Addendum to the Groundwater Flow Model for the Central Carbonate-Rock Province: Clark, Lincoln, and White Pine Counties Groundwater Development Project

DRAFT

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PREFACE

This report was prepared by the Southern Nevada Water Authority. The U.S. Geological Survey served as technical advisor to the Bureau of Land Management in the review of this report.

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TABLES

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ACRONYMS

BLM	Bureau of Land Management
CCRP	Central Carbonate-Rock Province
EIS	environmental impact statement
ESA	Endangered Species Act of 1973
ET	evapotranspiration
HA	hydrographic area
HFB	horizontal flow barrier
NEPA	National Environmental Policy Act of 1969
SNWA	Southern Nevada Water Authority
UGS	Utah Geological Survey
UTM	Universal Transverse Mercator

ABBREVIATIONS

afy	acre-feet per year
amsl	above mean sea level
cfs	cubic feet per second
ft	foot
m	meter

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1.0 INTRODUCTION

The Southern Nevada Water Authority (SNWA) prepared four technical reports in 2008 and 2009 to support the Environmental Impact Statement (EIS) to apply for rights of way from the Bureau of Land Management (BLM) in Clark, Lincoln, and White Pine Counties. The acquisition of these rights of way and the associated water-rights are required for the construction of the SNWA In-State Groundwater Development Project. A numerical groundwater flow model was developed and used to support analyses of indirect effects of proposed project alternatives described in the EIS for the Project. The model area, project basins, and locations of the water-right applications are shown in Figure 1-1.

The four technical reports are as follows:

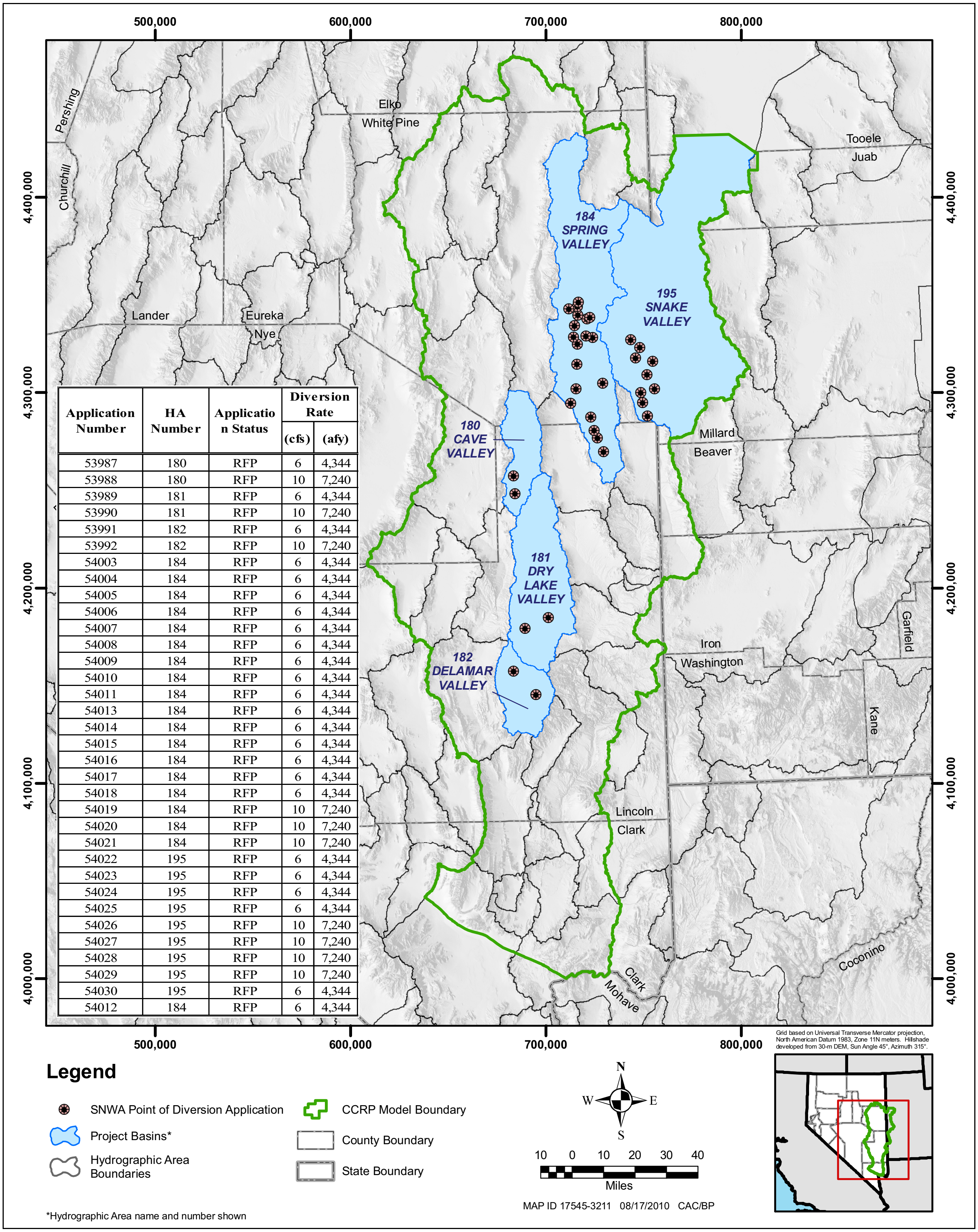
- *Baseline Characterization Report for Clark, Lincoln, and White Pine Counties Groundwater Development Project* (SNWA, 2008): This report documents the site baseline conditions.

