Cave, Dry Lake, and Delamar Valleys Hydrogeologic Rebuttal Report in Response to Myers (2011d)

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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

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Myers (2011d) - Hydrogeology of Cave, Dry Lake and Delamar Valleys

The Myers (2011d) report entitled *"Hydrogeology of Cave, Dry Lake and Delamar Valleys: Impacts of Pumping Underground Water Rights Applications #53987 through 53092"* is a revision of Myers (2007). Myers (2011d) compiles a groundwater budget for the White River Flow System (WRFS) and presents an overview of water rights, with emphasis on Cave, Dry Lake, Delamar, White River, and Pahranagat valleys. Additionally, Myers (2011d) describes the results of an analysis regarding the potential effects of proposed pumping associated with the Southern Nevada Water Authority (SNWA) applications utilizing a modified version of the Regional Aquifer Study Analysis (RASA) conceptual model developed by Prudic et al. (1995).

Like the Myers (2011a, b, and c) reports regarding Spring Valley, Myers (2011d) recites the findings of various previous investigations, but fails to perform any independent analysis to assess the validity of the results. Fundamental conceptual flaws and conflicting arguments are abundant in Myers (2011d), the most noteworthy are that the conclusions are not supported by data or sound scientific reasoning, and that data and results were chosen to support predetermined conclusions. One of the fundamental tenets of groundwater hydrology is the groundwater balance, which Myers (2011d, p. 10-11) emphatically discusses but quickly abandons in order to compile a patch-work groundwater budget comprised of selectively chosen estimates. The fundamental conceptual flaws and conflicting arguments are summarized below, and are discussed in greater detail in subsequent sections of this report.

Data Selection

1. Myers (2011d) geologic setting description is based on the 1:500,000 scale mapping from Stewart and Carlson (1978). Since that time, geologic maps have been published that include much greater detail. These maps should have been used in the description of the geologic setting and effects analysis (see reference list in Rowley et al., 2011). Myers (2011d) use of the out-dated large-scale mapping led to erroneous conclusions regarding the geologic framework and permissible routes of interbasin flow. In Myers (2011d), brief, simplistic chapters on Geology (p. 3-4) and Hydogeology (p. 8) might suggest that he has considered these specialties in his analysis of, at least, interbasin flow but there is no evidence of this in the report. Furthermore, in several places, he states that geology supports his conclusions, but in fact no specifics are given as to the how or why. In these cases the geology argues otherwise.

2. Myers (2011d) does not attempt to derive estimates of recharge using the available data and precipitation maps. Instead, Myers (2011d) adopts estimates from prior studies without applying consistent or standard criteria to the selection process. In fact, no such criteria are ever stated in Myers (2011d), or the Myers (2011a and b) reports regarding Spring Valley. This leads to conflicting results. For example, on one hand, Myers (2011d) criticizes and rejects BARCASS estimates reported by Flint and Flint (2007), yet they are relied upon in

Myers (2011a and b). This is a noteworthy inconsistency that demonstrates the arbitrary selection of estimates to support predetermined conclusions. For Myers (2011d), it appears that the older, outdated recharge estimates from the Reconnaissance Series Reports, which are typically the lowest estimates for these basins, were adopted to minimize recharge in the WRFS, particularly in Dry Lake and Delamar valleys. Only in the southern part of the flow system, in Coyote Spring and Kane Springs valleys, does Myers (2011d) diverge from this approach by selecting more recent estimates that are 2.5 times larger than the Reconnaissance estimates, apparently for the sole purpose of resolving an imbalance in the groundwater budget for this area.

