IMPACTS OF PROPOSED SNWA GROUNDWATER DEVELOPMENT CAVE, DRY LAKE, AND DELAMAR VALLEYS, WHITE PINE AND LINCOLN COUNTIES, NEVADA

REVIEW OF SNWA HYDROGEOLOGY REPORTS

John Bredehoeft, Ph.D.
Hydrodynamics Group, Sausalito, CA

John D. Bredehoeft
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INTRODUCTION

I reviewed a number of the Southern Nevada Water Authority (SNWA) reports in support of their applications for groundwater withdrawals in the subject valleys. It is my intent in this report to comment on fundamental flaws that I see in the SNWA analyses.

I will present model results that summarize the impacts of the proposed SNWA pumping, both from the results of the total project and the from the results of the pumping in Cave , Dry lake, and Delamar Valleys. Finally, I will make summary remarks regarding the implications of granting SNWA's request.

EFFECTS OF PUMPING

Both Burns et al (2007) and Turnipseed (2007), in reports supporting SNWA's applications, argued that the Theis Equation conceptual model was suitable to analyze the effects of pumping in Cave, Dry Lake, and Delamar Valleys. Their argument is that this is a simple model that is readily implemented and generally applicable for analyzing the impacts of pumping in the three valleys. According to Burns et al (2007):

This section (ES.4.3 Effects Analysis) *includes a simplified effects analysis of groundwater production requested under the SNWA applications… The simplified analysis used the Theis (1935) equation to evaluate the effects of continuously pumping the application volume from the points of diversion in each of the three basins for a period of 75 years….*

Simulated flow barriers were placed along the eastern and western margins of southern Cave, Dry Lake, and Delamar valleys to simulate the lack of interbasin flows in those directions. This interpretation is consistent with the interpretations presented in Sections 2.0 and 3.0 of Part B of this report. The flow barriers were simulated in the analysis using image wells, which are imaginary discharging wells placed on the opposite side of the flow boundaries from the application points of diversion, at the same distance from and perpendicular to, the simulate boundary. The resulting drawdown at any point within the boundaries is the algebraic sum of the drawdown produced at that point of diversion and its image. In this case, the use of image wells results in greater drawdowns within the valley than would be observed without the simulated flow barriers.

At first glance, this sounds like the description of a simple procedure, using the Theis Equation conceptual model; however, when there are two parallel boundaries there are a set of image wells extending to infinity in both directions away from the well, perpendicular to the boundary—to the east and west in this case. Freeze and Cherry (1979) have a discussion that nicely describes the two-parallel boundary problem; they state:

For this case (two parallel impermeable boundaries), *the imaginary infinite system must include the real pumping well R, and an image well* I_1 *equidistant from the right-hand impermeable boundary, and an image well* I_2 *equidistant from the left-hand impermeable boundary. These image wells give birth to the need for further image wells. For* *example,* I_3 *reflects the effect of* I_2 *across the left hand boundary, and* I_4 *reflects the effect of* I_1 *across the right-hand boundary. The result is a sequence of imaginary pumping wells stretching to infinity in each direction. In practice, image wells need only be added until the most remote pair produces a negligible effect on water-level response.*

As Freeze and Cherry (1979) indicate, we need only consider image wells that have a more than negligible impact on the resulting drawdown. We can solve for how far away imaginary wells must be considered. Suppose we assume that we only consider those image wells that produce more than 0.1 feet of drawdown after the 75-year period of pumping; in other words, all wells at distances sufficient to produce less than 0.1 feet of drawdown will be neglected. We are neglecting wells to both the right and left (east and west), and the sum of their calculated drawdowns. Therefore, we are neglecting a number of wells whose sum of drawdowns might approach 1 foot; in other words, we could be assuming an error on the order of 1 foot, perhaps more.

According to Burns et al (2007):

The corresponding values for the transmissivity and storage coefficient are 170,000 ft^2/d *and 0.013 for the alluvial aquifer, and 8,690* ft^2/d *and 0.03 for the carbonate aquifer. Additional assumptions included a 1,000 ft open hole for each well with a radii of 0.83 ft, and continuous pumping of those wells for a period of 75 years.*

The Theis equation is:

$$s = q/(4\pi T)\, W(u)$$

where s is the drawdown
q is the rate of pumping
T is the transmissivity
W(u) is the so-called well function that is tabulated

$$u = r^2\, S/(4tT)$$

where r is the radial distance from the center of the pumping well
S is the storage coefficient
t is the time of pumping

We can substitute the respective transmissivity and strorage coefficient values and solve for the distance at which the drawdown is equal to, or less than 0.1 feet after 75 years of continuous pumping:

T =	170,000	S =	0.013	distance to s = 0.1 ft	228 miles
T =	8,690	S =	0.03	distance to s = 0.1 ft	65 miles

In other words, for the more transmissive case one needs to consider image wells out to 225 miles both to the right and left (east and west), and in the less transmissive second case out to 65 miles to the right and left. In the case of the higher transmissivity we are talking about approximately 50 to 60 image wells that have to be considered.

In summary, what sounds like a simple Theis analysis turns out to involve a large bookkeeping problem. For any point of interest the distance from the real well and each image well must be determined, and then the drawdown calculated for that well. Finally the calculated drawdowns from all the wells are summed to obtain the total drawdown at the point of interest.

The task can be simplified by using a groundwater model. The model can be set up to solve the Theis Equation conceptual model. The model builds in boundaries when one defines the region of interest. From the model output one can contour the drawdown in the entire domain of interest—Figure 1.

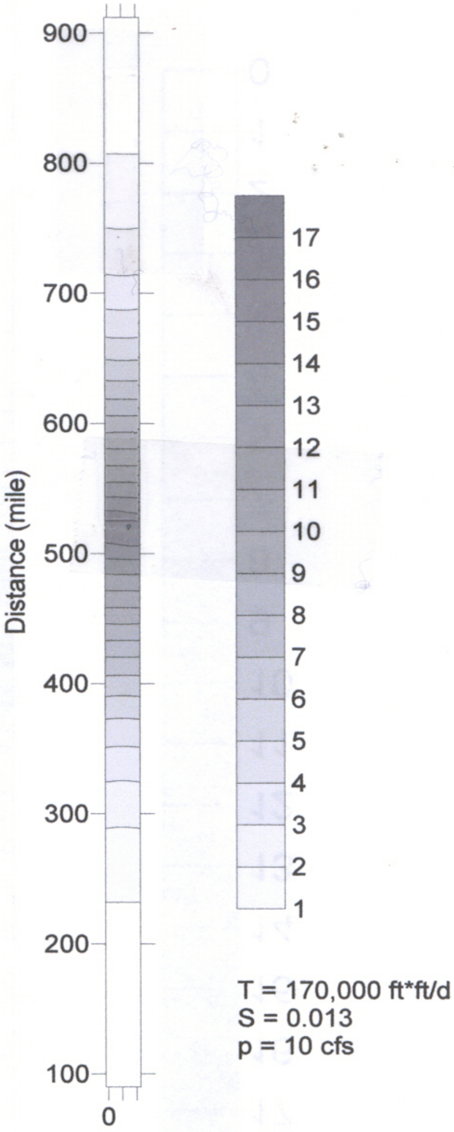

Figure 1 Drawdown (ft) calculated using the Theis Equation conceptual model for system with two parallel impermeable boundaries. (The right-hand column is the scale of

the drawdown for the model; the model result is in the left-hand column.) The drawdown in the vicinity of the pumping well is an average for the model cell that contains the well; it is not the drawdown at the well bore.

In the Theis conceptual model with two parallel impermeable boundaries the domain between the boundaries is assumed to extend to infinity both to the north and to the south. The model domain has to be of sufficient length so that the drawdown after 75 years of pumping does not impinge upon either a north or south boundary. You will note that in the case of the more transmissive aquifer, one calculates 1 foot of drawdown, both to the north and south, at distances of approximately 300 miles.

This hardly seems the appropriate conceptual model to use to evaluate the effect of pumping in the three valleys in question. In the real world, in all three valleys, physical boundaries will be reached by the drawdown, both to the north and the south, within the 75 years of pumping. In addition, the only water available to supply the well in the Theis conceptual model is water drawn from storage. There is no way that this conceptual system can ever reach a new equilibrium—the equilibrium required by Nevada groundwater law.

THE BIGGER PICTURE

All of the investigators from Eakin (1966) to Burns et al (2007), indicate that there is almost no discharge within the basins in question, almost all of the outflow occurs as interbasin flow to basins downstream in the White River Flow System where there are springs that are dependent upon this interbasin flow.

The question is, not one of feasibility—*can we pump 16 cfs for 75 years in each of the subject valleys?* The real question is the one posed in Bulletin 3—*is there non-beneficial discharge in the downstream basins that can be salvaged by the pumping?*
Nevada's Water Resources—Report 3 defines perennial yield:

***Perennial yield** of a ground water reservoir may be defined as the maximum amount of ground water that can be salvaged each year over the long term without depleting the ground water reservoir. Perennial yield is ultimately limited to the maximum amount of the natural discharge that can be salvaged for beneficial use. Perennial yield cannot be more than the natural recharge to a ground water basin and in some cases is less.*

In order to estimate the impacts of pumping and how that pumping might salvage (capture) natural discharge, one needs a realistic model of the White River Flow System. We know of two models that attempted to model the impacts of the proposed SNWA pumping:

The USGS did a RASA model of the entire Paleozoic Carbonate province (Prudic et al, 1995). Because it covered such a large area, the cell dimensions were large; the model consisted of two layers—1) the carbonate Aquifer and 2) the overlying material. Schaeffer and Harrill (1995) used the RASA model to simulate the impact of a large-scale SNWA-like development. Schaeffer and Harrill analyzed a proposed pumping scheme of 180,000 ac-ft/yr. Their analysis provides an overview of the impact of a large-scale SNWA-like development on the entire province. The results indicate the order of magnitude of the drawdown produced by the proposed pumping. The model analysis also indicates the impacts on the major springs within the province. The model was criticized as being too coarse in its cell dimensions, and with only two layers being overly simplistic.

