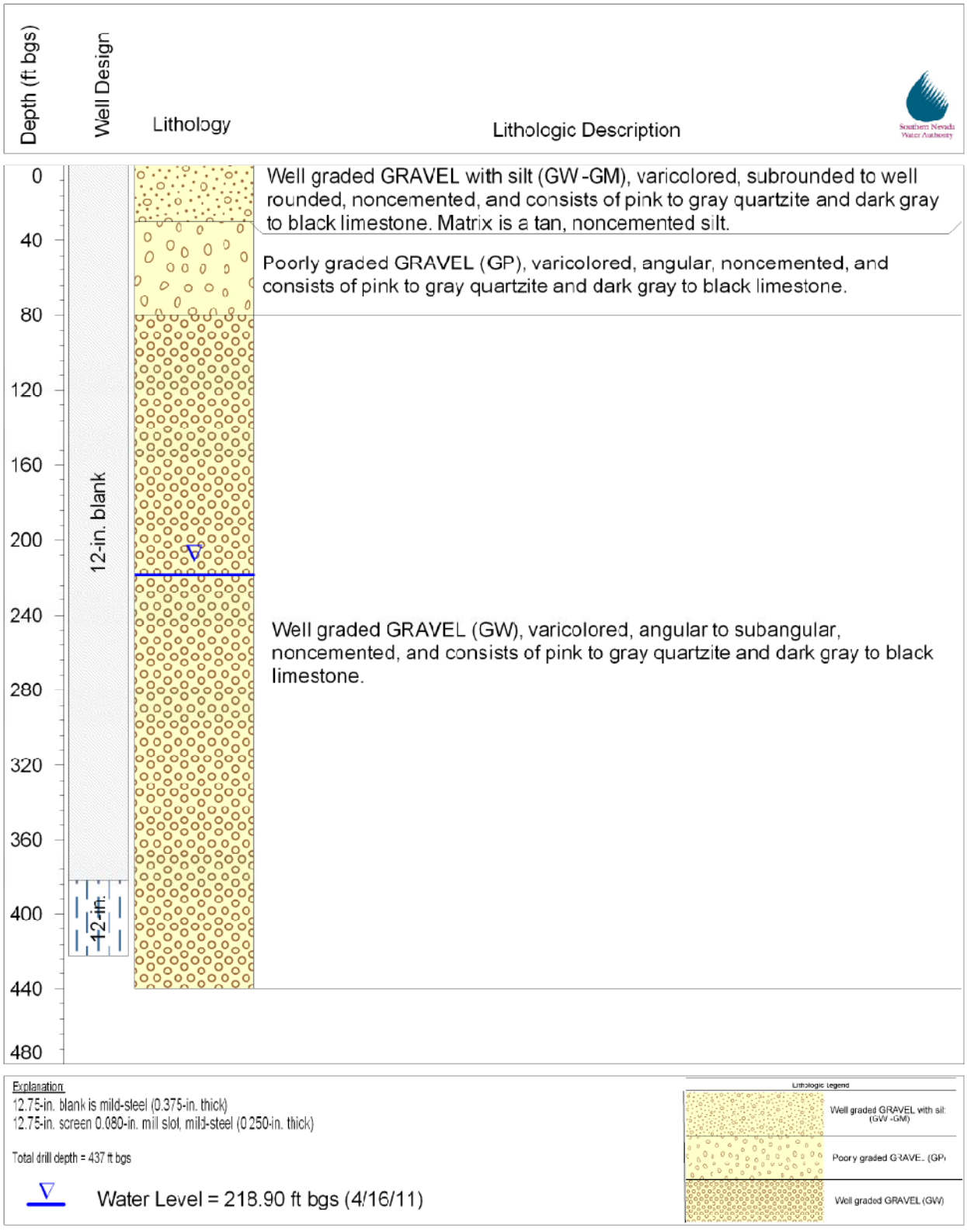


**Figure B- 1**
**Well SPR7029M2 Preliminary Lithologic Log**

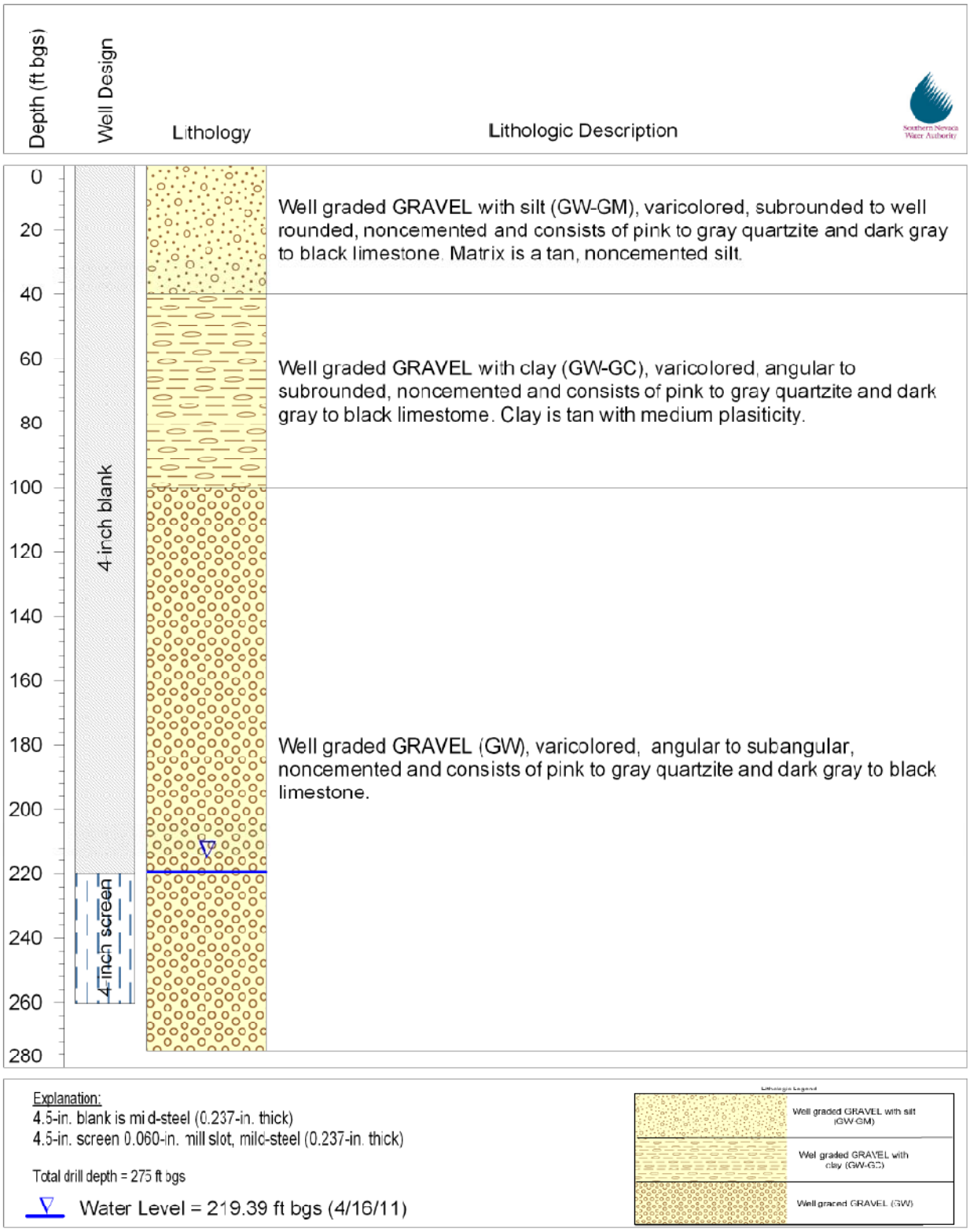


**Figure B- 2**
**Well SPR7029M Preliminary Lithologic Log**

| | | |
|---|---|---|
| **LOCATION DATA**<br>Surveyed Coordinates | UTM, Zone 11, NAD83, N 4,344,122 m; E 716,052 m | |
| Ground Elevation | 5,883 ft amsl | |
| **DRILLING DATA**<br>Spud Date | 4/1/2011 | |
| Total Depth (TD) | 440 ft bgs | |
| Date TD Reached | 4/16/2011 | |
| Date Well Completed | 4/30/2011 | |
| Hole Diameter | 30 -in. from 0 to 28 ft bgs<br>17.5 -in. from 28 to 437 ft bgs<br>9.875 -in from 437 to 440 | |
| Drilling Techniques | Auger from 0 to 27.5 ft bgs<br>Conventional Mud Rotary<br>Pilot from 27.5 to 440 ft bgs<br>Ream from 27.5 to 437 ft bgs | |
| Drilling Fluid Materials Used | Quick -Gel (390 bags)<br>Soda Ash (4.25 bags)<br>EZ Mud Gold (25 cups) | QuiK Trol (7 buckets) |
| Drilling Fluid Properties | *Properties*<br>Viscosity Range = 34 to 52 sec/qt<br>Weight Range = 8.6 to 9.1 lbs<br>Filtrate Range = 4.5 to 19.6 ml<br>Filter Cake Range = 2/32 to4/32-in. | *Averages*<br>44.54 sec/qt<br>8.83 lbs<br>10.82 ml<br>3/32-in. |
| **CASING DATA** | 20-in. MS Conductor Casing from 0 to 27.5 ft bgs<br>12-in. MS Completion Casing from +2 to 422 ft bgs | |
| **WELL COMPLETION DATA** | 384 ft of blank MS 12.75-in. completion casing from +2 to 382 ft bgs<br>40 ft of 12.75-in. mill slot screen from 382 to 422 ft bgs.<br><br><u>Grout, Plug and Gravel Pack Depth</u><br>0 to 28 ft bgs on outside of conductor casing (grout)<br>0 to 353 ft bgs between conductor casing/borehole and completion casing (grout)<br>353 to 358 ft bgs bentonite chips<br>358 to 360 ft bgs sand plug<br>360 to 430 ft bgs SRI$^{TM}$ 6-9 gravel pack | |
| **GROUNDWATER LEVEL** | Static Water Level: 215.56 ft bgs (5/17/2011)<br>Groundwater Elevation: 5,664 ft amsl | |
| **DRILLING CONTRACTOR** | WDC Exploration & Wells | |
| **OVERSIGHT** | Southern Nevada Water Authority | |

