Spring, Cave, Dry Lake and Delamar Valleys

SOUTHERN NEVADA
WATER AUTHORITY

Presentation for
Jones/Mayo Cross

SNWA Application and Perennial Yield

Regardless of the State Engineer's final ruling on net groundwater ET, three critical groundwater budget issues need to be examined: 1) the total diversion rates from SNWA's points of diversion relative to reasonable estimates of perennial yield, 2) the feasibility of successfully accomplishing ET salvage based on the locations of the points of diversion relative to the spatial distribution of groundwater ET, and 3) the well design relative to ET salvage and groundwater mining.

The total SNWA Spring Valley application is for 91,224 AFA of unappropriated perennial yield (Table 5). Approval of all points of diversion at the requested diversion rate would result in groundwater mining. Existing consumptive use of vested and appropriated groundwater rights not owned by SNWA are about 14,000 AFA; thus, assuming the most optimistic estimate of perennial yield 94,800 AFA (SNWA, 2011a) only about 81,000 AFA of perennial yield is available. Based on the State Engineer's previous finding of 80,000 AFA perennial yield (Nevada State Engineer, 2007) and the most recent inventory of Spring Valley appropriated groundwater (Nevada Division of Water Resources, 2011) 14,202 AFA of groundwater is committed groundwater and only 65,797 AFA is available for appropriation.

Table 5 Summary of SNWA Spring Valley Points of Diversion.

Site ID	CFS	AFA
54003	6	4,344
54004	6	4,344
54005	6	4,344
54006	6	4,344
54007	6	4,344
54008	6	4,344
54009	6	4,344
54010	6	4,344
54011	6	4,344
54012	6	4,344
54013	6	4,344
54014	6	4,344
54015	6	4,344
54016	6	4,344
54017	6	4,344
54018	6	4,344
54019	10	7,240
54020	10	7,240
54021	10	7,240
	Total	**91,224**

Equally important as the final estimated perennial yield in Spring Valley is the spatial ET distribution relative to the location of the SNWA proposed points of diversion. The reason that this is critical is that SNWA is proposing an ET salvage project that will capture the entire unappropriated perennial yield

Table 3 Summary of Northern Spring Valley Groundwater Age Data from the Vicinity of Cleveland and Rogers Ranches.

Sample ID	BYU lab #	Sampling Date	pH	^{14}C [pmc]	+/-	$\delta^{13}C$	+/-	^{3}H [TU]	+/-	HCO_3^- [mg/L]	Fontes calculated 14C age [years]
Bastian Creek Spring	9232	7/19/2011	8.01	44.39	0.15	-7.87	0.04			184	1200
Irrigation Well	9234	7/19/2011	8.11	37.56	0.13	-8.22	0.04	3.9	0.2	186	2500
Stephens Creek	9236	7/19/2011						11.1	0.4		
Big Resevoir Spring (#1/2)	9237	7/20/2011	7.93	77.12	0.22	-13.90	0.04			131	modern
Millick Spring	9238	7/20/2011	7.92	44.94	0.14	-8.63	0.04	2.0	0.1	270	1200
Negro Creek Spring	9239	7/19/2011						9.1	0.1		

Valley Floor

Northern Spring Valley was occupied by the Pleistocene age Lake Spring to an elevation of 6428 feet (Reheis, 1999). Many of the lake shorelines are visible on the alluvial fans (Figure 3) and some wave-cut terraces are the locations of alluvial fan spring discharges. Surficial deposits on the valley floor include recent playa muds, fine-grained pluvial lake sediments, and reworked alluvial fan sediments. Depth to bedrock may exceed 10,000 feet and the details of the deep stratification are unknown. Because the basin has periodically been closed during the past 11 million years or so, lake deposits interfingered with coarser grained alluvial fan sediments and possibly lava flows likely occur.

The basin is topographically closed, thus nearly all surface and groundwater, except for groundwater loss to interbasin flow, either discharges on the alluvial fan margins or upwells in the valley bottom. Yelland playa is the current location of the topographic low of the northern valley and, as such, all surface and groundwater in the valley bottom flows toward the playa (Figure 3). Because of the relatively low relief of the valley floor, upwelling groundwater and surface flows that reach the valley floor support a significant region of both surface water ponds and groundwater ET as characterized by the unusual grove of swamp cedars located below the Bastian alluvial fan, the sub-irrigated pasture land of the Cleveland Ranch, and the extensive wetlands located north of Cleveland Ranch. SNWA (2009a, 2011a) has mapped the ET zone in the valley floor.

The Nevada State Engineer has determined that in most Nevada basins groundwater discharge is primarily by evapotranspiration (ET) and that the perennial yield is approximately equal to the estimated groundwater ET (Nevada State Engineer, 2007). Because almost all Spring Valley groundwater ET occurs in the valley floor, SNWAs' application to appropriate groundwater is based on the idea that wells can be constructed so as to capture all unappropriated groundwater prior to potential ET loss. What this entails is either capturing the groundwater prior to entering the ET area and/or lowering the groundwater table below the root extinction depth without causing groundwater mining. The significance of ET capture relative to the SNWA application is discussed below.

Table 4 Summary of Spring Valley Groundwater Budgets Based on Non-Geochemical Methods

Source	Groundwater Recharge [x1000 AFA]	Net ET or Perennial Yield [x1000 AFA]	Net Interbasin Flow [x1000 AFA]
Rush and Kazmi, 1965	75.0	70.0	
Watson et al., 1976	63.0		
Harill et al., 1988			-21.0
Dettinger, 1989	62.0		
Nicols,2000	104.0	90.0	-14.0
Flint et al., 2004	67.0		
Epststein, 2004	35.0		
Epststein, 2004	93.0		
Brothers et al., 1994	72.0	70.0	
Nevada State Engineer, 2007		80.0	
Welch and Bright, 2008	93.0	75.6	-15.0
SNWA, 2009a[1]	81.4	75.4	-12.0
SNWA, 2011a[2]	99.2	94.8	-4.4

[1] *Groundwater recharge (Table 9-2), groundwater ET volume (Table F3)*
[2] *Groundwater recharge (Table 6-2), groundwater ET volume (Table D6, average for period of record 2006-2010)*

There are several factors that make it clear that a definitive estimate of potential yield extending 200+ years into the future cannot be made. They include: 1) the complexity of the groundwater systems, 2) the uncertainty in estimating groundwater recharge rates relative to precipitation, 3) the relatively limited time record of measured precipitation, 4) the uncertainty in calculating groundwater ET, 5) the fact that Spring Valley groundwater recharge and net ET calculation results vary greatly based on the methodology and the assumptions used, and 6) other factors such as the potential effect of climate change. Because a definitive estimate of perennial yield extending 200+ years into the future cannot be made, the State Engineer's approach in establishing a conservative estimate of perennial yield is appropriate.

SNWA has presented a moving target for estimated groundwater ET: 87,000 AFA at the 2006 State Engineers hearing, 75,600 AFA in 2009, and 94,800 AFA in 2011. The 2011 SNWA groundwater budget includes 84,800 AFA perennial yield (SNWA Exhibit 258, p. 10-1 and 10-2), 12,768 AFA or 10,429 AFA (excluding later priority) committed groundwater and 84,370.49 AFA unappropriated water (SNWA Exhibit 258, p. 10-4). Both the 2009 and 2011 estimates have been submitted as exhibits (Exhibit 88 and Exhibit 258, respectively). It appears that the SNWA is using the 2009 number (75,600 AFA) in the baseline groundwater model.

Groundwater Budget

Establishing the groundwater budget is one of the critical factors in the groundwater appropriation process in that the budget, combined with existing appropriations, is the basis for determining the quantity of unappropriated water. Groundwater budgets are based on the simple continuity equation where inflow = outflow ± change in storage. In the case of perennial yield for a closed basin such as Spring Valley, inflow includes direct basin groundwater recharge plus interbasin inflow, and outflow includes groundwater ET plus interbasin outflow. Perennial or safe annual yield is based on the assumption that there is no change in storage (i.e., increasing water table or potentiometric elevations, or groundwater mining).

In the case of Spring Valley, more than a dozen estimates of a groundwater recharge, net groundwater ET and perennial yield, or net interbasin outflow have been published since 1965 (Table 4). Most groundwater recharge calculations have been based on a version of the well-established Maxey-Eakin method and some have used PRISM data to calculate precipitation for inclusion in the Maxey-Eakin method. ET estimates have been based on an analysis involving phreatophyte mapping and assigning groundwater consumption factors to various plant and bare land communities or by assuming that calculated net groundwater recharge equals ET. During the 2006 water rights hearing before the State Engineer, SNWA presented a revised groundwater budget that included 87,000 AFA of ET using the Maxey-Eakin method and an additional 12,000 AFA from stream flow and 2,000 AFA from underflow from Tippet Valley. Since then, SNWA (2009a, 2011a) has prepared reports that suggest net ET is 75,400 and 94,000 AFAA, respectively. During the State Engineers' hearing, numerous arguments were made regarding the validity of some assumptions used in many of the existing groundwater budget calculations. SNWA has prepared a new document (Exhibit 258, SNWA 2011a) which: 1) describes in detail various assumptions and variations of methodologies that can be used to calculate groundwater budget components, and 2) includes calculations of groundwater budget components using various assumptions and methodologies. The most recent SNWA methodology has resulted in the largest perennial yield estimate to date (94,800 AFA). In this calculation, SNWA assumes that groundwater ET equals perennial yield and that groundwater ET equals calculated groundwater recharge. SNWA calculated groundwater recharge using a version of Maxey-Eakin and PRISM data for precipitation values.

Transitional Storage Reserve

Transitional storage reserve is the quantity of water in storage in a particular ground water reservoir that is extracted during the transition period between natural equilibrium conditions and new equilibrium conditions under the perennial-yield concept of ground water development.

In the arid environment of Nevada, the transitional storage reserve of such a reservoir means the amount of stored water which is available for withdrawal by pumping during the non-equilibrium period of development, (i.e., the period of lowering water levels).

In valleys where natural discharge is partly or entirely by sub-surface outflow, the amount that can be salvaged with a dewatering (taken from storage) of 50 feet is estimated to average roughly 50 percent of the outflow. The transitional storage reserve estimates for the regions are based on an average dewatering of 30 to 40 feet of valley-fill reservoir. These values are shown for each region in Table 1-A.

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Table 2 Alluvial Fan Gain-Loss Stream Measurements.

		Discharge [cfs]	Reach [miles]	Loss [cfs]	Infiltration [%]	Loss/Mile [cfs]
Cleve Creek						
	Mountain Front	15.98	0		0.0	
	USGS gauging Station	15.35	0.7	0.63	4.0	
	USGS 10243700 Cleve Creek[1]	15	0.7			
	Mid alluvial fan	10.95	3	5.03	32.0	
	Just before holding pond	9.69	4.1	6.29	39.0	1.53
Indian Creek						
	Mountain front	1.51	0		0.0	
	Just before holding pond	1.04	1.3	0.47	31.0	0.36
Stephens Creek						
	Mountain front	1.73	0		0.0	
	Sprinkler system inlet	0.98	0.5	0.75	44.0	1.50

Negro Creek[2]		Discharge [AF]	Reach [miles]	Loss [AF]	Infiltration [%]	Loss/Mile [AF]
April	Homestead	**199**	**0**			
	Downstream diversion	52	3.6	147	73.9	40.83
May	Homestead	184	0			
	Downstream diversion	50	3.6	134	72.8	37.22
June	Homestead	223	0			
	Downstream diversion	99	3.6	124	55.6	34.44
July	Homestead	128	0			
	Downstream diversion	26	3.6	102	79.7	28.33
August	Homestead	81	0			
	Downstream diversion	6	3.6	75	92.6	20.83
September	Homestead	94	0			
	Downstream diversion	13	3.6	81	86.2	22.50
October	Homestead	114	0			
	Downstream diversion	32	3.6	82	71.9	22.78