Durbin (SNWA, 2006), created for SNWA, a realistic model of Spring and adjoining Valleys. (Spring Valley Exhibit Nos. 506-508.) The Durbin model covered the area of the Carbonate Rock Province impacted by SNWA's proposed pumping. Prediction scenarios were made with the model of the probable impacts from SNWA's proposed pumping prior to the Spring Valley hearing. The Durbin model is being submitted with this report along with the model predictions. The model results indicate that there will be significant impacts that result from the proposed SNWA pumping.

DURBIN'S MODEL

The Durbin (SNWA, 2006) Report for Spring Valley describes the approach, the conceptual model, and its implementation in a finite-difference numerical code, and the model calibration. I will only describe the salient points; the details are covered by Durbin (SNWA, 2006).

The modeled area includes that portion of the Carbonate Rock Province impacted by the proposed SNWA pumping—Figure 2.

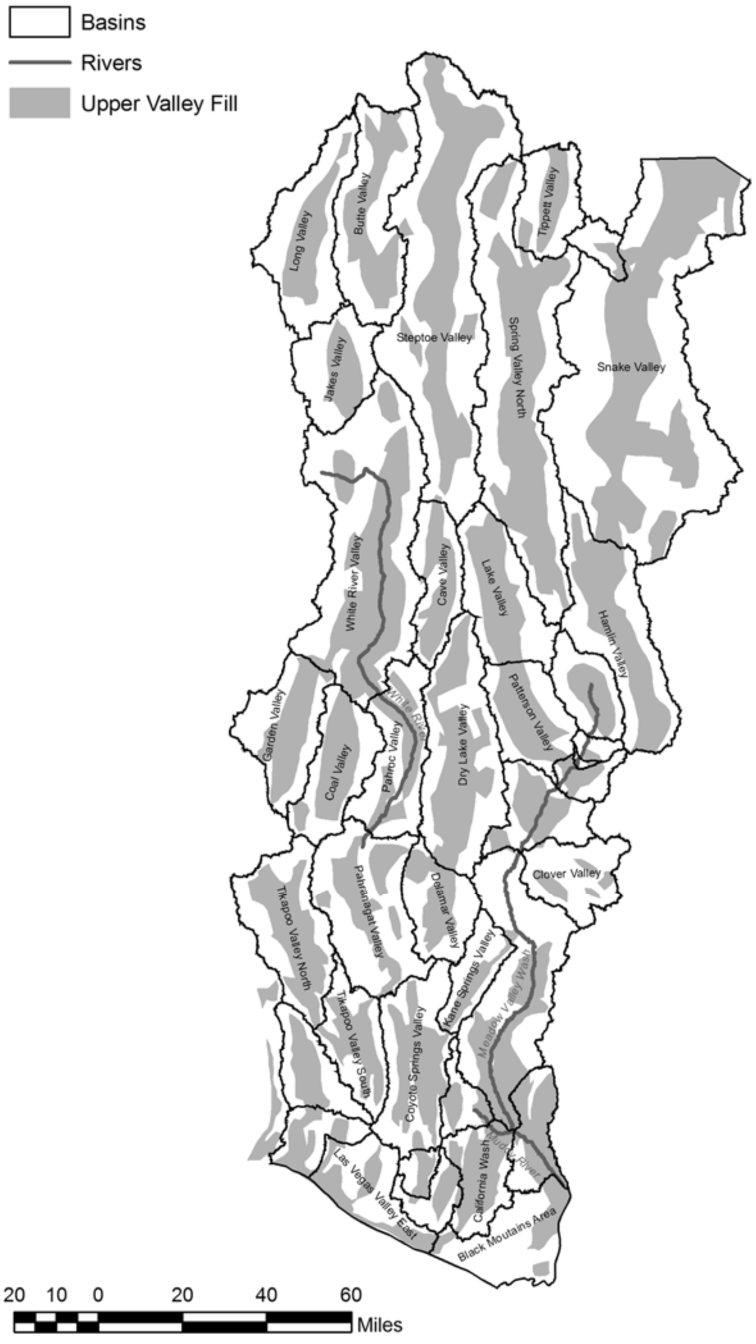

Figure 2. Area included in the Durbin SNWA model.

As Durbin (SNWA, 2006) explained the creation of the model involved six principal steps:

First is the translation of the hydrologic framework developed by SNWA (2006c) into a model mesh. Second is the characterization of the hydrologic properties of the groundwater system. Third is the specification of recharge, community and agricultural use, and groundwater underflows across the model boundaries. Fourth is the characterization of groundwater discharges to phreatophytes. Fifth is the *characterization of groundwater recharge from mountain-front streamflow. Sixth is the calibration of the model.*

Once these steps are completed to one's satisfaction, one is in a position to predict the impact of future development. Durbin made predictions of the impact of development, using the model, prior to the Spring Valley hearing. As I comment in my Spring Valley hearing testimony, the Durbin model is a good representation of the groundwater system. It is my intent to present Durbin's predictions.

Hydrogeology and Model units

Table 1 indicates how the translation of the hydrogeologic units was converted to model units:

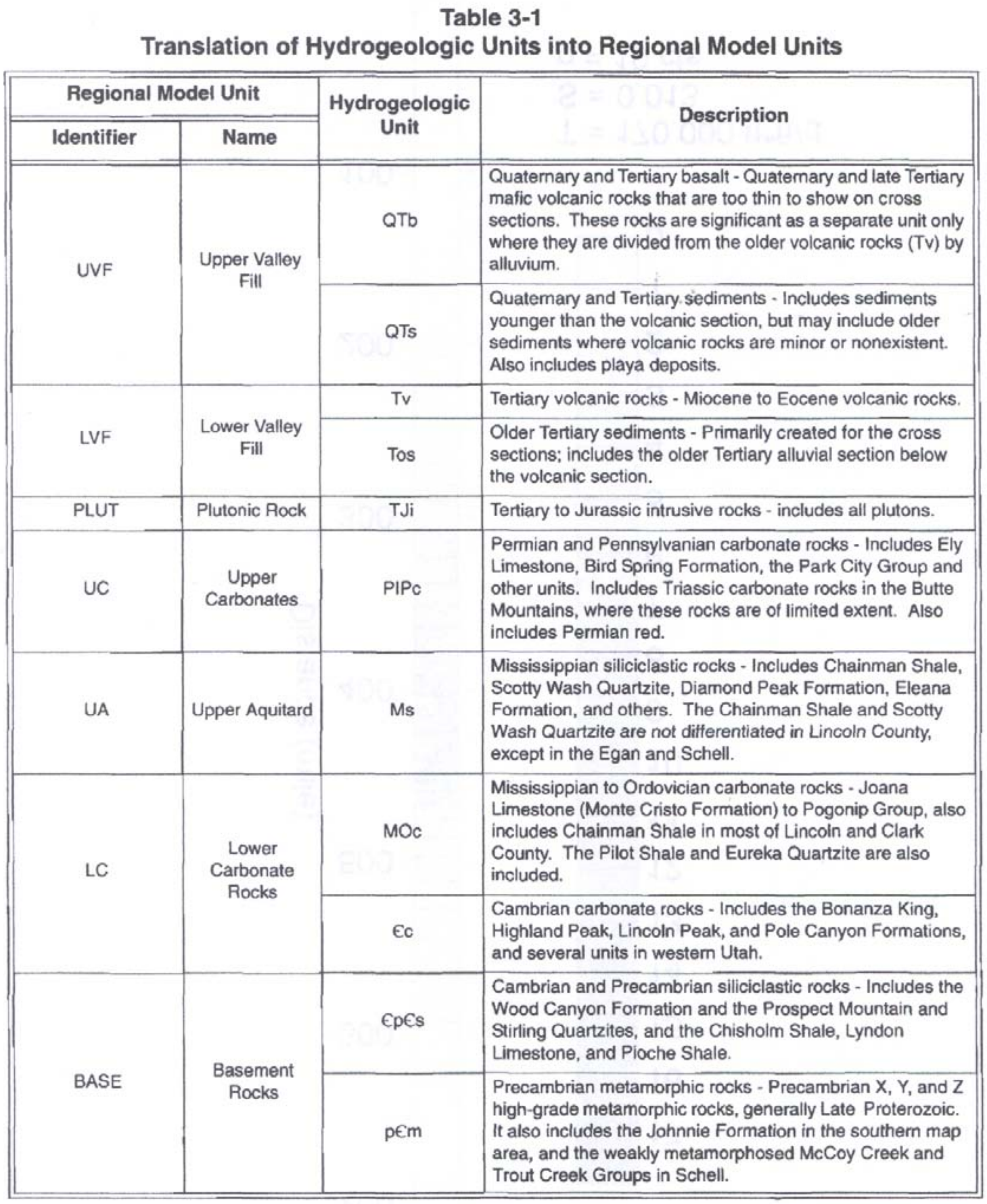

Table 3-1
Translation of Hydrogeologic Units into Regional Model Units

Regional Model Unit		Hydrogeologic Unit	Description
Identifier	Name		
UVF	Upper Valley Fill	QTb	Quaternary and Tertiary basalt - Quaternary and late Tertiary mafic volcanic rocks that are too thin to show on cross sections. These rocks are significant as a separate unit only where they are divided from the older volcanic rocks (Tv) by alluvium.
		QTs	Quaternary and Tertiary sediments - Includes sediments younger than the volcanic section, but may include older sediments where volcanic rocks are minor or nonexistent. Also includes playa deposits.
LVF	Lower Valley Fill	Tv	Tertiary volcanic rocks - Miocene to Eocene volcanic rocks.
		Tos	Older Tertiary sediments - Primarily created for the cross sections; includes the older Tertiary alluvial section below the volcanic section.
PLUT	Plutonic Rock	TJi	Tertiary to Jurassic intrusive rocks - includes all plutons.
UC	Upper Carbonates	PIPc	Permian and Pennsylvanian carbonate rocks - Includes Ely Limestone, Bird Spring Formation, the Park City Group and other units. Includes Triassic carbonate rocks in the Butte Mountains, where these rocks are of limited extent. Also includes Permian red.
UA	Upper Aquitard	Ms	Mississippian siliciclastic rocks - Includes Chainman Shale, Scotty Wash Quartzite, Diamond Peak Formation, Eleana Formation, and others. The Chainman Shale and Scotty Wash Quartzite are not differentiated in Lincoln County, except in the Egan and Schell.
LC	Lower Carbonate Rocks	MOc	Mississippian to Ordovician carbonate rocks - Joana Limestone (Monte Cristo Formation) to Pogonip Group, also includes Chainman Shale in most of Lincoln and Clark County. The Pilot Shale and Eureka Quartzite are also included.
		€c	Cambrian carbonate rocks - Includes the Bonanza King, Highland Peak, Lincoln Peak, and Pole Canyon Formations, and several units in western Utah.
BASE	Basement Rocks	€p€s	Cambrian and Precambrian siliciclastic rocks - Includes the Wood Canyon Formation and the Prospect Mountain and Stirling Quartzites, and the Chisholm Shale, Lyndon Limestone, and Pioche Shale.
		p€m	Precambrian metamorphic rocks - Precambrian X, Y, and Z high-grade metamorphic rocks, generally Late Proterozoic. It also includes the Johnnie Formation in the southern map area, and the weakly metamorphosed McCoy Creek and Trout Creek Groups in Schell.