**Figure B- 3**
**Monitor Well SPR7029M2 Borehole and Well Statistics**

| | | |
|---|---|---|
| **LOCATION DATA**<br>Surveyed Coordinates | Universal Transverse Mercator (UTM), Zone 11, North American Datum of 1983 (NAD83), N 4,344,089 m; E 716,055 m | |
| Ground Elevation | 5,870 ft amsl | |
| **DRILLING DATA**<br>Spud Date | 4/18/2011 | |
| Total Depth (TD) | 275 ft bgs | |
| Date TD Reached | 4/27/2011 | |
| Date Well Completed | 4/29/2011 | |
| Hole Diameter | 11.75 in. from 0 to 38 ft bgs<br>9.625 in. from 38 to 275 ft bgs | |
| Drilling Techniques | ARCH from 0 to 38 ft bgs<br>Conventional Mud Rotary from 38 to 275 ft bgs | |
| Drilling Fluid Materials Used | Quick-Gel (112 bags)<br>Soda Ash (2.25 bags)<br>Quik-Trol (2.5 buckets) | |
| Drilling Fluid Properties | *Properties*<br>Viscosity Range = 45 to 58 s/qt<br>Weight Range = 8.6 to 8.9 lbs<br>Filtrate Range = 8 to 13.2 ml<br>Filter Cake Range = 2/32 to 3/32-in. | *Average*<br>52 s/qt<br>8.8 lbs<br>10.2 ml<br>3/32-in. |
| **CASING DATA** | 4.5-in. Mild Steel Completion Casing from +2 ft ags to 260 ft bgs | |
| **WELL COMPLETION DATA** | 222 ft of blank 4.5-in. completion casing from +2 to 220 ft bgs<br><br>40 ft of 4.5-in. mill slot screen casing from 220 to 260 ft bgs<br><br><u>Grout, Bentonite and Gravel Pack Depth</u><br>0 to 207 ft bgs between completion casing and borehole (grout)<br>207 to 213 ft bgs bentonite chips<br>213 to 262 ft bgs Carmeuse™ 8-12 gravel pack | |
| **GROUNDWATER LEVEL** | Static Water Level: 196.89 ft bgs (04/27/2011)<br>Groundwater Elevation: 5,673 ft amsl | |
| **DRILLING CONTRACTOR** | WDC Exploration & Wells | |
| **OVERSIGHT** | Southern Nevada Water Authority | |

**Figure B- 4**
**Monitor Well SPR7029M Borehole and Well Statistics**

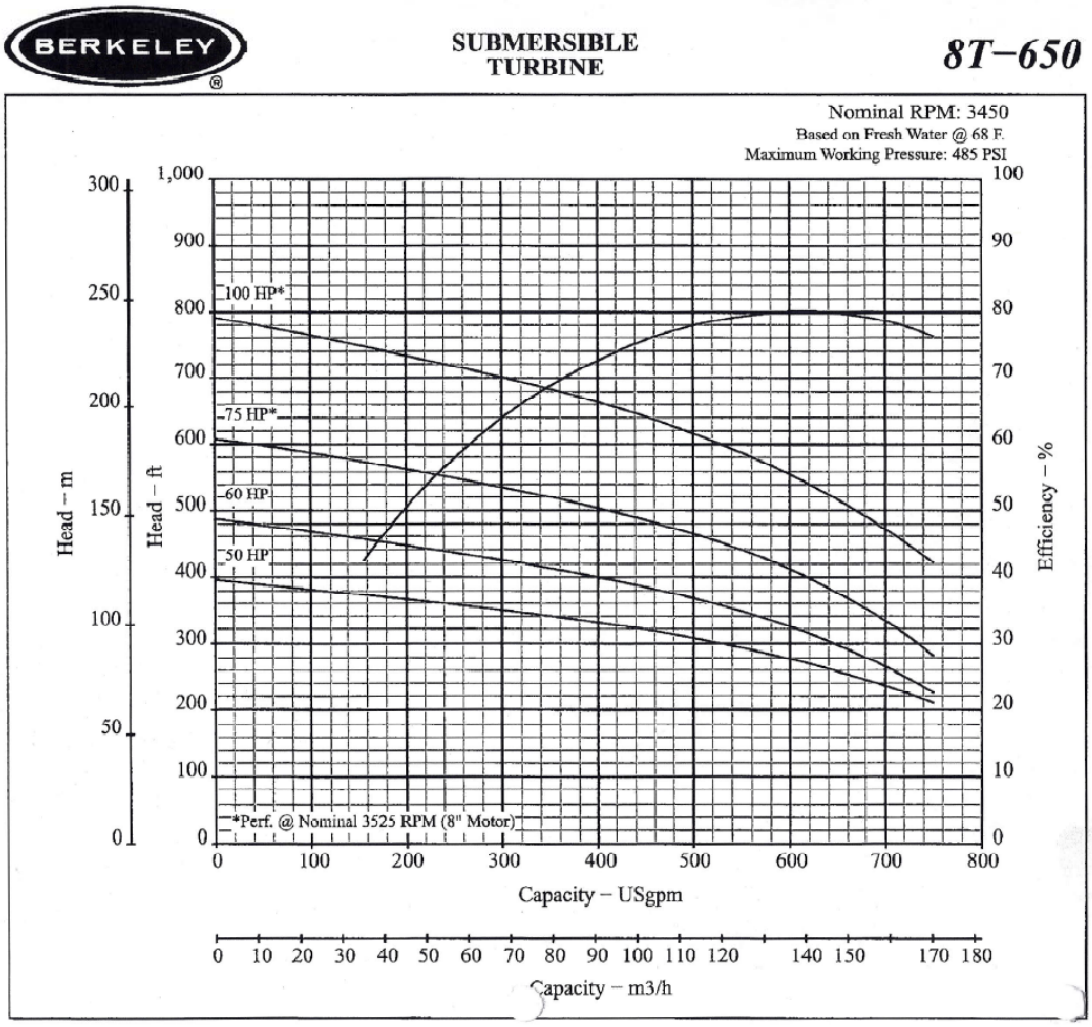
BERKELEY
SUBMERSIBLE
TURBINE
8T–650
Nominal RPM: 3450
Based on Fresh Water @ 68 F.
Maximum Working Pressure: 485 PSI
100 HP*
75 HP*
60 HP
50 HP
*Perf. @ Nominal 3525 RPM (8" Motor)
Head – m
Head – ft
Efficiency – %
Capacity – USgpm
Capacity – m3/h

