Effects of Proposed Groundwater Development by the Southern Nevada Water Authority on the Hydrogeology of Spring Valley, White Pine and Lincoln County, Nevada

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INTRODUCTION

One of the remarkable facets of Nevada groundwater hydrogeology is the recognition in the later part of the 20th century that much of eastern and southern Nevada was underlain by a deep carbonate aquifer that served to integrate the groundwater flow into a mega flow system that incorporated many valleys. Winograd and Thordarson, of the U.S. Geological Survey (USGS), working on the groundwater hydrology of the Nevada Test Site (Winograd, 1962; Winograd and Eakin, 1965; Winograd and Friedman, 1972; Winograd and Thordarson, 1975) first proposed the hypothesis. Ike Winograd recognized that that water chemistry of groundwater from both wells and springs in the area had very similar water chemistry. The idea quickly took hold. The hypothesis explained the discrepancy in water budgets for a number of individual valleys investigated by Tom Eakin (Eakin, 1966). Marty Mifflin, working at the Desert Research Institute (DRI) of the University of Nevada, did a PhD dissertation on the ground-water flow systems of Nevada that outlined the entire carbonate aquifer (Mifflin, 1968); the aquifer was recognized to be geographically very extensive.

The USGS, in an effort to investigate the groundwater resources of the United States did a number of Regional Aquifer Systems Analyses (RASA studies). Each of these studies produced a regional groundwater model of the particular aquifer system. Among RASA studies was one for the carbonate aquifer of the Great Basin in Nevada and Utah; it too generated a groundwater model (Prudic et al., 1995).

Importance of a Groundwater Model

It is of interest in proposed groundwater developments to predict future impacts. The numerical groundwater model is designed to make these assessments. An integral part of groundwater modeling is the conceptual model of the aquifer. The conceptual model is the hydrologist construct of the aquifer—his/her view of the basic hydrogeology of the aquifer. The model represents mathematically the hydrogeologist's conceptual model. The conceptual model is an a priori decision by the hydrologist, and generally not subject to being checked mathematically (Bredehoeft, 2003). Let me state this idea another way—a poorly conceived conceptual model can often be fit to the empirical data. It is at the conceptual model stage of analysis that models often differ radically in design. The parameters within the model are adjusted to provide the best fit to the data, but the conceptual model is rarely changed.

In order for the carbonate aquifer to integrate the groundwater hydrology of eastern and southern Nevada it must somehow have continuous hydraulic continuity—implying some kind of integrated network of permeability that transcends deep structural valleys and mountain ranges. It is of interest to examine how various investigators envision that this occurs in the subsurface—the subsurface is of necessity interpreted from geologic data, much of it from a small set of drill holes. These concepts underlie the various models of the system.

THE USGS RASA MODEL

As indicated above, the USGS constructed a RASA model of the entire carbonate aquifer system of the Great Basin that included both Nevada and Utah (Prudic et al., 1995). The model had two active layers, generally: 1) the carbonate aquifer, and 2) the overlying material. The model was intended to cover the entire carbonate regional aquifer. The cells within the model were quite large, 5 miles in the direction normal to the mountain ranges by 7.5 miles in the direction parallel to the mountains; this makes for low spacial resolution in the model.

Schaefer and Harrill (1995) used the RASA model to evaluate the proposed development by the Southern Nevada Water Authority (SNWA). Their analysis indicated several hundred feet of drawdown after 200 years of pumping in parts of Spring Valley—indicating large impacts on the Spring Valley hydrology. Most observers think that the USGS model was two simplistic with only two layers, and had grid cells too large to yield a good estimate of the local impacts

TOM MYERS MODFLOW MODEL OF SPRING VALLEY

Tom Myers prepared a five-layer groundwater model of Spring Valley that he used to make analyses for the present hearing to assess the impacts of SNWA's proposed development. Tom's model has five, more or less, horizontal layers, and utilizes a 1-mile by 1-mile grid spacing for Spring Valley. In the model he includes the major hydrologic features observed in the valley. Within the valley, the upper three layers portray the valley fill deposits; the lower two layers the carbonate aquifer

Recharge Estimates

There are several of estimates of recharge for Spring Valley that range from a low of 61,000 ac-ft/yr to a high of 104,000 ac-ft/yr; three of five estimates are in the approximate range of 75,000 ac-ft/yr. Prudic et al. (1995) used a recharge rate of 75,000 ac-ft/yr; the State of Nevada reports a recharge rate of 75,000 ac-ft/yr (Nevada Water Resources—Bulletin 3). Myers used 75,000 ac-ft/yr as the recharge rate for his model analysis.