Table 1. Translation of hydogeologic units into regional model units, from Durbin (SNWA, 2006).

A map was created for each of the regional model units. Two of the more important aquifers are the Upper Valley fill deposits (UVF) and the Carbonate Aquifer that combines the three model units (UC + UA + LC). Maps of both of these model units are shown as Figures 3 and 4:

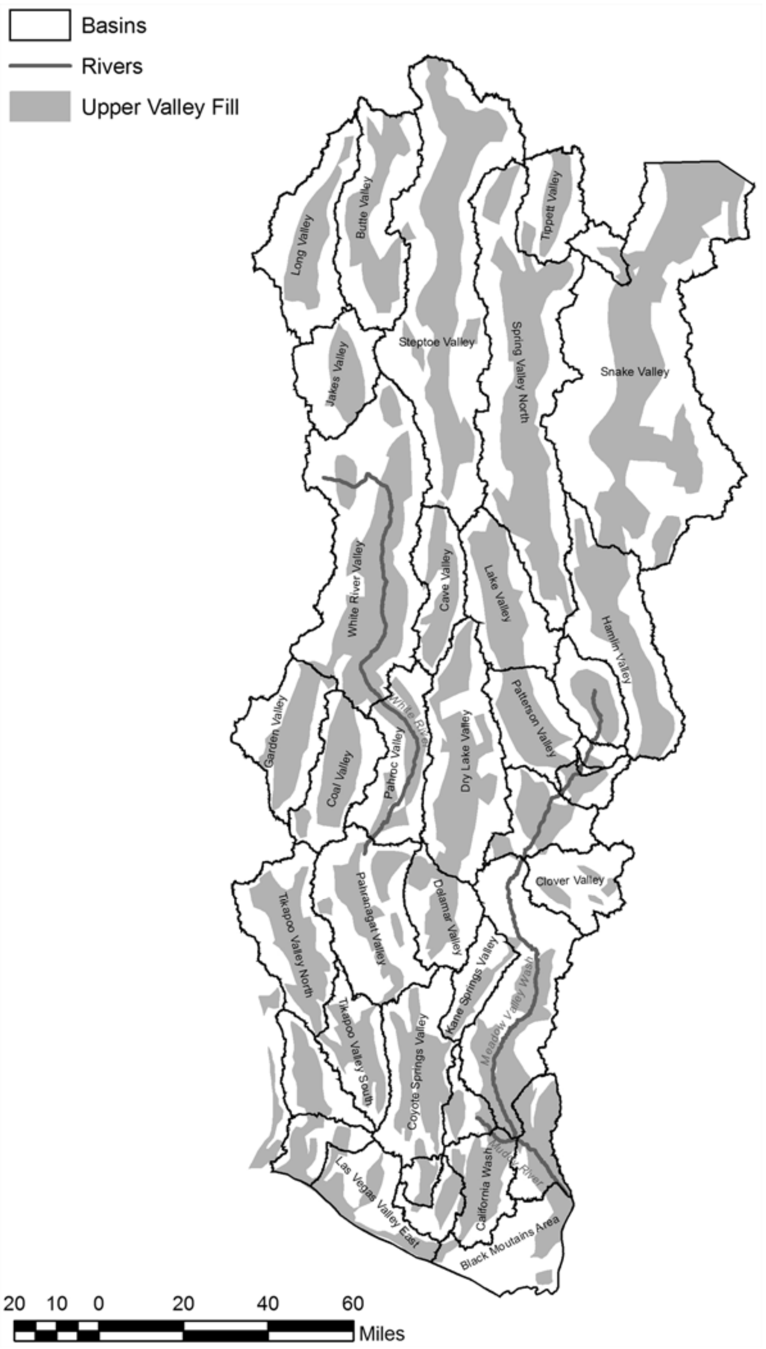

Figure 3. Map of the Upper Valley Fill (UVF) model unit

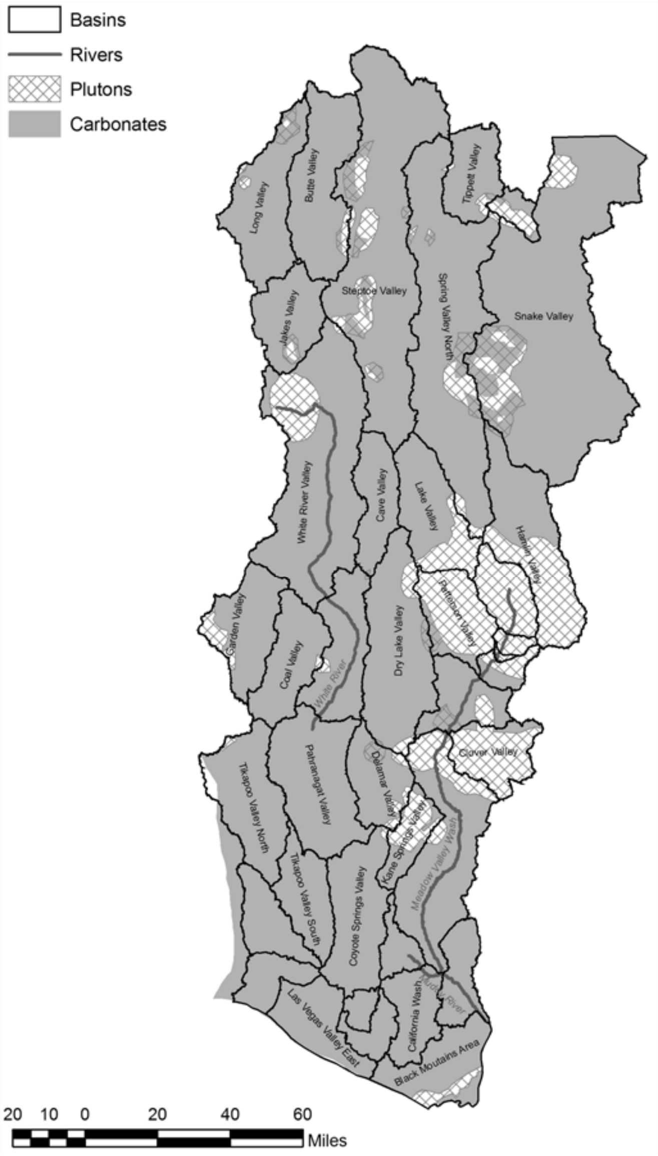

Figure 4. Map of the Carbonate Aquifer—combined model units UC + UA + LC.

For each of the model units thickness maps were prepared; the permeability of the unit was then estimated and input into the model. Where there was a lack of data, Durbin assembled data from the entire Carbonate Rock Province; statistical analysis of the permeability distributions for the various rock units was assembled from the regional data.

Inputs and Outputs

Once the hydrogeologic units are inserted into the three-dimensional model and initial permeabilities are assigned, one moves on to assign the recharge and its distribution, along with the discharge and its distribution, in the model.

Durbin (SNWA, 2006) used a modified Maxey/Eakin (1949) approach to assign precipitation and then assumed some fraction of the precipitation as recharge. Each investigator tweaks the Maxy/Eakin (1949) recharge coefficients, using somewhat different values than those originally suggested.

Of special importance in the analysis are the phreatophytes. This is the largest potential natural discharge, referred to in Nevada Bulletin 3 (above), which can be salvaged for beneficial use. The other major points of discharge from the system are the springs. Springflow too can be captured by the pumping. Figure 5 is the map of phreatophytes and springs used in the Durbin modeling.

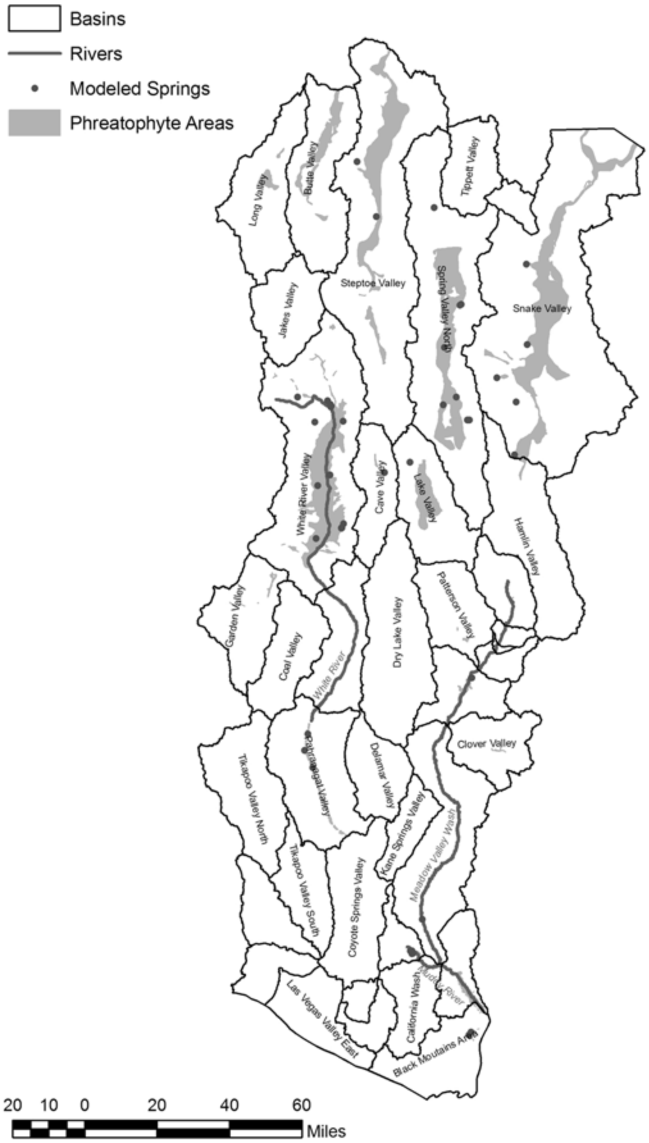

Figure 5. Map of phreatophytes and springs, from Durbin (2006).