- *Conceptual Model of Groundwater Flow for the Central Carbonate-Rock Province–Clark, Lincoln, and White Pine Counties Groundwater Development Project* (SNWA, 2009a): This report describes the development of a conceptual model of groundwater flow in the flow system underlying the study area.

- *Transient Numerical Model of Groundwater Flow for the Central Carbonate-Rock Province–Clark, Lincoln, and White Pine Counties Groundwater Development Project* (SNWA, 2009b): This report describes the development of a transient numerical flow model. The data necessary to describe the transient behavior of the flow system including historical water use and observation data are also provided in this report.

- *Simulation of Groundwater Development Scenarios Using the Transient Numerical Model of Groundwater Flow for the Central Carbonate-Rock Province: Clark, Lincoln, and White Pine Counties* (SNWA, 2010): This report presents the simulated potential effects of pumping under various water-use scenarios including SNWA's proposed groundwater withdrawals and EIS alternatives as well as the cumulative pumping effects associated with groundwater development in the model area.

The BLM reviewed the four reports and provided comments. To avoid unnecessary duplicative report reviews, the BLM requested that all four reports prepared by SNWA in support of the BLM EIS not be reissued. The BLM requested that any revisions to these reports be documented in a single addendum to these reports. This request, which was formulated prior to the Nevada Supreme Court advance opinion (NSC, 2010), was honored for the first three reports (SNWA, 2008; 2009a and b). As a result, this document was prepared as an addendum to the first three technical reports (SNWA, 2008; 2009a and b). The scenario simulation report, however, which necessitated major changes



Application Number	HA Number	Application Status	Diversion Rate	
			(cfs)	(afy)
53987	180	RFP	6	4,344
53988	180	RFP	10	7,240
53989	181	RFP	6	4,344
53990	181	RFP	10	7,240
53991	182	RFP	6	4,344
53992	182	RFP	10	7,240
54003	184	RFP	6	4,344
54004	184	RFP	6	4,344
54005	184	RFP	6	4,344
54006	184	RFP	6	4,344
54007	184	RFP	6	4,344
54008	184	RFP	6	4,344
54009	184	RFP	6	4,344
54010	184	RFP	6	4,344
54011	184	RFP	6	4,344
54013	184	RFP	6	4,344
54014	184	RFP	6	4,344
54015	184	RFP	6	4,344
54016	184	RFP	6	4,344
54017	184	RFP	6	4,344
54018	184	RFP	6	4,344
54019	184	RFP	10	7,240
54020	184	RFP	10	7,240
54021	184	RFP	10	7,240
54022	195	RFP	6	4,344
54023	195	RFP	6	4,344
54024	195	RFP	6	4,344
54025	195	RFP	6	4,344
54026	195	RFP	10	7,240
54027	195	RFP	10	7,240
54028	195	RFP	10	7,240
54029	195	RFP	10	7,240
54030	195	RFP	6	4,344
54012	184	RFP	6	4,344

Figure 1-1
Location of Study Area, Project Basins, and SNWA Water-Right Applications

following the Nevada Supreme Court opinion (NSC, 2010) and the subsequent decisions made by the Nevada State Engineer (NSE, 2010), was revised.

This addendum and the scenario simulation report (SNWA, 2010) are designed to address issues identified by the authors and the BLM in the first three reports (SNWA, 2008; 2009a and b). BLM review comments affecting the scenario simulations, as well as new issues resulting from the Nevada Supreme Court Advance Notice dated June 17, 2010 (NSC, 2010) were addressed in the revised scenario simulation report (SNWA, 2010).

The remainder of this section summarizes the issues addressed in this addendum and the revised scenario report and the organization of this document.