1 Preliminary data from USGS website (waterdata.usgs.gov, 2011)
2 2008 measurements (CPB Exh-001, 2011)

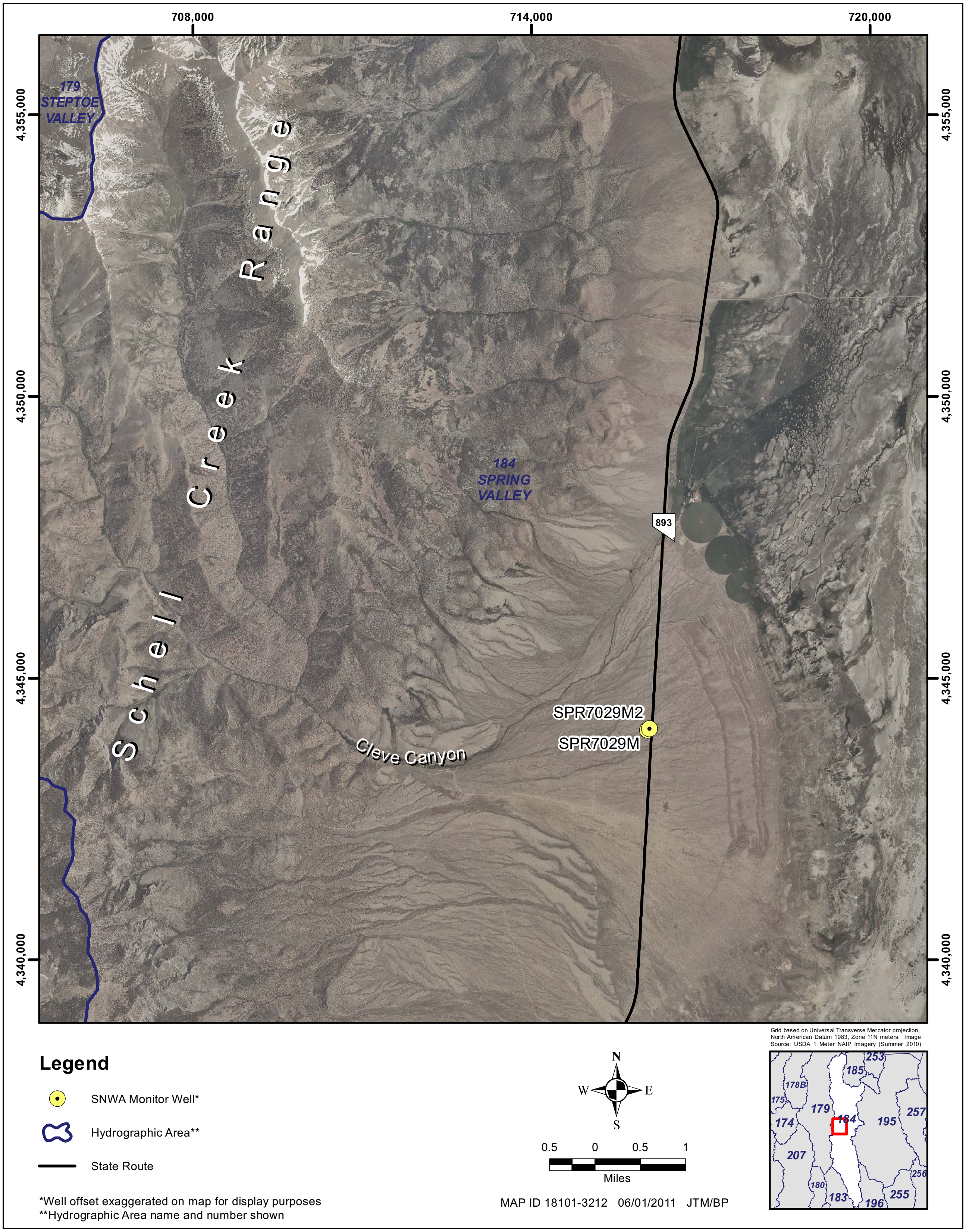


FIGURE 1
LOCATION OF MONITOR WELLS SPR7029M AND SPR7029M2

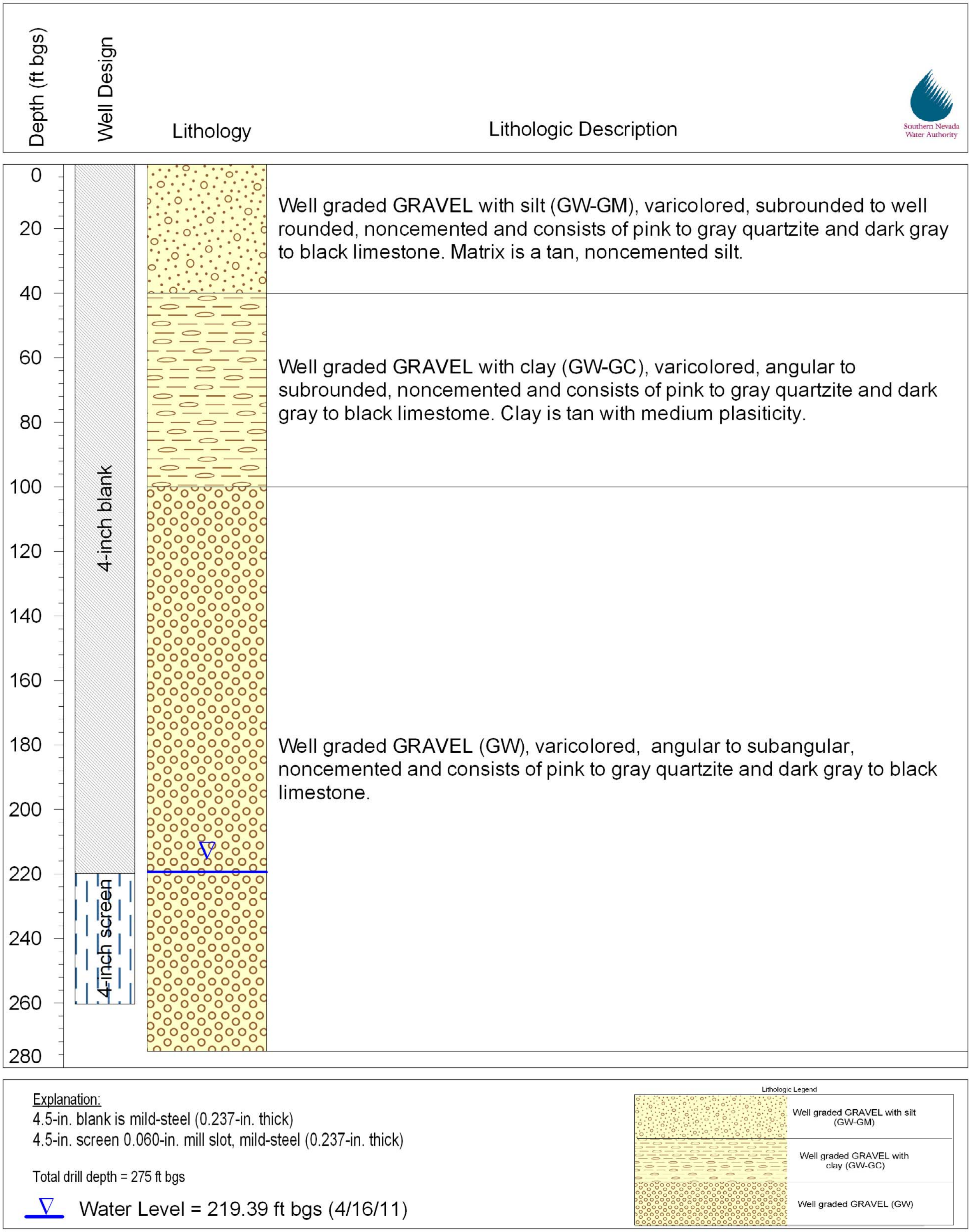


FIGURE 5
MONITOR WELL SPR7029M BOREHOLE STRATIGRAPHIC COLUMN

An appreciable but unquantified portion of the Spring Valley groundwater recharge occurs as mountain front recharge by the infiltration of surface flows on the mountain front alluvial fans. Evidence for mountain front recharge includes: 1) measured stream infiltration from perennial streams, 2) the abundance of braided ephemeral alluvial fan stream channels, and 3) the location of most spring discharges at either the toe of alluvial fans or where pluvial lake shorelines resulted in subtle breaks in slope near the alluvial fan/lake bed interface (Figure 6 and Figure 7). The springs shown in Figure 7 discharge at the distal end of the low gradient Cleve Creek alluvial fan. Indian Creek flows across the steep alluvial fan in the far ground. The spring discharges are largely controlled by two factors: 1) groundwater recharge from Cleve Creek infiltration, and 2) the break in slope caused by a pluvial lake wave-cut terrace. Similar but smaller volume spring discharges issue from the distal end of the southern portion of Cleve Creek fan (unnamed springs), Negro Creek alluvial fan (unnamed and north and south Millick springs), and the Bastian Creek alluvial fan (Bastian Creek springs).

Mountain front (i.e., alluvial fan) stream losses were measured on the perennial Negro Creek (Snake Range) in 2008 (CPB Exhibit 001) and on Cleve, Indian and Stephens Creeks (Schell Creek Range) on August 15, 2010, as part of this investigation. A summary of the measurements is shown in Table 2 and the measurement locations and raw measurement data are contained in Appendix A. The purpose of the gain-loss measurements was to help document the relationship between surface water infiltration and the groundwater recharge sources of the springs that are critical to the operation of Cleveland and Rogers Ranches.

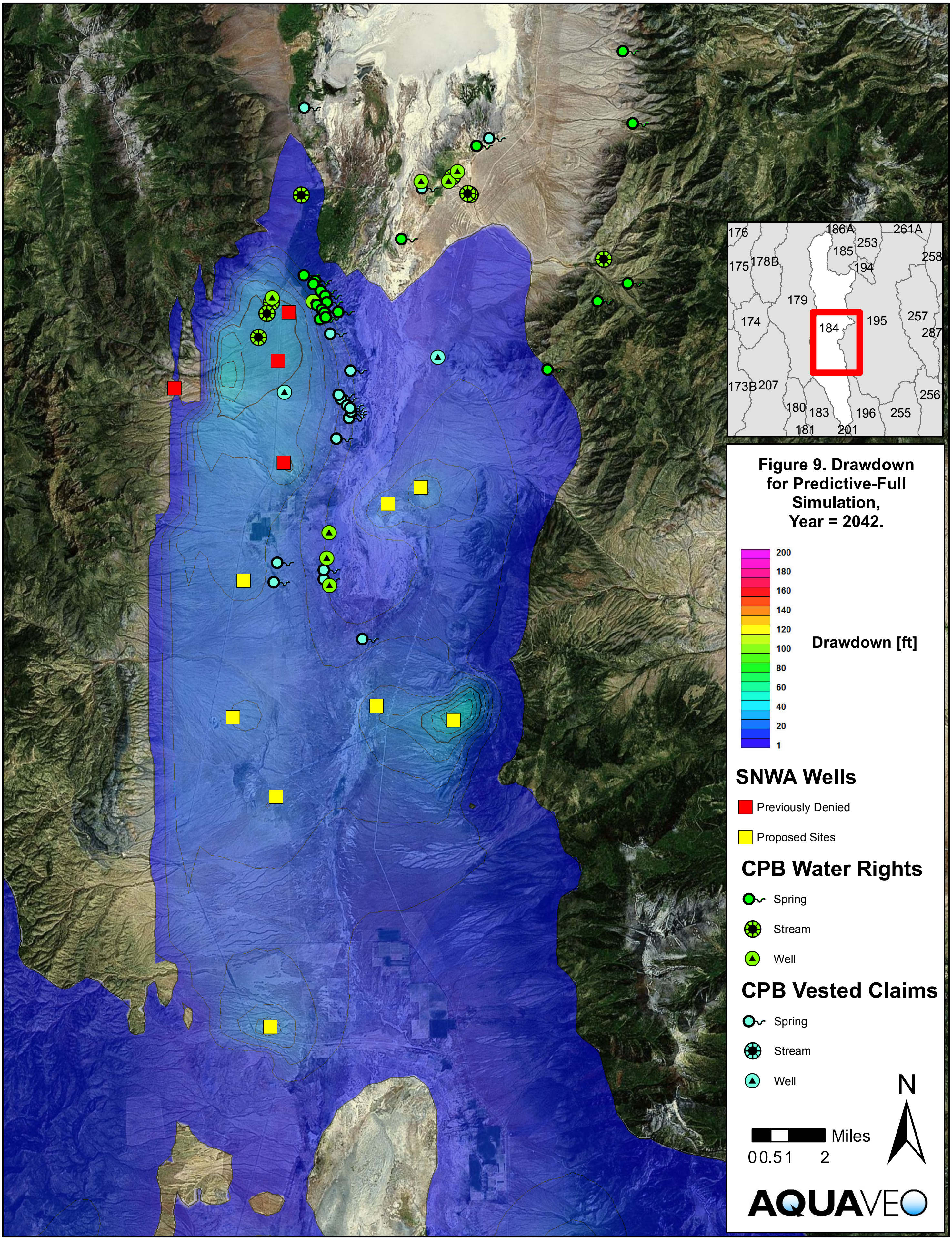
Measured infiltration rates ranged from about 31 to 93% of total perennial stream flows. The groundwater recharge rate into west side alluvial fans (Cleve and Stephens Creek fans) was about 40% of total stream flow during August 2010. Under natural conditions the net infiltration rate would be greater than measured because the measure rates only include the stream reaches up gradient of Cleveland Ranch points of diversion. Indian Creek is a small discharge tributary to Cleve Creek. The groundwater recharge rate from Negro Creek into the Negro Creek alluvial fan, located at the base of the Snake Range on the west side of the valley (Figure 3), was typically more than 70% during the seven month 2008 study. The higher infiltration rate of Negro Creek may be due to the fact that the creek free flows along its entire reach for approximately three miles from the canyon sources to the ranch. The Negro Creek data demonstrates that appreciable groundwater recharge continues during low flow months when most of the stream flow is lost to groundwater recharge and suggests that much of the water in ephemeral streams is also lost to groundwater recharge. Using unpublished data from Pilot Valley (Nevada-California) we have found a similar recharge mechanism from ephemeral mountain front alluvial fan systems.

The largest number and total discharge volume of alluvial fan springs in Spring Valley issue from the distal end of the Cleve Creek alluvial fan. This concentration of springs and spring discharge volume is consistent with the fact that Cleve Creek is the largest perennial stream in the Valley. The average monthly flow of Cleve Creek between 1960 and 2010 ranged from 6.5 to 23 cfs and the average annual flow ranged from 5.6 to 22.2 cfs (waterdata.usgs.gov, 2011).

The relationship between surface water infiltration into the Cleve Creek alluvial fan and the Big Reservoir springs is further evidenced by a groundwater age investigation performed as part of this study. Carbon-14 ages and tritium analyses were performed on six surface and groundwater samples collected from northern Spring Valley (Table 3). The Stephens Creek sample which contains ~ 11 tritium units (TU) and the Negro Creek spring sample, collected from the bedrock spring at the mouth of Negro Canyon, indicate that recent recharge water contains about 10 TU. Ten TU for modern precipitation is consistent with the 15 year tritium precipitation record of rain and snowfall along the Wasatch Front (unpublished data). Because tritium has a half-life of about 12.5 years, groundwater in the western Great Basin that is older than about 60-75 years contains little or no measurable tritium. The Big Reservoir spring (1/2) water contains 77 percent modern carbon (pmc) which means the water has a modern recharge source. A modern recharge source is consistent with recharge from Cleve Creek and rapid groundwater flow toward the spring.

The Cleveland Ranch flowing-artesian well contains ~37.6 pmc and 3.9 tritium units (TU), which means the water has mixed recharge sources, including both modern and older groundwater recharge. The old component of recharge is appreciably older than the calculated Fontes 14C age of 2,500 years and the tritium content is a mixture of pre-atmospheric nuclear testing groundwater and more recent recharge water. Because the well is screened from about 100 feet to about 600 feet below ground surface, it is likely that the well acquires modern groundwater near the surface and older groundwater deeper in the alluvial fan. The fact that the well is a flowing artesian well indicates that the well penetrates a confining layer, and that there are at least two groundwater systems in the alluvial fan within 700 feet of the ground surface. The significance of the two groundwater systems with different groundwater travel times is that deeper alluvial fan groundwater is not rapidly replenished by annual groundwater recharge, whereas the overlying shallow alluvial system has an active hydrodynamic communication with surface water and annual recharge events. The importance of this to groundwater extraction by deep alluvial fan wells is that shallow alluvial fan groundwater will be readily replenished by annual recharge events, whereas the replenishment of the deeper groundwater will require hundreds to thousands of years.

The carbon-14 ages and tritium contents of the Bastian Creek spring and the Millick spring (Table 3) suggest that these spring discharges are also supported by young shallow and older deep groundwater. Both of the springs discharge at the distal ends of alluvial fans but not in direct line with the perennial surface water which contributes to alluvial fan recharge. Based on the limited isotopic data, it is not possible to determine the percentages of annual groundwater recharge vs. paleo-groundwater recharge that contribute to Spring Valley ET. It is clear, however, that annual groundwater recharge constitutes a major component of the Murphy and Big Reservoir Springs discharges that are critical to the operation of Cleveland Ranch.