Calibration

Once the hydrogeologic parameters are input, and the inflows and outflows are established for the model, one is in a position to calibrate the model. Both the parameters and the inputs and outputs were adjusted, within specific constraints, by the automatic procedure PEST that provides an optimal fit to all of the variables of interest.
A scatter plot provides one visual measure of the ability of the model to reproduce the observed data. Figure 6 is a scatter plot of weighted computed head versus weighted measured head from the calibration runs of the Durbin model. You can see that the model nicely reproduces the data.

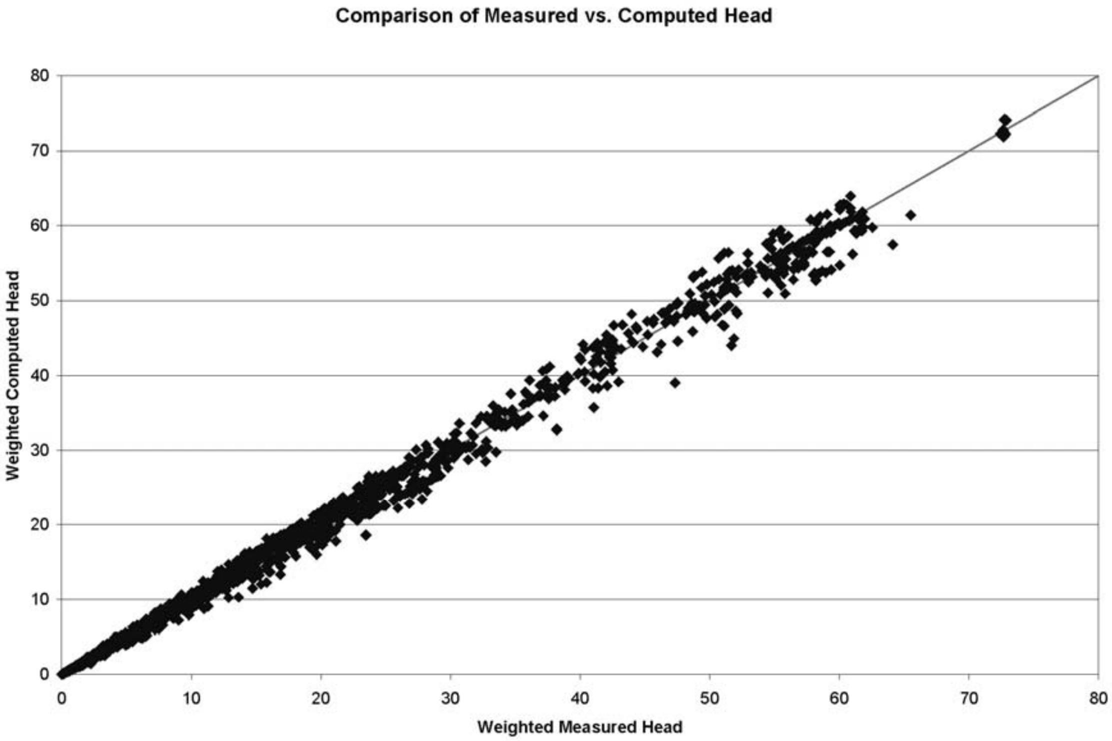

Figure 6, Scatter plot of weighted computed versus weighted observed head from a calibration run of the Durbin model.

RESULTS

Finally the model was used to make predictions of the impact of the SNWA proposed pumping. Figure 7 is a location map of the proposed pumping wells.

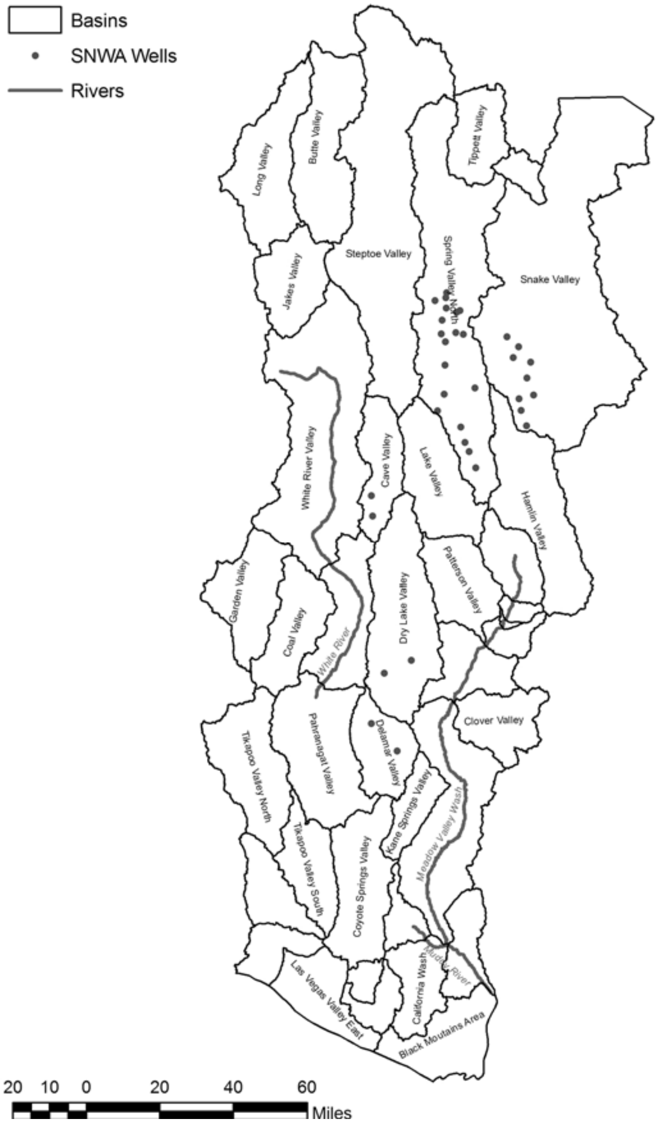

Figure 7. Proposed SNWA pumping included in the model.

Since the proposed pumping is less than both the recharge and the initial discharge from the area, the pumping will eventually capture sufficient discharge to reach a new equilibrium condition, as prescribed by Nevada water law—see the statement of perennial yield (above). The proposed pumping is summarized in Table 2:

Table 2. Proposed SNWA pumping

Spring Valley	91,000 acre-ft/yr
Snake Valley	46,000
Cave Valley	12,000
Delamar Valley	12,000
Dry Lake Valley	12,000
Total All Wells	173,000

There are major impacts on the system once this new equilibrium state is reached. It is of interest to examine the calibrated and computed evapotranspiration (ET) for all valleys—Table 3:

Valley	Evapotranspiration (acre-feet per year)			
	Historical Estimates	**Computed Historical Steady State (from Calibration)**	**Computed New Equilibrium (all SNWA pumping)**	**Computed New Equilbrium (only 3 valleys pumping)**
Black Mountains Area	1,200	1,273	1,269	1,269
Butte South Valley	11,000	11,035	11,000	11,027
California Wash	1,700	5,449	5,057	5,136
Cave Valley	300	199	-	-
Clover Valley	200	1,053	92	571
Dry Valley	10	2,701	2,072	2,471
Eagle Valley	300	458	95	334
Garden Valley	1,700	2,023	496	1,038
Lake Valley	8,500	9,999	-	4,942
Lower Meadow Valley Wash	1,400	6,372	773	1,052
Lower Moapa Valley	11,000	20,743	20,348	20,464
Long Valley	2,200	2,199	2,180	2,193
Muddy River Springs Area	5,000	2,241	1,777	1,887
Pahranagat Valley	25,000	21,501	13,546	15,868
Panaca Valley	600	6,124	1,864	4,528
Patterson Valley	80	80	-	-
Rose Valley	10	667	532	628
Snake Valley	80,000	87,951	40,532	87,138
Spring Valley North	70,000	92,709	26,953	90,725
Spring Valley South	1,000	998	255	910
Steptoe Valley	70,000	76,037	69,961	74,578
White River Valley	34,000	37,009	27,373	30,861

Table 3. The second column of data shows the model-calibrated values of ET. The third column shows the computed ET once a new equilibrium state is reached that includes all of the proposed SNWA pumping, including that in Spring, Snake, Cave, Dry Lake, and Delamar Valleys. The fourth column shows the computed ET once a new equilibrium is reached that includes only the proposed pumping in Cave, Dry Lake, and Delamar Valleys.

For the proposed total pumping scenario the big changes in ET occur in Spring and Snake Valleys. For the proposed pumping in Cave, Dry Lake, and Delamar Valleys the principal changes in ET occur in Pahranagat and the White River Valleys.

Table 4 is a similar table for spring discharge:

Spring	Discharge (cubic feet per second)			
	Historical Estimates	Computed Historical Steady State (from Calibration)	Computed New Equilibrium (all SNWA pumping)	Computed New Equilibrium (only 3 valleys pumping)
Cherry Creek Hot Springs	0.08	0.09	0.09	0.09
Monte Neva Hot Springs	1.50	1.45	1.44	1.45
North Millick Spring	0.44	0.58	-	0.58
South Millick Spring	1.00	0.95	-	0.95
Big Springs	9.00	8.47	-	8.39
Warm Springs	8.00	12.96	12.27	12.96
Panaca Spring		2.13	2.00	2.09
Arnoldson Spring	3.50	3.59	3.59	3.59
Cold Spring	1.30	1.32	1.32	1.32
Preston Big Spring	8.00	7.95	7.88	7.93
Lund Spring	7.70	7.73	7.62	7.69
Moorman Spring	0.50	0.60	0.49	0.55
Flag Spring 3	2.30	2.16	1.46	1.77
Flag Spring 2	2.90	2.86	2.08	2.42
Flag Spring 1	2.30	2.28	1.53	1.86
Hardy Springs	0.45	0.45	0.18	0.33

Table 4. Comparison of spring discharge for 1) column 3—calibrated predevelopment steady state model, 3) column 4—computed new equilibrium state with all SNWA proposed wells pumping, 4) column 5—computed new equilibrium with only the SNWA proposed pumping in Cave, Dry Lake, and Delamar Valleys.