**Figure B- 5**

# Appendix C
# WELL COMPLETION DIAGRAMS

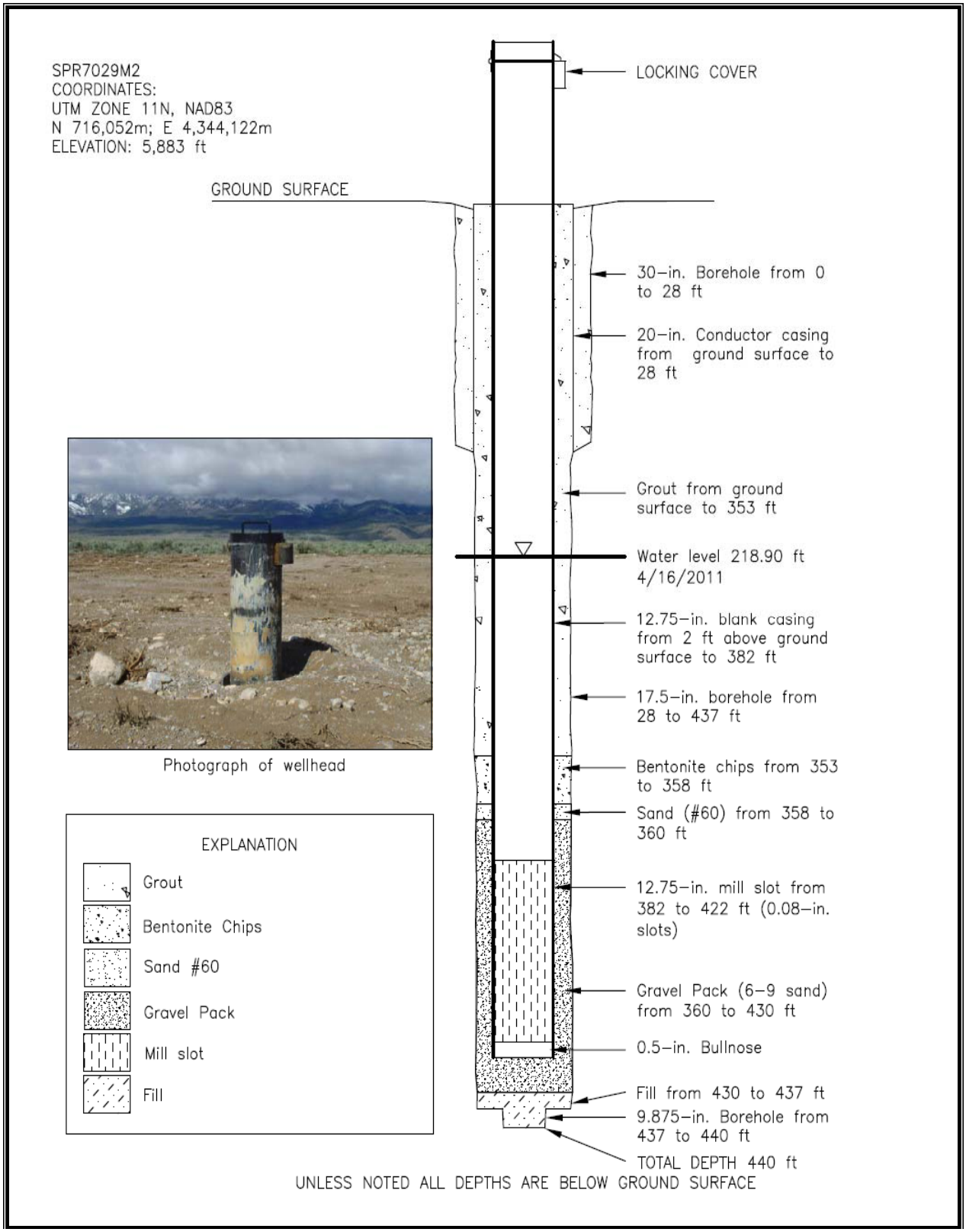


**Figure C- 1**
**Well Diagram for Monitor Well SPR7029M2**

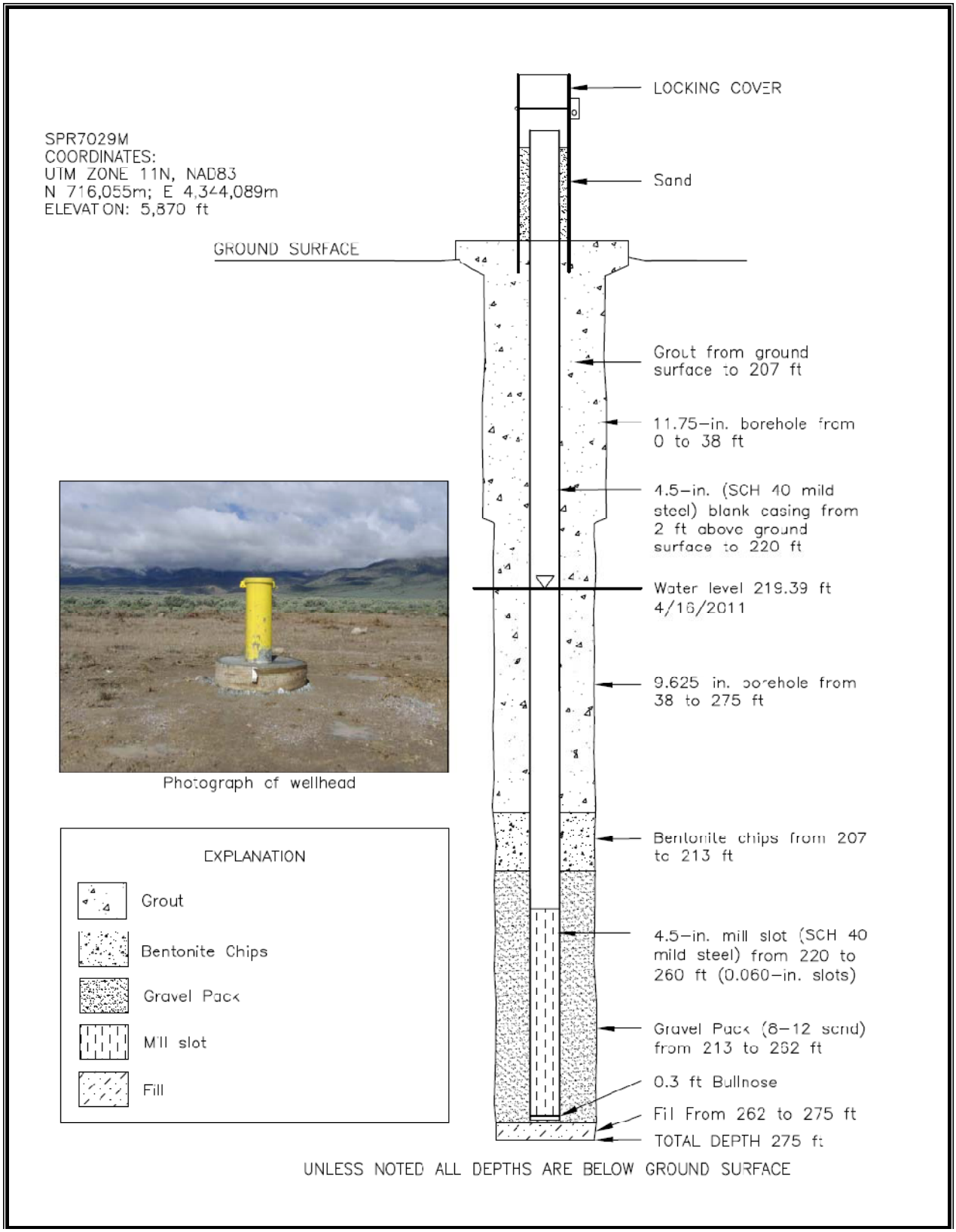


**Figure C- 2**
**Well Diagram for Monitor Well SPR7029M**

# Appendix D
# TEST DATA
# SPR7029M2

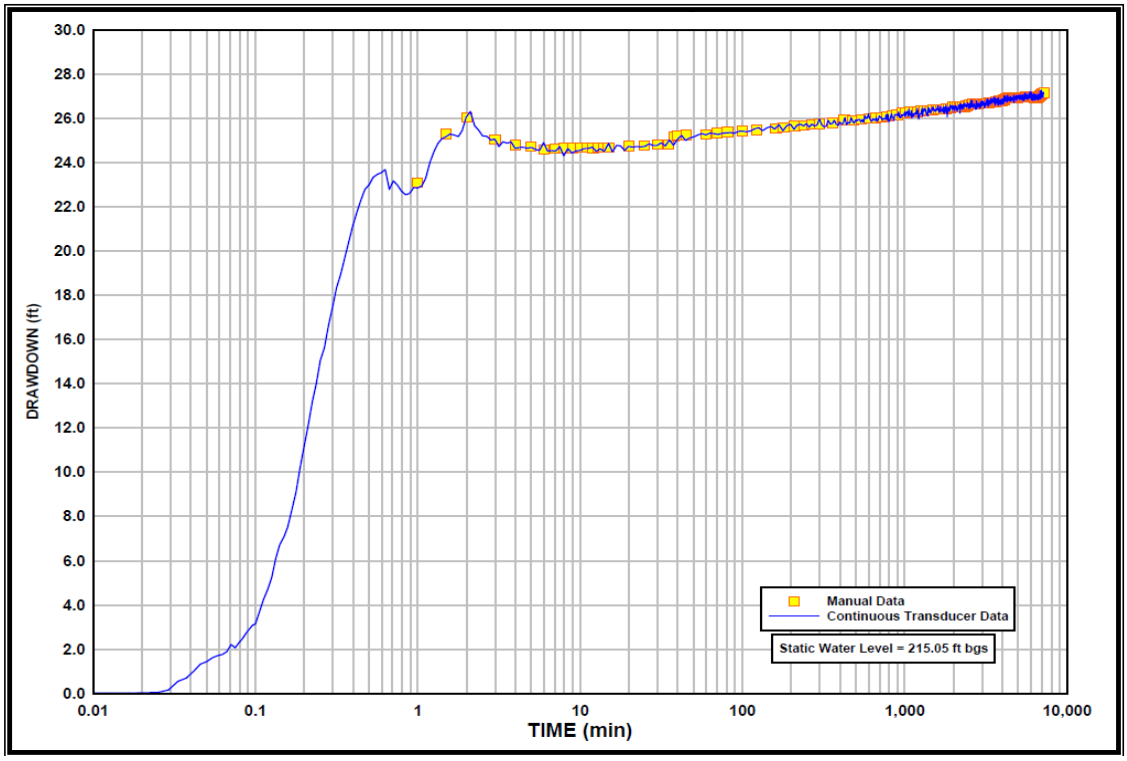