3. Unlike the recharge estimates where Myers (2011d) selects estimates to minimize recharge in the WRFS and in Dry Lake and Delamar valleys, Myers (2011d) adopts more recent and larger estimates of groundwater evapotranspiration (ET) from Welch et al. (2007), proclaiming:

   "The BARCAS GWET estimate is more accurate and a preferable long-term predevelopment estimate that can be used for water budget and perennial yield analysis." Myers (2011d, p. 26)

   The BARCASS groundwater ET estimate for White River Valley is significantly higher than the estimates Maxey and Eakin (1949) relied upon to calibrate their recharge efficiencies in the Reconnaissance Series Reports. Adopting the low, outdated recharge estimates of the Reconnaissance Reports and the more recent and higher groundwater ET estimate of BARCASS yields a pre-development groundwater budget that does not balance, and is inconsistent with the fundamentals of the groundwater balance approach. Therefore, Myers (2011d) adopts the extraordinary estimate of interbasin flow from Jakes Valley postulated by the BARCASS in Welch et al. (2007), yet provides no data, analysis, or rationale supporting the selected estimate. Curiously, Myers (2011d) selects the BARCASS estimate of inflow from Jakes Valley, but not the estimate from Steptoe Valley to White River Valley. Again, no analysis or explanation of the selection is provided.

4. Myers (2011d) does not utilize all available data to inform the development of the groundwater budget. No detailed analysis of hydraulic gradients, aquifer properties, hydrogeologic framework, or groundwater chemistry/stable isotopes was performed to support Myers (2011d) conclusions regarding interbasin flow. No assessment of external boundary fluxes was performed, despite clear evidence of such fluxes across the southern boundary of the flow system (Burns and Drici, 2011; Thomas and Mihevc, 2011).

Technical Approach and Data Analysis

1. Myers (2011d, p. 10-11) presents the primary parameters for the groundwater balance of an aquifer system, and goes on to discuss at great length the Maxey-Eakin method, highlighting the following excerpt from Maxey and Eakin (1949):

   "The recharge estimates were then balanced by trial-and-error with the discharge estimates." (p. 10-11)

While it is appropriate to apply the groundwater-balance method in an assessment of the groundwater budget for the WRFS, it is inappropriate to adopt recharge estimates derived from one set of discharge estimates, and then adopt independent and separate discharge estimates in the budget accounting, as Myers (2011d) does here. In doing so, Myers (2011d) violates the fundamental concepts of steady-state mass-balance expressed by the equation listed on page 10 of his report. In adopting the groundwater ET estimate of Welch et al. (2007) for White River Valley, Myers (2011d) should have completed the groundwater-budget analysis and derived new estimates of recharge. Because this was not done, the groundwater-budget accounting presented in Myers (2011d) is fundamentally flawed, and any opinions/conclusions drawn from it are equally flawed.

2. No genuine attempt was made by Myers (2011d) to compile the requisite data and complete the necessary analyses to support the direction and magnitude of interbasin flow described in the report. No geologic, potentiometric, or geochemical data are presented to substantiate the interbasin flow interpretations. It is important to call attention to this serious limitation because these interpretations are used by Myers (2011d) to describe the groundwater-budget accounting and potential effects related to the SNWA applications. Not considering this information has led to conflicting, confusing, and unsubstantiated statements regarding interbasin flow and potential effects of the SNWA applications.

3. Myers (2011d) presents a groundwater budget analysis for the WRFS for existing groundwater uses (p. 38, Table 9) and full development of the SNWA applications (p. 39, Table 10). Besides the fact that the groundwater budget compilation is greatly flawed as previously described, there are also several conceptual errors assumed in the budget analysis that, when coupled with suspicious accounting methods, leads Myers (2011d) to his pre-determined groundwater budget conclusions. These are addressed as follows:

   First, Myers (2011d) states that all groundwater in Cave Valley flows to White River Valley, except for 1,200 afy that is consumed in the valley by ET. Myers (2011d) provides no data or data analysis to support this opinion, and, in fact, this opinion is contrary to the results of Myers (2011d) conceptual model that describes the steady-state flow regime of Cave Valley. Myers (2011d, p. 46, Table 12) lists the steady-state water balance for Cave Valley for the impacts analysis. This table indicates that over 56 percent of the outflow is to the south rather than to the west and White River Valley.