Figures 8 and 9 are maps of the drawdown of 1) the water table, and 2) the Carbonate Aquifer produced in reaching the new equilibrium caused by all the proposed SNWA pumping, including that in Spring, Snake, Cave, Dry Lake, and Delamar valleys.

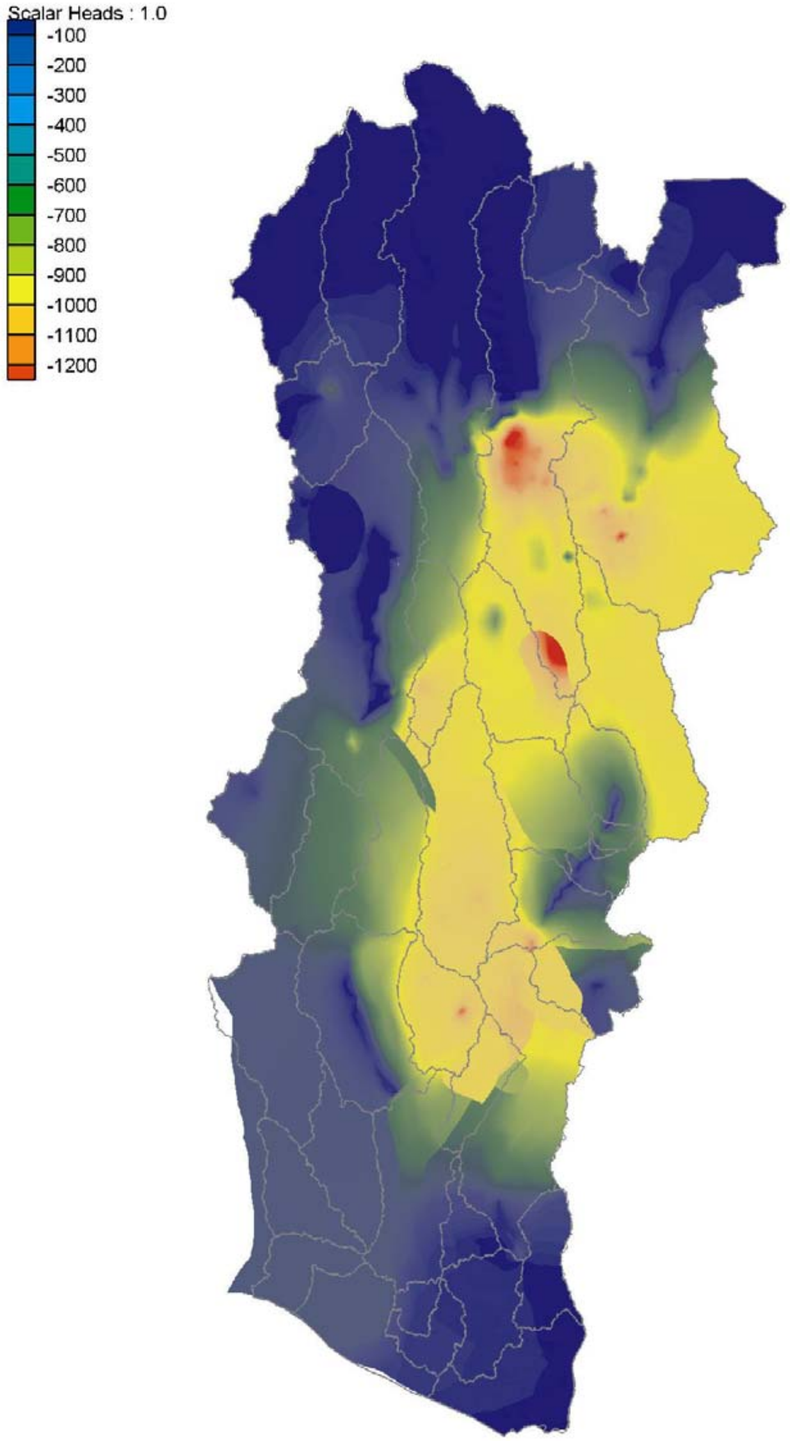

Figure 8. Computed drawdown of the water table produced in reaching a new equilibrium state that includes all of the proposed SNWA pumping.

It is also of interest to look at the computed drawdown in the Carbonate Aquier (Units UC + UA + LC) once the new equilibrium state is reached—Figure 9.

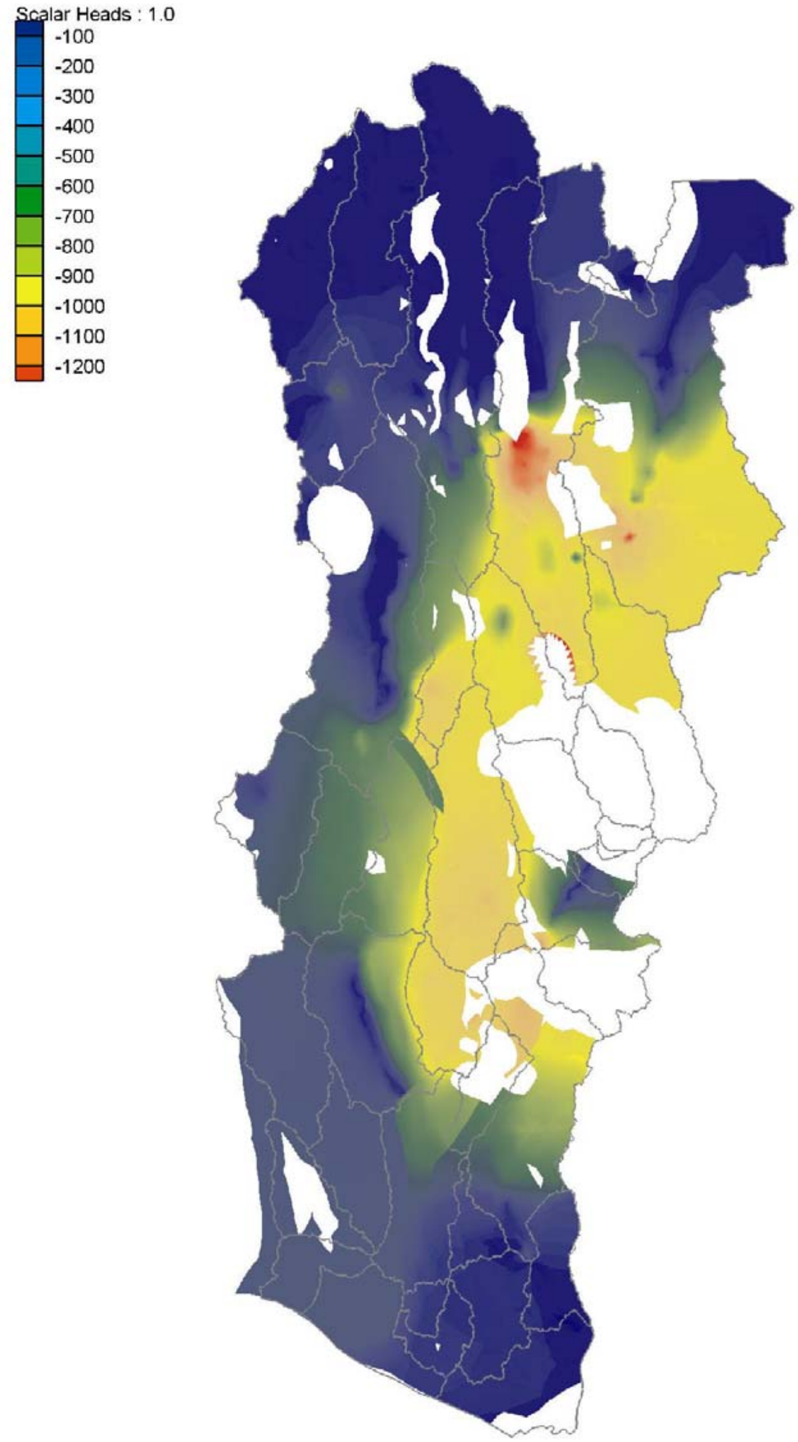

Figure 9. Computed drawdown produced in the Carbonate Aquifer (Units UC + UA +LC) by all the proposed SNWA once the new equilibrium state is reached.

In both instances you see large areas where the computed drawdown exceeds 700 feet. In some valleys the drawdown exceeds 1,000 feet. The predicted impacts are large and widespread. Figure 10 is a map of drawdown of the water table at the new equilibrium state for the proposed SNWA pumping only in Cave, Dry Lake, and Delamar Valleys.

