Review and Evaluation of the Spring Valley Groundwater Model Developed by Myers (2011b)

PRESENTATION TO THE OFFICE OF THE NEVADA STATE ENGINEER

Prepared for

SOUTHERN NEVADA WATER AUTHORITY

Prepared by

EarthKnowledge
Information for Sound Decisions

August 2011

Suggested citation:
D'Agnese, F.A., 2011, Review and evaluation of the Spring Valley groundwater model developed by Myers (2011b): Presentation to the Office of the Nevada State Engineer: EarthKnowledge, Tucson, Arizona.

Review and Evaluation of the Spring Valley Groundwater Model Developed by Myers (2011b)

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Pertaining to:
Groundwater Applications 54003 through 54021 in
Spring Valley
and
Groundwater Applications 53987 through 53992 in
Cave, Dry Lake, and Delamar Valleys

August 2011

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8/20/2011
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1.0 INTRODUCTION

This section presents an evaluation of the Myers (2011b) groundwater model.

The evaluation demonstrates that the numerical model and the accompanying documentation contain (1) ***obvious*** model construction errors, (2) ***highly-subjective*** hydrogeologic framework features, and (3) ***significant documentation omissions*** that render the model ***insupportable*** and ***unreliable*** as a predictive or decision-making tool.

Furthermore, many of the hydrogeologic features incorporated in the model clearly over-constrain model simulation results, in effect, forcing the model to simulate clearly interpretive or preconceived groundwater flow conditions.

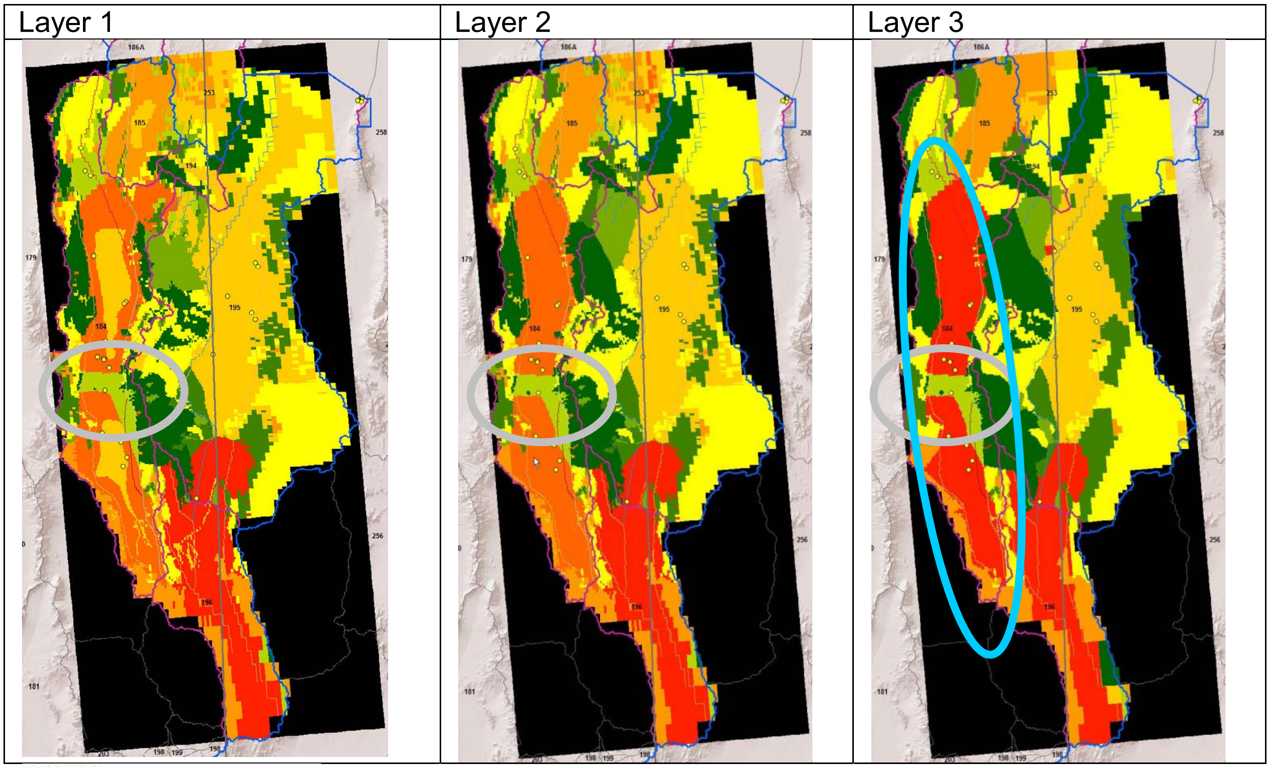
The evaluation is comprised of (1) a description of several aspects of the model configuration including hydraulic conductivity (K), transmissivity (T), general head boundaries, and horizontal flow barriers; and (2) a description of several aspects of the numerical model simulations and results including simulated flow regions and inter-basin flows, hydraulic-heads (water levels), and spring pool elevations.

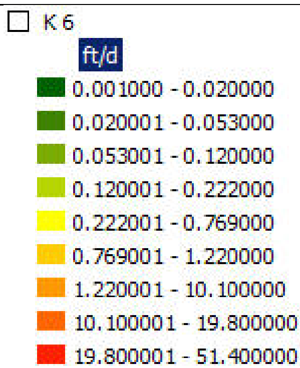
The model evaluation and the development of this document were conducted over a time-period of approximately 300 person hours. The effort involved:

1. reviewing the models files that were received,
2. importing the files into the Groundwater Vistas Pre- and Post-Processing Software Package,
3. running the steady-state version of the model,
4. comparing steady-state simulation results to Myers' hydraulic-head (water-level) observations,
5. comparing steady-state simulation results to hydraulic-head and spring-flow observations from the Central Carbonate Rock Province Model (SNWA, 2009) model,
6. post processing of model results to visualize hydraulic conductivity and transmissivity by layer and/or over the aggregate thickness of the seven model layers,
7. an accounting of interbasin flows between hydrographic areas, and
8. an evaluation of model fit through a comparison of observed versus simulated hydraulic heads (water levels).

1.1 *Hydraulic Conductivity and Transmissivity Distributions*

A series of highly interpretive hydrogeologic features are clearly present in the hydraulic conductivity and transmissivity distributions incorporated into the model. The justification for incorporating these features is rarely if ever provided in the Myers (2011b) report. These features are not adequately associated with known hydrogeologic units or structures.





Note: Same explanation is used for all hydraulic conductivity arrays in Layers 1 through 7

Figure 1
Hydraulic Conductivity Distribution in Layers 1, 2, and 3

In Figure 1 (above), various unusual hydrogeologic features are apparent, including:

1. A small-K (hydraulic conductivity) unit separating north and south Spring Valley (circled in Gray) has been placed into the Myers model in Layers 1, 2, and 3. This east-west trending unit forces the model to simulate a groundwater divide between north and south Spring Valley

creating two distinctly separate basin-fill groundwater systems. Ultimately, this feature will result in predicted drawdowns from pumping wells (placed on either side of this feature) to be over-estimated (greater than expected) as the propagation of drawdown reaches this interpreted barrier to flow.