**Figure D- 1**
**SPR7029M2 Semi-Log Constant-Rate Drawdown**

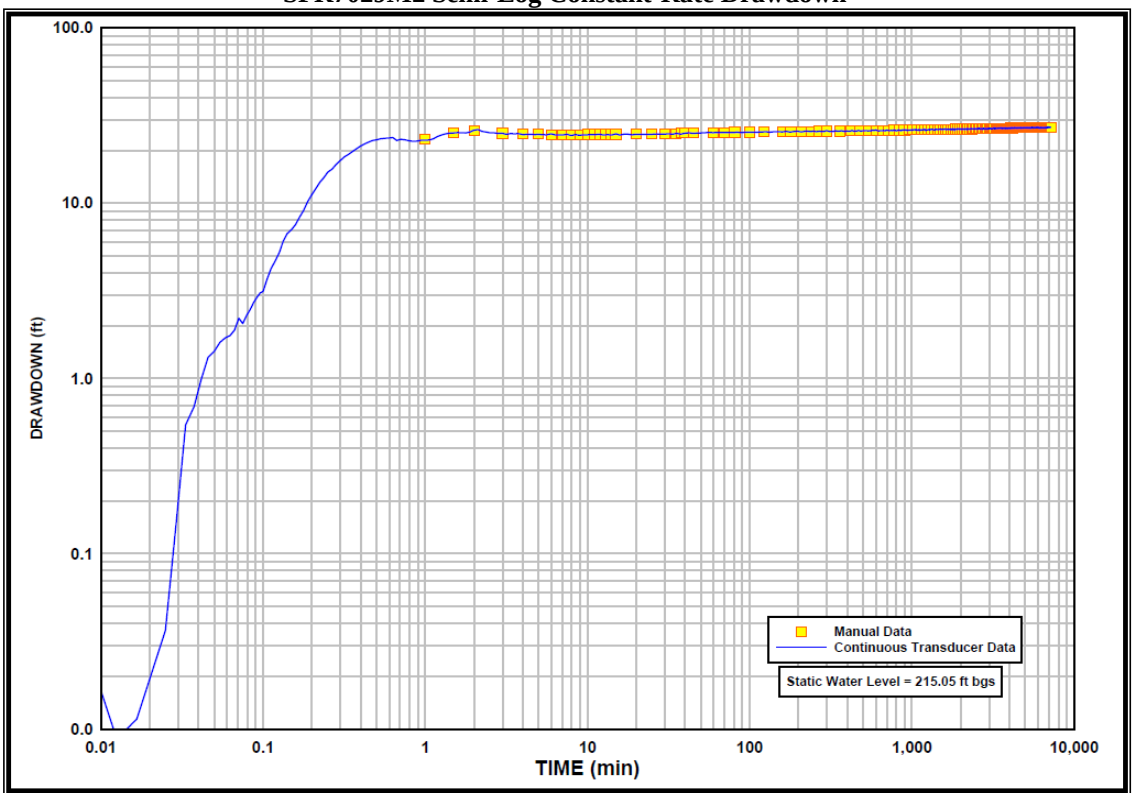


**Figure D- 2**
**SPR7029M2 Log-Log Constant-Rate Drawdown**

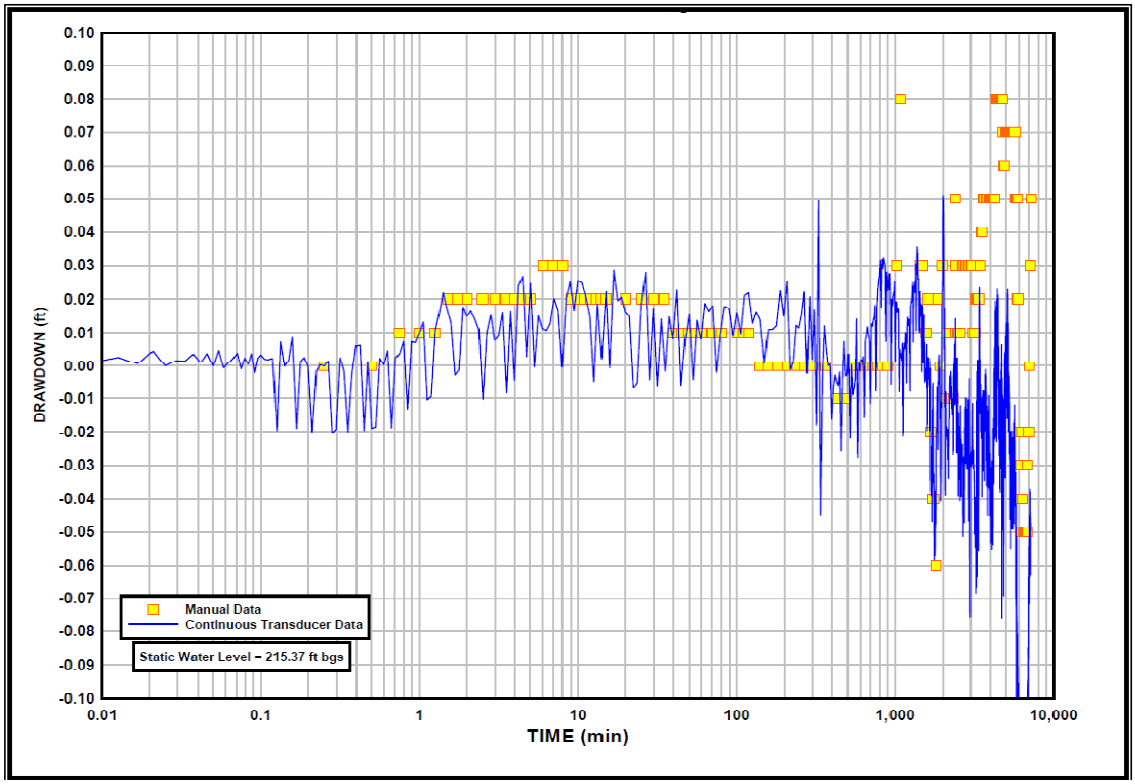


**Figure D- 3**
**SPR7029M Semi-Log Constant-Rate Drawdown**

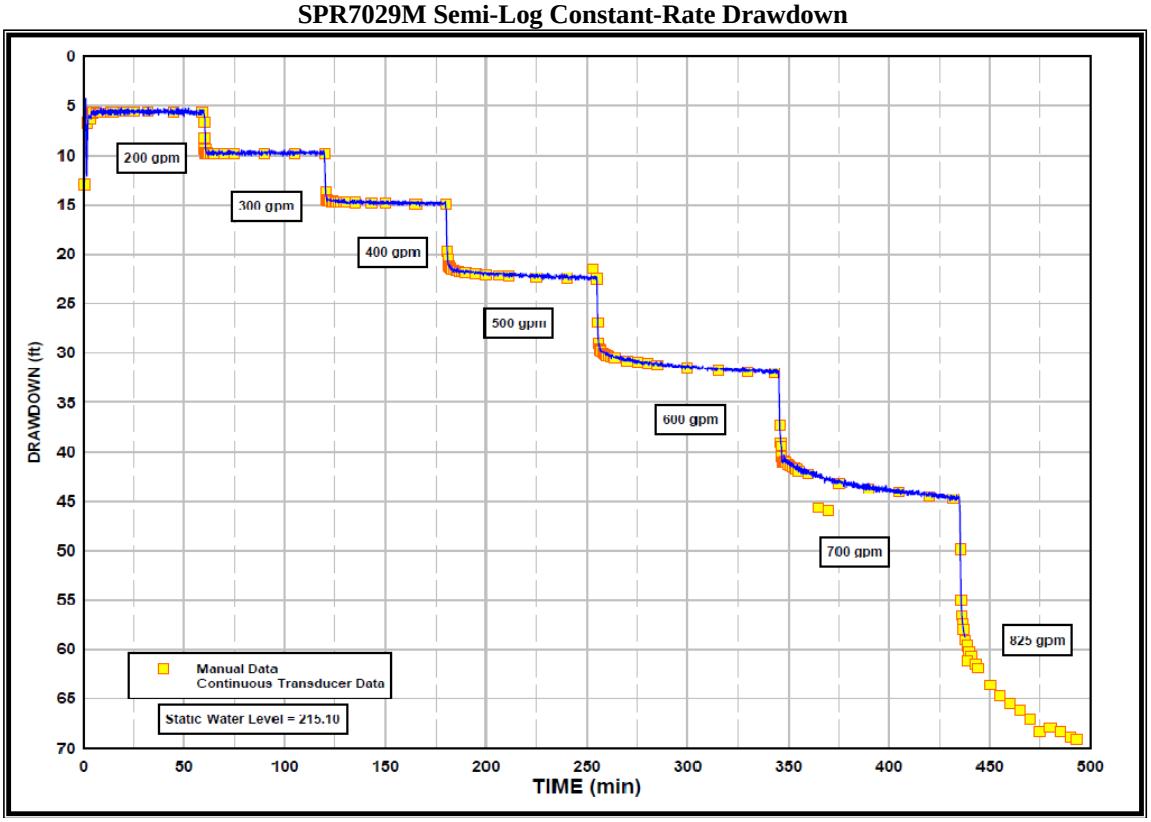