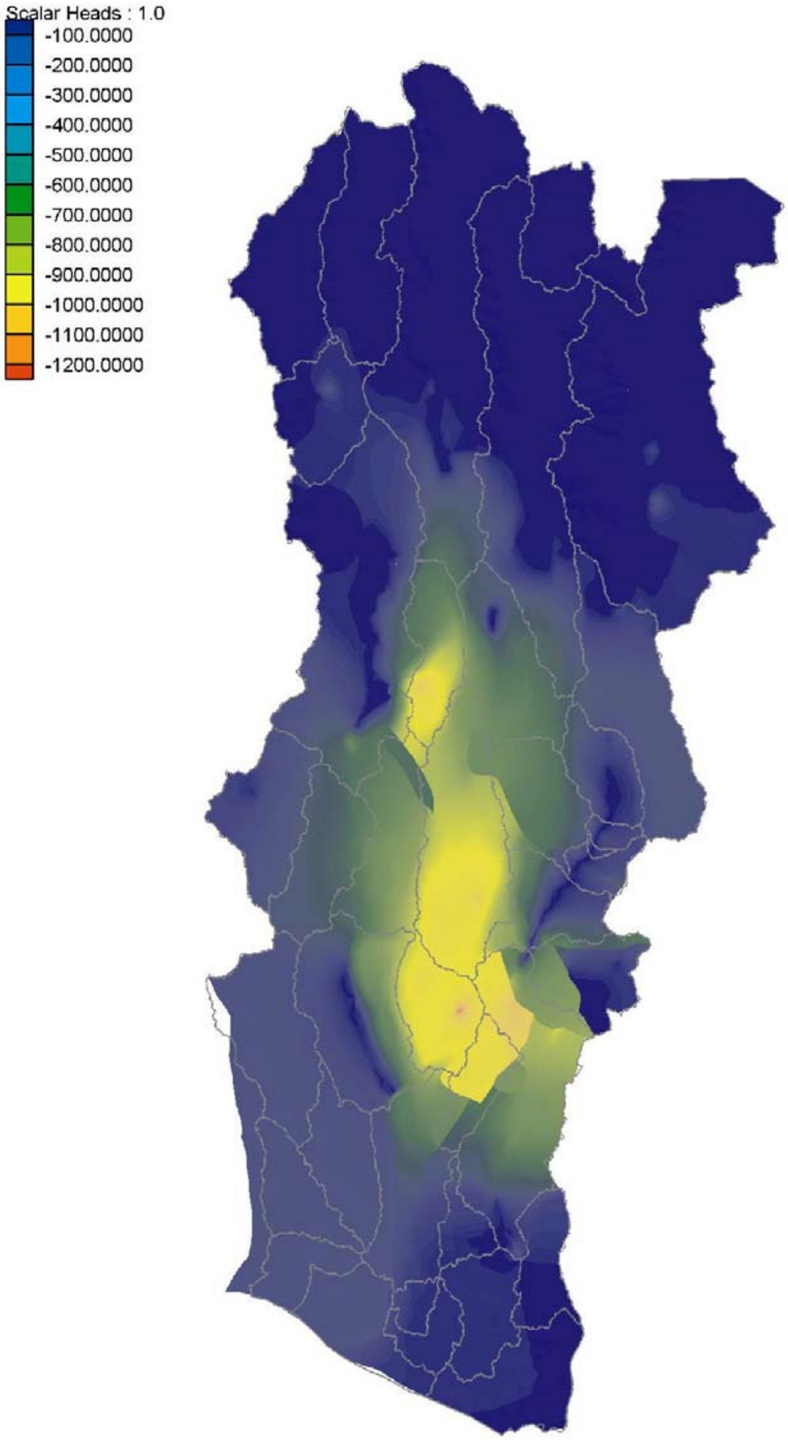

Figure 10. Computed drawdown of the water table at the new equilibrium state created by the proposed SNWA pumping in only Cave, Dry Lake, and Delamar valleys.

The predicted impacts of the pumping at the new equilibrium of the proposed wells in Cave, Dry Lake, and Delamar Valleys are also large and widespread. The drawdown of the water table at the new equilibrium state is more that 700 feet over a large area.

Changes with Time—ET and Storage

We first look at the scenario with all the proposed SNWA pumping included in the model. Figure 11 is a plot of the ET from the system versus time.

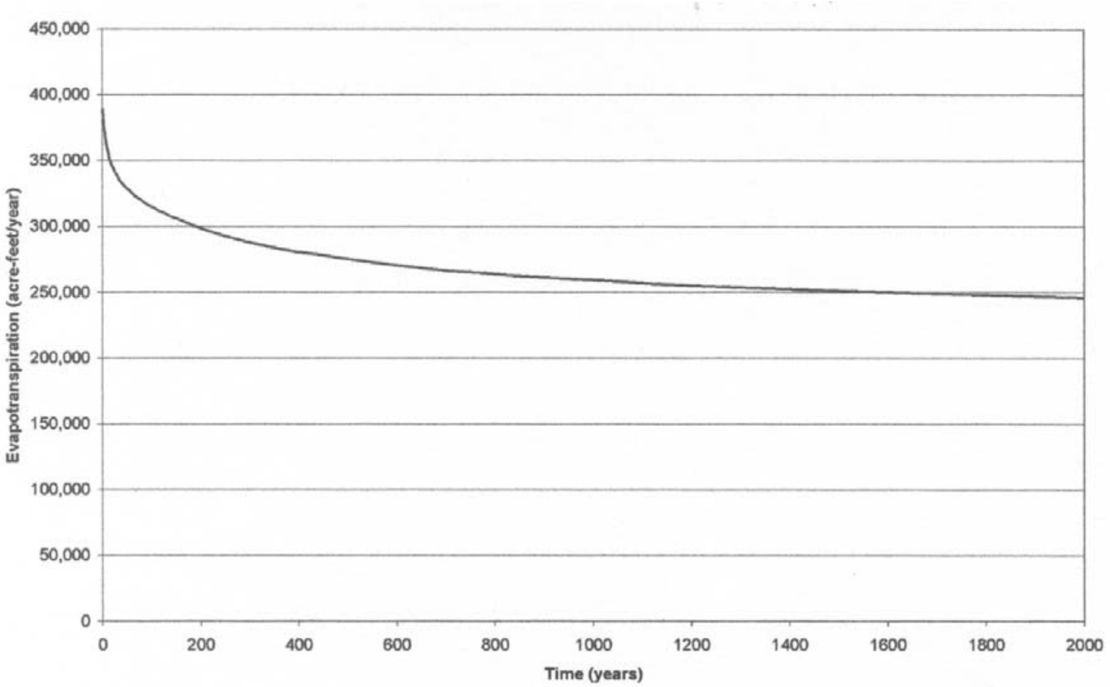

Figure 11. Computed rate of phreatophyte ET from the entire model area for the scenario that includes all of SNWA's proposed pumping.

Once the new equilibrium state is reached, the rate of ET consumption should stabilize, and not continue to change with time. The rate of predicted ET consumption declines rapidly for approximately 500 years. After 500 years the rate of decline slows; however the ET has not stabilized in 2000 years; it is still declining. This continuing decline at 2000 years is a sign that the system may not reach a new equilibrium within any meaningful time.

It is interesting to look at the predicted change in water storage in the system versus time. Figure 12 is a plot of the change in storage for the scenario of all the proposed SNWA wells pumping.

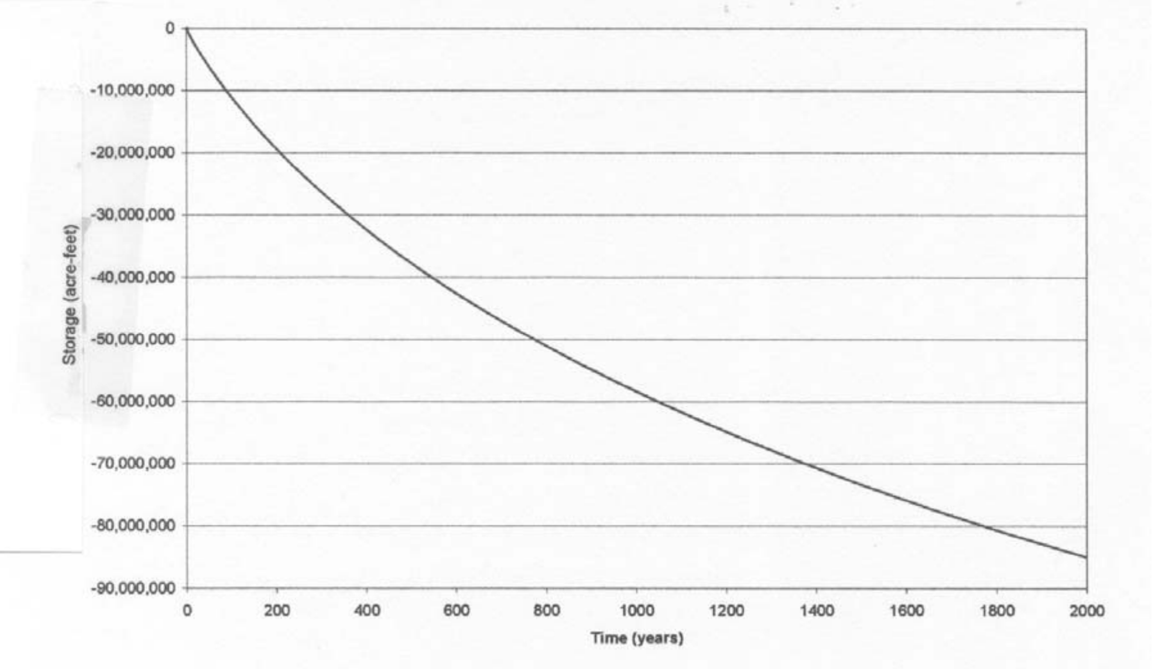

Figure 12. Plot of the computed change in storage versus time for the scenario with all the proposed SNWA wells pumping.

The change in storage should reach a stable value once a new equilibrium state is reached. One can see that the predicted change in storage is still declining steadily at 2000 years in the future. The modeling indicates that the system has not reached a new equilibrium state even 2000 years into the future.

We see similar results when modeling just the proposed pumping from Cave, Dry Lake, and Delamar Valleys. Figure 13 is a plot of the computed rate of ET versus time.