176
186A
261A
253
185
258
175
178B
194
179
174
184
195
257
287
173B
207
256
180
183
196
255
181
201
Figure 9. Drawdown for Predictive-Full Simulation, Year = 2042.
200
180
160
140
120
100
80
60
40
20
1
Drawdown [ft]
SNWA Wells
Previously Denied
Proposed Sites
CPB Water Rights
Spring
Stream
Well
CPB Vested Claims
Spring
Stream
Well
N
Miles
0 0.5 1 2
AQUAVEO

4.3.2 Points in Time of Interest

The results presented in Section 6.0 are summarized for selected points in time over a 75-year period following full build-out of the application volumes. The 75-year period was selected to match the expected life of the equipment and infrastructure. The 75-year time period was also chosen as a result of the reduced level of confidence in the model predictions for the 200-year simulation period versus the 75-year simulation period. Model outputs and further analysis have been performed for the following points in time:

- December 31, 2029: 10 years after the initiation of pumping in Cave, Dry Lake and Delamar valleys.
- December 31, 2042: Start of full production of the application volumes in Spring, Cave, Dry Lake, and Delamar valleys.
- December 31, 2062: 20 years after the start of full production.
- December 31, 2082: 40 years after the start of full production.
- December 31, 2117: 75 years after the start of full production.

4.4 Application Point of Diversion 54021

During preliminary simulations of the scenarios described above, it was noticed that a single POD location (54021) was not able to fully simulate the pumping of the required volume of water. Upon inspection of the model files, it was discovered that this POD is located within the coarse geologic framework of the model, in the BASE regional modeling unit (RMU) representing extremely low-permeability rocks. Figure 4-2 depicts the location of application number 54021 along with the geology and model grid cells for this region. The bedrock geology within the model cell is dominated by the Lower Cambrian to Neoproterozoic sedimentary rocks and therefore, the hydraulic conductivity of this cell is more representative of the BASE RMU. However, this POD is actually located on a coarse grained alluvial surface with nearby bedrock being composed of Upper and Middle Cambrian carbonate rocks and Lower Cambrian to Neoproterozoic sedimentary rocks (Rowley et al., 2011). As such, while the model places the well at the center of the grid cell, rather than at this location, the actual location of the POD may be suitable for a production well.

In order to simulate the pumping of the entire application volume and maintain the results of pumping in their approximate location, the POD was shifted two model cells to the east for the purpose of these simulations.

Subsidence

The drawdown maps and the time series analysis illustrate that the SNWA model predicts extreme amounts of drawdown will occur in central Spring Valley in the vicinity of the CPB water rights. When an aquifer dewaters to this extent, the soil and rock particle in the aquifer lose the buoyancy effect of the water and are subjected to a greatly increased inter-particle stress. This stress causes the aquifer matrix to consolidate leading to ground subsidence. With drawdown levels as high as 185 ft, the subsidence levels are likely to be severe. In addition to subsidence, aquifer consolidation results in a permanent loss of storage capacity. Since soils are inelastic and exhibit hysteresis, the void space in the aquifer prior to dewatering would never be fully recovered, even if the water levels were allowed to rebound to pre-pumping conditions.

Effect of Coarse Grid Resolution

As mentioned above, the SNWA model is a regional model covering an extensive part of Southeastern Nevada, of which Spring Valley is only a small part. As a result, the grid cells used in the simulation are large relative to the distribution of the water rights locations. This fact leads to uncertainty when analyzing simulated water levels at specific points. The region of the SNWA model in the vicinity of the ranch property is shown in Figure 22. The colored lines are drawdown contours from year 2242 for the Predictive-Full simulation. The contours illustrate a large degree of drawdown in the coarse-grained alluvial deposits to the south and west of the ranch. The center of Spring Valley is filled with fine-grained deposits and playas that have a lower hydraulic conductivity than the coarse-grained alluvial deposits.

Many of the CPB water rights are wells and springs located on the edge of alluvial fan deposits near the Cleveland Ranch. The transition from high-permeability coarse-grained deposits to low-permeability fine-grained deposits results in a rapid change in head/drawdown as indicated by the closely-packed contours. Since the water rights locations are located on the boundary of the transition, they are extremely sensitive to the location of the boundary in the model marking the transition between the coarse-grained alluvial fan and the finer-grained playa materials.

The fact that most of the springs were not explicitly represented in the model means that we cannot use the OBS process to analyze the model simulated discharge to the springs. This discharge should go to zero once the simulated head drops below the spring elevation. However, if we examine the simulated heads at the water table locations output by the OBS process (as described in the previous section), we can compare these elevations to the spring elevations in an attempt to estimate when the springs will go dry. The springs will go dry when the head drops below the ground surface elevation as shown by the intersection of the solid red line and the dotted green line in Figure 26. When conducting this type of analysis, the emphasis should be on overall trends since there is considerable uncertainty with the data associated with individual sites. This uncertainty comes from a number of factors, including but not limited to the following:

- **Impact of coarse grid resolution**. The large grid cells used in the regional model can introduce significant error at individual locations even if the model is relatively accurate on a regional scale. This is especially true with springs since they are strongly impacted by local scale conditions such as fissures and localized confinement which leads to vertical head gradients. The model-simulated head represents an average value over the entire layer thickness, which is approximately 500 ft in this portion of the regional model.
- **Elevation error**. The ground surface elevations may not be precise. We obtained the elevations at each of the spring locations by interpolating from a one-arc-second USGS digital elevation model downloaded from the USGS website (seamless.usgs.gov, 2011). We checked these interpolated values with a site survey at selected locations and found good agreement.
- **Model calibration error**. No groundwater model is expected to precisely match field observations. A model may match overall trends in an aquifer while exhibiting a poor match between observed and simulated heads at certain locations in the model domain.

In other words, when looking at an individual spring the point in time at which the spring is predicted to go dry may be off by several years (either too early or too late), but the overall trends provides an estimate of when the springs will go dry.

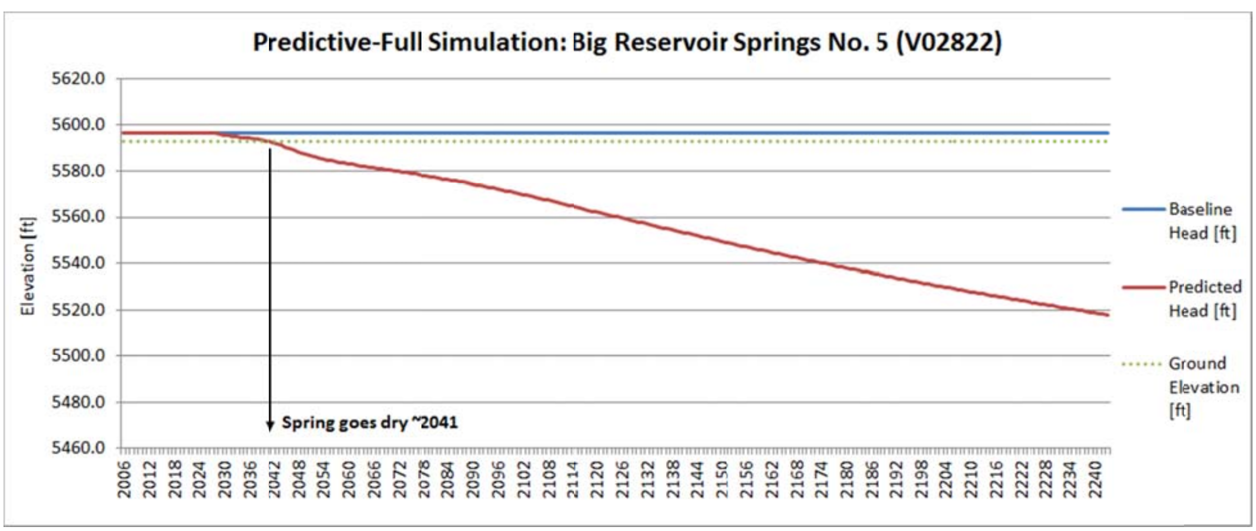


Figure 26 Simulated Head Relative to Spring Elevation.

The CCRP model is specifically designed to simulate historical, existing, reasonably foreseeable, and future groundwater withdrawals, including the proposed SNWA pumping and environmental impact statement (EIS) alternatives, to evaluate the potential effects on the following:

- Potential drawdowns in the regional and intermediate flow systems within the model area;
- Regional (primarily) and intermediate (secondarily) springs, groundwater evapotranspiration (ET) areas, streams, or wells that are hydraulically connected to regional and intermediate parts of the flow system; and
- Flow system boundaries.

The CCRP model is NOT designed for the following uses:

- Simulation of perched (local) portions of the flow system, including perched springs, perched groundwater ET areas, perched streams, or wells located in perched zones or the effects that pumping from the regional flow system would have on these features.
- Prediction of drawdown at a specific pumping well due to the resolution of the model cells. [The inability of a finite-difference model to accurately represent the drawdown at a well is described rather clearly in the groundwater modeling text by Anderson and Woessner (1992) where they state the following:

  "The diameter of a well is typically much smaller than the dimensions of the (model) cell. To represent the effects of a point sink more accurately, small cells around pumping nodes are preferred. But field problems generally require large grids and can seldom accommodate cells as small as the actual well diameter…A finite difference model does not simulate this gradient accurately because the model extracts or injects water to the entire cell rather than to the nodal point. The head calculated by the model is not a good approximation of the head in the well, but heads at nodes away from the point source or sink are correct." (Anderson and Woessner, 1992; page 147, paragraph 3)]

- Derivation of accurate predevelopment steady-state groundwater budgets for individual basins or flow systems within the study area or estimates of interbasin flow (directions and volumes) across boundaries.
- Derivation of new delineations of groundwater basin or new flow-system boundaries.

The effort focused specifically on the design, construction, calibration, and evaluation of the CCRP Numerical Model, which was conducted predominantly in two major phases of work. The model was developed in cooperation with the BLM, including review and input from a BLM technical team, and was also reviewed by the EIS cooperating agencies.

The first phase consisted of model construction activities and preliminary simulations to derive a numerical representation of the conceptual model that approximately matched the response of the

Water Rights Reallocation

The flow budget analysis demonstrated that in the center and southern parts of Spring Valley, the proposed SNWA wells will reduce the water table elevation to a level that will eliminate evapotranspiration. Some of this evapotranspiration is currently used by CPB-owned ranching operations for sub-irrigated lands. Furthermore, our analysis regarding impacts to springs indicates that lowering the water table will also destroy all of the valley floor springs owned by CPB. As the sub-irrigation and spring discharge are eliminated, CPB would be forced to drill new wells to recapture water associated with the affected water rights locations or collect a portion of the water pumped the SNWA wells. This fact is acknowledged by Watrus and Drici on pages 6-7,6-9, and 6-10 of SNWA (2011b). In spite of this acknowledgement, the SNWA predictive model does NOT simulate the addition of these replacement wells (or increased pumping rates at SNWA wells) at points in time when the spring discharges are eliminated. This affects a substantial fraction of the overall water budget for Spring Valley. The omission of these replacement wells or sources causes the predictive models to underestimate the drawdown and groundwater mining caused by the proposed SNWA wells. A full accounting for the groundwater withdrawn by these water rights via replacement would result in substantially more drawdown than is predicted by the SNWA models.

value. Continued monitoring within the valley may provide additional information on the sources of water, and how these locations may be impacted by future pumping within the valley. If a water-level decline does occur, the greater than 200 ft bgs depths of these wells may provide for a reasonable lowering of the water table at these locations. Should drawdowns at these locations become unreasonable, mitigation may include installing pumps in the previously flowing wells, installing new wells, or providing a like amount of water from either existing SNWA water-rights or those being applied for as part of these applications.

SNWA currently has a hydrologic monitoring, management, and mitigation plan in place for Spring Valley that includes a well-distributed existing-well monitoring network as well as requirements for the completion of additional monitoring wells. Some of the additional monitoring locations such as the Cleveland Ranch, Cleve Fan, Shoshone Ponds area wells, and piezometers at spring locations have already been completed. An effective hydrologic monitoring, management, and mitigation program as described by Prieur (2011) will avoid adverse impacts at these locations.

6.4.1.2 Spring Water Rights

Spring water rights accounted for 15 of the 31 PODs located in an area where the model simulated a drawdown of greater than 50 ft. These include 4 vested, 1 certificated, and 10 federally reserved water rights. Additionally, 3 water-rights associated with North and South Millick springs were simulated as having a greater than 15 percent reduction in flow. Table 6-2 contains summary information for each of these PODs.

Application numbers 4171 and V02077 are two stockwatering rights that are included within the 15 springs. Both rights are located at springs in the central portion of Spring Valley. Application number 4171 is the single certificated spring water right for 14.33 afy and the POD for this right is Layton Spring. Layton Spring was selected as a monitoring location for both spring discharge and piezometer installation within the Spring Valley Hydrologic Monitoring and Mitigation Plan (SNWA, 2011). Miscellaneous discharge measurements have been made by SNWA at the spring since 2004 with the largest flow measured being 1 gallon per minute. Three discharge measurements were made in 2010, each of which recorded the spring as dry (SNWA, 2011). Piezometer SPR7019Z was installed at this location in May of 2010 and a DTW measurement of 11.17 ft bgs was made on November 10, 2010 (SNWA, 2011). Application V02077 is a stockwatering right for 11.20 afy and the POD for this right is Willard Springs. Willard Springs has been selected as a biological monitoring location within the Spring Valley Stipulated Agreements (Marshall and Luptowitz, 2011). As described in Section 5.0 and Section 6.2, the CCRP model does not contain the variability within the alluvium that may control these springs. Continued monitoring at these locations may provide additional information on the sources of water, the variability of flow, and how these locations may be impacted by future pumping within the valley. Both of these rights are small volume stockwater rights that, should they become impacted by the proposed pumping, could be mitigated by providing a like amount of water from either existing SNWA water-rights or those being applied for as part of these applications.

Ten of the spring water rights are federally reserved rights. Nine of these rights are located near the valley floor while R05274 is located high on an alluvial fan. Application R05274 is located approximately 0.7 mi southeast of Well SPR7023I where Burns and Drici (2011) report a DTW of

301.47 ft bgs. Therefore, this spring is likely perched and it is highly improbable that there will be any effect to reserved water right R05274 as a result of the proposed SNWA applications.