The State of Nevada estimated that there is 90,000 ac-ft/yr of surface water runoff in Spring Valley. In assessing the magnitude of the potential water yield for Spring Valley, the State assumed that 1/3 of the 90,000 ac-ft/yr of surface runoff could be captured by a groundwater development. Adding 30,000 ac-ft/yr of surface water capture to the 75.000 ac-ft/yr of recharge and subtracting 4,000 ac-ft/yr for outflow from Spring Valley to Hamlin Valley, the State arrives at approximately 100,000 ac-ft/yr as the potential groundwater yield for Spring Valley.

Myers argues that the 75,000 ac-ft/yr of recharge includes water that discharges as baseflow to surface water. In other words, some part of the 90,000 ac-ft/yr of surface flow is counted in the recharge estimate—the State is double counting some water with the two estimates. I agree that the recharge estimate includes some surface water runoff, and should not be counted twice. It is not clear how large the magnitude of double accounting is.

Impacts

Tom Myers' analysis indicates that much of the southern part of Spring Valley would be quickly impacted by groundwater development. This agrees with the earlier USGS RASA analysis (Schaefer and Harrill, 1995). The models predict that depending upon the duration of the SNWA pumping there will be up to several hundred feet of drawdown in the southern part of Spring Valley. This will be sufficient to dry up the springs of the area, and have adverse impacts on existing wells.

It is of interest to examine how much of the groundwater pumped will come from aquifer storage in the valley. In *Water For Nevada: Bulletin 3* the State discusses "transitional storage reserve"; they write:

> *Transitional storage reserve is the quantity of water in storage in a particular ground water reservoir that is extracted during the transition period between equilibrium conditions and new equilibrium conditions under 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 of water levels).*
>
> *... The transitional storage reserve estimates for the regions are based upon an average dewatering of 30 to 40 feet of the valley-fill reservoir. These values are shown for each region in Table 1-A.*

Table 1-A indicates that the transition storage for Central Hydrographic Region in which Spring Valley is located is 45,000,000 acre-feet. The table does not suggest transitional storage reserves for each valley—the question is what reserve is applicable to Spring Valley? The potential water yield estimated by the State for the Central Region is 800,000 ac-ft/yr. Of that total, the State estimates 100,000 ac-ft/yr for Spring Valley, or 12.5% of the total. Using the 12.5% as a basis for estimating the fraction of the transitional storage reserve suggests that that Spring Valley portion of the reserve is 5,625,000 ac-ft.

Figure 1 is a plot taken from Myers' model for a simulated SNWA development that pumped for 1000 years. In Figure 1 is plotted the fraction of the pumping that is provided from storage.