   Second, Myers (2011d) budget analysis assumes that SNWA pumping in Cave Valley will capture the outflow to White River Valley, but none of the groundwater discharge in White River Valley that relies on this outflow. Based on a comparison of Table 9 and 10 of Myers (2011d) budget analysis, the groundwater discharge in White River Valley does not decrease even though the bulk of the inflow from Cave Valley is captured. The groundwater discharge remains at 76,700 afy, instead of being reduced by the amount of inflow from Cave Valley assumed to be captured by SNWA pumping. In fact, none of the pre-development groundwater discharge estimates (Myers 2011d, p. 35, Table 6) are adjusted to account for the capture of groundwater discharge. The implicit assumption is that pumping can only capture interbasin flow, not groundwater discharge by ET. Myers (2011d) uses these flawed assumptions and suspicious accounting methods to present an erroneous groundwater budget that is used to conclude the groundwater system is completely appropriated.

Third, for the groundwater budget analysis, Myers (2011d) assumes that interbasin groundwater flow is the only water captured by SNWA pumping; however, this assumption is inconsistent with the impacts analysis which presents contrary results describing the capture of groundwater discharge in White River Valley (Myers 2011d, p. 50). Myers (2011d) can not have it both ways. Relying on contradictory results to present different arguments against permitting the SNWA applications is disingenuous at best, and the results of the analysis and conclusions drawn from it should not be relied upon.

Fourth, Myers (2011d) uses the flawed groundwater-budget analysis to conclude that the entire WRFS is appropriated, and that development of the SNWA applications will affect downgradient uses by supposedly capturing all, or a significant portion, of the interbasin flow. As noted later in this report, Myers (2011d) relies on significant interbasin flow from Steptoe and Jakes valleys to balance the postulated groundwater budget. Yet, Myers (2011d) fails to apply the same rationale regarding future development in Steptoe and Jakes valleys that would capture the interbasin flow to the WRFS and White River Valley. As described later in this report, this interbasin flow accounts for 55 percent of the groundwater budget in White River Valley, and 44 percent of the budget for the entire WRFS. Here again, Myers (2011d) demonstrates selective reasoning to argue against the SNWA applications. Applying the same reasoning, all future groundwater development in Jakes Valley and Steptoe Valley (where Ely is located) should be rejected because development in these basins will capture the interbasin flow relied upon by existing uses and environmental resources in White River Valley and the WRFS, Lake Valley and the Meadow Valley Flow System, and Spring, Hamlin, and Snake valleys of the Great Salt Lake Desert Flow System. If applied, this flawed rationale would cease any groundwater development for 26 basins in eastern Nevada. There are several other serious flaws with Myers (2011d) that are addressed in detail in the following sections.

Specific Comments to Myers (2011d)

1. *"The lack of GW ET from areas around the Cave Valley playa (Welch et al, 2008; Moreo et al, 2007) reflects the fact that little groundwater flows from the north, where most recharge occurs, to the south end of the valley."* (p. 9)

   The lack of groundwater ET in the southern part of Cave Valley is not an indication of groundwater flow in one direction or another. Factors that affect groundwater flow are expressed in Darcy's Law, and include the hydraulic properties and thickness of the rock units through which the flow occurs, and the hydraulic gradient across the flow section. Observations of groundwater ET do not provide data from which conclusions on groundwater flow in Cave Valley can be drawn. Furthermore, this statement is contrary to the conceptual model presented later in the report (p. 46, Table 12) and relied upon for the potential effects analysis.

2. *"Groundwater recharge is the meteoric water that reaches the regional groundwater in a basin."* (p. 10)

   Meteoric water recharges regional, intermediate, local, and perched groundwater systems, not just the regional system. The perennial yield includes the groundwater recharge to all of these systems, not just the regional system.

3. *"Because Maxey-Eakin was constrained using discharge estimates, and because they have relatively low coefficients of variation (Avon and Durbin 1994, LVVWD 1992), the Maxey-Eakin method is probably the best estimate for these valleys."* (p. 13)

   "The BARCAS GWET estimate is more accurate and a preferable long-term predevelopment estimate that can be used for water budget and perennial yield analysis." (p. 26)

   Myers (2011d) rationalizes that because the Maxey-Eakin recharge estimates are constrained by groundwater discharge estimates (i.e., groundwater-balance approach), these are the best estimates of recharge for the WRFS. However, Myers (2011d) then states later, in direct conflict with this previous finding, that the Basin and Range Carbonate Aquifer System Study (BARCASS) groundwater-ET estimate is the most accurate and representative of long-term pre-development conditions. Myers (2011d) is again conflicted. An appropriate approach would have been be to revise the groundwater balance using the newer, more accurate estimates of groundwater discharge to derive commensurate recharge efficiencies and volume estimates for each basin.