1.1 Issues Addressed in this Addendum

A few comments submitted by BLM required additional clarifications and/or modeling work. Revisions to the first three reports (SNWA, 2008; 2009a and b) are documented in this addendum and consist of the following:

- Corrections and/or clarifying language to address issues identified by the authors and BLM in SNWA (2008; 2009a and b).
- The development of a modified representation of the Big Springs area in the numerical model.

1.1.1 Corrections and Clarifications

Issues identified by BLM in their review comment, other than the additional modeling, which are addressed in this addendum are as follows:

- Addition of a transmissivity map to the numerical model documentation, that includes the effects of decreased horizontal hydraulic conductivity with depth.
- Clarification of drain conductance calculations provided in the numerical model report (SNWA, 2009b).
- Addition of DOS/Windows version of MODFLOW with standard binary output files for the revised model files.
- Clarifications regarding the uselessness of estimating well-screen intervals in the numerical model.

Issues identified by the authors after the first three reports were issued necessitated corrections and/or additional clarifications. These issues do not affect the original numerical model (SNWA, 2009b).

These updates to the first three reports (SNWA, 2008; 2009a and b) are described in Section 2.0 of this addendum.

1.1.2 Modified Numerical Model

The conceptualization of the Big Springs area, based on the available information, though uncertain, is unchanged (SNWA, 2009a). Its representation in the numerical model is at issue.

In the numerical flow model described in the transient flow model report (SNWA, 2009b), the faults interpreted to occur in the Big Springs area were represented by a single horizontal flow barrier (HFB) as a simplification judged reasonable at the regional scale of the model. This representation also allowed the groundwater discharge observed at Big Springs to be closely simulated.

During their review of the numerical model and draft scenario simulation reports, the BLM requested an alternate representation of the Big Springs area because the simplified representation of the HFB also appears to impede the effects of pumping SNWA wells on the discharge at Big Springs.

1.2 Scenario Simulation Report

Revisions to the scenario simulation report are documented in the updated scenario simulation report (SNWA, 2010). These revisions consist of: (1) updating the alternative scenarios to account for the Nevada Supreme Court Ruling, (2) conducting the simulations of all alternatives and additional cumulative scenarios using the modified numerical model, (3) conducting an uncertainty analysis on the Proposed Action results; and (4) removing the Endangered Species Act of 1973 (ESA) scenarios from the scenario simulation report.

1.2.1 Alternative Scenario Update

The alternative scenarios were revised following the issuance of the Nevada Supreme Court Advance (NSC, 2010) on June 17, 2010 and its interpretation by the Nevada State Engineer. The notice states:

> *Because we determine that the 1989 water appropriation applications were not pending in 2003, we conclude that the State Engineer violated his statutory duty by failing to take action within one year after the final protest date. Based on the State Engineer's failure to act on the applications in this case, we further conclude that an equitable remedy is warranted. We determine that the State Engineer must renotice SNWA's 1989 applications and reopen the period during which appellants may file protests. Thus, we reverse the order of the district court and remand the matter to the district court with instructions to remand the matter to the State Engineer for further proceedings consistent with this opinion.*

Alternative scenarios were added to represent the potential effects of pumping the requested application rates, which are larger than the withdrawal rates previously granted by the Nevada State Engineer for Spring, Delamar, Dry Lake and Cave valleys.

1.2.2 Simulation of Scenarios with Modified Numerical Model

Per BLM request, a National Environmental Policy Act of 1969 (NEPA) cumulative scenario was considered for each Project alternative. All alternative groundwater development scenarios and associated NEPA cumulative scenarios were then simulated using the modified numerical model described in this addendum (Sections 3.0 and 4.0).

1.2.3 Uncertainty Analysis Using Modified Numerical Model

A two-part uncertainty analysis was conducted to evaluate the uncertainty associated with the drawdowns simulated for the Proposed Action. The first part of this analysis was conducted as directed by the BLM. A simulation using the maximum hydraulic diffusivity was conducted to estimate the maximum spatial extent of the cones of depression caused by Project pumping under the Proposed Action using the reduced pumping option. The second part consisted of comparing results simulated for the Big Springs area under the Proposed Action using the numerical model (SNWA, 2009b) and the modified numerical model described in this addendum.

1.2.4 ESA Scenarios

The final ESA scenarios have not been identified as of the publication of this addendum and the scenario report (SNWA, 2010). Consequently, they are not included in the scenario simulation report (SNWA, 2010). They will be appropriately documented at a later date, if different from NEPA scenarios.

1.3 Addendum Organization

This document is organized in six sections and a brief description of the contents of each is provided.

Section 1.0 is this introduction.

Section 2.0 contains the updates to the first three main reports. Updates include revisions to material previously presented in SNWA (2008; 2009a and b).

Section 3.0 provides a description of the modified numerical model containing a decreased number of springs and the alternate representation of the Big Springs area.