2. Large-K basin fill units have been placed in Spring Valley in Layer 3 (circled in Blue). These units represent a zone of increased flow at depth. It is unlikely that this zone would exist as lithologic borehole data of basin-fill units in this region indicate that hydraulic conductivity decreases with depth. The presence of this large transmissivity zone is contrary to observed data. Ultimately, this feature will result in a highly-connective layer at depth. Any pumping wells that intersect this unit in the predictive simulations will essentially draw water from this layer causing effects to propagate easily through the valley.

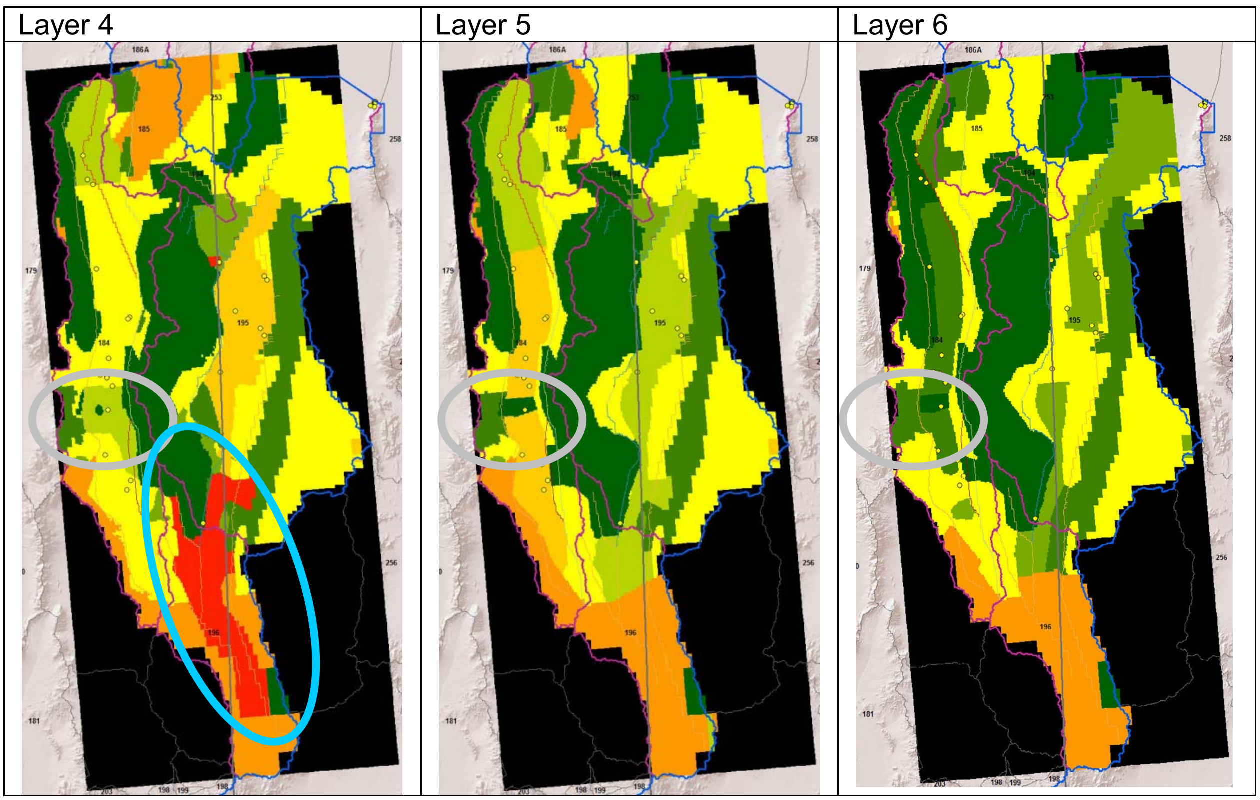


Figure 2
Hydraulic Conductivity Distribution in Layers 4, 5, and 6

In Figure 2 (above), two unusual hydrogeologic features are apparent, including:

1. Similar to Item #1 corresponding to Figure 1 (above), a small-K unit separating north and south Spring Valley (circled in Gray) has been placed into the model in Layers 4, 5, and 6. This east-west trending unit forces the model to simulate a groundwater divide between north and south Spring Valley creating two distinctly separate basin-fill groundwater systems. Ultimately, this feature will result in predicted drawdowns from pumping wells (placed on

either side of this feature) to be over-estimated (greater than expected) as the propagation of drawdown reaches this interpreted barrier to flow.

2. A large-K zone of 20 – 51 ft/day has been incorporated into Hamlin Valley and extends up through Snake Valley in Layers 1, 2, 3, and 4 (circled in Blue). The justification for the increased flow characteristics of the basin fill in this area is not provided in the documentation and no known data supports its existence. Ultimately, this feature results in very high connectivity between Spring, Hamlin, and Snake Valleys. Any pumping wells that intersect this zone in the predictive simulations will essentially draw water from throughout this region (and these model layers) causing effects of drawdown and groundwater capture to propagate more quickly than would be expected if the model had been built with generally accepted conductivity in this zone.

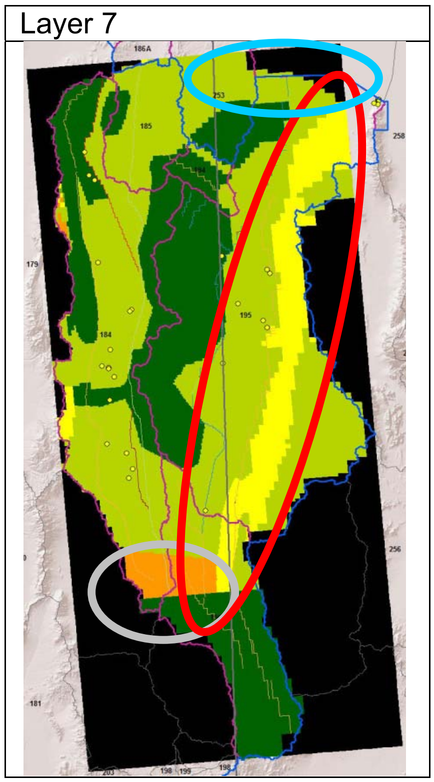


Figure 3
Hydraulic Conductivity Distribution in Layer 7

In Figure 3 (above), three unusual hydrogeologic features are apparent, including:

1. A moderate-K zone of basin fill has been placed in the model in Layer 7. This zone (circled in Red) extends from Hamlin Valley to the northern end of Snake Valley. Ultimately, this feature results in very high connectivity between Hamlin Valley and Snake Valley. Any pumping wells that intersect this zone in the predictive simulations will essentially draw water from throughout this region causing effects of drawdown and ground water capture to propagate quickly.