4. Section entitled *"Interbasin Flow Estimate"* (p. 31-34)

   Myers (2011d) does not perform any compilation or analysis of data required to evaluate interbasin flow associated with Cave, Dry Lake, and Delamar valleys. The description of the hydrogeologic framework is inadequate for the purpose of evaluating the hydrogeologic conditions at the basin boundaries; consequently, Myers (2011d) does not provide a map depicting the locations of interbasin flow, nor hydrogeologic cross-sections that depict the units through which the purported flow supposedly occurs. No compilation or analysis of aquifer-property data was performed and, despite Myers (2011d, p. 8) conceptual description of fault characteristics, faults are not considered as features affecting groundwater flow except in southern Delamar Valley. Myers (2011d) does not mention the presence of the Chainman Shale confining unit that is prevalent throughout the Egan Range, or the eastward dip of the bedding planes. These conditions, coupled with north-south trending range-front faults, would inhibit any flow through the range to the west from Cave Valley to White River Valley, except for some minor amount through Shingle Pass.

   Groundwater elevations were not compiled or evaluated to determine flow directions or hydraulic gradients across potential flow boundaries. For Cave Valley, Myers (2011d) relies upon the regional interpretation of groundwater potentials in the carbonate aquifer based on 500-foot contour intervals (Wilson, 2007). This map does not consider the hydrologic and geologic controls on groundwater flow at the scale needed to evaluate and quantify interbasin flow from the Project Basins. Because of the inadequate description of the hydrogeologic framework, coupled with a coarse interpretation of the regional potentials of the carbonate aquifer, Myers (2011d) incorrectly assumes groundwater flow from Cave Valley through the Egan Range and Chainman Shale confining unit, and across bedding planes. This is an unlikely scenario.

Myers (2011d) does not use available stable-isotope data to evaluate the interbasin flow directions or estimates. Myers (2011d, p. 34) references the well-completion depth of the North Dry Lake MX well and groundwater temperatures measured in the well to conclude the following:

"Groundwater flow to the west, to Pahroc or Pahranagat Valley could occur along the western bound of the valley."

This conclusion is incorrect, as the deuterium observations for groundwater samples collected from the well indicate that the water is consistent with groundwater originating in southern Cave and White River valleys (Burns and Drici, 2011; Thomas and Mihevc, 2011). The deuterium observations for this well are incompatible with local recharge derived in the North Pahroc Range, or ranges to the east of Dry Lake Valley (Burns and Drici, 2011; Thomas and Mihevc, 2011).

Regarding Dry Lake and Delamar valleys, Myers (2011d, p. 34) concludes the following:

"The mountains on the west side were low enough that no groundwater divide would likely form, and contain sufficient carbonate rock to allow flow, therefore the discharge from both valleys is west to Pahranagat and Pahroc Valleys."

Again, Myers (2011d) failure to evaluate all of the information leads to a conclusion that is not supported by the data. The county geology maps of Stewart and Carlson (1978) are 1:500,000 scale and do not depict the detail of the structural geology at a scale needed to evaluate the boundary conditions. Many more faults bound the west side of Dry Lake and Delamar valleys as presented on the more detailed and updated geologic maps of Rowley et al. (2011) and discussed in their Section 6.2.3.2. Myers (2011d) chooses to ignore the control these faults have on groundwater flow, even though the concept is discussed on page 8 of his report. Groundwater flow perpendicular to the strike of these faults (through the low-permeability fault core) and the volcanic rocks of the North Pahroc and South Pahroc ranges is unlikely. Furthermore, deuterium observations for the regional springs in Pahranagat Valley are significantly lighter (i.e., more negative) than the recharge in Dry Lake and Delamar valleys, indicating that groundwater originating in Dry Lake and Delamar valleys is not the source of these springs (Burns and Drici, 2011; Thomas and Mihevc, 2011).