Application number R05273 is located in the west-central portion of Spring Valley at the alluvial fan/valley floor interface. Application number R05269 corresponds to 4WD Spring which was selected as a monitoring location for piezometer installation within the current Spring Valley Hydrologic Monitoring and Mitigation Plan (SNWA, 2011). Piezometer SPR7012Z was installed at this location on May 8, 2010 and has a DTW recorded on October 14, 2010 of 2.36 ft bgs (SNWA, 2011). Application numbers R05272 and R05278 are for Unnamed Springs located within a 0.25 mi of 4WD spring. Application numbers R05279, R05280, R05292, and R05294 are all located within 1.25 mi from Spring Valley Monitoring Plan location SPR7016Z which corresponds to Unnamed Spring 5. Piezometer SPR7016Z was installed on May 4, 2010 and has a DTW of 1.65 ft bgs measured on October 12, 2010. The final reserved water right R05293 is located less than 0.5 mi southwest of Spring Valley Monitoring Plan Location 1848501 which corresponds to Cleveland Ranch Spring South (SNWA, 2011). A 3-in. modified parshall flume with concrete wing walls was installed at this location on November 2, 2010 and a discharge measurement of 52.5 gal per minute was made on November 4, 2010. As described in Section 5.0 and Section 6.2, the CCRP model does not contain the variability within the alluvium that may control these springs. Continued monitoring in this area may provide additional information on the sources of water, the variability of flow, and how these locations may be impacted by future pumping within the valley. These federally reserved water rights are small volume rights that, should they first be adjudicated and then become impacted by the proposed pumping, could be mitigated by providing like quantities of water from existing SNWA water rights or waters that are the subject of these applications.

Application numbers V02821, V02824, and V02825 are irrigation water rights located on the valley floor or at the valley floor and alluvial fan interface on the Cleveland Ranch. The area surrounding the Cleveland Ranch is an area of significant monitoring associated with the Spring Valley Monitoring and Mitigation Plan (SNWA, 2011). Monitoring locations in this area include the monitoring of Cleve Creek, station number 1841611, the installation of two monitoring wells on the alluvial fan, SPR7029M and SPR7029M2, the installation of two wells on Cleveland Ranch, SPR7030M and SPR7030M2, and the monitoring of spring discharge at South Cleveland Ranch Spring, station number 1848501 (Prieur, 2011). As described in Section 5.0 and Section 6.2, the CCRP model does not contain the variability within the alluvium that may control these springs. Continued monitoring at these location may provide additional information on the sources of water, the variability of flow, and how these locations may be impacted by future pumping within the valley. The collection of additional data at these locations will allow SNWA to make the necessary management decisions such as reduction in pumping or the filing of change applications to move the point of diversion in order to avoid adverse impacts at these locations. As an example of the type of data collection that may occur, a short term aquifer test has recently been completed at SPR7029M and preliminary data results are provided in Prieur and Ashinhurst (2011).

Application numbers 8721 and 10921 correspond to South Millick Spring while application number 10993 corresponds to North Millick Spring. While the simulated drawdowns at North and South Millick springs never become greater than 50 ft, the model simulates a change in spring discharge reduction of greater than 15 percent. However, it should be noted that these springs were not included as calibration targets for flow during model construction and therefore no attempt has been made to accurately simulate the initial flows of these springs. South Millick Spring was selected as a hydrologic monitoring location (Site 1845702) for spring discharge as part of the Spring Valley Hydrologic Monitoring and Mitigation Plan (SNWA, 2011). Continued monitoring at these location may provide additional information on the sources of water, the variability of flow, and how these locations may be impacted by future pumping within the valley. The collection of additional data at these locations will allow SNWA to make the necessary management decisions such as reduction in pumping or the filing of change applications to move the point of diversion in order to avoid adverse impacts at these locations.

6.4.1.3 Stream Water Rights

Stream water rights accounted for 6 of the 31 PODs located in an area where the model simulated a drawdown of greater than 50 ft. The 6 stream PODs include 3 on Cleve Creek, 2 on Willard Creek, and 1 on Bastian Creek. Table 6-3 contains summary information for each of these PODs along with comments related to the likely hydrology at each location. As described in Table 6-3, all of these locations occur up on the alluvial fans where the streams do not appear to be in direct connection with the aquifers below. This lack of hydrologic connection indicates that if drawdowns within the aquifers reach these locations there will be no effects to the PODs. Additional data collection on Cleve Creek and the surrounding area is occurring as a result of the Stipulated Agreements. Current monitoring includes the USGS gage on Cleve Creek as well as two SNWA monitor wells SPR7029M and SPR7029M2 that were installed in 2011 on the alluvial fan near the Cleve Creek PODs (Prieur, 2011).

Table 6-3
Spring Valley Stream Water Rights

App.	Cert.	Use	Duty Balance (afy)	Stream Name	Geographic Location	First Simulation Period where Drawdown is Greater than 50 ft (Year)	Comments
V00790	NA	Irrigation	10,847.7	Cleve Creek	Alluvial Fan	2062	These PODs are located on the alluvial fan. A nearby well 184 N16 E66 26A1 has a DTW of 230 ft bgs (Burns and Drici, 2011). Additionally, SNWA has installed two wells SPR7029M and SPR7029M2 in this area with DTW greater than 200 ft bgs. The significant DTW would indicate there is no connection between the stream and aquifer at this location.
2852	902	Irrigation	2,406.48	Cleve Creek	Alluvial Fan	2062	
V01217	NA	Irrigation	12,000	Cleve Creek	Alluvial Fan	2062	
V02078	NA	Stockwatering	11.20	Bastian Creek	Alluvial Fan	2062	This POD is located approximately 1 mi up the alluvial fan from wells 390940114314801 and 184 N15 E66 24CD 1 that have DTW of approximately 20 ft bgs (Burns and Drici, 2011). The DTW would indicate there is no connection between the stream and aquifer at this location.
983	171	Mining and Milling	723.95	Willard Creek	Alluvial Fan	2082	This POD is located approximately 2 mi up the alluvial fan from well 390032114281901 where the DTW is approximately 14 ft bgs (Burns and Drici, 2011). The DTW would indicate there is no connection between the stream and aquifer at this location.
1052	244	Irrigation	80	Willard Creek	Alluvial Fan	2117	This POD is located on the alluvial fan between two wells with drillers log numbers 23441 and 107717. These logs indicate the DTW is greater than 80 ft at this location. The DTW would indicate there is no connection between the stream and aquifer at this location.

NA = Not Applicable

Water Rights Reallocation

The flow budget analysis demonstrated that in the center and southern parts of Spring Valley, the proposed SNWA wells will reduce the water table elevation to a level that will eliminate evapotranspiration. Some of this evapotranspiration is currently used by CPB-owned ranching operations for sub-irrigated lands. Furthermore, our analysis regarding impacts to springs indicates that lowering the water table will also destroy all of the valley floor springs owned by CPB. As the sub-irrigation and spring discharge are eliminated, CPB would be forced to drill new wells to recapture water associated with the affected water rights locations or collect a portion of the water pumped the SNWA wells. This fact is acknowledged by Watrus and Drici on pages 6-7,6-9, and 6-10 of SNWA (2011b). In spite of this acknowledgement, the SNWA predictive model does NOT simulate the addition of these replacement wells (or increased pumping rates at SNWA wells) at points in time when the spring discharges are eliminated. This affects a substantial fraction of the overall water budget for Spring Valley. The omission of these replacement wells or sources causes the predictive models to underestimate the drawdown and groundwater mining caused by the proposed SNWA wells. A full accounting for the groundwater withdrawn by these water rights via replacement would result in substantially more drawdown than is predicted by the SNWA models.

Conclusions

Based on our analysis of the proposed SNWA wells in Spring Valley near CPB properties, we offer the following conclusions:

1. Northern Spring Valley contains three groundwater flow regimes: mountain block, alluvial fan, and valley floor. SNWA points of diversion are all located in alluvial fans.

2. The alluvial fan sediments are thousands of feet thick and support both confined and unconfined groundwater flow systems. The unconfined systems are recharged by surface infiltration of perennial and ephemeral stream flows as evidenced by stream gain-loss measurement and the age groundwater discharging from the distal end of the Cleve Creek alluvial fan. The confined system (i.e., within 1,000 feet of the land surface), as exemplified by the flowing artesian well in the Cleve Creek fan and spring discharges from Millick and Bastian springs, contains paleo-groundwater with a mean resident time near the distal end of the fan of thousands of years.

3. The State Engineer has determined that in most Nevada basins groundwater discharge is primarily by evapotranspiration (ET) and that the perennial yield is approximately equal to the estimated groundwater ET. Because almost all Spring Valley groundwater ET occurs in the valley floor, SNWA's application to appropriate groundwater is based on the idea that wells can be constructed so as to capture all unappropriated groundwater prior to ET loss. What this entails is either capturing the groundwater prior to entering the ET area and/or lowering the groundwater table below the root extinction depth without causing groundwater mining.

4. More than a dozen estimates of a groundwater recharge, net groundwater ET and perennial yield, or net interbasin outflow have been published since 1965. Since 2006 SNWA has presented at least three different estimates of perennial yield based on different methodologies and assumptions. This moving target is difficult to assess. The perennial yield calculation in SNWA's most recent assessment (SNWA, 2011a) is the largest perennial yield estimate to-date (i.e., 94,800 AFA). This estimate exceeds the State Engineers 2007 ruling regarding perennial yield by 14,800 AFA.

5. SNWA's appropriation application exceeds the unappropriated perennial yield of the Spring Valley basin by thousands of acre-feet. Assuming the State Engineer's 2007 perennial yield estimate of 80,000 AFA and existing groundwater rights of 14,202 AFA, SNWA's application exceeds the unappropriated perennial yield by 25,427 AFA. In other words only 72% of the requested appropriation is potentially available for perennial yield appropriation.

6. In the northern portion of the Spring Valley 12 of the SNWA 19 points of diversion are clustered about the large Cleve Creek, Bastian Creek and nearby alluvial fans, and much of the perennial yield originating north of the Cleveland Ranch will not be salvaged by SNWA wells. In the

southern portion of the valley, no points of diversion are located along much of the base of the Snake Range. Thus, assuming full project development, much of perennial yield will continue to be lost to ET. Groundwater mining would make up this uncaptured groundwater. The SNWA groundwater flow model confirms the large aerial extent of the valley floor where ET will remain uncaptured by the SNWA wells.

7. At full development SNWA's groundwater extraction plan would result in: a) drying up most springs in the northern valley including those relied upon by CPB ranching activities, b) the loss of the unusual grove of swamp cedars located below the Bastian alluvial fan, c) the loss of the sub-irrigated pasture land of the Cleveland Ranch and d) the loss of the extensive wetlands located north of Cleveland Ranch and elsewhere.

   The idea that CPB springs will dry up and phreatophytes will die is supported by SNWA's groundwater flow model. The phreatophyte root extinction depth varies by plant type but most such roots only extend ~5-20 feet below ground surface.

   The model predicts the following:

   a) Pumping all wells at the requested flow rates: water levels will decline ~70 to 185 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch, and the unnamed springs located south of Cleveland Ranch.

   b) Pumping all wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

   c) Pumping all but the four Cleve Creek alluvial fan wells at requested flow rates (Predictive-Minus4 Simulation): water levels will decline ~10 to 115 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch and the unnamed springs located south of Cleveland Ranch.

   d) Pumping all but the four Cleve Creek alluvial wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

8. Implementation of the Cleve Creek alluvial fan points of diversion (54016, 54017, 54018, and 54021) would dry up Cleveland Ranches Murphy and Big Reservoir springs, located at the distal end of the Cleve Creek fan, and the Ranches sub-irrigated land. In the State Engineer's 2007 ruling (#5726) these four wells were denied, presumably because the State Engineer recognized the impact that these wells would have on the Cleveland Ranch existing water rights and the deleterious impact the wells would have on the ranching operation.

9. Pumping the entire requested 91,224 AFA will result in extensive groundwater mining. The SNWA groundwater flow model predicts the following groundwater mining as a percentage of total groundwater extraction:

   a) Pumping all wells at the requested flow rates: 90% at project start, 50% in 2050, 30+% in 2150, and 28% in 2242.

   b) Pumping all but the four Cleve alluvial fan wells at requested flow rates (Predictive-Minus4 Simulation): 90% at project start, ~60% in 2050, ~30% in 2150, and 22% in 2242.

10. The distribution of hydraulic conductivities computed by the MODFLOW HUF Package in the SNWA model exhibits a low permeability anomaly in the middle of the alluvial fans that inconsistent with typical alluvial systems and leads to an under-prediction of drawdown at water rights locations on the fringe of the alluvial fan near the Cleveland Ranch.

11. CPB would be forced to drill new wells to capture water associated with their affected water rights. This fact is acknowledged by Watrus and Drici on pages 6-7,6-9, and 6-10 of SNWA (2011b). In spite of this acknowledgement, the SNWA predictive model does NOT simulate the addition of these replacement wells (or increased pumping rates at SNWA wells) at points in time when the spring discharges are eliminated. This affects a substantial fraction of the overall water budget for Spring Valley. The omission of these replacement wells or sources causes the predictive models to underestimate the drawdown and groundwater mining caused by the proposed SNWA wells. A full accounting for the groundwater withdrawn by these water rights via replacement would result in substantially more drawdown than is predicted by the SNWA models.

12. The extreme drawdown levels and groundwater mining causes by the SNWA wells are likely to cause land subsidence and irreversible aquifer consolidation.

13. The well field layout (i.e., points of diversion) in Spring Valley is a good design to optimize groundwater withdrawal from selected alluvial fans, but will not capture a significant portion of the groundwater ET (i.e., perennial yield). The small number of long-screened alluvial fan wells proposed by SNWA is more appropriate for groundwater mining than for a comprehensive ET salvage plan. This fact is demonstrated by the large proportion of the groundwater that the SNWA model demonstrates will be derived from groundwater mining.

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southern portion of the valley, no points of diversion are located along much of the base of the Snake Range. Thus, assuming full project development, much of perennial yield will continue to be lost to ET. Groundwater mining would make up this uncaptured groundwater. The SNWA groundwater flow model confirms the large aerial extent of the valley floor where ET will remain uncaptured by the SNWA wells.

7. At full development SNWA's groundwater extraction plan would result in: a) drying up most springs in the northern valley including those relied upon by CPB ranching activities, b) the loss of the unusual grove of swamp cedars located below the Bastian alluvial fan, c) the loss of the sub-irrigated pasture land of the Cleveland Ranch and d) the loss of the extensive wetlands located north of Cleveland Ranch and elsewhere.

   The idea that CPB springs will dry up and phreatophytes will die is supported by SNWA's groundwater flow model. The phreatophyte root extinction depth varies by plant type but most such roots only extend ~5-20 feet below ground surface.