**Figure D- 4**
**SPR7029M2 Step-Drawdown Test Results**

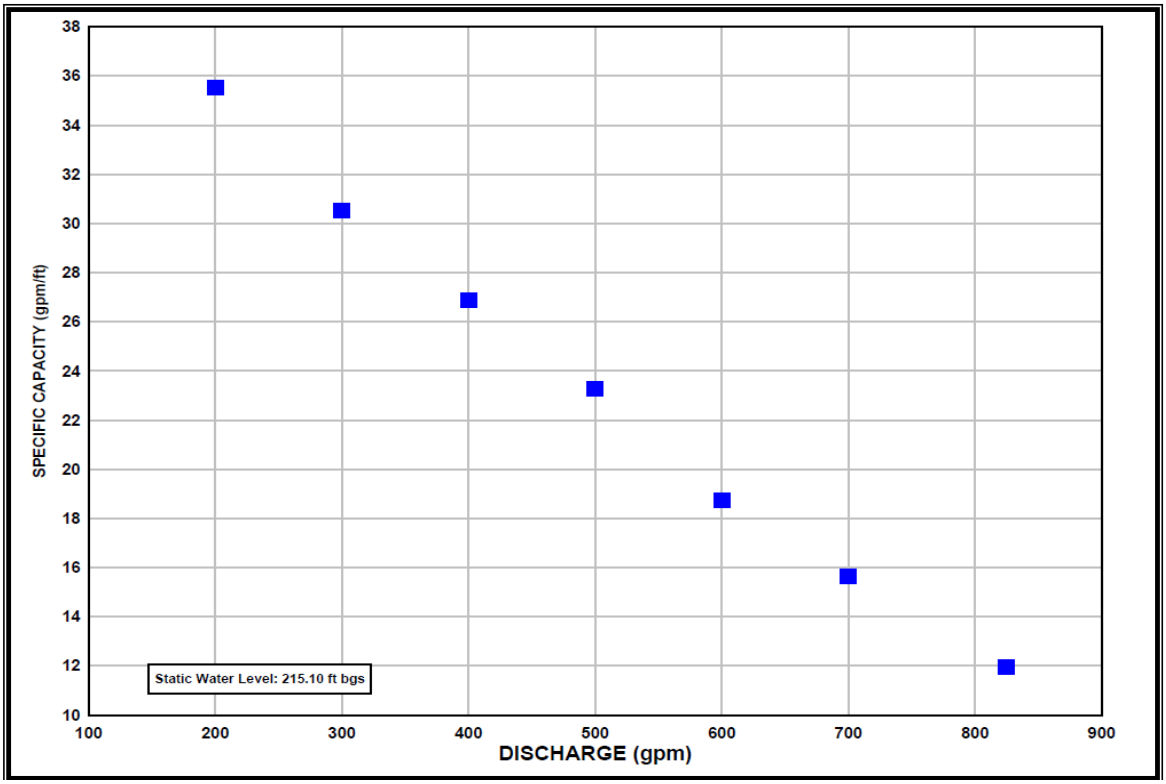


**Figure D- 5**
**SPR7029M2 Step-Drawdown Test Specific Capacity vs. Discharge**

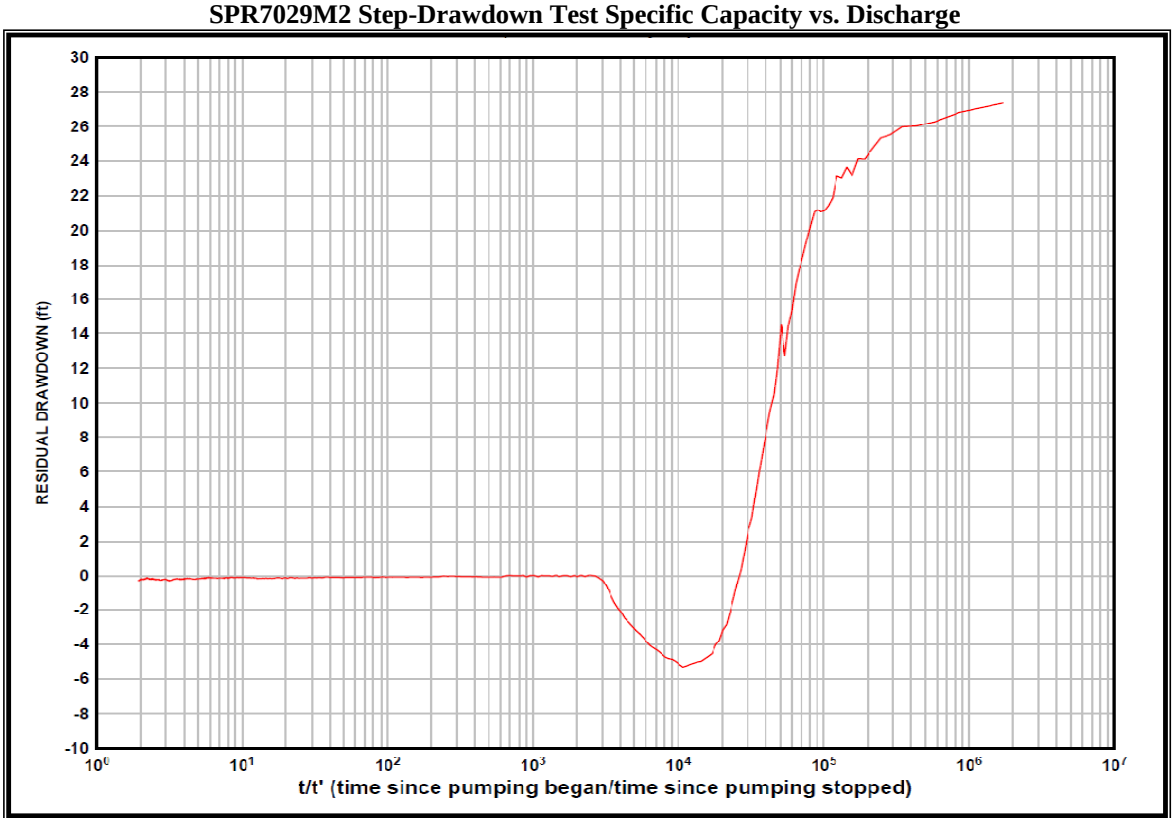


**Figure D- 6**
**SPR7029M2 Constant-Rate Recovery Diagnostic Plot**

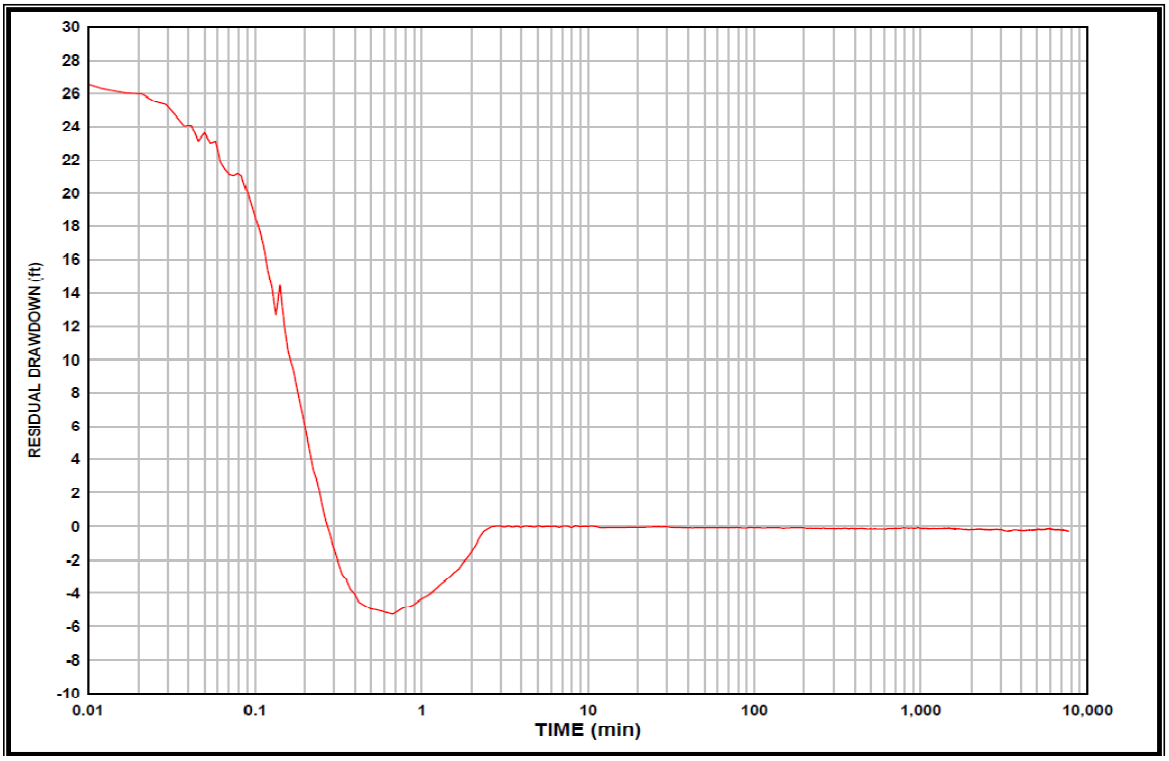


**Figure D- 7**
**SPR7029M2 Constant-Rate Recovery Semi-Log