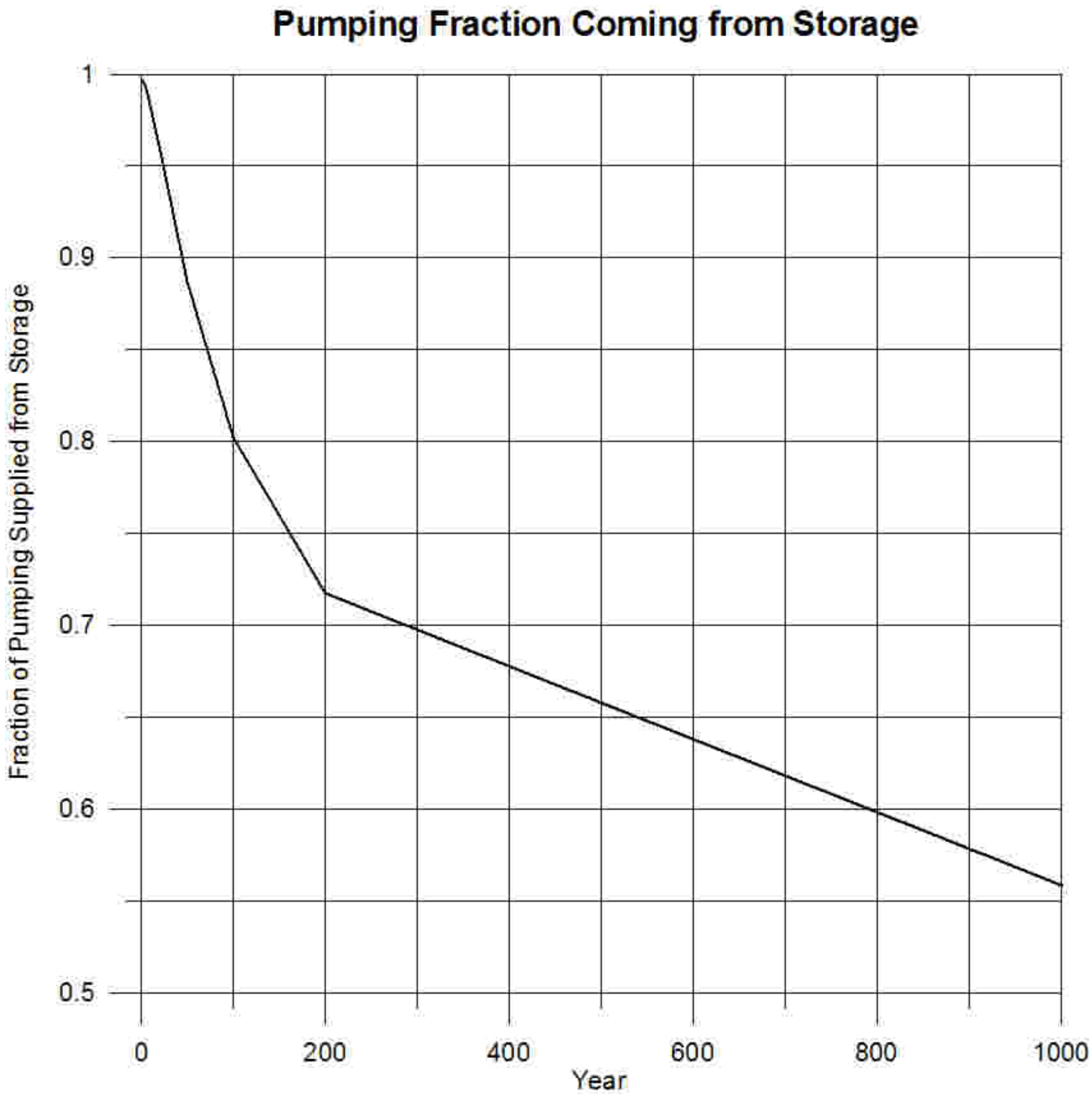

Figure 1. Fraction of the ground water pumped that comes from storage.

In this scenario after 100 years, 80% of the ground water being pumped comes from storage; after 200 years, 72% is coming from storage. Even after 1000 years, 55% of the water being pumped is coming from storage. The system is nowhere near reaching a new equilibrium condition after 1000 years of simulated pumping. A new equilibrium will be reached when groundwater levels stop declining, and no water continues to come from storage.

The total quantity of water removed from storage is of interest. Figure 2 is a plot of the cumulative storage depletion from the continued SNWA pumping.