   The model predicts the following:

   a) Pumping all wells at the requested flow rates: water levels will decline ~70 to 185 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch, and the unnamed springs located south of Cleveland Ranch.

   b) Pumping all wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

   c) Pumping all but the four Cleve Creek alluvial fan wells at requested flow rates (Predictive-Minus4 Simulation): water levels will decline ~10 to 115 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch and the unnamed springs located south of Cleveland Ranch.

   d) Pumping all but the four Cleve Creek alluvial wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

8. Implementation of the Cleve Creek alluvial fan points of diversion (54016, 54017, 54018, and 54021) would dry up Cleveland Ranches Murphy and Big Reservoir springs, located at the distal end of the Cleve Creek fan, and the Ranches sub-irrigated land. In the State Engineer's 2007 ruling (#5726) these four wells were denied, presumably because the State Engineer recognized the impact that these wells would have on the Cleveland Ranch existing water rights and the deleterious impact the wells would have on the ranching operation.

9. Pumping the entire requested 91,224 AFA will result in extensive groundwater mining. The SNWA groundwater flow model predicts the following groundwater mining as a percentage of total groundwater extraction:

Table 8 **Impact to Alluvial Fan and Valley Floor Springs, Predictive-Full Simulation.**

Name	Permit	Goes Dry?	Year
Mud Springs 1,2, and 3	3973	Yes*	2029
South Millick Spring	8721	Yes*	2029
Murphy Springs	V02817	Yes*	2029
Big Reservoir Springs No. 1	V02818	Yes*	2044
Big Reservoir Springs No. 2	V02819	Yes	2040
Big Reservoir Springs No. 3	V02820	Yes	2045
Big Reservoir Springs No. 4	V02821	Yes*	2029
Big Reservoir Springs No. 5	V02822	Yes	2041
Big Reservoir Springs No. 6	V02823	Yes	2041
Big Reservoir Springs No. 7	V02824	Yes*	2029
Big Reservoir Springs No. 8	V02825	Yes*	2029
Big Reservoir Springs No. 9	V02826	Yes*	2029
Big Reservoir Springs No. 10	V02827	Yes*	2029
Big Reservoir Springs No. 11	V02828	Yes*	2029
South Bastian Spring 2	P01	Yes*	2029
South Bastion Spring	P02	Yes*	2029
Cleveland Ranch Spring - North	P03	Yes*	2029
Cleveland Ranch Spring - South	P04	Yes*	2029
Layton Spring	P08	Yes*	2029
North Cleveland Unit Spring	P09	Yes*	2029
North Millick Spring	P10	Yes*	2029
Rogers Ranch Spring	P11	Yes*	2029
Unnamed Spring #1.1	P13	Yes*	2029
Unnamed Spring #1.2	P14	Yes*	2029
Unnamed Spring #2.1	P15	Yes*	2029
Unnamed Spring #2.2	P16	Yes*	2029
Unnamed Spring #3.1	P17	Yes*	2029
Unnamed Spring #3.2	P18	Yes*	2029
Unnamed Spring #3.3	P19	Yes*	2029
Unnamed Spring #4	P20	Yes*	2029
Unnamed Spring #7	P21	Yes*	2029
Unnamed Spring #8	P22	Yes*	2029

**Dry at beginning of simulation.*

The fact that most of the springs were not explicitly represented in the model means that we cannot use the OBS process to analyze the model simulated discharge to the springs. This discharge should go to zero once the simulated head drops below the spring elevation. However, if we examine the simulated heads at the water table locations output by the OBS process (as described in the previous section), we can compare these elevations to the spring elevations in an attempt to estimate when the springs will go dry. The springs will go dry when the head drops below the ground surface elevation as shown by the intersection of the solid red line and the dotted green line in Figure 26. When conducting this type of analysis, the emphasis should be on overall trends since there is considerable uncertainty with the data associated with individual sites. This uncertainty comes from a number of factors, including but not limited to the following:

- **Impact of coarse grid resolution**. The large grid cells used in the regional model can introduce significant error at individual locations even if the model is relatively accurate on a regional scale. This is especially true with springs since they are strongly impacted by local scale conditions such as fissures and localized confinement which leads to vertical head gradients. The model-simulated head represents an average value over the entire layer thickness, which is approximately 500 ft in this portion of the regional model.
- **Elevation error**. The ground surface elevations may not be precise. We obtained the elevations at each of the spring locations by interpolating from a one-arc-second USGS digital elevation model downloaded from the USGS website (seamless.usgs.gov, 2011). We checked these interpolated values with a site survey at selected locations and found good agreement.
- **Model calibration error**. No groundwater model is expected to precisely match field observations. A model may match overall trends in an aquifer while exhibiting a poor match between observed and simulated heads at certain locations in the model domain.

In other words, when looking at an individual spring the point in time at which the spring is predicted to go dry may be off by several years (either too early or too late), but the overall trends provides an estimate of when the springs will go dry.

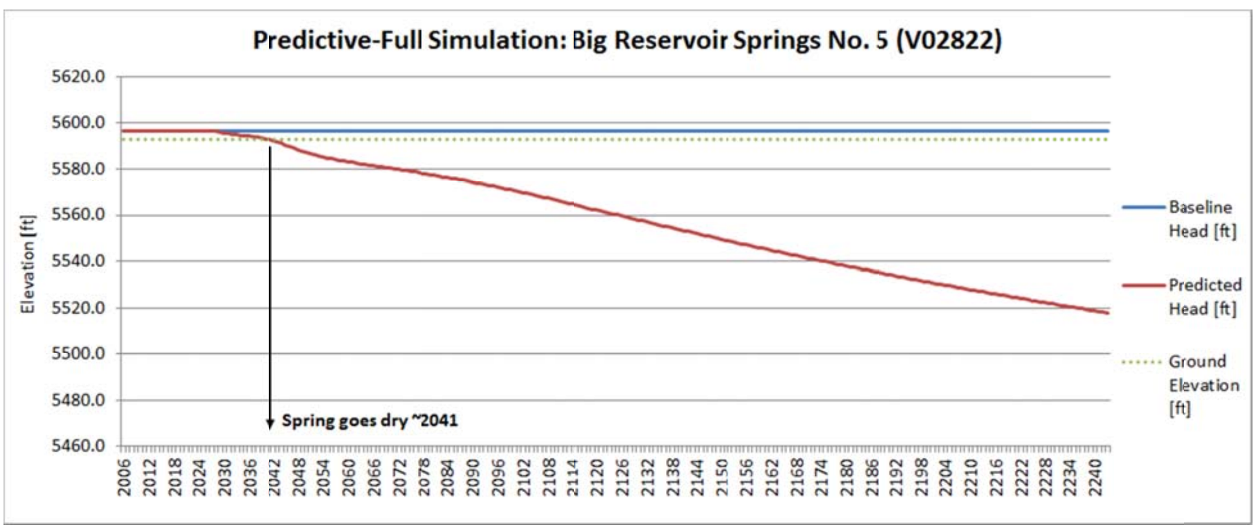

Figure 26 Simulated Head Relative to Spring Elevation.

southern portion of the valley, no points of diversion are located along much of the base of the Snake Range. Thus, assuming full project development, much of perennial yield will continue to be lost to ET. Groundwater mining would make up this uncaptured groundwater. The SNWA groundwater flow model confirms the large aerial extent of the valley floor where ET will remain uncaptured by the SNWA wells.

7. At full development SNWA's groundwater extraction plan would result in: a) drying up most springs in the northern valley including those relied upon by CPB ranching activities, b) the loss of the unusual grove of swamp cedars located below the Bastian alluvial fan, c) the loss of the sub-irrigated pasture land of the Cleveland Ranch and d) the loss of the extensive wetlands located north of Cleveland Ranch and elsewhere.

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   The model predicts the following:

   a) Pumping all wells at the requested flow rates: water levels will decline ~70 to 185 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch, and the unnamed springs located south of Cleveland Ranch.

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8. Implementation of the Cleve Creek alluvial fan points of diversion (54016, 54017, 54018, and 54021) would dry up Cleveland Ranches Murphy and Big Reservoir springs, located at the distal end of the Cleve Creek fan, and the Ranches sub-irrigated land. In the State Engineer's 2007 ruling (#5726) these four wells were denied, presumably because the State Engineer recognized the impact that these wells would have on the Cleveland Ranch existing water rights and the deleterious impact the wells would have on the ranching operation.

9. Pumping the entire requested 91,224 AFA will result in extensive groundwater mining. The SNWA groundwater flow model predicts the following groundwater mining as a percentage of total groundwater extraction:

The CCRP model is specifically designed to simulate historical, existing, reasonably foreseeable, and future groundwater withdrawals, including the proposed SNWA pumping and environmental impact statement (EIS) alternatives, to evaluate the potential effects on the following:

- Potential drawdowns in the regional and intermediate flow systems within the model area;
- Regional (primarily) and intermediate (secondarily) springs, groundwater evapotranspiration (ET) areas, streams, or wells that are hydraulically connected to regional and intermediate parts of the flow system; and
- Flow system boundaries.

The CCRP model is NOT designed for the following uses:

- Simulation of perched (local) portions of the flow system, including perched springs, perched groundwater ET areas, perched streams, or wells located in perched zones or the effects that pumping from the regional flow system would have on these features.
- Prediction of drawdown at a specific pumping well due to the resolution of the model cells. [The inability of a finite-difference model to accurately represent the drawdown at a well is described rather clearly in the groundwater modeling text by Anderson and Woessner (1992) where they state the following:

  "The diameter of a well is typically much smaller than the dimensions of the (model) cell. To represent the effects of a point sink more accurately, small cells around pumping nodes are preferred. But field problems generally require large grids and can seldom accommodate cells as small as the actual well diameter…A finite difference model does not simulate this gradient accurately because the model extracts or injects water to the entire cell rather than to the nodal point. The head calculated by the model is not a good approximation of the head in the well, but heads at nodes away from the point source or sink are correct." (Anderson and Woessner, 1992; page 147, paragraph 3)]
- Derivation of accurate predevelopment steady-state groundwater budgets for individual basins or flow systems within the study area or estimates of interbasin flow (directions and volumes) across boundaries.
- Derivation of new delineations of groundwater basin or new flow-system boundaries.

The effort focused specifically on the design, construction, calibration, and evaluation of the CCRP Numerical Model, which was conducted predominantly in two major phases of work. The model was developed in cooperation with the BLM, including review and input from a BLM technical team, and was also reviewed by the EIS cooperating agencies.

The first phase consisted of model construction activities and preliminary simulations to derive a numerical representation of the conceptual model that approximately matched the response of the

southern portion of the valley, no points of diversion are located along much of the base of the Snake Range. Thus, assuming full project development, much of perennial yield will continue to be lost to ET. Groundwater mining would make up this uncaptured groundwater. The SNWA groundwater flow model confirms the large aerial extent of the valley floor where ET will remain uncaptured by the SNWA wells.

7. At full development SNWA's groundwater extraction plan would result in: a) drying up most springs in the northern valley including those relied upon by CPB ranching activities, b) the loss of the unusual grove of swamp cedars located below the Bastian alluvial fan, c) the loss of the sub-irrigated pasture land of the Cleveland Ranch and d) the loss of the extensive wetlands located north of Cleveland Ranch and elsewhere.

   The idea that CPB springs will dry up and phreatophytes will die is supported by SNWA's groundwater flow model. The phreatophyte root extinction depth varies by plant type but most such roots only extend ~5-20 feet below ground surface.

   The model predicts the following:

   a) Pumping all wells at the requested flow rates: water levels will decline ~70 to 185 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch, and the unnamed springs located south of Cleveland Ranch.

   b) Pumping all wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

   c) Pumping all but the four Cleve Creek alluvial fan wells at requested flow rates (Predictive-Minus4 Simulation): water levels will decline ~10 to 115 feet beneath Murphy, Big Reservoir, Bastian Creek, Cleveland Ranch and the unnamed springs located south of Cleveland Ranch.

   d) Pumping all but the four Cleve Creek alluvial wells at the requested flow rates according to the well implementation schedule will cause many of the CPB springs to dry up immediately.

8. Implementation of the Cleve Creek alluvial fan points of diversion (54016, 54017, 54018, and 54021) would dry up Cleveland Ranches Murphy and Big Reservoir springs, located at the distal end of the Cleve Creek fan, and the Ranches sub-irrigated land. In the State Engineer's 2007 ruling (#5726) these four wells were denied, presumably because the State Engineer recognized the impact that these wells would have on the Cleveland Ranch existing water rights and the deleterious impact the wells would have on the ranching operation.

9. Pumping the entire requested 91,224 AFA will result in extensive groundwater mining. The SNWA groundwater flow model predicts the following groundwater mining as a percentage of total groundwater extraction:

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Subsidence

The drawdown maps and the time series analysis illustrate that the SNWA model predicts extreme amounts of drawdown will occur in central Spring Valley in the vicinity of the CPB water rights. When an aquifer dewaters to this extent, the soil and rock particle in the aquifer lose the buoyancy effect of the water and are subjected to a greatly increased inter-particle stress. This stress causes the aquifer matrix to consolidate leading to ground subsidence. With drawdown levels as high as 185 ft, the subsidence levels are likely to be severe. In addition to subsidence, aquifer consolidation results in a permanent loss of storage capacity. Since soils are inelastic and exhibit hysteresis, the void space in the aquifer prior to dewatering would never be fully recovered, even if the water levels were allowed to rebound to pre-pumping conditions.

Effect of Coarse Grid Resolution

As mentioned above, the SNWA model is a regional model covering an extensive part of Southeastern Nevada, of which Spring Valley is only a small part. As a result, the grid cells used in the simulation are large relative to the distribution of the water rights locations. This fact leads to uncertainty when analyzing simulated water levels at specific points. The region of the SNWA model in the vicinity of the ranch property is shown in Figure 22. The colored lines are drawdown contours from year 2242 for the Predictive-Full simulation. The contours illustrate a large degree of drawdown in the coarse-grained alluvial deposits to the south and west of the ranch. The center of Spring Valley is filled with fine-grained deposits and playas that have a lower hydraulic conductivity than the coarse-grained alluvial deposits.

Many of the CPB water rights are wells and springs located on the edge of alluvial fan deposits near the Cleveland Ranch. The transition from high-permeability coarse-grained deposits to low-permeability fine-grained deposits results in a rapid change in head/drawdown as indicated by the closely-packed contours. Since the water rights locations are located on the boundary of the transition, they are extremely sensitive to the location of the boundary in the model marking the transition between the coarse-grained alluvial fan and the finer-grained playa materials.