Plot**

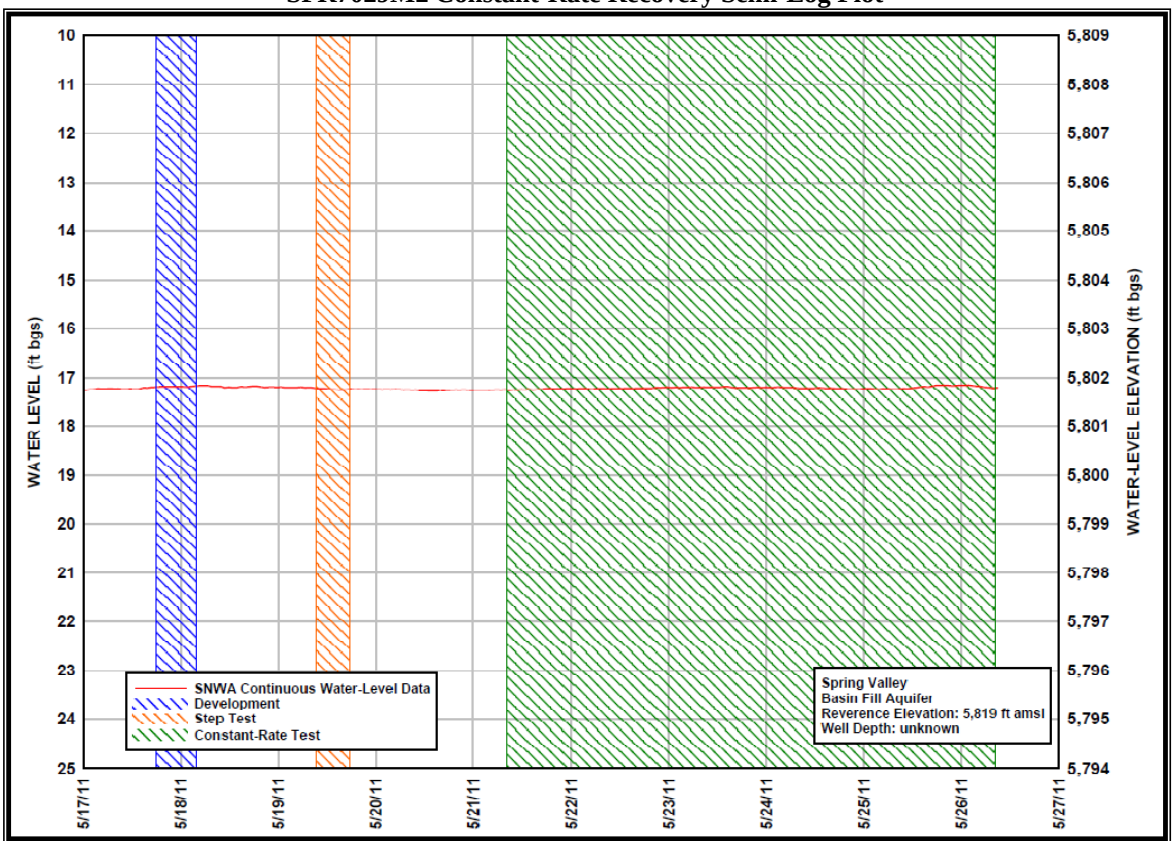


**Figure D- 8**
**184 N15 E66 24 CD1 Background Well**

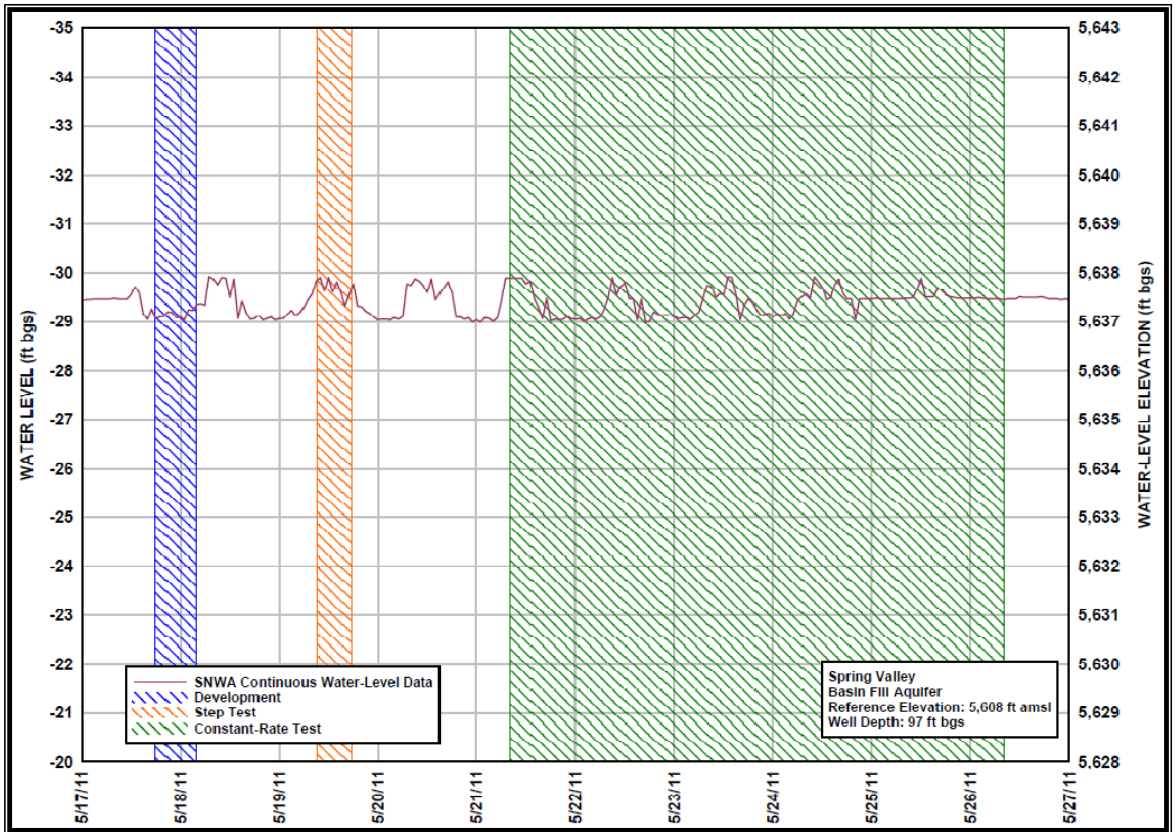


**Figure D- 9**
**SPR7030M Background Well**

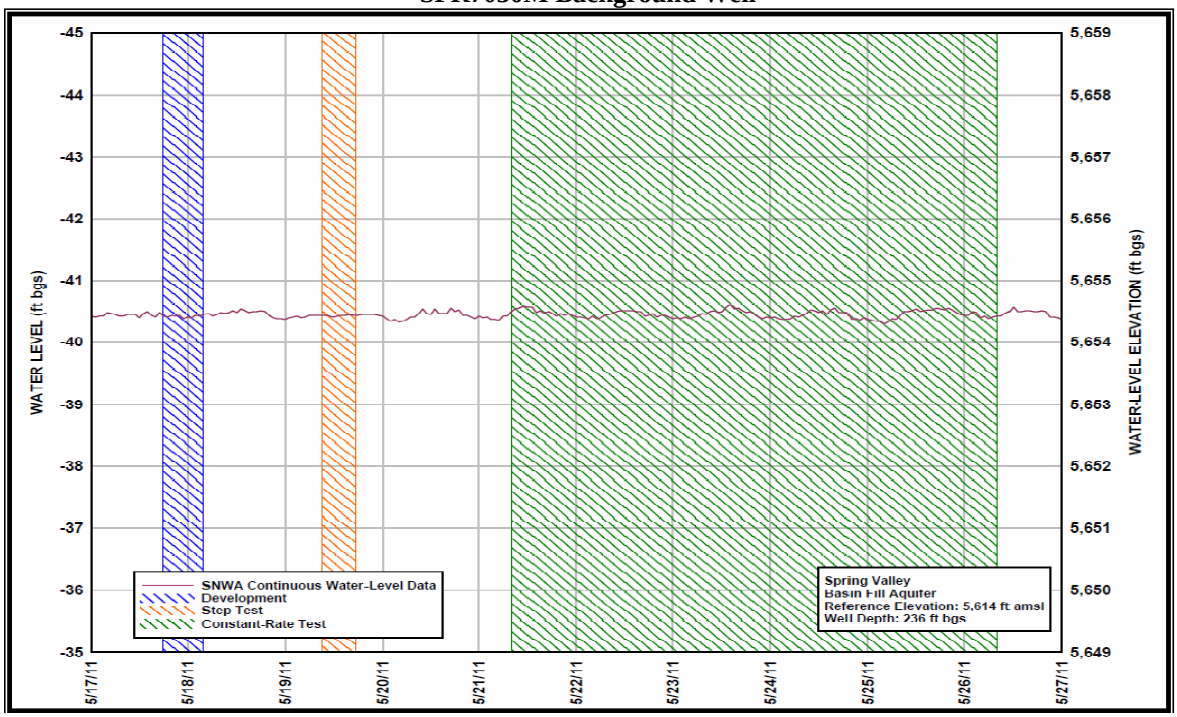


**Figure D- 10**
**SPR7030M2 Background Well**

# Appendix E
# WATER QUALITY SAMPLE LAB RESULTS

## SNWA GW RESOURCES - SPRING VALLEY WELLS

**SNWS Laboratory** **Certified Lab ID NV00009**

| | | | | | |
|---|---|---|---|---|---|
| Location | SPRING VALLEY WELLS | Sample ID | 11050466-001 | PWS ID | N/A |
| Sub-Location | SPR7029M2(A) | Received | 5/23/2011 15:40 | Collected By | customer |
| Tag Location | | Collected | 5/22/2011 08:00 | State Tag No | |