2. An east-west trending larger-K unit has been placed in the model in Layer 7 that creates a significant hydraulic connection between southern Spring and Hamlin Valleys (circled in Gray). The feature results in east-west connectivity between Steptoe, Spring, and Hamlin Valleys at depth and is not associated with any hydrogeologic feature that is described in the model documentation.

3. A zone of increased K has been placed in model Layer 7 that connects northern Snake Valley with Deep Creek Valley (circled in Blue). The zone has a larger-K relative to the rock units overlying it in layers 3, 4, 5, and 6. There is no explanation in the documentation explaining why a rock unit occurring under a mountain block would have an increased hydraulic conductivity, and its existence goes against established geologic principles. This zone effectively creates a "permeable tube" that connects these valleys at the bottom layer of the model. This zone will allow any simulated pumping in Snake Valley to affect water levels in Deep Creek valley more easily.

The Layer-7 Transmissivity Map (Figure 4, below left) and the Total Thickness Transmissivity Map (Figure 4, below right) illustrate features that are not described in the numerical model documentation but clearly force the model to simulate a specific flow field. These do not seem to follow readily observed and apparent hydrogeologic features. The features include:

1. A large-T (hydraulic transmissivity) east-west feature connects Steptoe Valley, Spring Valley, and Hamlin Valley (circled in Purple). This large-T zone creates significant hydraulic connection between southern Spring Valley and Hamlin Valley. Any pumping wells that intersect this zone in the predictive simulations will essentially draw water from throughout this region (and associated model layers) causing effects of drawdown and groundwater capture to propagate quickly.

2. A very large T zone occurs through the entire aggregate thickness of the model in Hamlin Valley (circled in Gray). This results in a significant hydraulic connection between Hamlin Valley, Spring Valley, and Snake Valley. There is no justification for basin fill units in Hamlin Valley to have such extreme transmissivities that range from 38,000 to 130,000 ft^2/day.

3. A small T zone occurs through the entire aggregate thickness of the model that separates north and south Spring Valley (circled in Green). As discussed in the section on hydraulic conductivity above, this east-west trending unit forces the model to simulate a groundwater divide between north and south Spring Valley creating two distinctly separate basin-fill groundwater systems. Ultimately, this feature will result in predicted drawdowns from pumping wells (placed on either side of this feature) to be over-estimated (greater than expected) as the propagation of drawdown reaches this interpreted barrier to flow.

4. A large T zone extends from the Big Springs area to the north end of Snake Valley in Layer 7 (circled in White) resulting in a "buried permeable tube" that creates a significant hydraulic connection between Hamlin Valley and the northern end of Snake Valley. No explanation is provided to justify this feature and existing data does not support its existence.

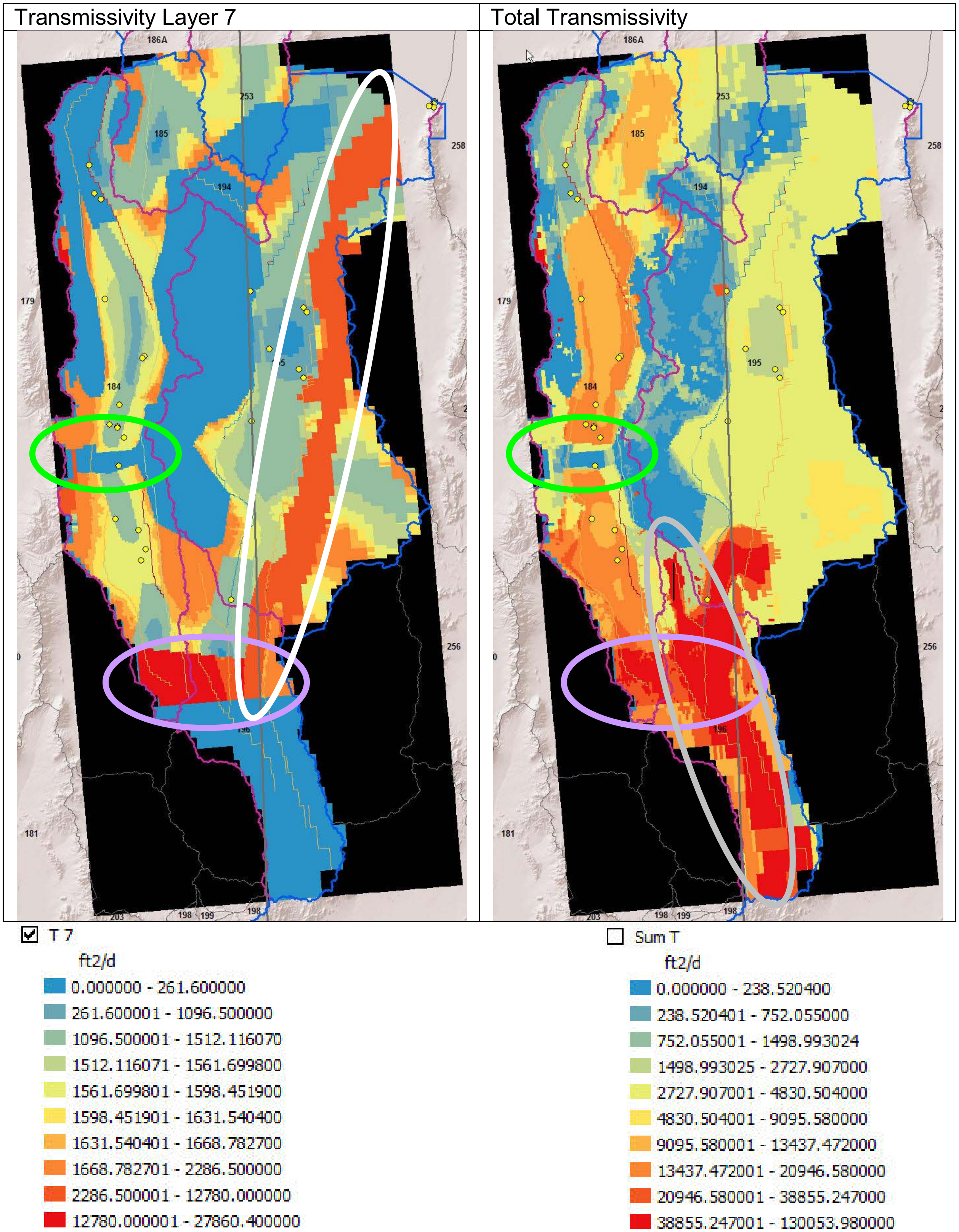


Figure 4
Transmissivity Distribution for Layer 7 and for the Total Model Thickness

1.2 General Head Boundaries (GHBs)

GHBs are used to define (permanently fix) water levels at the model boundaries and directly control how ground water flows into, or out of, the model. For the CCRP model (SNWA, 2009), these features were determined to be some of the most sensitive model parameters (the most important model features). The definition of these boundaries are inadequately described and poorly illustrated in Myers' report. In fact, the figure provided in the documentation does not even represent where these features occur. The figures provided below illustrate that most of these GHB features (circled in Blue) occur at depth suggesting deep connection rather than a shallow groundwater system connection between adjoining hydrographic areas (Figures 5 and 6).