Section 4.0 describes the calibration of the modified numerical model and the associated results.

Section 5.0 provides a summary of the contents of this document.

Section 6.0 provides a list of references cited in this document.

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2.0 UPDATES TO PREVIOUS REPORTS

Updates to three of the EIS model reports (SNWA, 2008; 2009a and b) consist of corrections to errors found after the reports were issued and revisions in response to review comments from BLM. The updates to these three documents are provided by report in the following sections.

2.1 Baseline Characterization Report Updates

Since publication of the predevelopment water-level data set documented in Table A.2-1 of Volume 4 of the Baseline Characterization Report (SNWA, 2008), several inconsistencies in the data set were noted. For example, 18 monitor wells from the Utah Geological Survey (UGS) Snake Valley Ground-Water Monitoring-Well Project were included in the steady-state water-level data set, but the monitor wells were not documented in SNWA (2008). In addition, site information for 30 monitoring wells from the steady-state water-level data set were updated for use in the Transient Numerical model (SNWA, 2009b). The following sections discuss the updates made to the steady-state water-level data set originally documented in the Baseline Characterization Report (SNWA, 2008).

2.1.1 UGS Well Locations

The Snake Valley Ground-Water Monitoring-Well Project was established in Utah's west desert in response to the Proposed Project (UGS, 2010). According to UGS (2010), the program had several objectives including improving the understanding of groundwater flow systems and characterizing groundwater levels and chemistry in the area. The first phase of monitor-well drilling for the UGS Snake Valley Ground-Water Monitoring-Well Project occurred from early July to early December 2007. This phase included the installation of 18 piezometers at 10 different locations throughout Snake and Hamlin valleys. The data for these monitoring-well locations were not available prior to compilation of the data set for the Baseline Characterization Report (SNWA, 2008). The well data and associated water-level information were, however, incorporated into the predevelopment water-level data set (Table A.2-1 in Volume 4) after publication of the Baseline Characterization Report. Table 2-1 shows the UGS monitoring-well locations that were incorporated into the steady-state water-level data set.

2.1.2 Updated Coordinate Information

After publication of the Baseline Characterization Report (SNWA, 2008), the coordinate locations or reference point elevations for 30 well locations from the predevelopment water-level data set (Table A.2-1 in Volume 4) were updated. The coordinate locations and elevations were updated to incorporate new information or resolve inconsistencies. Updated coordinates and elevations for monitor wells from the predevelopment water-level data set are provided in Table 2-2.

Table 2-1
Addition to Table A.2-1 in Volume 4: UGS Monitor Well Locations

HA Number	Site No.	Station Name	Location[a]		Reference Point Elevation[b] (ft amsl)
			UTM Northing (m)	UTM Easting (m)	
195	(C-21-20)36c - 1	(C-21-20)36c - 1	4,314,393.58	755,750.07	5,312.7
195	(C-21-20)36c - 2	(C-21-20)36c - 2	4,314,393.60	755,750.09	5,312.7
195	(C-21-20)36c - 3	(C-21-20)36c - 3	4,314,393.54	755,750.01	5,312.7
195	(C-21-19)32d - 1	(C-21-19)32d - 1	4,315,015.72	760,327.04	5,325.0
195	(C-21-19)32d - 2	(C-21-19)32d - 2	4,315,015.81	760,327.01	5,325.0
196	(C-26-20) 2 - 1	(C-26-20) 2 - 1	4,274,445.53	757,603.48	6,180.2
196	(C-26-20) 2 - 2	(C-26-20) 2 - 2	4,274,445.60	757,603.39	6,180.2
195	(C-20-19)32d - 1	(C-20-19)32d - 1	4,322,866.26	759,633.74	5,079.7
195	(C-20-19)32d - 2	(C-20-19)32d - 2	4,322,866.29	759,633.73	5,079.7
195	(C-20-19)32d - 3	(C-20-19)32d - 3	4,322,866.34	759,633.75	5,079.7
195	(C-18-18)32c - 1	(C-18-18)32c - 1	4,343,398.88	767,253.95	5,000.9
195	(C-18-18)32c - 2	(C-18-18)32c - 2	4,343,398.89	767,253.83	5,000.9
195	(C-18-18)32c - 3	(C-18-18)32c - 3	4,343,398.95	767,253.83	5,000.9
195	(C-18-18)32c - 4	(C-18-18)32c - 4	4,343,407.30	767,252.45	5,000.5
195	(C-20-18)32a - 1	(C-20-18)32a - 1	4,324,549.02	769,072.37	5,019.6
195	(C-20-18)32a - 2	(C-20-18)32a - 2	4,324,546.30	769,066.64	5,020.1
195	(C-19-19)36d - 1	(C-19-19)36d - 1	4,333,520.09	765,832.60	5,126.0
195	(C-19-19)36d - 2	(C-19-19)36d - 2	4,333,514.91	765,846.97	5,124.5

[a]Universal Transverse Mercator projection, North American Datum of 1983, Zone 11N. Rounded to the nearest hundredths decimal place.
[b]Rounded to the nearest tenths decimal place.