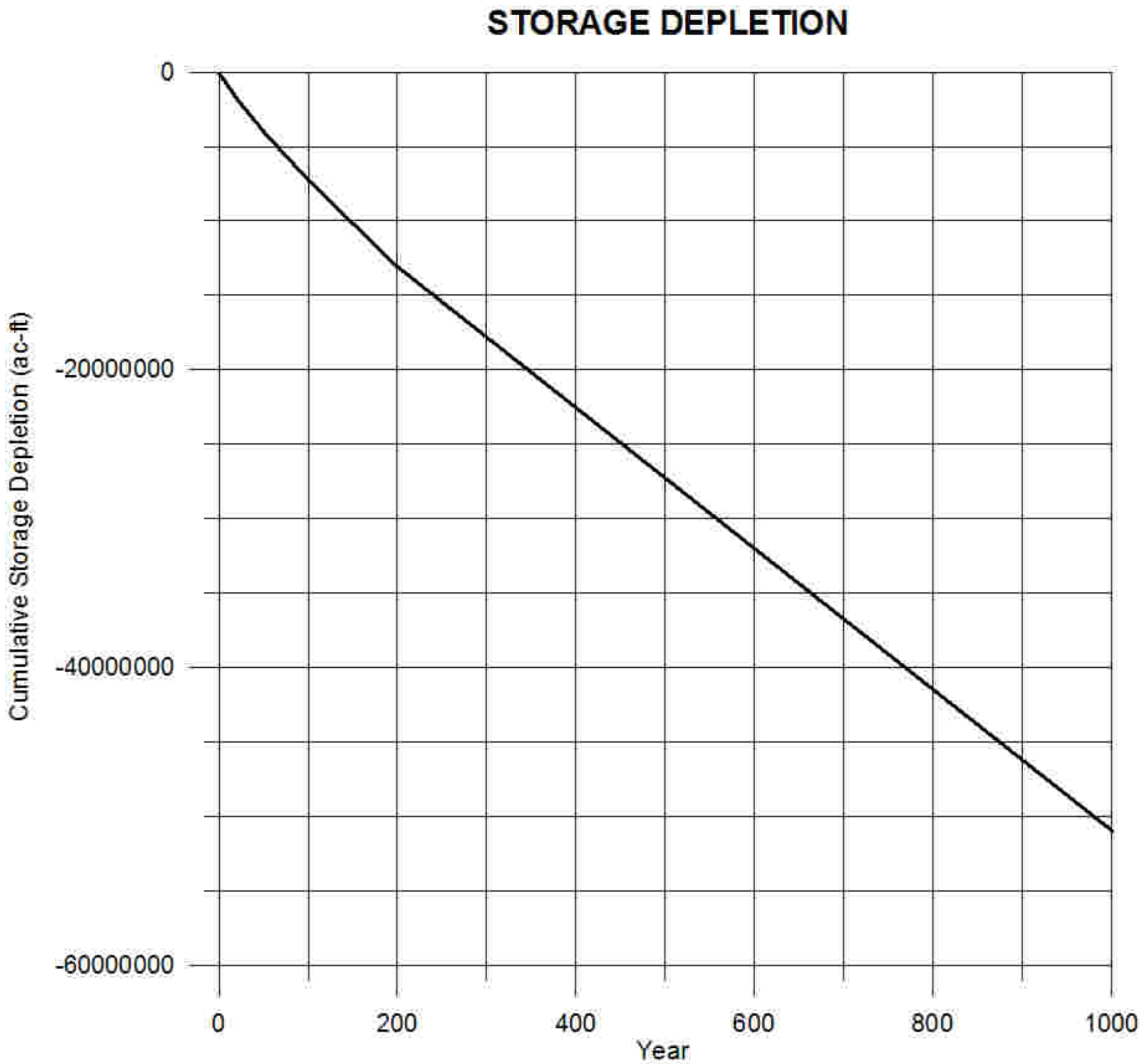

Figure 2. Cumulative depletion of storage caused by the SNWA pumping.

After 100 years of SNWA pumping the storage depletion is approximately 7,000,000 ac-ft, that exceeds the transitional storage reserve estimated above. After 900 years of pumping, the cumulative storage depletion exceeds 45,000,000 ac-ft the amount allocated by the State as the transitional storage reserve for the entire Central Region—Table 1-A.

CONCLUSIONS

Both the USGS RASA and Tom Myers MODFLOW model of Spring Valley indicate that the SNWA pumping will produce large drawdowns in the southern part of Spring Valley that will adversely impact the current water users in the Valley. The SNWA pumping, if it persists for long periods, will exceed the transitional storage reserve for the Central Hydrographic Region.

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