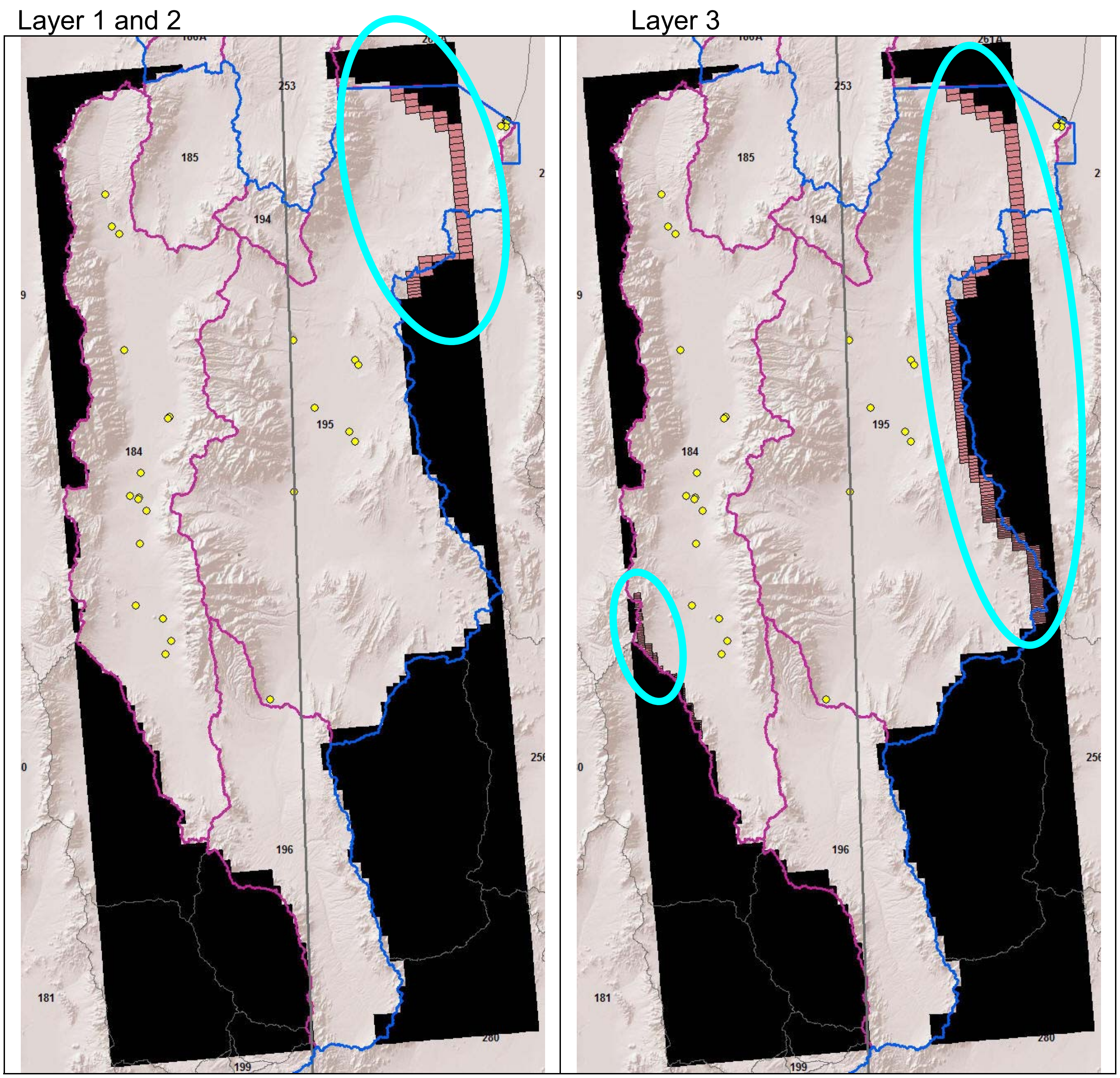


Figure 5
General Head Boundaries for Layers 1, 2, and 3

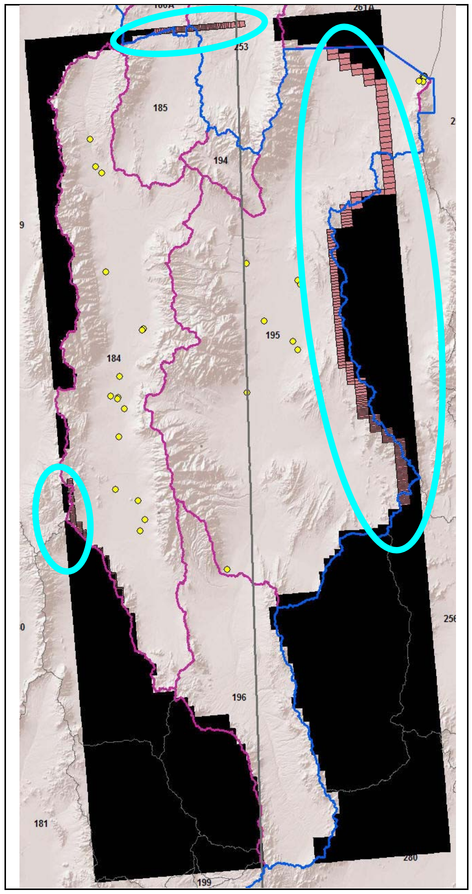


Figure 6
General Head Boundaries for Layers 4 through 7

1.3 Horizontal-Flow Barriers (HFBs)

The HFB Package is often used to represent a natural or man-made feature that impedes horizontal groundwater flow. The HFB package has often been used to represent geologic faults that are interpreted to impede and/or redirect groundwater in Great Basin groundwater flow systems.

In the Spring Valley model (Myers, 2011b) the HFB Package is used to represent faults occurring in the groundwater system; however, the setup and configuration of the HFBs is highly questionable. In many cases, the HFBs defined in Snake Valley are highly discontinuous and contorted. No reason for this is explained in the text.

For example, in North and East Snake Valley (Figure 7), the HFBs (shown in green below) are highly broken up laterally. Also, in shallow layers, HFB segments are more discontinuous than in deeper layers. This is also not explained.

HFBs are not continuous vertically. Many do not extend into layers 1 and 2. This also is not discussed in the documentation. Many HFBs also seem to be discontinuous along mountain fronts. The reasoning for these configurations are not explained.