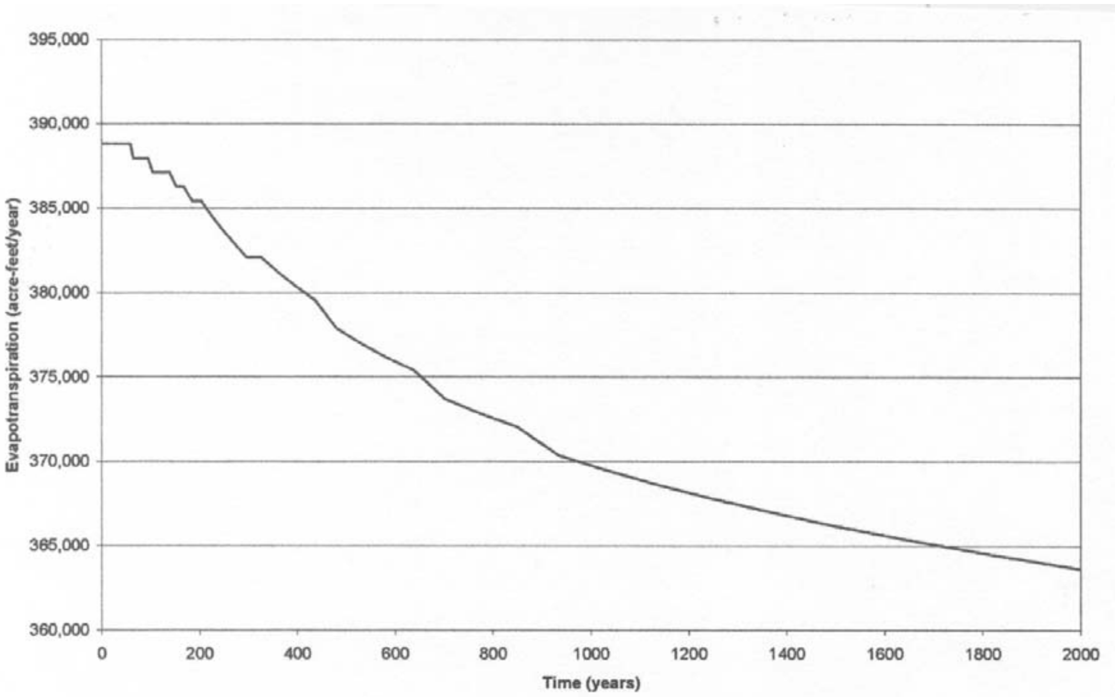

Figure 13. Computed rate of ET for the SNWA pumping scenario with pumping in Cave, Dry Lake, and Delamar valleys.

We see that the computed rate of ET is still declining after 2000 years of pumping; indicating that the system has not reached a new equilibrium. The change in storage shows the same result Figure 14.

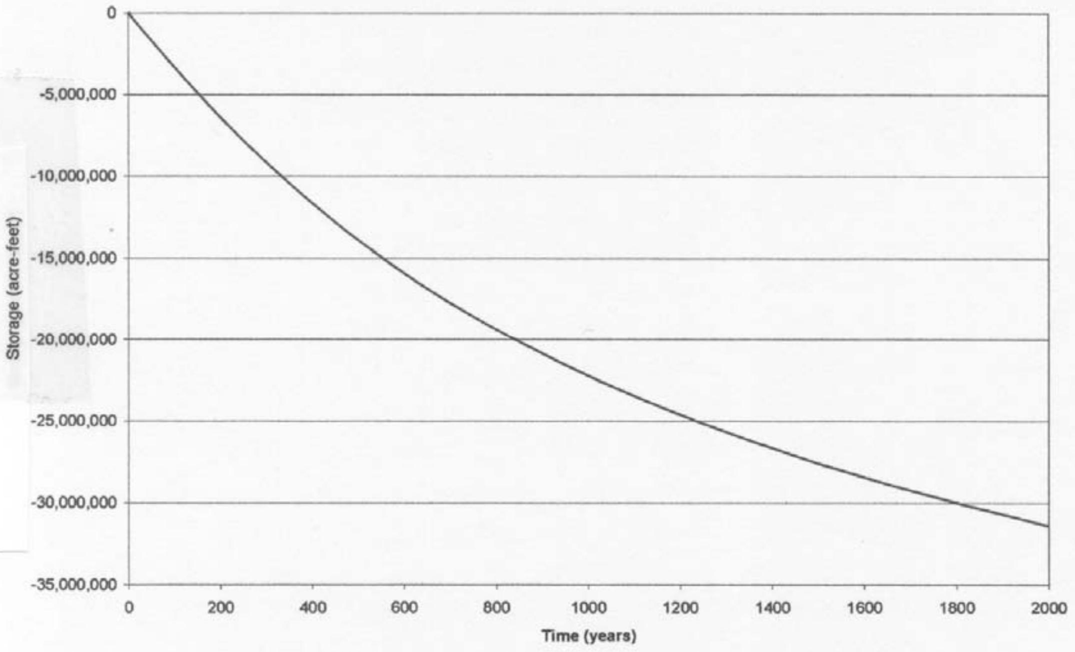

Figure 14. Computed change in storage for the SNWA scenario with pumping in Cave, Dry Lake, and Delamar Valleys.

Again one sees that the system has not reached a new equilibrium state in 2000 years. There is still a continued computed decline in storage,

Modeling Summary Remarks

Durbin (SNWA, 2006) went to considerable effort to produce a realistic model of the groundwater system for the analysis of SNWA's proposed pumping. The model was presented in Durbin (SNWA, 2006) for the Spring Valley hearing. The model also had been used to make predictions of the overall system response.

The model results are revealing. The model predicts large drawdowns over much of the model area once the system reaches a new equilibrium state. However, the model also suggests that reaching a new equilibrium is highly problematic.

The model predictions indicate that the system has not reached a new equilibrium after 2000 years of pumping. The graphs of computed change in storage with time indicate that the system has not reached the new equilibrium after this period of pumping. Tom Myers saw similar results from his model of Spring Valley. This places the development scheme in an entirely different realm.

If we have a system that does not reach a new equilibrium following 2000 years of pumping then the concept that it will some day, in the next several millennia, reach a new equilibrium has almost no relevance—it is way too far in the future to have meaning.

One must then consider this system as a system that will be developed in a transient mode—that is what the model prediction tells us. Water to supply the wells will come from capture of the natural discharge, in this case ET and springflow, and from storage. A large percentage of the water to supply the wells will come from storage even out to 2000 years. This is a groundwater mining scheme—something not envisioned by the framers of Nevada groundwater law.

BURNS LOWER MUDDY RIVER DISCHARGE

Burns (2007) argues that approximately 25,000 ac-ft/yr is estimated to flow downstream in the Muddy River Valley in the vicinity of Overton of which the largest part is groundwater underflow in the Muddy River Valley. I am not sure what the intent of Burn's argument is: 1) is this supposed to indicate an additional discharge from the White River Flow System that occurs between the stream gage at Moapa and Overton; or 2) is his point that this is water that is not be used and is escaping to Lake Mead?

Burns used as part of his argument a period of streamflow record on the Muddy River, from a gage near Overton, from 1913 to 1916. He neglected to mention that the same site was again occupied from 1948 to 1952. I have reproduced both periods of record as Figure 15 and 16.

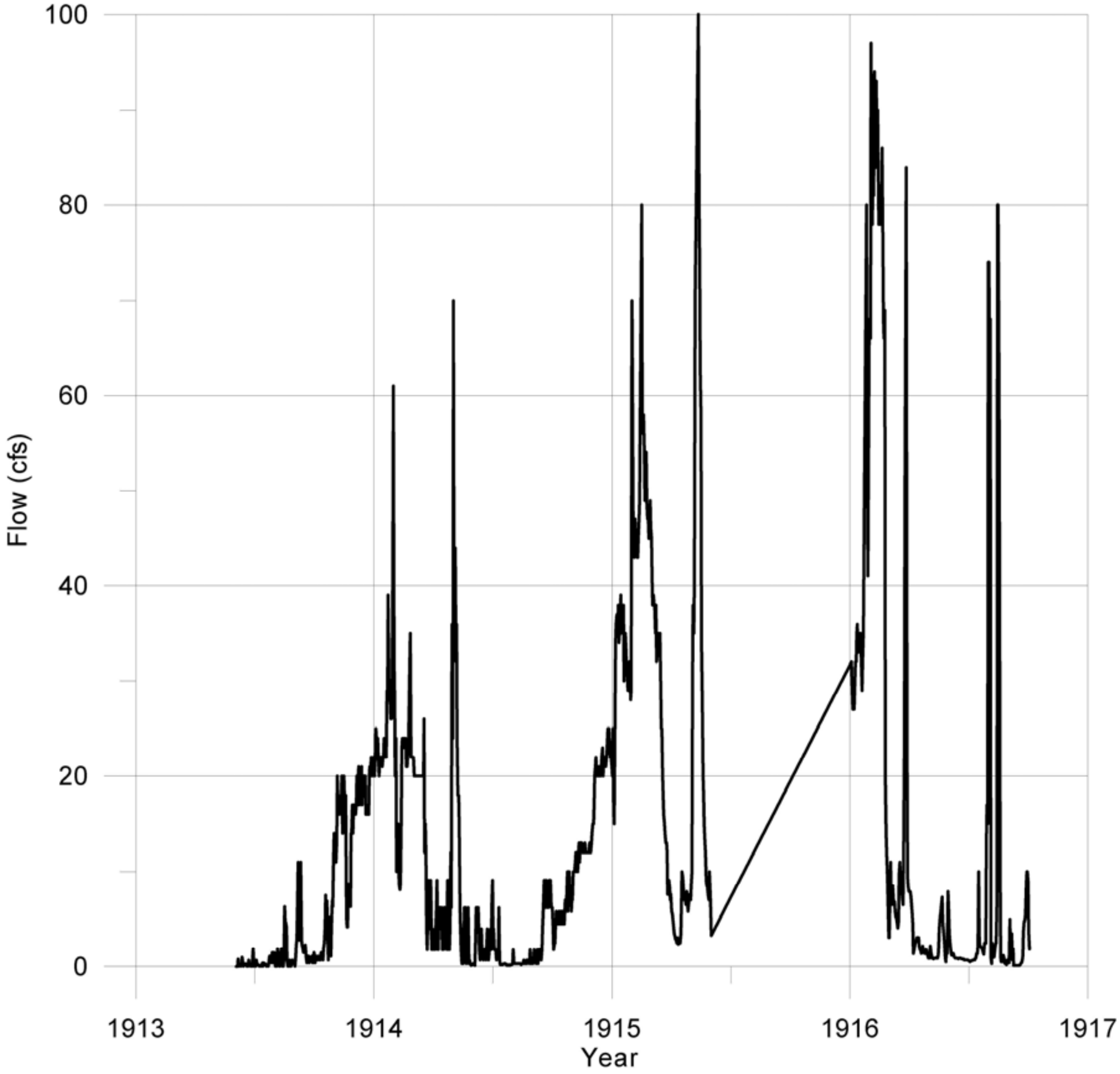

Figure 15. Daily mean discharge of the Muddy River for a gage near Overton, NV.