In summary, this section summarized the changes that were made to the steady-state water-level data set originally documented in Table A.2-1 of Volume 4 of the Baseline Characterization Report (SNWA, 2008). The updated steady-state water-level data set served as the foundation for the transient head observation data set that was documented in the Transient Numerical Model Report (SNWA, 2009b).

2.2 Conceptual Model Report Updates

The following tables in the conceptual model report (SNWA, 2009a) were found to be in error and were replaced by the correct tables.

An error was found in Table 7-11 on page 7-27. Column 3 (labeled Method 1) in this table mistakenly contains the numbers that were combined from the two methods (1 and 2) which ended up representing the final evapotranspiration (ET) estimates for the EIS model. The numbers in that

Table 2-2
Updates to Table A.2-1 in Volume 4: Updated Wells

HA	Site No.	Station Name	Location[a] UTM Northing (m)	UTM Easting (m)	Reference Point Elevation[b] (ft amsl)
195	394346113435501	(C-12-17)35cac- 1	4,403,099.79	780,401.37	4,570.4
195	(C-13-16)6C 1	(C-13-16)6C 1	4,401,143.43	782,933.98	4,663.1
195	393345113503201	(C-14-18)26dbc- 1	4,384,097.01	771,131.87	4,950.4
195	390629113560301	(C-19-19)36cda- 1	4,333,276.89	765,082.03	5,042.3
195	390141113532901	(C-20-18)32abd- 1	4,324,574.19	769,026.60	5,023.5
195	390243114012201	(C-20-19)19dcd- 1	4,326,232.56	757,489.50	5,081.8
195	(C-21-18)10CDD 1	(C-21-18)10CDD 1	4,321,387.87	771,987.20	5,043.4
195	(C-21-18)12CCD 1	(C-21-18)12CCD 1	4,321,510.12	774,861.26	5,049.1
195	(C-21-18)17AD 1	(C-21-18)17AD 1 USBLM	4,320,548.27	769,737.37	5,047.2
183	384529114335601	183 N10 E66 09ABAA1 USBLM	4,291,840.09	711,143.95	6,054.1
183	384324114355401	183 N10 E66 17CCAC1 USBLM	4,288,809	708,684	6,027.0
184	383351114180201	184 N08 E68 14A 1 USBLM	4,269,502.27	733,843.83	6,181.9
184	383704114225001	184 N09 E68 30AAAB1 USGS-MX (Spring Valley S.)	4,277,596.21	727,758.90	6,003.2
184	384310114261401	184 N10 E67 22AA 1 USGS-MX (Spring Valley Central)	4,289,333.69	722,825.22	5,857
184	384039114232701	184 N10 E68 31CD 1 USGS-MX	4,284,275.77	726,868.29	5,912.8
184	384831114314301	184 N11 E66 23AB 1 USGS-MX	4,298,408.65	714,630.88	5,842.6
184	384745114224401	184 N11 E68 19DCDC1 USGS-MX (Spring Valley)	4,297,304.01	727,553.03	5,899.2
184	385636114265501	184 N13 E67 33DDA 1	4,313,592.60	721,084.54	5,770.0
184	390352114305401	184 N14 E66 24BDDD1 USGS-MX (Spring Valley N.)	4,326,905.36	714,858.75	5,844.0
184	390330114264401	184 N14 E67 22CCCA1	4,326,441.81	720,896.74	5,786.4
184	390803114251001	184 N15 E67 26CA 1 USGS-MX	4,334,756.03	722,957.30	5,718.7
184	391713114244701	184 N16 E67 03AAAA1	4,351,809.84	722,993.03	5,589.9
184	392234114222801	184 N17 E68 06D 1 USGS	4,359,442.82	727,188.59	5,565.2
195	384714114051001	195 N11 E70 35BA 1 USGS-MX (Hamlin Valley N.)	4,297,064.53	752,282.10	5,693.1
195	384702114034101	195 N11 E70 36BD 1 USGS-MX	4,296,741.83	754,672.22	5,535.5
195	390812114033601	195 N15 E70 25DD 1 USGS-MX (Snake Valley N.)	4,336,475.40	754,001.02	5,098.8
196	383325114134901	196 N08 E69 15B 1	4,271,104.51	741,536.82	5,731.9
196	383023114115301	196 N08 E69 35DC 1 USGS-MX	4,265,450.12	743,740.31	5,817.9
196	383047114110001	196 N08 E69 36A 1 USBLM - Rosencran Well	4,266,648	746,136	5,761.8
196	383533114102901	196 N08 E70 06B 1 USBLM - Monument Well	4,275,170.63	747,012.92	5,673.9