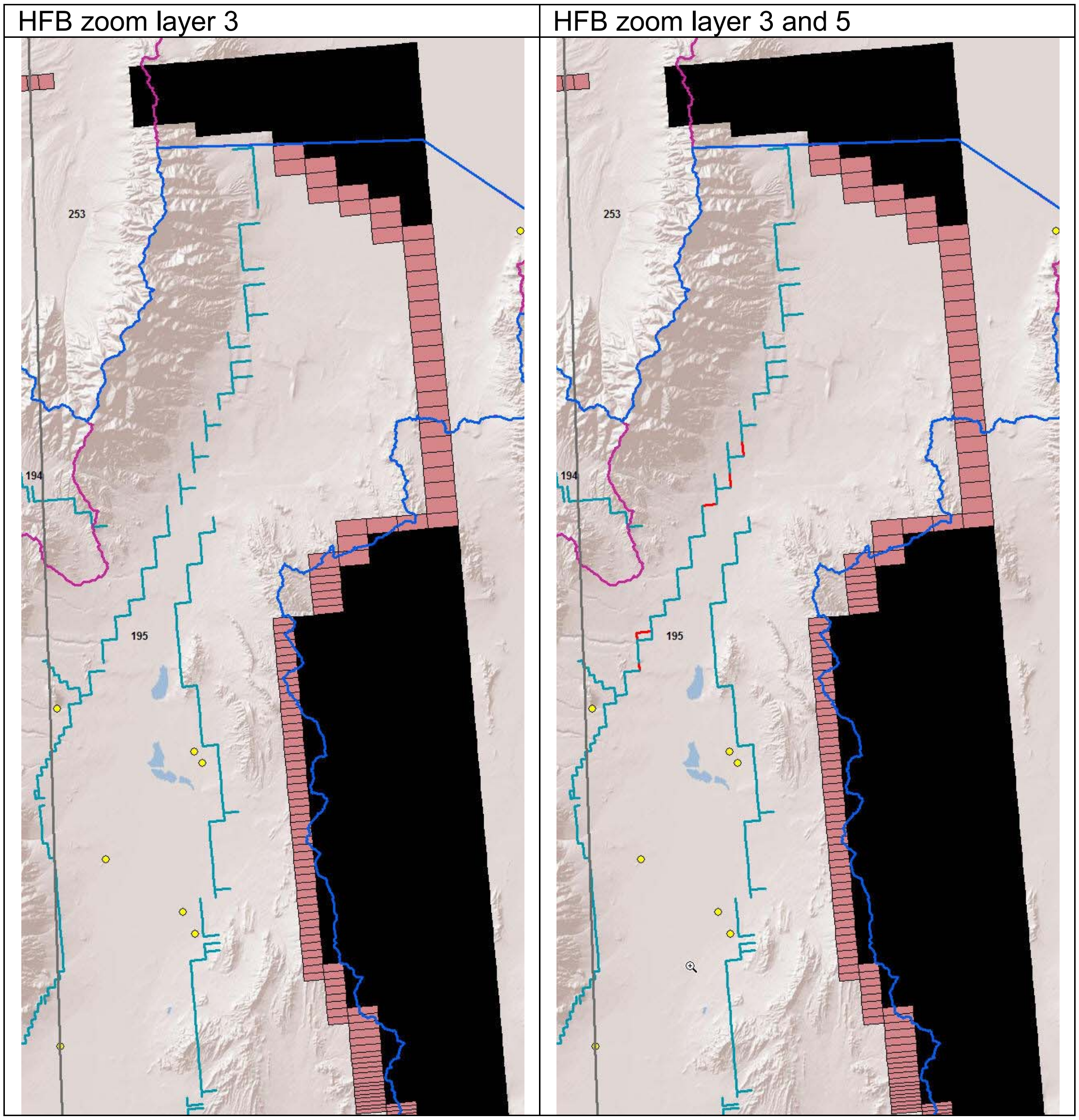


Figure 7
Horizontal Flow Barriers Layers 3 and 5

There also is a set of HFBs in Southern Spring Valley (not illustrated) along the Snake Range that are only in layers 5 and 6.

The inconsistent representation of faults as HFBs without discussion in the conceptual or numerical model documentation leads the reviewer to conclude that these are errors in model construction and not part of a consistent conceptual representation.

1.4 Flow Regions and Interbasin Flows

The resulting steady-state water levels from the Myers (2011b) model were evaluated to assess the location of groundwater divides and dominant groundwater flow paths for each model layer. Groundwater flow regions were delineated from the simulated water levels. This exercise indicates that the model simulates distinct groundwater divides and disconnected subregions in Layer 2 and less pronounced groundwater divides and more hydraulic connection between Spring and Snake Valley in Layer 7.

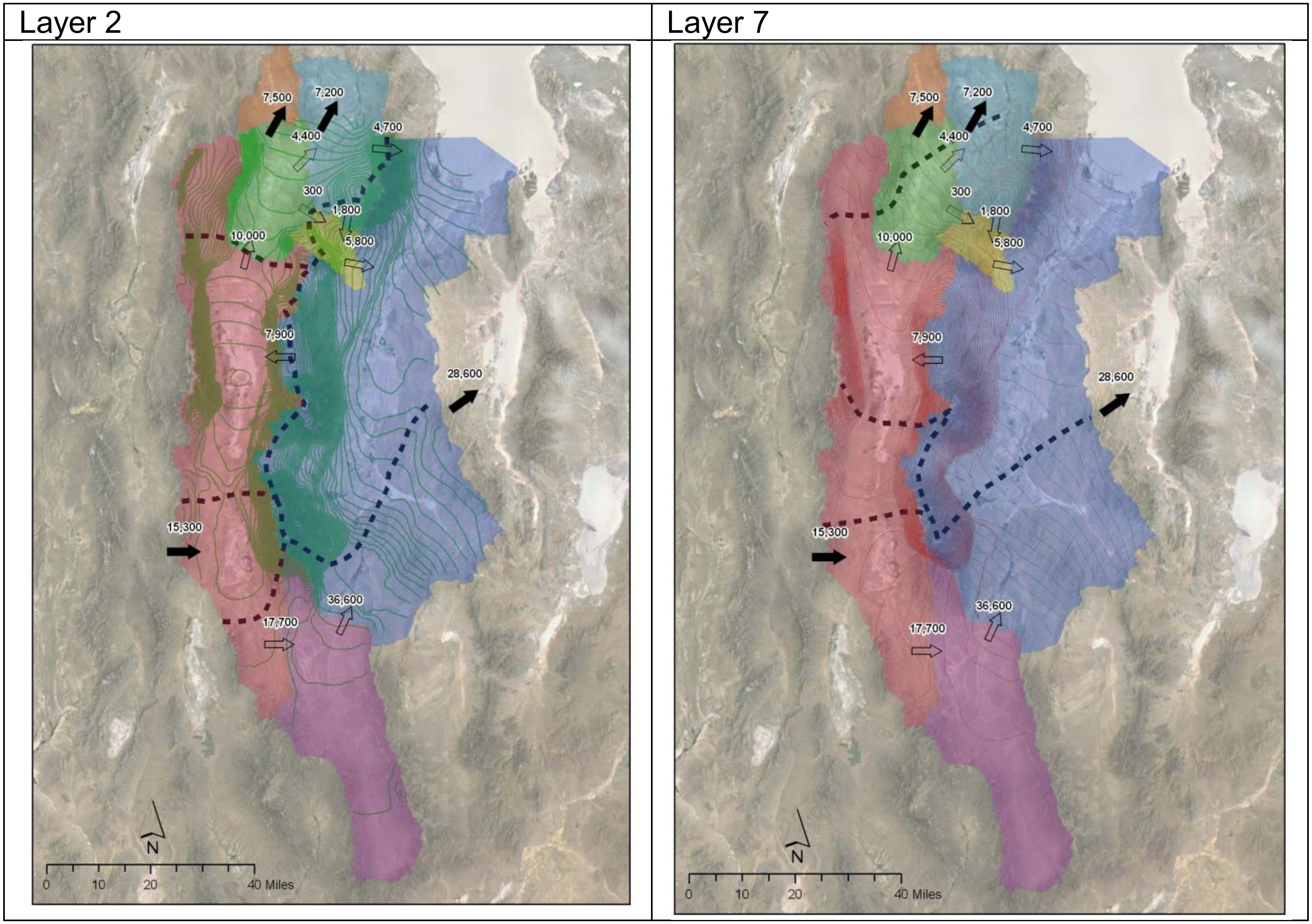
Ultimately, the Myers model hydraulic connection between Spring and Snake Valley will allow drawdowns and groundwater capture from simulated pumping to easily propagate into these adjacent valleys (Figure 8).