Myers (2011d, p. 35, Table 6) adopts BARCASS interbasin flow estimates reported in Welch et al. (2007) without any discussion or disclosure as to their derivation. Based on Table 6, it appears the inflow to White River Valley is the sum of the 63,000 afy from Jakes Valley reported by Welch et al. (2007) and the assumed outflow of 12,800 afy from Cave Valley (75,800 afy as reported in the table). The footnote at the bottom of the table that states *"48 kafy inflow from Steptoe and Jakes Valley, Welch et al. (2008)"* appears to be an error, as this value is not consistent with the reported values. Welch et al. (2007) reports 71,000 afy of inflow to White River Valley from Jakes (63,000 afy) and Steptoe (8,000 afy) valleys. Myers (2011d) does not explain why the 63,000 afy was adopted and not the 8,000 afy. This is another example of Myers (2011d) selectively choosing data and results to match predetermined conclusions, in this case the groundwater budget of White River Valley. Equally astonishing is the fact that Myers (2011d) provides no analysis, discussion, or explanation of the rationale for selecting these estimates, even though they comprise over 55 percent of his groundwater budget for White River Valley, and 44 percent of his entire WRFS budget.

Because of these many deficiencies, the lack of due diligence in the data compilation and analysis, the unexplained rationale of data and results selection, and unsubstantiated opinions on flow direction, Myers (2011d) interbasin flow interpretations and groundwater budget should not be relied upon.

5. *"With development proposed by SNWA, the discharge to Coyote Spring Valley may become negative (Table 10). SNWA's proposal will have negative consequences for the flow from Muddy River Springs."* (p. 40, 3rd paragraph)

   The basis for these statements is not presented in the report, and it is unclear how discharge can become negative. It appears that these statements are based on the flawed water budget analysis and flow interpretations for which comments were previously provided. These unsubstantiated statements suggest that not only can the interbasin flow be entirely captured in the Project Basins and in downgradient basins, but that the gradients will reverse such that flow from Coyote Spring Valley will be induced. A review of the potentiometric data for the regional carbonate aquifer indicates that the hydraulic potential between Pahranagat Valley (Ash Springs) and Coyote Spring Valley (CSVM-3) is about 1,400 ft (Burns and Drici, 2011, p. 7-21). For groundwater discharge from Coyote Spring Valley to become negative, the drawdown at the northern boundary would have to be greater than 1,400 ft. This concept lacks credibility given (1) the volume of water in storage as compared to the proposed pumping volumes, (2) the heterogeneity of the geologic framework between the application PODs and these areas, and (3) distance between the application PODs and these areas.

6. *"Existing development has reduced the steady flow from Pahranagat Valley to about a third of its pre-development value."* (p. 56)

   There is absolutely no evidence presented in Myers (2011d) to support this statement. No decline in the regional spring flow has been observed in the discharge records for the three regional springs in Pahranagat Valley. Presumably the regional discharge would be captured by "*existing development*" before interbasin outflow, yet no discernable decline in the discharge has been observed. If this statement is correct, then the pre-development discharge from Pahranagat Valley should have been at least 84,000 afy for it to have been reduced "*...to about a third of its pre-development value.*" Myers (2011d) estimates the existing groundwater uses in the WRFS at about 18,000 afy, which if subtracted from the pre-development discharge of 84,000 afy, yields 66,000 afy in Pahranagat Valley with 28,000 afy for spring discharge and 38,000 afy as interbasin flow to Coyote Spring Valley.

7. *"Full development of the applications will cause Moon River and Hot Creek Springs to lose a third of their flow within three years; eventually these springs go dry."* (p. 56, 4th paragraph)

This statement is not substantiated by any analysis of the existing data and information.