[a]Universal Transverse Mercator projection, North American Datum of 1983, Zone 11N. Rounded to the nearest hundredths decimal place.
[b]Rounded to the nearest tenths decimal place.

column (column 3 in Table 7-11) should represent Method 1 and should be exactly the same as the ones presented in the last column of Table 7-4. This is because the text describing Table 7-11 only compares Methods 1 and 2 to each other. This error was corrected and the updated table is presented in Table 2-3.

An error was identified in Table 7-12 on page 7-29. The reported groundwater ET volume for Long Valley is in error. The correct groundwater ET volumes for Categories 1, 2 and 3 are 1,100 afy, 0, and 0 afy, respectively. The total groundwater ET volume is 1,100 afy. Because of this change, the total groundwater ET volumes for Categories 1 and 2 for the WRFS should be 142,800 and 2,000 afy, respectively. The total groundwater ET volume for the WRFS should be 147,500 afy. This error was corrected and the updated table is presented in Table 2-4.

On page 7-30, a table callout error was found in the second full paragraph which is as follows:

> *The combined groundwater ET map is shown on Figure 7-6. After the two maps were combined, the categories previously defined (Table 7-2) were applied to the ET areas. The groundwater ET map showing the three categories is shown on Figure 7-7. The areas of potential groundwater ET are presented in Table 7-13 by category. The combined groundwater ET volumes by ET class, by category, and by basin are also presented in Table 7-13.*

The 4th sentence should be revised as follows: "*The areas of potential groundwater ET are presented in Table 7-12 by category.*" Table 7-13 does not contain ET areas.

A clarification is needed to explain the ET estimates presented in Table 7-13. The following paragraph is added at the end of Section 7.1.8.2:

> *Using GIS techniques, (1) the BARCASS ET units were combined into larger ET units that are equivalent to Method 1 ET units subdividing; (2) the basins were subdivided into subareas; and (3) the ET and precipitation rates were averaged over the larger ET units. The groundwater ET volumes calculated using these manipulated numbers are close, but not identical to those reported by BARCASS. The correct table is presented in Table 2-5.*

Table 7-14 on page 7-37 contains an error. The groundwater ET volume in the "Deterministic Mean" column for Long Valley is not right for the same reason as in Table 7-12. This error was corrected and the updated table is presented in Table 2-6.

2.3 Numerical Model Report Updates

Some errors were identified in the numerical model report (SNWA, 2009b) after the report was issued to BLM. These errors and the corresponding corrections are described in the following text.

Table 2-3
Corrected Table 7-11: Net ET Volumes Obtained by Method 1 and Method 2

HA Number	HA Name	Method 1	Method 2	
		SNWA (This Study)[a]	Welch et al. (2008)[a]	DeMeo et al. (2008)
Goshute Valley Flow System				
179	Steptoe Valley	110,400	101,500	NE
178B	Butte Valley South	11,300	11,900	NE
Great Salt Lake Desert Flow System				
184	Spring Valley	72,100	75,600	NE
185	Tippett Valley	2,000	1,700	NE
254	Big Snake[b]	139,700	132,300	NE
Meadow Valley Flow System				
183	Lake Valley	6,800	6,100	NE
198	Dry Valley	3,700	NE	NE
199	Rose Valley	600	NE	NE
200	Eagle Valley	1,000	NE	NE
201	Spring Valley	3,900	NE	NE
202	Patterson Valley	1,300	NE	NE
203	Panaca Valley	18,900	NE	NE
204	Clover Valley	5,200	NE	5,840
205	Lower Meadow Valley Wash	21,900	NE	16,168
White River Flow System				
172	Garden Valley	1,700	NE	NE
174	Jakes Valley	400	900	NE
175	Long Valley	3,000	1,200	NE
180	Cave Valley	1,300	1,600	NE
207	White River Valley	67,600	76,700	NE
209	Pahranagat Valley	28,500	NE	NE
215	Black Mountains Area	1,400	NE	1,952
218	California Wash	4,500	NE	6,080
219	Muddy River Springs Area	6,000	NE	4,090
220	Lower Moapa Valley	25,300	NE	11,510

NE = Not Estimated
[a]Values are rounded to the nearest hundred (see Table 7-14 and Table F-3).
[b]Big Snake includes Pleasant, Snake, and Hamlin valleys.