A map of hydraulic head unweighted residuals (observed minus simulated water levels) indicates that the majority of well-matched simulated heads occur only in isolated locations in the valley bottom of Spring and Snake Valley. Many of the simulated hydraulic heads (water levels) are more than 50 ft above their target. These over-simulated water levels (negative unweighted residuals) are dominant in Tippett Valley, northern Spring Valley, southern Spring Valley, northern Hamlin Valley, southern Snake Valley, and northern Snake Valley.

Unfortunately, Myers' model tends to simulate water levels well below the targets in large expanses of the valley bottoms of Spring and Snake Valley. These areas are also coincident with large areas of groundwater evapotranspiration. The effect of simulating water levels more than 50 ft below the intended target results in an extreme under simulation of groundwater discharge particularly from Snake Valley.

Specifically, simulated ET rates by Myers are consistently smaller than BARCASS rates (Table 1). For example, rates in Snake Valley range approximately 31 to 62 percent lower than BARCASS. Perhaps as a way to compensate for this Myers simulates ET areas that are considerably larger than Welch et al. (2007). For example, Myers simulates an ET area for Big Snake Valley that is 131 percent larger than that of Welch et al. (2007).

Even with a larger ET area, simulated ET in Snake Valley is about half the estimate of Welch et al. (2007). The under-simulation of ET in Snake Valley is consistent with the under simulated heads in Snake Valley. As shown in Figure 9, the distribution of unweighted head residuals in Snake Valley clearly shows that the water table in the central Snake Valley is underestimated by at least 50 ft. This region of under-simulated heads, and subsequent under-estimation of ET, is an example of the consistently poor calibration (poor fit to observations) throughout the model domain. Under-simulating ET by half and disregarding the size of ET areas significantly highlights the weakness of the conceptualization presented for the flow system in Myers' numerical model.



Note: Interbasin flow represents flow across a hydrographic area boundary for the entire model thickness.