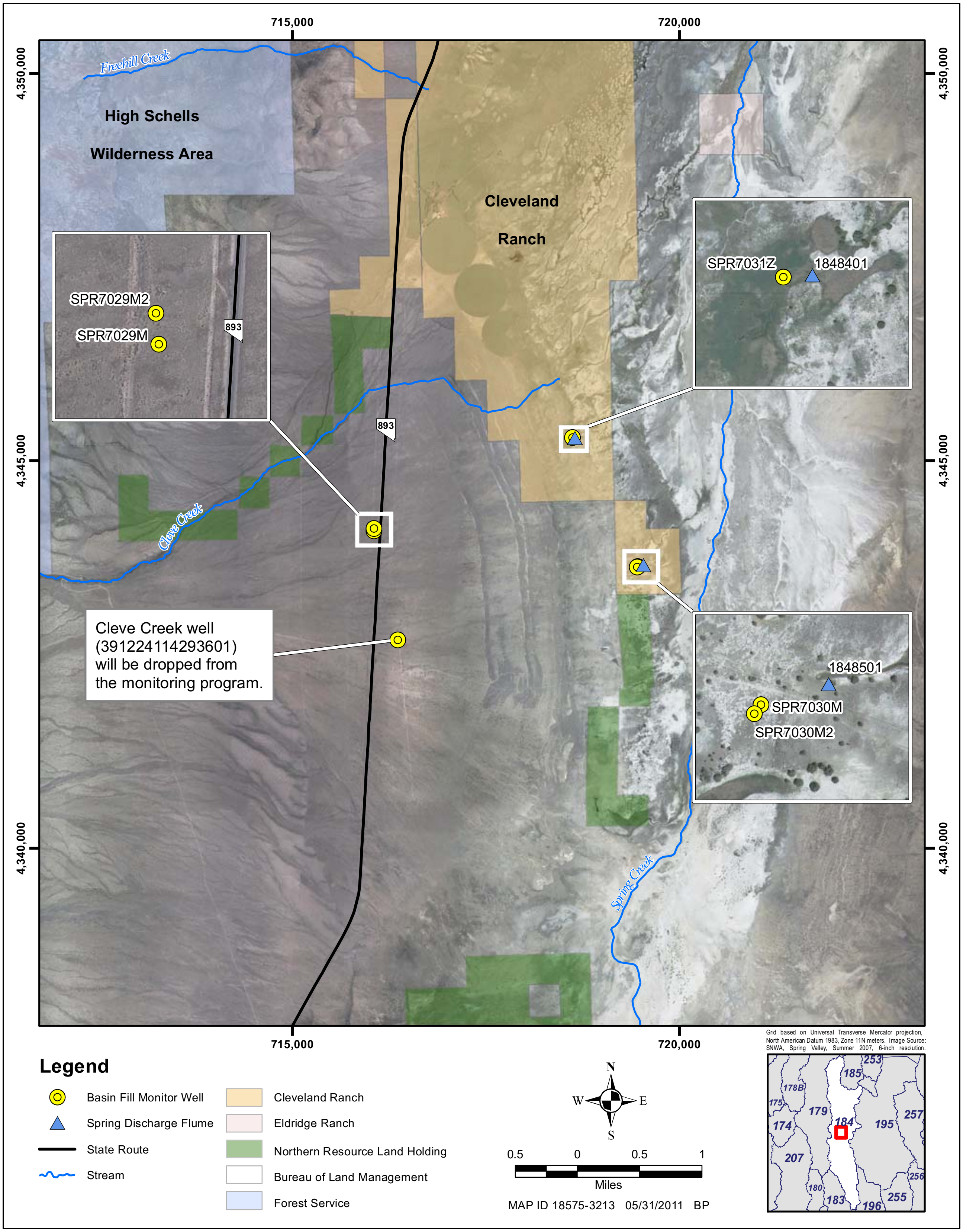

Figure 13
Monitoring Locations Associated with Cleveland Ranch

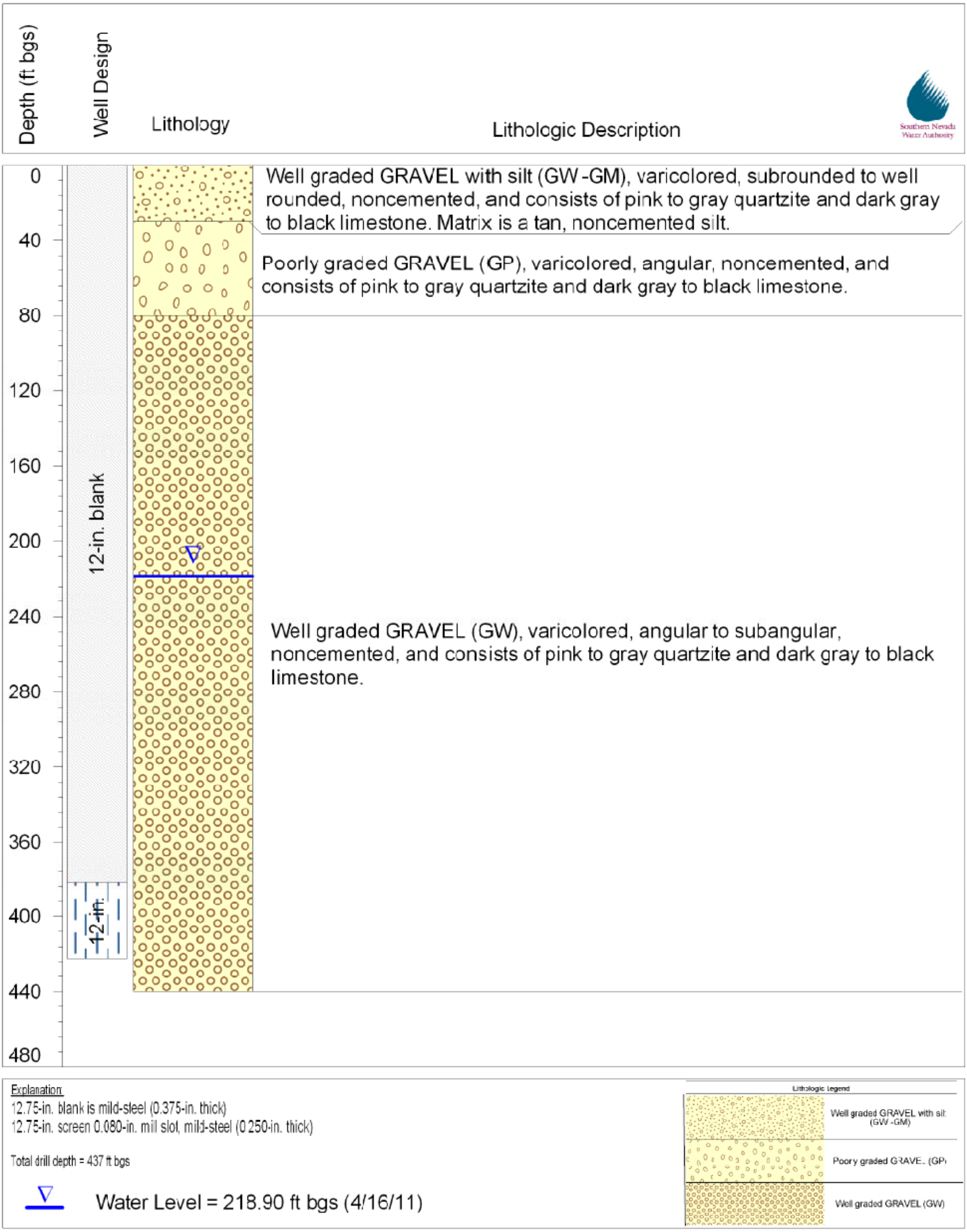

Figure B- 1
Well SPR7029M2 Preliminary Lithologic Log

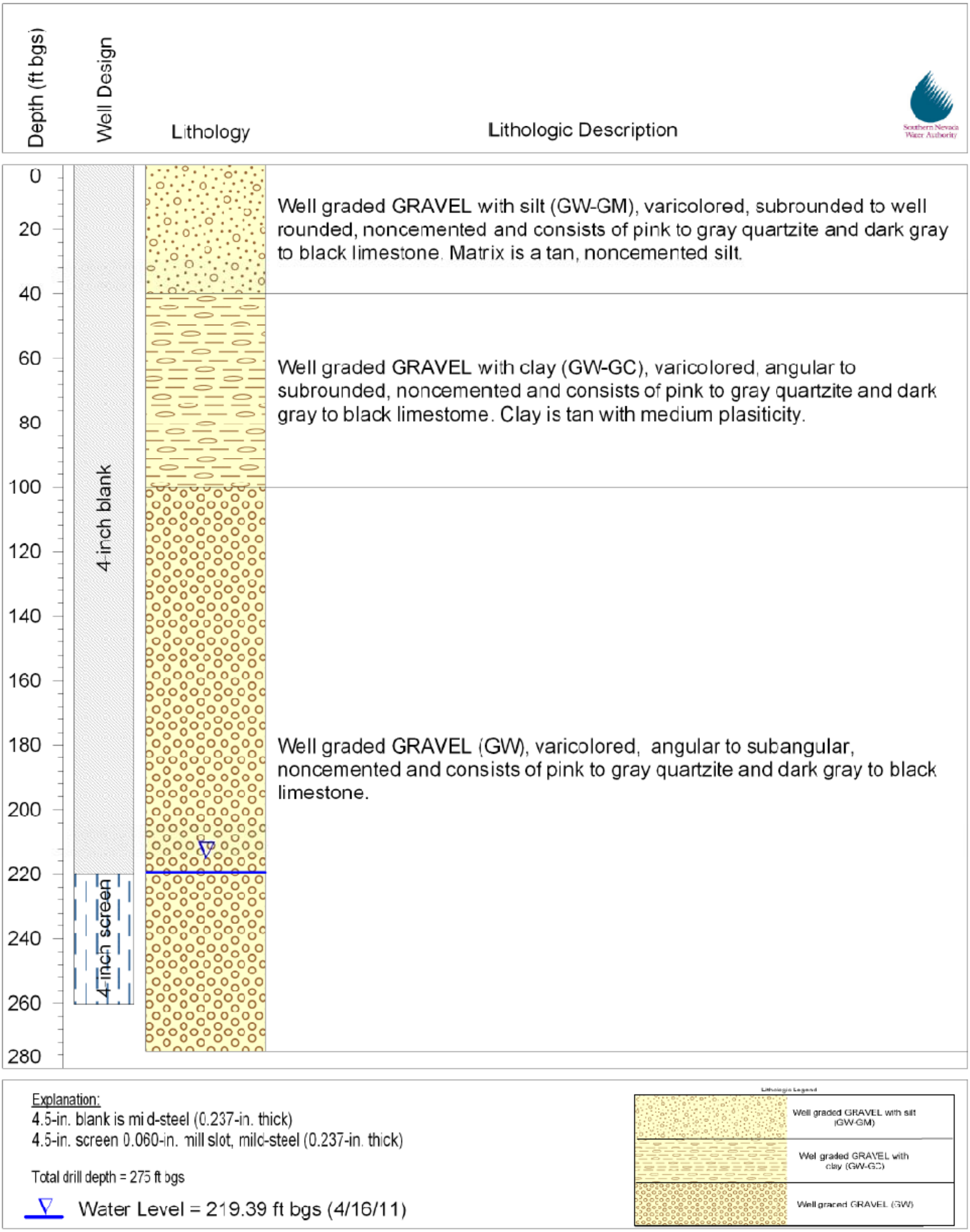

Figure B- 2
Well SPR7029M Preliminary Lithologic Log

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.

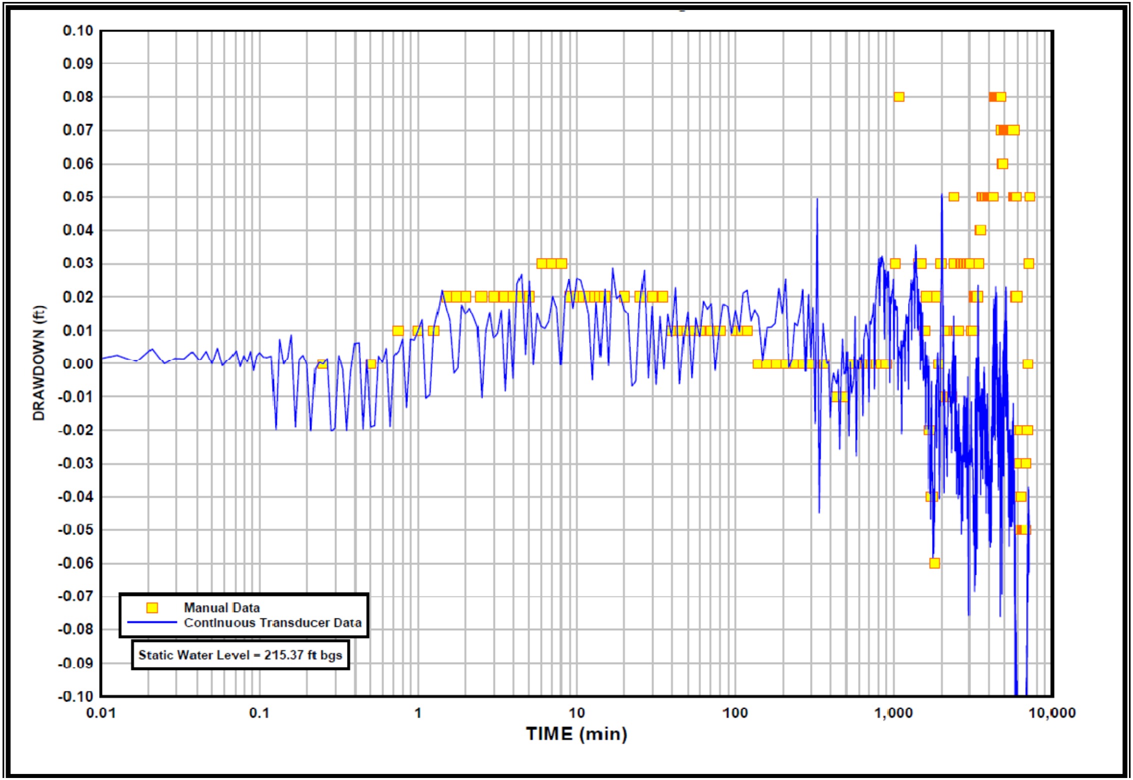

Figure D- 3
SPR7029M Semi-Log Constant-Rate Drawdown

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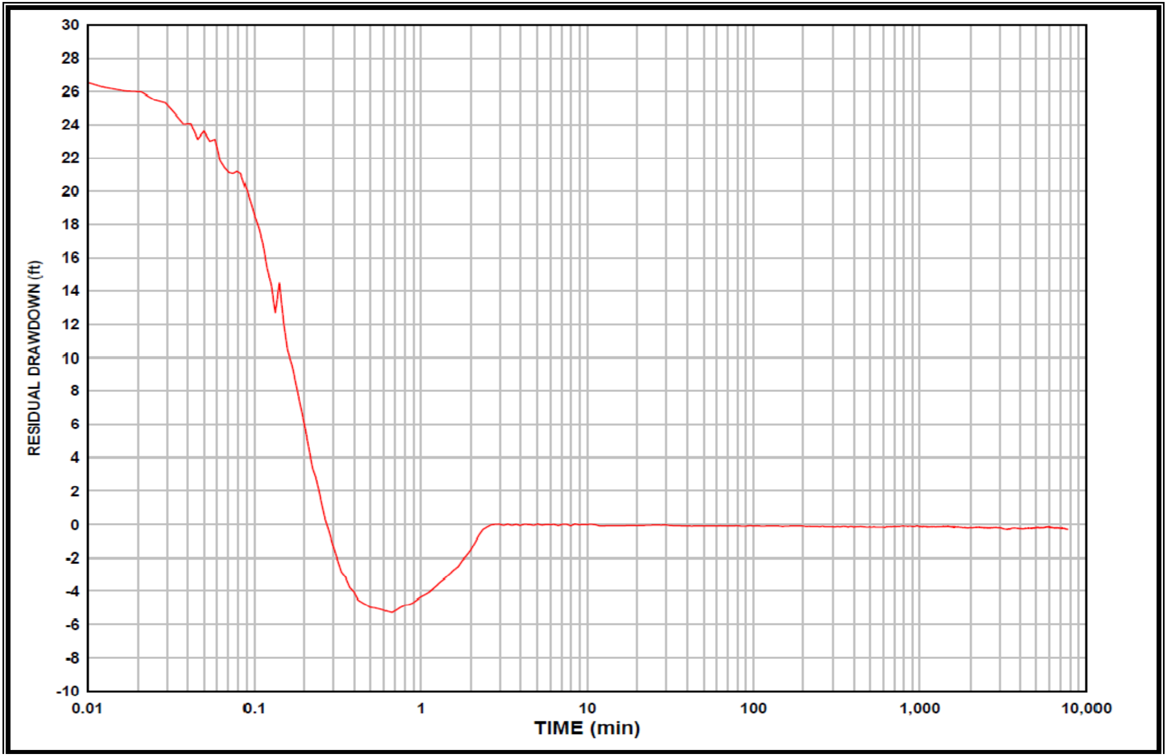