A review of the existing geologic, hydrologic, and geochemical data indicate that Hot Creek and Moon River springs in south-central White River Valley are (1) regional springs structurally controlled by the normal fault comprising the western part of a horst that occurs in and along middle the portion of the basin (Figure 1; Rowley et al., 2011, Sections 6.2.2.1, 6.2.2.2), and (2) their recharge source is not Cave Valley based on isotopic and temperature data. For comparison purposes, Table 1 lists isotopic and temperature data for representative groundwater sites in Cave Valley and Moon River and Hot Creek Springs in White River Valley. The deuterium and temperature data for Moon River and Hot Creek Spring range from -120 to -119.2 per mil and 31.3 to 32.5°C, while the values for the representative sites in Cave Valley range from -102.2 to -105.6 per mil and 11.7 to 18.5°C (Thomas and Mihevc, 2011). These are significant differences and are indicative of different water sources.

Table 1
Isotopic and Temperature Data for Selected Groundwater Sites in White River and Cave Valleys

Site ID	Sample Date	δD (per mil)	$\delta^{18}O$ (per mil)	Temperature (°C)	Source[a]
Cave Valley					
180W501M	5/17/2006	-105.63	-14.12	18.5	SNWA
180W902M	5/18/2006	-105.05	-14.12	18.2	SNWA
Cave Valley (MX)	7/10/2003	-104.7	-13.94	13	USGS NWIS
Cave Valley Seeding Well	7/25/2005	-104.7	-13.75	---	SNWA
Big Spring	7/13/2006	-105.8	-13.86	12.8	DRI
Cave Spring	7/142006	-102.2	-14.2	11.7	DRI
White River Valley					
Moon River Springs	4/27/1982	-120	-15.8	32.5	USGS NWIS
Hot Creek Spring	10/28/2006	-119.2	-15.77	31.3	DRI

[a]DRI = Thomas and Mihevc (2011)
SNWA = Southern Nevada Water Authority.
USGS NWIS = U.S. Geological Survey National Water Information System.

Myers (2011d) assertion that development of the SNWA applications would reduce the flow from Moon River and Hot Creek Springs by one third within three years is difficult to believe given (1) the geologic heterogeneity (i.e., geometry, structure, and lithology of the hydrogeologic framework) between the springs and the application PODs, (2) the volume of storage in the basin fill and carbonate-rock aquifer, and (3) the proximity of the application PODs to the two springs and the mountain ranges that lie between.