Table 2-4
Corrected Table 7-12: Groundwater ET Areas and Volumes by Basin Using Combined Data Set

HA Number	HA Name	Groundwater ET Area (acre)				Groundwater ET Volume (afy)			
		Categories			Total[a]	Categories			Total[a]
		1	2	3		1	2	3	
Goshute Valley Flow System									
178B	Butte Valley (South)	69,400	0	300	**69,700**	11,800	0	100	**11,900**
179	Steptoe Valley	169,000	400	5,200	**174,600**	96,600	200	4,900	**101,700**
	Totals	**238,400**	**400**	**5,500**	**244,300**	**108,400**	**200**	**5,000**	**113,600**
Great Salt Lake Desert Flow System									
184	Spring Valley	176,800	300	700	**177,800**	74,900	100	400	**75,400**
185	Tippett Valley	7,700	0	0	**7,800**	1,700	0	0	**1,700**
194	Pleasant Valley	0	0	1,100	**1,100**	0	0	1,000	**1,000**
195	Snake Valley	316,600	1,400	2,300	**320,300**	126,500	1,100	1,800	**129,400**
196	Hamlin Valley	3,800	400	0	**4,200**	1,800	200	0	**2,100**
	Totals	**504,900**	**2,100**	**4,100**	**511,200**	**204,900**	**1,400**	**3,200**	**209,600**
Meadow Valley Flow System									
183	Lake Valley	55,500	0	0	**55,500**	5,900	0	0	**5,900**
198	Dry Valley	2,100	0	0	**2,100**	3,700	0	0	**3,700**
199	Rose Valley	300	0	0	**300**	600	0	0	**600**
200	Eagle Valley	600	0	0	**600**	1,000	0	0	**1,000**
201	Spring Valley	2,200	100	100	**2,300**	3,700	100	100	**3,900**
202	Patterson Valley	800	0	0	**800**	1,300	0	0	**1,300**
203	Panaca Valley	9,100	0	0	**9,100**	18,900	0	0	**18,900**
204	Clover Valley	500	0	3,000	**3,500**	900	0	4,900	**5,800**
205	Lower Meadow Valley Wash	7,800	0	0	**7,800**	9,700	0	0	**9,700**
	Totals	**78,900**	**100**	**3,100**	**82,000**	**45,700**	**100**	**5,000**	**50,800**
White River Flow System									
172	Garden Valley	600	0	300	**900**	1,100	0	600	**1,700**
174	Jakes Valley	0	0	1,200	**1,200**	0	0	900	**900**
175	Long Valley	17,800	500	0	**18,300**	1,100	0	0	**1,100**
180	Cave Valley	1,900	11,300	200	**13,400**	1,200	400	100	**1,700**
207	White River Valley	174,000	2,900	1,300	**178,200**	73,700	1,600	1,100	**76,400**
209	Pahranagat Valley	8,700	0	0	**8,700**	28,500	0	0	**28,500**
215	Black Mountain Area	500	0	0	**500**	1,400	0	0	**1,400**
218	California Wash	1,400	0	0	**1,400**	4,500	0	0	**4,500**
219	Muddy River Springs Area	2,000	0	0	2,000	6,000	0	0	6,000
220	Lower Moapa Valley	7,500	0	0	7,500	25,300	0	0	25,300
	Totals	**214,400**	**14,700**	**3,000**	**232,100**	**142,800**	**2,000**	**2,700**	**147,500**

Note: Values are rounded to the nearest hundred.
[a]Hydrographic area totals are rounded from the totals reported in Table F-3.

Table 2-5
Corrected Table 7-13: CCRP Model Groundwater ET Volumes Estimates and Comparison to Reported Estimates in afy