Figure D- 7
SPR7029M2 Constant-Rate Recovery Semi-Log Plot

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/

Bedrock Highlands

The bedrock highlands include the Schell Creek Range to the west and the Snake Range to the east. Both ranges rise as much as 6,000 feet above the valley floor and they receive considerable precipitation and accumulate winter snow pack. The high relief of the mountain ranges is due to mountain block bounding faults that are covered by alluvial fan debris. Bordering Spring Valley, the Schell Creek Range consists mostly of upper and lower carbonate bedrock (Mississippian to Permian and Cambrian to Devonian age, respectively) south of Cleve Creek and lower siliciclastic rocks (early Cambrian and older) north of Cleve Creek. The siliciclastic rocks have been designated by SNWA (2009a) as Basement Rock (Figure 4). The basement rocks are a regional confining unit (SNWA 2009a, 2011a) and do not support appreciable groundwater flow. The carbonate rocks have greater hydraulic conductivity than the siliciclastic rocks (SNWA, 2011a, Appendix C), which means the carbonate rocks have a greater capacity to recharge, store, and transmit groundwater than do the siliciclastic basement bedrock.

The high elevations of the bedrock highlands receive most of the Spring Valley precipitation, and this precipitation has been assigned by SNWA (2009a, 2011a) as the primary recharge source. The large mass of high elevation, low permeability, non-carbonate bedrock (basement rock) in the Schell Creek Range contributes to the large base flow of Cleve Creek. Although the basement rock has been characterized as an aquitard, SNWA (2009a, Plate 1) indicates that five plus inches of groundwater recharges annually into this mass of rock.

Alluvial Fans

The mountain front alluvial fan deposits are not mapped as separate units by SNWA (2009a, 2011a) but are lumped as upper valley fill (UVF), which also includes playa deposits. In northern Spring Valley the alluvial fan deposits are hydrogeologically significant in that: 1) almost all of the proposed SNWA wells would be completed in alluvial fan deposits (Figure 5), 2) the fans are important groundwater recharge locations via mountain front recharge, and 3) groundwater discharge from the fans supports most of the valley springs after which the valley was named.

Although the data are limited, the Cleve Creek alluvial fan supports at least two groundwater flow regimes: 1) a shallow flow system that is recharged by mountain front recharge and discharges from springs located at the base of the fan, and, 2) a deeper confined systems that may be recharged by a combination of mountain front and mountain block underflow. The deeper system is manifested in flowing artesian wells. Evidence for a multilayer alluvial fan system is described below. The three-dimensional geometry of the two systems is unknown due to insufficient data. Similar multilayer aquifer systems likely exist in other alluvial fans that flank the valley mountain ranges.

Table 3 Summary of Northern Spring Valley Groundwater Age Data from the Vicinity of Cleveland and Rogers Ranches.

Sample ID	BYU lab #	Sampling Date	pH	^{14}C [pmc]	+/-	$\delta^{13}C$	+/-	^{3}H [TU]	+/-	$HCO3^{-}$ [mg/L]	Fontes calculate 14C age [years]
Bastian Creek Spring	9232	7/19/2011	8.01	44.39	0.15	-7.87	0.04			184	1200
Irrigation Well	9234	7/19/2011	8.11	37.56	0.13	-8.22	0.04	3.9	0.2	186	2500
Stephens Creek	9236	7/19/2011						11.1	0.4		
Big Resevoir Spring (#1/2)	9237	7/20/2011	7.93	77.12	0.22	-13.90	0.04			131	modern
Millick Spring	9238	7/20/2011	7.92	44.94	0.14	-8.63	0.04	2.0	0.1	270	1200
Negro Creek Spring	9239	7/19/2011						9.1	0.1		

Valley Floor

Northern Spring Valley was occupied by the Pleistocene age Lake Spring to an elevation of 6428 feet (Reheis, 1999). Many of the lake shorelines are visible on the alluvial fans (Figure 3) and some wave-cut terraces are the locations of alluvial fan spring discharges. Surficial deposits on the valley floor include recent playa muds, fine-grained pluvial lake sediments, and reworked alluvial fan sediments. Depth to bedrock may exceed 10,000 feet and the details of the deep stratification are unknown. Because the basin has periodically been closed during the past 11 million years or so, lake deposits interfingered with coarser grained alluvial fan sediments and possibly lava flows likely occur.

The basin is topographically closed, thus nearly all surface and groundwater, except for groundwater loss to interbasin flow, either discharges on the alluvial fan margins or upwells in the valley bottom. Yelland playa is the current location of the topographic low of the northern valley and, as such, all surface and groundwater in the valley bottom flows toward the playa (Figure 3). Because of the relatively low relief of the valley floor, upwelling groundwater and surface flows that reach the valley floor support a significant region of both surface water ponds and groundwater ET as characterized by the unusual grove of swamp cedars located below the Bastian alluvial fan, the sub-irrigated pasture land of the Cleveland Ranch, and the extensive wetlands located north of Cleveland Ranch. SNWA (2009a, 2011a) has mapped the ET zone in the valley floor.

The Nevada State Engineer has determined that in most Nevada basins groundwater discharge is primarily by evapotranspiration (ET) and that the perennial yield is approximately equal to the estimated groundwater ET (Nevada State Engineer, 2007). Because almost all Spring Valley groundwater ET occurs in the valley floor, SNWAs' application to appropriate groundwater is based on the idea that wells can be constructed so as to capture all unappropriated groundwater prior to potential ET loss. What this entails is either capturing the groundwater prior to entering the ET area and/or lowering the groundwater table below the root extinction depth without causing groundwater mining. The significance of ET capture relative to the SNWA application is discussed below.

The relationship between surface water infiltration into the Cleve Creek alluvial fan and the Big Reservoir springs is further evidenced by a groundwater age investigation performed as part of this study. Carbon-14 ages and tritium analyses were performed on six surface and groundwater samples collected from northern Spring Valley (Table 3). The Stephens Creek sample which contains ~ 11 tritium units (TU) and the Negro Creek spring sample, collected from the bedrock spring at the mouth of Negro Canyon, indicate that recent recharge water contains about 10 TU. Ten TU for modern precipitation is consistent with the 15 year tritium precipitation record of rain and snowfall along the Wasatch Front (unpublished data). Because tritium has a half-life of about 12.5 years, groundwater in the western Great Basin that is older than about 60-75 years contains little or no measurable tritium. The Big Reservoir spring (1/2) water contains 77 percent modern carbon (pmc) which means the water has a modern recharge source. A modern recharge source is consistent with recharge from Cleve Creek and rapid groundwater flow toward the spring.

The Cleveland Ranch flowing-artesian well contains ~37.6 pmc and 3.9 tritium units (TU), which means the water has mixed recharge sources, including both modern and older groundwater recharge. The old component of recharge is appreciably older than the calculated Fontes 14C age of 2,500 years and the tritium content is a mixture of pre-atmospheric nuclear testing groundwater and more recent recharge water. Because the well is screened from about 100 feet to about 600 feet below ground surface, it is likely that the well acquires modern groundwater near the surface and older groundwater deeper in the alluvial fan. The fact that the well is a flowing artesian well indicates that the well penetrates a confining layer, and that there are at least two groundwater systems in the alluvial fan within 700 feet of the ground surface. The significance of the two groundwater systems with different groundwater travel times is that deeper alluvial fan groundwater is not rapidly replenished by annual groundwater recharge, whereas the overlying shallow alluvial system has an active hydrodynamic communication with surface water and annual recharge events. The importance of this to groundwater extraction by deep alluvial fan wells is that shallow alluvial fan groundwater will be readily replenished by annual recharge events, whereas the replenishment of the deeper groundwater will require hundreds to thousands of years.

The carbon-14 ages and tritium contents of the Bastian Creek spring and the Millick spring (Table 3) suggest that these spring discharges are also supported by young shallow and older deep groundwater. Both of the springs discharge at the distal ends of alluvial fans but not in direct line with the perennial surface water which contributes to alluvial fan recharge. Based on the limited isotopic data, it is not possible to determine the percentages of annual groundwater recharge vs. paleo-groundwater recharge that contribute to Spring Valley ET. It is clear, however, that annual groundwater recharge constitutes a major component of the Murphy and Big Reservoir Springs discharges that are critical to the operation of Cleveland Ranch.