| Analyte | MRL | Value | Units | Date Analyzed | Analyst | Prep / Setup | Method/Ref | Sta Vol | Condition | Dil |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, OH | | 0.00 | mg/L | 5/26/2011 13:10 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, CO3 | | 0.00 | mg/L | 5/26/2011 13:10 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, HCO3 | | 151 | mg/L | 5/26/2011 13:10 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, Total | 2 | 151 | mg/l | 5/26/2011 13:10 | tousignh | | SM 2320 B | | | 1.0 |
| TDS | 20 | 170 | mg/L | 5/24/2011 15:30 | demaurem | 5/24/2011 15:30 | SM2540C | | | 1.0 |
| Diss Fluoride | .1 | < MRL | mg/L | 5/25/2011 12:24 | georges | | SM4500F C | | | 1.0 |
| Diss o-Phosphate as P | .001 | 0.010 | mg/L | 5/24/2011 18:32 | tousignh | | SM4500P F | | HTE | 1.0 |
| T-Phosphate as P | .001 | 0.015 | mg/L | 6/7/2011 15:59 | tousignh | 5/25/2011 10:15 | SM4500P F | | | 1 |
| Diss Silica, Reactive | 1 | 10 | mg/L | 5/26/2011 11:49 | galzaj | | SM4500SiO2 C | | | 1.0 |
| Diss Bromide | .02 | < MRL | mg/L | 5/24/2011 09:00 | bradyh | | EPA 300.0 | | | 1.0 |
| Diss Chloride | 5 | < MRL | mg/L | 5/24/2011 11:35 | bambaoa | | EPA 300.0 | | | 1.0 |
| Diss Nitrate as N | .02 | 0.27 | mg/L | 5/24/2011 09:00 | bradyh | | EPA 300.0 | | HTE | 1.0 |
| Diss Nitrite as N | .02 | < MRL | mg/L | 5/24/2011 09:00 | bradyh | | EPA 300.0 | | HTE | 1.0 |
| Diss Sulfate | 5 | 7.6 | mg/L | 5/24/2011 11:35 | bambaoa | | EPA 300.0 | | | 1.0 |
| Diss Iron | .1 | < MRL | mg/L | 5/26/2011 09:50 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Calcium | 1 | 44 | mg/L | 5/26/2011 08:32 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Magnesium | 1 | 14 | mg/L | 5/26/2011 08:32 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Potassium | 1 | < MRL | mg/L | 5/26/2011 08:32 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Sodium | 1 | 3.0 | mg/L | 5/26/2011 08:32 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Hardness, Total | | 170 | mg/L a | 5/26/2011 08:32 | abkilanb | 5/24/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Mercury | .0002 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Aluminum | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Antimony | .0006 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Arsenic | .001 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Barium | .005 | 0.17 | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Beryllium | .0004 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Cadmium | .0005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Chromium | .0005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Copper | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Lead | .001 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Manganese | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Molybdenum | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Nickel | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Selenium | .001 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Silver | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Thallium | .0002 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Vanadium | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Zinc | .005 | < MRL | mg/L | 5/26/2011 12:57 | eivazip | 5/24/2011 15:00 | EPA 200.8 | | | 1.0 |
| Conductivity | | 353 | uS/cm | 05/22/2011 08:00 | customer | | SM 2510 B | | | |
| Temperature | | 17.6 | Deg. C | 05/22/2011 08:00 | customer | | SM 2550 B | | | |

Laboratory Manager: Date: 6/13/2011

SNWA GW RESOURCES - SV WELLS

## SNWA GW RESOURCES - SPRING VALLEY WELLS

**SNWS Laboratory** **Certified Lab ID NV00009**

| | | | | | |
|---|---|---|---|---|---|
| Location | SPRING VALLEY WELLS | Sample ID | 11050466-001 | PWS ID | N/A |
| Sub Location | SPR7029M2(A) | Received | 5/23/2011 15:40 | Collected By | customer |
| Trip Location | | Collected | 5/22/2011 08:00 | State Tag No. | |

| Analyte | MRL | Value | Units | Date Analyzed | Analyst | Prep / Setup | Method ref | Std Vial | Condition | Dil |
|---|---|---|---|---|---|---|---|---|---|---|
| pH | | 7.72 | pH uni | 05/22/2011 08:00 | customer | | SM4500H B | | | |
| Dissolved Oxygen | | 7.26 | mg/L | 05/22/2011 08:00 | customer | | SM 4500 OG | | | |

| | | | | | |
|---|---|---|---|---|---|
| Location | SPRING VALLEY WELLS | Sample ID | 11050545-001 | PWS ID | N/A |
| Sub Location | SPR7029M2 | Received | 5/26/2011 13:45 | Collected By | customer |
| Trip Location | | Collected | 5/25/2011 10:20 | State Tag No. | |

| Analyte | MRL | Value | Units | Date Analyzed | Analyst | Prep / Setup | Method ref | Std Vial | Condition | Dil |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, OH | | 0.00 | mg/L | 6/3/2011 00:47 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, CO3 | | 0.00 | mg/L | 6/3/2011 00:47 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, HCO3 | | 151 | mg/L | 6/3/2011 00:47 | tousignh | | SM 2320 B | | | 1.0 |
| Alkalinity, Total | 2 | 151 | mg/L | 6/3/2011 00:47 | tousignh | | SM 2320 B | | | 1.0 |
| TDS | 20 | 167 | mg/L | 6/1/2011 12:05 | schoolcd | 6/1/2011 12:05 | SM2540C | | | 1.0 |
| Diss Fluoride | .1 | < MRL | mg/L | 6/1/2011 16:24 | georges | | SM4500F C | | | 1.0 |
| Diss o-Phosphate as P | .001 | 0.0097 | mg/L | 6/1/2011 15:04 | tousignh | | SM4500P F | | HTE | 1.0 |
| T-Phosphate as P | .001 | 0.017 | mg/L | 6/8/2011 09:01 | tousignh | 6/6/2011 10:30 | SM4500P F | | | 1 |
| Diss Silica, Reactive | 2 | 11 | mg/L | 5/31/2011 10:15 | gelzaj | | SM4500SiO2 C | | | 2.0 |
| Diss Bromide | .02 | < MRL | mg/L | 5/27/2011 05:36 | bradyh | | EPA 300.0 | | | 1.0 |
| Diss Chloride | 5 | < MRL | mg/L | 6/1/2011 16:23 | bambaoa | | EPA 300.0 | | | 1.0 |
| Diss Nitrate as N | .02 | 0.27 | mg/L | 5/27/2011 05:36 | bradyh | | EPA 300.0 | | | 1.0 |
| Diss Nitrite as N | .02 | < MRL | mg/L | 5/27/2011 05:36 | bradyh | | EPA 300.0 | | | 1.0 |
| Diss Sulfate | 5 | 7.6 | mg/L | 6/1/2011 16:23 | bambaoa | | EPA 300.0 | | | 1.0 |
| Diss Iron | .1 | < MRL | mg/L | 6/1/2011 15:01 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Calcium | 1 | 41 | mg/L | 5/31/2011 08:07 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Magnesium | 1 | 13 | mg/L | 5/31/2011 08:07 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Potassium | 1 | < MRL | mg/L | 5/31/2011 08:07 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Sodium | 1 | 2.9 | mg/L | 5/31/2011 08:07 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Hardness, Total | | 160 | mg/L a | 5/31/2011 08:07 | abkilanb | 5/26/2011 15:00 | EPA 200.7 | | | 1.0 |
| Diss Mercury | .0002 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Aluminum | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Antimony | .0006 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Arsenic | .001 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Barium | .005 | 0.16 | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Beryllium | .0004 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Cadmium | .0005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Chromium | .0005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Copper | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Lead | .001 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Manganese | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Molybdenum | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Nickel | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |

Laboratory Manager: Linda K. Bish Date: 6/13/2011

SNWA GW RESOURCES - SV WELLS

## SNWA GW RESOURCES - SPRING VALLEY WELLS

**SNWS Laboratory** **Certified Lab ID NV00009**

| | | | | | |
|---|---|---|---|---|---|
| Location | SPRING VALLEY WELLS | Sample ID | 11050545-001 | PWS ID | N/A |
| Sub Location | SPR7029M2 | Received | 5/26/2011 13:45 | Collected By | customer |
| Tap Location | | Collected | 5/25/2011 10:20 | State Tag No. | |

| Analyte | MRL | Value | Units | Date Analyzed | Analyst | Prep/ Setup | Method ref | Std Vol | Condition | Dil |
|---|---|---|---|---|---|---|---|---|---|---|
| Diss Selenium | .001 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Silver | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Thallium | .0002 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Vanadium | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Diss Zinc | .005 | < MRL | mg/L | 6/1/2011 15:44 | eivazip | 5/26/2011 15:00 | EPA 200.8 | | | 1.0 |
| Conductivity | | 302 | uS/cm | 05/25/2011 10:20 | customer | | SM 2510 B | | | |
| Temperature | | 17.2 | Deg. C | 05/25/2011 10:20 | customer | | SM 2550 B | | | |
| pH | | 7.7 | pH uni | 05/25/2011 10:20 | customer | | SM4500H B | | | |
| Dissolved Oxygen | | 7.39 | mg/L | 05/25/2011 10:20 | customer | | SM 4500 OG | | | |

Laboratory Manager: Date: 6/13/2011
SNWA GW RESOURCES - SV WELLS