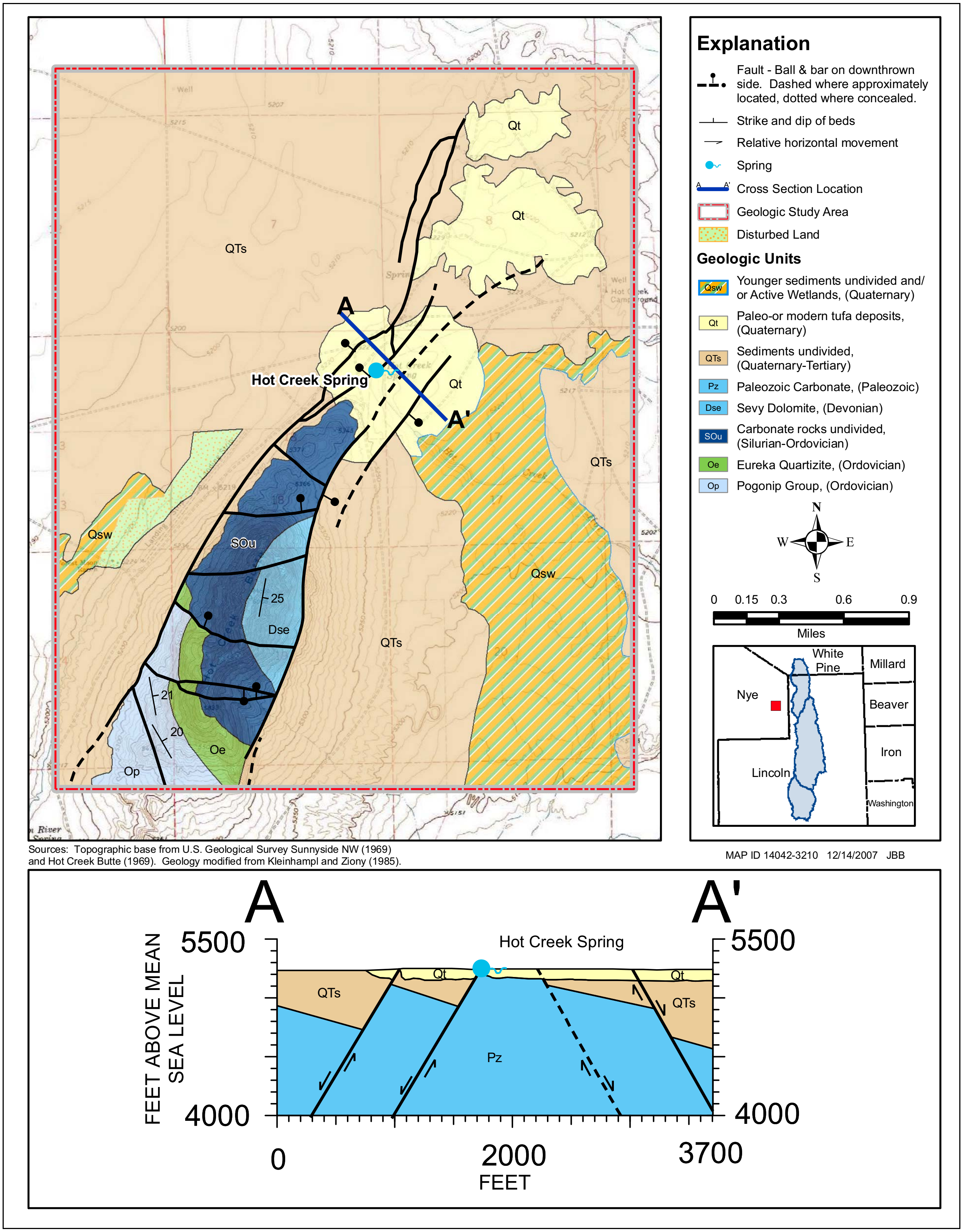

Figure 1
Geology of Hot Creek Springs

Conclusion

Myers (2011d) recites the findings of various previous investigations, but fails to perform any independent analyses to assess the validity of the results. Instead, Myers (2011d) selectively adopts estimates for groundwater budget components for the WRFS, and in doing so, violates one of the fundamental tenets of groundwater hydrology, the groundwater balance, a concept which Myers (2011d) emphatically advocates on pages 10 and 11 of his report. The result is a fundamentally flawed groundwater budget which Myers (2011d) couples with equally flawed accounting schemes to arrive at pre-determined conclusions regarding groundwater availability in the WRFS and the Project Basins, in particular.

Using the erroneous accounting in which only interbasin flow can be captured by groundwater pumping, Myers (2011d) seeks to demonstrate that the WRFS is fully appropriated. The rationale Myers (2011d) applies to groundwater budget accounting are contrary to the laws of nature and his conclusions presented in the pumping-effects analysis. On one hand, for the budget accounting Myers (2011d) assumes that groundwater pumping only captures interbasin flow. On the other hand, for the effects analysis, Myers (2011d) concludes pumping will significantly capture groundwater discharge from springs and phreatophytes after just a few years of pumping. This is one of several inconsistencies in Myers (2011d) that demonstrate data and results were chosen to support predetermined conclusions regarding groundwater availability and the potential effects of pumping the SNWA applications.

The conclusions of Myers (2011d) are not supported by data or sound scientific reasoning, they are drawn from a patchwork groundwater budget borne from creative selection of estimated groundwater budget components and suspicious accounting methods. Because of these many deficiencies, the lack of due diligence in the data compilation and analysis, the unexplained rationale of data and results selection, and unsubstantiated opinions on flow direction, Myers (2011d) conclusions regarding interbasin flow, unappropriated groundwater, and pumping effects can not be relied upon and should be rejected.

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