Figure 8
Flow Regions Based on Simulated Water Levels for Layers 2 and 7

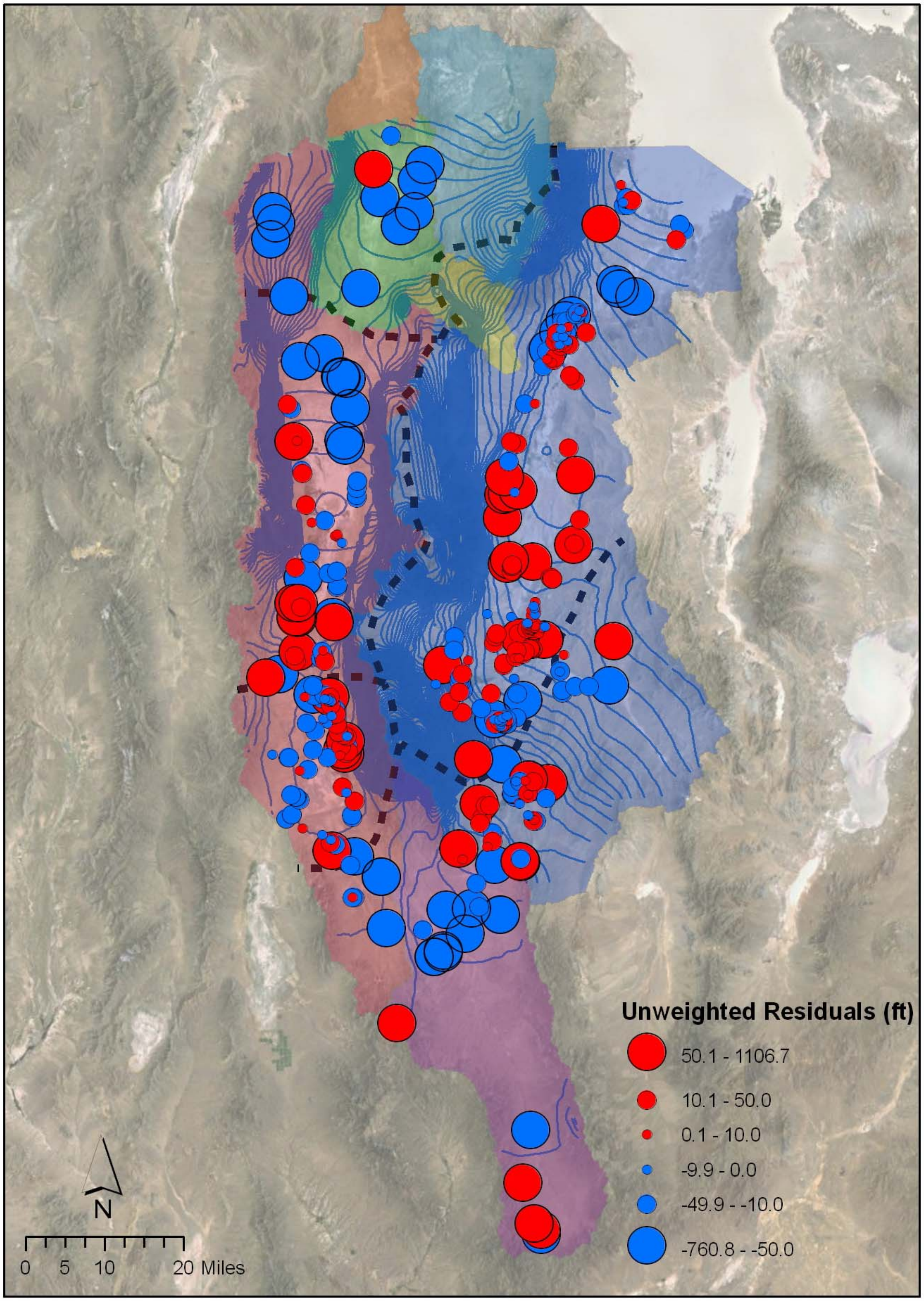


Figure 9
Map of Unweighted Residuals Based on CCRP Observations

Table 1
Maximum and Myers Model Simulated ET Rates and ET Extinction Depths

Myers Model ET Zone	Type	Valley	Calibrated Maximum ET Rate (ft/d)	Calibrated Maximum ET Rate (ft/yr)	BARCASS ET Rate (ft/d)	BARCASS ET Rate (ft/yr)	Myers Simulated ET Rate[a] (ft/d)	Myers Simulated ET Rate[a] (ft/yr)	Extinction Depth (ft)
1	Playas	All	0.00073	0.27	0.00197	0.72	0.000608	0.22	30
2	Sparse shrub	Snake	0.00236	0.86	0.00236	0.86	0.000830	0.30	50
3	Sparse shrub	Spring	0.0004	0.15	0.00258	0.94	0.000352	0.13	50
4	Moderate shrub	Snake	0.00288	1.05	0.00288	1.05	NA	NA	50
5	Moderate shrub	Spring, Tippett	0.00301	1.10	0.00201	0.73	0.001808	0.66	50
6	Moist bare soil	Spring	0.00548	2.00	0.00548	2.00	0.004214	1.54	20
7	Avg of marsh and meadowland	Snake[b]	0.00908	3.31	0.00908	3.31	0.005649	2.06	20
8	Avg of marsh and meadowland	Spring[b]	0.00738	2.69	0.00933	3.41	0.004497	1.64	20
9	Sparse shrub	Tippett	0.00271	0.99	0.00271	0.99	0.002144	0.78	50
11	Riparian marshland	Spring	0.0114	4.16	0.01123	4.10	0.010275	3.75	20
NA	Close to BARCAS agriculture areas	Snake	0.003501	1.28	---	---	0.002375	0.87	50

[a]ET rate at water table.
[b]Valley not detectable in Table 3 of Myers (2011b)

1.5 Summary

To reiterate, the model evaluation presented demonstrates that the Myers numerical model and the accompanying documentation contain (1) ***obvious*** model construction errors, (2) ***highly-subjective*** hydrogeologic framework features, and (3) ***significant documentation omissions*** that render the model ***insupportable*** and ***unreliable*** as a predictive or decision-making tool.

Furthermore, many of the hydrogeologic features incorporated in the model clearly over-constrain model simulation results, in effect, forcing the model to simulate clearly interpretive or preconceived groundwater flow conditions.

2.0 ADHERENCE TO THE METHODS AND GUIDELINES OF EFFECTIVE MODEL CALIBRATION (HILL AND TIEDEMAN, 2007)

The following discussion provides examples of how Myers inadequately documents his adherence to, or inappropriately interprets the “methods and guidelines” developed by Hill and Tiedeman (2007). These inaccuracies and inadequacies in documentation result in a false indication that the model has been rigorously developed in accordance with these important guidelines.

Guideline 1: Apply the Principle of Parsimony

Myers indicates that he strictly adheres to the principle of parsimony. According to Hill and Tiedeman (2007): “using the principle of parsimony, a groundwater model is kept as simple as possible while still accounting for the system processes and characteristics evident in the observations and while respecting other information about the system. In many fields, including groundwater hydrology, the known complexities of the systems being simulated often seem overwhelming, and being parsimonious in model development can require substantial restraint.”

Myers’ documentation of the Spring Valley model, however, provides documentation of insufficient detail and quality to adequately assess if a meaningful model design and construction has been undertaken.

Examples include:

- The original source of the 3D hydrogeologic framework presented and its representation in the model (i.e., sections, block model, etc.) is not provided.
- Grid layering with respect to hydrogeologic framework is not illustrated.
- Distribution of hydraulic conductivity parameter zones is indistinguishable due to poor quality of figures (Myers, 2011b, Figures 3 through 9).
- Representation of faults within the model (i.e., units, depth of penetration, vertical/ non-vertical) is not discussed or illustrated.

Guideline 2: Use a Broad Range of Information to Constrain the Problem

Myers indicates that he adheres to Guideline 2 because he used a great deal of available data related to this hydrologic basin. He demonstrates this by describing the comprehensive nature of his geographic information systems. However, the guideline, described by Hill and Tiedeman (2007) actually refers to the type of data that is used to constrain the objective function that is mathematically minimized during non-linear regression. For example, if a groundwater model is to have any credibility, it must respect what is known about the hydrology and hydrogeology of a groundwater system. In the case of the Spring Valley region, a very complex conceptual model must be justified with numerous model observations that in fact constrain the numerical model, so the model matches natural conditions well (i.e., the model is "constrained by real world observations"). Observations used to constrain the model should include hydraulic-head, hydraulic-drawdown, spring-head, groundwater ET, spring-flow, spring-flow change, and stream-flow observations. However, Myers confuses this issue by merely stating that he uses a great deal of data, but actually only uses hydraulic-head observations to constrain the objective function.

Guideline 3: Maintain a Well-Posed, Comprehensive Regression Problem

Hill and Tiedeman (2007) describe a well-posed regression problem as one that will converge to an optimal set of parameter values given reasonable starting parameter values. Given commonly available data, the requirement of maintaining a well-posed regression produces rather simple models with relatively few estimated parameters. However, the best regression results are typically derived when very simple models are created. In a hydrogeologically complex region like the Great Basin, there is a challenge to determine the greatest possible level of model complexity while still maintaining a well-posed regression.

Myers does not directly address this issue by illustrating defined parameters or by describing parameter sensitivity. Instead, he states that in many cases parameters were defined "based of subjective judgment." (Myers, 2011b, page 3).

Guideline 4: Include Many Kinds of Data as Observations in the Regression

Guideline 4 (Hill and Tiedeman, 2007) stresses the importance of using as many kinds of observations as possible. For example, in many cases in groundwater models of the Great Basin, it is very important to augment the available hydraulic-head observations with numerous flow observations. The latter serves to constrain the model solution much more than the relatively easy-to-fit hydraulic heads, and therefore, using observations that reflect the rate of groundwater flow out of the model at a specific location promotes the development of a more accurate model.

Despite Myers' claim that he adheres to this guideline, he actually violates it by only utilizing head observations to constrain the objective function. As a result, the regression statistics tell us nothing at all about the flows (springs, ET, boundary flux). If these are not included as part of the regression then the statistics are not a valid indicator of model fit. This is significant because there is no information gained from the regression statistics that provide useful insight into the validity of the predictions of drawdowns or reductions in spring flows resulting from pumping.