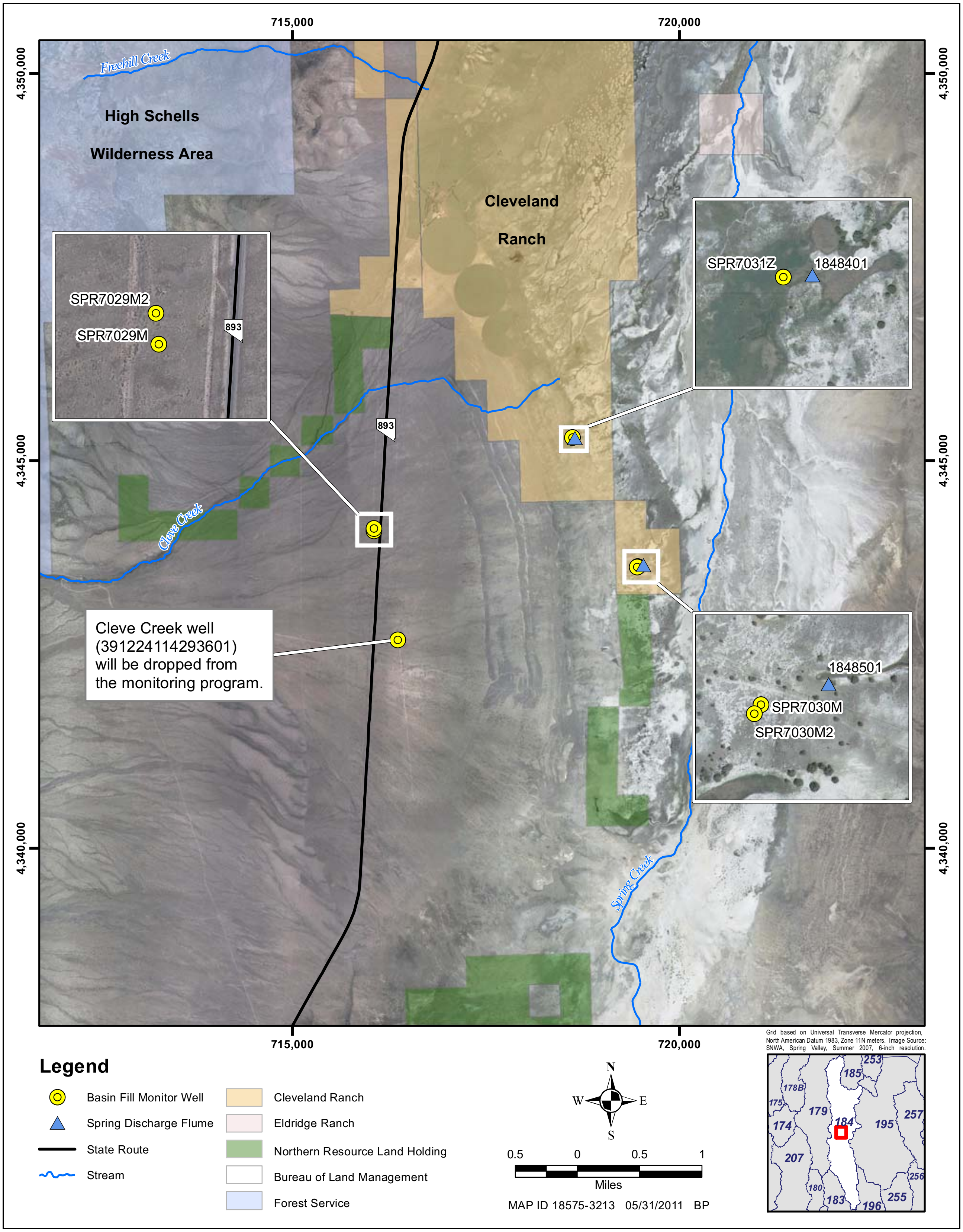


Figure 13
Monitoring Locations Associated with Cleveland Ranch

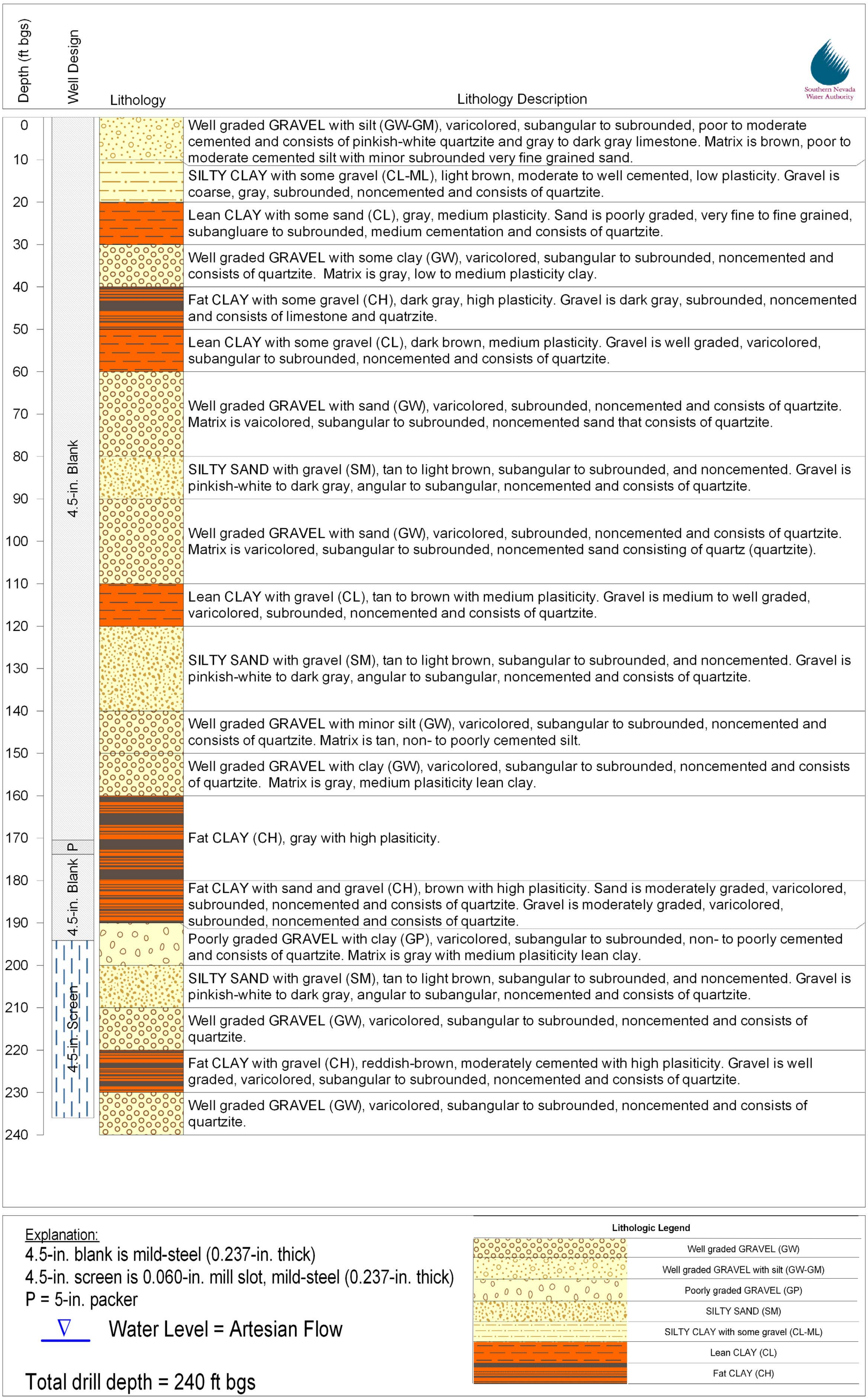
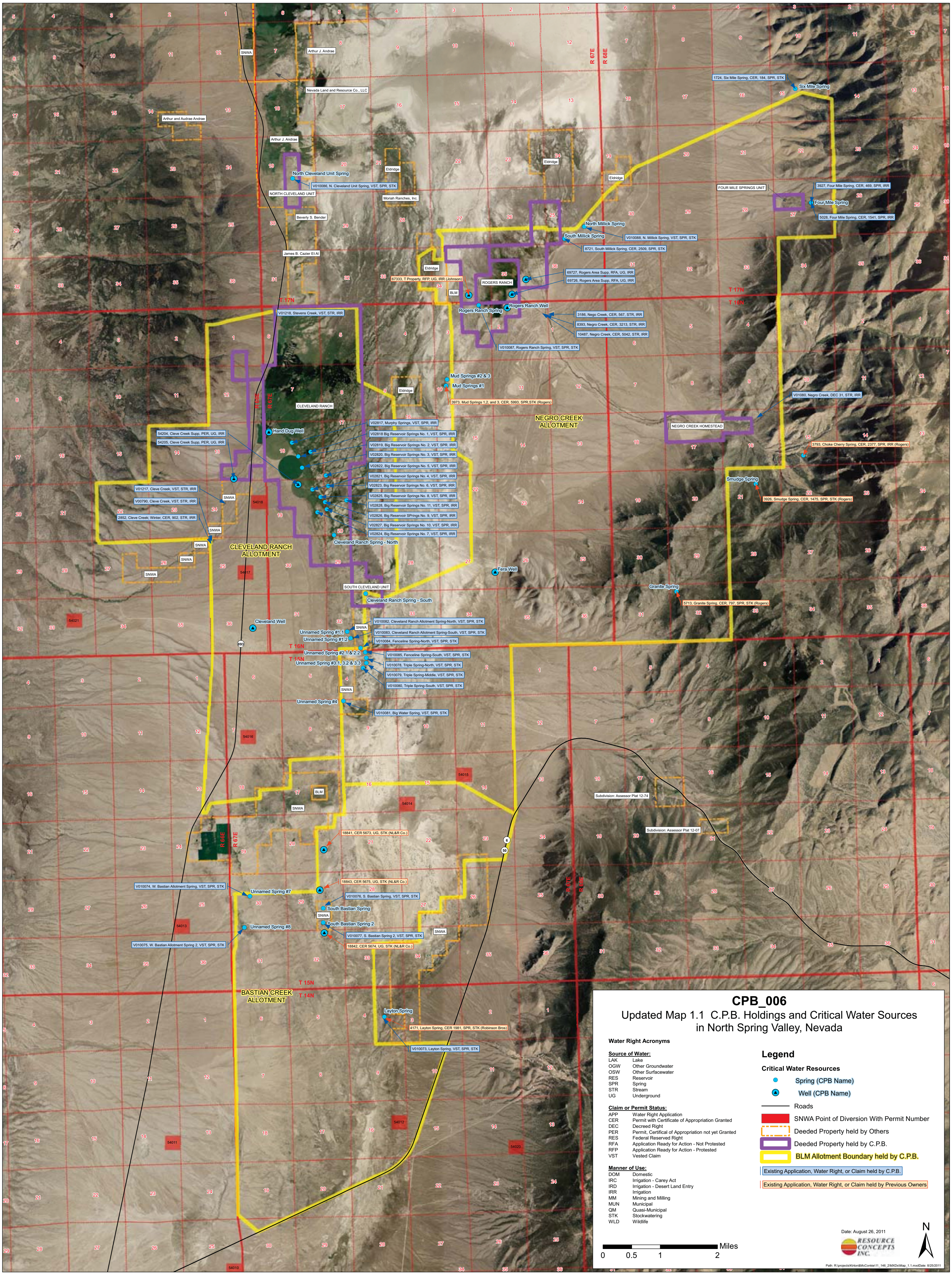


FIGURE 10
MONITOR WELL SPR7030M2 BOREHOLE STRATIGRAPHIC COLUMN


CPB_006
Updated Map 1.1 C.P.B. Holdings and Critical Water Sources
in North Spring Valley, Nevada
Water Right Acronyms
Source of Water:
LAK Lake
OGW Other Groundwater
OSW Other Surfacewater
RES Reservoir
SPR Spring
STR Stream
UG Underground
Claim or Permit Status:
APP Water Right Application
CER Permit with Certificate of Appropriation Granted
DEC Decreed Right
PER Permit, Certifical of Appropriation not yet Granted
RES Federal Reserved Right
RFA Application Ready for Action - Not Protested
RFP Application Ready for Action - Protested
VST Vested Claim
Manner of Use:
DOM Domestic
IRC Irrigation - Carey Act
IRD Irrigation - Desert Land Entry
IRR Irrigation
MM Mining and Milling
MUN Municipal
QM Quasi-Municipal
STK Stockwatering
WLD Wildlife
Legend
Critical Water Resources
Spring (CPB Name)
Well (CPB Name)
Roads
SNWA Point of Diversion With Permit Number
Deeded Property held by Others
Deeded Property held by C.P.B.
BLM Allotment Boundary held by C.P.B.
Existing Application, Water Right, or Claim held by C.P.B.
Existing Application, Water Right, or Claim held by Previous Owners
Miles
0 0.5 1 2
Date: August 26, 2011
RESOURCE CONCEPTS INC.
N
Path: R:\projects\Kirton&McConkie\11_146_2\MXDs\Map_1.1.mxdDate: 8/25/2011
CLEVELAND RANCH ALLOTMENT
NEGRO CREEK ALLOTMENT
BASTIAN CREEK ALLOTMENT
CLEVELAND RANCH
ROGERS RANCH
NEGRO CREEK HOMESTEAD
NORTH CLEVELAND UNIT
SOUTH CLEVELAND UNIT
FOUR MILE SPRINGS UNIT
Six Mile Spring
Four Mile Spring
North Millick Spring
South Millick Spring
North Cleveland Unit Spring
Rogers Ranch Spring
Rogers Ranch Well
Mud Springs #2 & 3
Mud Springs #1
Hand Dug Well
Cleveland Ranch Spring - North
Cleveland Ranch Spring - South
Fera Well
Granite Spring
Smudge Spring
Cleveland Well
Unnamed Spring #1.1
Unnamed Spring #1.2
Unnamed Spring #2.1 & 2.2
Unnamed Spring #3.1, 3.2 & 3.3
Unnamed Spring #4
Unnamed Spring #7
Unnamed Spring #8
South Bastian Spring
South Bastian Spring 2
Layton Spring
T 17N
T 16N
T 15N
T 14N
R 67E
R 68E

CPB_Exh_006

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT

OFFICE USE ONLY
Log No. 111291
Permit No. 54204
Basin 184

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

NOTICE OF INTENT NO 65588

1. OWNER LDS Church
MAILING ADDRESS 50 East North Temple
Salt Lake City, UT 84150

ADDRESS AT WELL LOCATION Cleveland Ranch
0
Subdivision Name 0 County White Pine

2. LOCATION NW 1/4 NE 1/4 1/4 Sec SEC 19 T T16N N/S R R67E E
PERMIT/WAIVER No 54204
Issued by Water Resources
Parcel No.
Latitude 39 14.610N
Longitude 114 28.780W
UTM E NAD 27
N
X [illegible]

3. WORKED PERFORMED
Replace Recondition
Deepen Other X exploration

4. PROPOSED USE
Municipal/Industrial Monitor Stock
to be e-logged X Test

5. WELL TYPE
Cable X Rotary RVC
Air Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
3" minus gravel		0	12	12
cobbles		12	25	13
gravel, sand		25	45	20
3" minus gravel		45	50	5
cobbles, gravel, sand		50	75	25
cobbles		75	80	5
gravel, sand		80	85	5
cobbles, gravel		85	100	15
soft clay, sand		100	110	10
cobbles, gravel		110	115	5
clay		115	140	25
cobbles, gravel		140	150	10
boulder		150	152	2
cobbles, gravel		152	215	63
clay		215	217	2
gravel sand		217	230	13
clay		230	237	7
sand, gravel		237	250	13
sand, clay		250	265	15
gravel, clay		265	280	15
gravel, clay, cobbles		280	345	65
clay		345	360	15
gravel, sand		360	365	5
clay		365	375	10
continued on next page				
				375.00

Date started 5-19-2010
Date completed 6-10-2010

9. WELL CONSTRUCTION
Depth Drilled Feet Depth Cased 0
HOLE DIAMETER (BIT SIZE)
7 7/8 Inches From 0 Feet To 720 Feet
Inches Feet Feet
Inches Feet Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)

Perforations
Type of perforation
Size of perforation
From feet to feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

Annular Seal
Neat Cement to Pumped Poured
Cement Grout to Pumped Poured
Concrete Grout to Pumped Poured
≥30% Bentonite Grout to Pumped Poured
Gravel Pack
Type
Bentonite Chips
Type

7. Water Level
Static water level feet below land surface
Artesian Flow G.P.M. P.S.I.
Water Temperature °F
Quality

8. WELL TEST DATA
TEST METHOD Bailer Pump Air Lift x
G.P.M. Draw Down (Feet Below Static) Time (Hours)

E-logged by Dewey Data Inc

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name High Desert Drilling LLC
Contractor
Address 4225 E Mary Way
Contractor
Winnemucca Nevada 89445
Nevada contractor's license number issued by the State Contractor's Board 62237
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 2140
Signed [signature] 6-10-2010

USE ADDITIONAL SHEETS IF NECESSARY

page 1

STATE ENGINEER 2010 JUL 22 PM 12:25 REC'D

NAD-27 GPS 39.243562°N
114.478814°W

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT

OFFICE USE ONLY
Log No. 111291
Permit No. 54204
Basin 184

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

NOTICE OF INTENT NO 65588

1. OWNER LDS Church
MAILING ADDRESS 50 East North Temple
Salt Lake City, UT 84150

ADDRESS AT WELL LOCATION Cleveland Ranch
0
Subdivision Name 0 County White Pine

2. LOCATION NW 1/4 NE 1/4 1/4 Sec SEC 19 T T16N N/S R R67E E
PERMIT/WAIVER No. 54204
Issued by Water Resources
Parcel No
Latitude 39 14.610N
Longitude 114 28.780W
UTM E NAD 27
N
X [illegible]

3. WORKED PERFORMED
Replace Recondition
Deepen Other X exploration

4. PROPOSED USE
Municipal/Industrial Monitor Stock
to be e-logged X Test

5. WELL TYPE
Cable X Rotary RVC
Air Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
gravel, sand, cobbles		375	405	30
clay, sand		405	435	30
grave, cobbles		435	485	50
clay, sand		485	495	10
gravel, cobbles, sand		495	520	25
cobbles		520	550	30
clay		550	575	25
gravel, sand		575	630	55
clay, silt		630	660	30
sand, gravel		660	690	30
clay, silt		690	720	30
				720.00

Date started 5-19-2010
Date completed 6-10-2010

9. WELL CONSTRUCTION
Depth Drilled 720 Feet Depth Cased 0
HOLE DIAMETER (BIT SIZE)
7 7/8 Inches From 0 Feet To 720 Feet
Inches Feet Feet
Inches Feet Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)

Perforations
Type of perforation
Size of perforation
From feet to feet
From feet to feet
From feet to feet
From feet to feet
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≥30% Bentonite Grout to Pumped Poured
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Contractor
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Nevada driller's license number issued by the Division of Water Resources, the on-site driller 2384
Signed [signature] 6-10-2010

USE ADDITIONAL SHEETS IF NECESSARY

page 2

STATE ENGINEER 2010 JUL 22 PM 12:25 REC'D