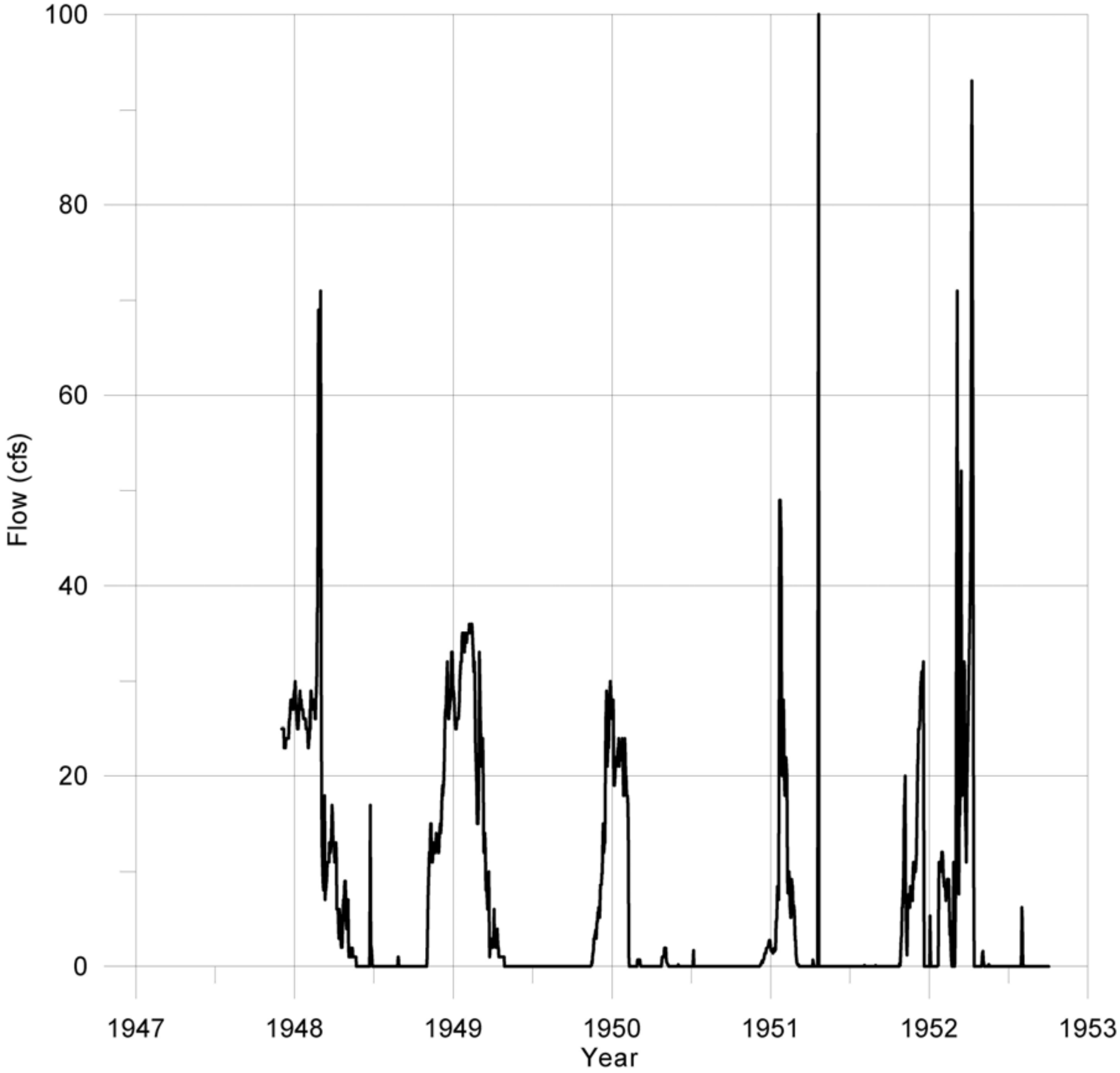

Figure 16. Daily mean discharge of the Muddy River at Overton, NV.

Of particular interest in this record is the period 1948 through 1952. During long periods during each year the river was dry. There appears to be no continuous groundwater baseflow during the 1948-1952 period. There were also periods of no streamflow in 1913 and 1914. The Overton hydrograph does have the characteristics of a major spring area, or gaining stream reach of river.

Figure 17 is a plot of the Muddy River near Moapa, NV.

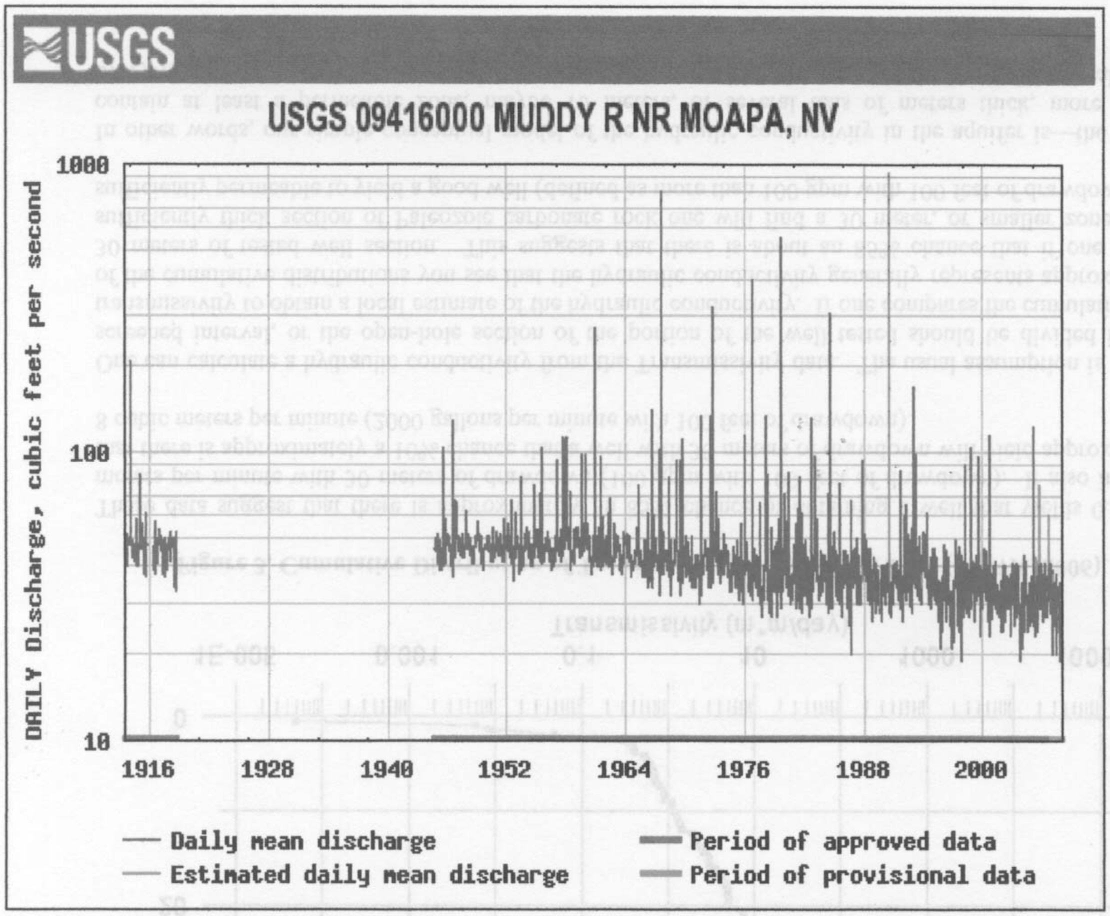

Figure 17. Daily mean discharge for the Muddy River near Moapa, NV.

There is a long gap in this record between 1916 and the mid 1940s, but the data indicate a baseflow discharge of approximately 36 cfs during the period from the early 1900s to approximately1958—26,000 ac-ft/yr. This is a portion of the 40,000 ac-ft/yr that most investigators attribute to the outflow from the Muddy River springs discharge area.

It is approximately 14.5 river miles between Moapa downstream to Overton. I submit that what Burns (2007) is calculating as underflow at Overton is a portion of the discharge from the Muddy River at Moapa that has flowed downstream. As suggested above, I do not see anything in the discharge record from the early 1900s for Overton that suggests that there are major outflows from the White River Flow System in the river reach between Moapa and Overton. In other words, both the gage flow and the underflow at Overton reflect flow that mostly comes downstream from Moapa and the Muddy River Springs.

If, on the other hand, Burn's point is that water is flowing to Lake Mead unused; then one might be tempted to ask how might we capture this discharge? This discharge cannot be captured by pumping from Cave, Dry Lake, and/or Delamar Valleys. Other discharges, much closer to the pumping, will be captured. If the idea is to capture this discharge, one needs to move a pumping center near Overton to accomplish this task.

IN SUMMARY

The Muddy River streamflow tells an additional story. The Muddy River flow at Moapa has steadily declined since 1960. Prudic (USGS, Carson City) tells me that the same decline is not observed in other streams in the region that he has investigated, including the Virgin and Mojave Rivers (Prudic, personal communication, December 2007). This suggests that the decline in the flow of the Muddy River is not the result of some change in the climate, but rather the result of developments that have been ongoing since the 1950s in the overall watershed of the entire White River Flow System.

The downstream springs and senior water rights holders in the White River Flow System fully utilize the interbasin flow out of Cave, Dry Lake, and Delamar Valleys. The decline of the Muddy River at Moapa further indicates that there is no downstream non-beneficial use to be captured by the pumping, and therefore the pumping in the valleys under consideration should not be authorized.

Nevada water law has only an implied reference to time; it only requires that the system reach a new equilibrium state at some undetermined future time. The law was written before the tools were available to predict the future of groundwater developments. I venture to say that no one at the time the law was written could imagine that it would take more than 2000 years for any conceivable pumping scheme to reach a new equilibrium. The fact that the model predicts times greater than 2000 years to reach a new equilibrium changes one’s entire view of the system. The time to reach a new steady state is of the order of recorded history; the fact that a new equilibrium may ultimately be reached is meaningless—it is too far into the future. Too much can happen on the earth in this kind of a time frame—civilizations change, the climate may change dramatically. One must concern one’s self with what happens in the next several hundred years, perhaps 500 years. After 500 years of pumping, the models predict that for the larger SNWA development, the wells will still obtain approximately 30 percent of their water from the depletion of groundwater storage. From this perspective, one has in essence a groundwater mining scheme—it can hardly be viewed otherwise. Approving such a development seems contrary to the spirit of the Nevada water law.

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