Guideline 5: Use Prior Information Carefully

Hill and Tiedeman (2007) discuss the use of prior information in groundwater flow models. By definition "prior information" are data or information that are the result of direct measurements in the natural system that are directly transferable to the scale and scope of the numerical model that is being constructed of the natural system. This is rarely or never possible in models of this scale. Myers' claim that he is using prior information is a reflection of his misunderstanding of the term and its inappropriate use.

Guideline 6: Assign Observation Weights that Reflect Measurement Errors

Guideline 6 described by Hill and Tiedeman emphasizes the need to assign appropriate observation weights as an important component of auto-calibration by non-linear regression. They clearly indicate that model observation weights ultimately constrain the model calibration. In general, relatively accurate water levels or spring flows that are used as observations are weighted more heavily than relatively inaccurate measurements.

Myers only utilizes hydraulic-head observations in his regression and states that all observations are provided a weight of 1.0. This would suggest that all water levels in the model domain have the same accuracy and should be matched during calibration with equal significance. This is very clearly not the case and is a clear violation of Guideline 6.

In fact, the observation dataset presented in Appendix A appears to be the mean water levels developed by SNWA (2008, Volume 4). SNWA provides details of multiple sources of observation error: "a mean hydraulic head value for a site is derived from the land-surface elevation and the average water-level elevation measurement. As a result, the uncertainty associated with a mean water-level elevation for a given site results from four main sources of error: (1) the error associated with estimating the land-surface elevation, (2) the error associated with the location of a site, (3) the error associated with measuring the depth to water, and (4) the error associated with reducing multiple water-level measurements to a mean value (i.e., water-level variability)." By not sufficiently conducting the comprehensive data analysis that Hill and Tiedeman (2007) call for in this guideline, Myers significantly limits a rigorous discussion about the quality of the model fit or the effectiveness of the predictive capacity of the model he has developed.

Guideline 7: Encourage Convergence by Making the Model More Accurate

Myers states that there was no point in the modeling exercise where model convergence was an issue. However, he is not clearly addressing the definition of convergence provided by Hill and Tiedeman (2007). They point out that nonlinear regression models of complex systems often have difficulty converging on an optimal solution. In general, convergence is improved as the model becomes a better representation of the system that produced the observations being matched by the regression, so that the goal of achieving convergence and a valid regression and the goal of model calibration generally are identical. Substantial insight about the model can be obtained by using the information available from unconverged regressions, such as dimensionless and scaled sensitivities, composite scaled sensitivities, parameter correlation coefficients, weighted and unweighted residuals, and parameter updates calculated by the regression. This information can be used to evaluate the parameters, observations, and fit of the existing model, and to detect inaccuracies in model construction.

Since Myers provides no documentation on model convergence and the execution of a valid regression there is no evidence that this was achieved or that he even evaluated this as part of model calibration criteria.

Guideline 8: Test Alternative Models

In most groundwater models, there is more than one possible representation of the system involved, and this guideline encourages testing as many alternative models as feasible. Such testing is a viable alternative when inverse modeling is used. Models that are more likely to be accurate tend to have three attributes: better fit, weighted residuals that are more randomly distributed, and more realistic optimal parameter values.

Myers discusses the evaluation of alternative conceptual models only in the context of HFBs. In this evaluation, he tests a conceptual model in which all HFBs are removed from the model. He concludes that the faults are necessary components of the model configuration (Myers, 2011b; p. 41).

Guideline 9: Evaluate Model Fit

Guideline 9 predominantly addresses model fit (or in essence "goodness" of model calibration). The most basic attribute of nonlinear regression methods is that, given a well-posed problem, parameter values are calculated that produce the best fit between simulated and observed values. The model can then be evaluated without wondering whether a different set of parameter values would be better.

Two common problems are strong indicators of model error: (1) the model does a poor job of matching real observations of the natural system, and (2) the optimized parameter values are unrealistic and confidence intervals on the optimized values do not include reasonable values.

There is really no way to evaluate these indicators of model fit because Myers does not evaluate the quality of all of his observations (hydraulic heads, spring flows, evapotranspiration [ET], and boundary fluxes), he does not use these data to adequately constrain his calibration, and he does not provide sufficient discussion about the resulting model fit.

Guideline 10: Evaluate Optimized Parameter Values

Optimized parameter values are evaluated by comparing them and their confidence intervals with independent information about the parameter values. The independent information may include ranges of expected values, and (or) a relative ordering of values.

Myers only compares the storage values he uses in his transient simulations to previous reports. There is no discussion on the validity of the hydraulic conductivity values used. There is a brief comparison of the simulated ET rates used in the model but how the differences might affect the calibrated model is not described.

Guideline 11: Identify New Data to Improve Simulated Processes, Features, and Properties

Hill and Tiedeman (2007) discuss the need to evaluate the model with newly available data to test existing hypotheses about model configuration and the hydrologic conceptual model. Potentially new data may be evaluated to test specific aspects of the model. In the case of Myers' model, he states that: "New wells were added several times, as they were drilled by SNWA, Utah Geological Survey, and U.S. Geological Survey. Additionally, I performed synoptic surveys on two streams and used such data from Elliot et al. (2006). Additionally, spring data at Stateline Springs and the secondary recharge below several springs was estimated and modeled." This data, however, is not presented and the results of having added this new data are not described. As he does earlier in his investigation, Myers neglects to discuss the quality of the data and the significance of the model fit to this data in any way. The reader is left not knowing the relevance of this new data or its significance in the post audit he apparently has conducted.

Guideline 12: Identify New Data to Improve Predictions

Hill and Tiedeman (2007) discuss how a model may be used to help select the location and type of new data to help improve predictions by reducing uncertainty in parameters that clearly affect a specific prediction. Myers misinterprets this guideline by inferring that a recent transient simulation developed by Halford and Plume (2011) provides insight that ultimately improves the predictions of Myers' model. However, consideration of a new transient simulation is not identification of new data.

Guideline 13: Evaluate Prediction Uncertainty and Accuracy Using Deterministic Methods

Hill and Tiedeman (2007) describe a process by which omitted data and post-audits may be used to assess the validity of model simulated predictions. In this particular case the model is assessed for prediction accuracy by actually replicating the model predictive scenario in the actual system. Myers states that he addresses this by "bracketing the specific storage values in the model." Because storage values are not capable of direct field measurement, clearly Myers is not referring to an actual field test., which would be the deterministic method Hill and Tiedeman recommend.

Guideline 14: Quantify Prediction Uncertainty Using Statistical Methods

Hill and Tiedeman (2007) describe a process by which the validity of model predictions can be assessed using inferential statistical methods or through stochastic methods external to the model. They also provide a means for assessing the uncertainty of the model predictions by utilizing regression statistics from the uncertainty analysis conducted on the transient numerical model. There is no indication in Myers' report that any of these methods were used to assess the uncertainty of his model statistics. The lack of a very objective statistical uncertainty analysis leads the reader to conclude that the model is and its predictions are purely interpretive and highly subjective.

3.0 REFERENCES

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