HA Number	HA Name	CCRP Model	Welch et al. (2008)[a]	Nichols (2000)	LVVWD (2001)	SNWA (2007)	DeMeo et al. (2008)	Reconnaissance Studies
Goshute Valley Flow System								
179	Steptoe Valley	101,700	101,500	128,000	NE	NE	NE	70,000
178B	Butte Valley South	11,900	11,900	44,500[b]	NE	NE	NE	1,200
Great Salt Lake Desert Flow System								
184	Spring Valley	75,400	75,600	90,000	NE	NE	NE	70,000
185	Tippett Valley	1,700	1,700	2,900	NE	NE	NE	NE
254	Big Snake[c]	132,500	132,300	NE	NE	NE	NE	80,000
Meadow Valley Flow System								
183	Lake Valley	5,900	6,100	NE	24,000	NE	NE	8,500
198	Dry Valley	3,700	NE	NE	4,000	NE	NE	3,600
199	Rose Valley	600	NE	NE	700	NE	NE	
200	Eagle Valley	1,000	NE	NE	1,000	NE	NE	
201	Spring Valley	3,900	NE	NE	1,000	NE	NE	
202	Patterson Valley	1,300	NE	NE	5,000	NE	NE	
203	Panaca Valley	18,900	NE	NE	26,000	NE	NE	
204	Clover Valley	5,800	NE	NE	2,000	NE	5,840	
205	Lower Meadow Valley Wash	9,700	NE	NE	27,000	NE	16,168	
White River Flow System								
172	Garden Valley	1,700	NE	NE	5,000	1,696	NE	2,000
174	Jakes Valley	900	900	600	600	392	NE	NE
175	Long Valley	1,100	1,200	11,000	11,000	2,952	NE	2,200
180	Cave Valley	1,700	1,600	NE	5,000	1,285	NE	200
207	White River Valley	76,400	76,700	NE	80,000	67,342	NE	37,000
209	Pahranagat Valley	28,500	NE	NE	38,000	28,516	NE	25,000
215	Black Mountains Area	1,400	NE	NE	0	1,432	1,952	1,200
218	California Wash	4,500	NE	NE	6,000	4,505	6,080	6,700[d]
219	Muddy River Springs Area	6,000	NE	NE	5,000	5,989	4,090	2,300
220	Lower Moapa Valley	25,300	NE	NE	26,000	25,311	11,510	24,000[d]

NE = Not Estimated
[a]Values are rounded to the nearest hundred.
[b]The reported value is the total ET for Butte Valley North and South.
[c]Big Snake includes Pleasant, Snake, and Hamlin valleys.
[d]The reported discharge value is a combination of water used by natural plants and crops.

Table 2-6
Corrected Table 7-14: Uncertainty on Annual Volumes of Groundwater ET by Sub-Area
(Page 1 of 2)

Forecast Name	HA Name	Groundwater ET Volume (afy)		Standard Deviation (afy)	COV	Groundwater ET Volume Confidence Interval (afy)			
		Deterministic Mean	Monte Carlo Mean			95% Lower	95% Upper	99% Lower	99% Upper
172 Basin	Garden Valley	1,696	1,703	466	0.27	946	2,477	659	2,800
174 Basin	Jakes Valley	864	885	308	0.35	430	1,424	323	1,667
175 Basin	Long Valley	1,144	3,608	3,331	0.92	14	10,076	10	13,309
178B Basin	Butte Valley South	11,893	16,522	14,728	0.89	1,484	44,955	1,050	59,165
179 Sub-basin 1	Steptoe Valley	90,297	90,991	26,840	0.29	47,225	136,309	33,968	155,064
179 Sub-basin 2		11,418	11,477	2,200	0.19	7,958	15,186	6,801	16,759
179 Basin		101,715	102,468	29,040	0	55,183	151,495	40,769	171,823
180 Basin	Cave Valley	1,710	3,113	2,192	0.7	869	7,546	553	9,900
183 Basin	Lake Valley	5,944	13,333	9,464	0.71	3,668	32,459	2,660	43,515
184 Sub-basin 1	Spring Valley	2,870	2,881	605	0.21	1,903	3,894	1,556	4,369
184 Sub-basin 2		38,374	38,705	9,532	0.25	23,329	54,854	18,293	62,734
184 Sub-basin 3		8,111	8,234	3,875	0.47	1,872	14,813	762	17,802
184 Sub-basin 4		26,080	26,324	10,394	0.39	9,573	44,045	6,799	51,455
184 Basin		75,435	76,144	14,769	0.19	52,692	100,910	43,837	112,581
185 Basin	Tippett Valley	1,727	1,992	1,355	0.68	202	4,480	91	5,655
194 Basin	Pleasant Valley	1,023	1,027	154	0.15	782	1,291	696	1,402
195 Sub-basin 1	Snake Valley	12,304	13,885	6,418	0.46	5,724	25,971	4,621	31,481
195 Sub-basin 2		15,124	15,217	3,819	0.25	9,282	21,859	7,077	24,764
195 Sub-basin 3		82,324	82,484	26,155	0.32	44,159	129,427	32,139	153,115
195 Sub-basin 4		19,600	19,704	4,957	0.25	11,637	28,094	8,748	31,586
195-Basin		129,352	131,290	27,694	0.21	89,731	179,926	75,669	203,818
196-Basin	Hamlin Valley	2,054	2,063	792	0.38	789	3,405	266	3,959
198-Basin	Dry Valley	3,710	3,716	996	0.27	2,120	5,382	1,481	6,120
199-Basin	Rose Valley	594	596	193	0.32	285	919	170	1,062
200-Basin	Eagle Valley	1,033	1,033	361	0.35	443	1,654	258	1,927
201-Basin	Spring Valley	3,912	3,925	1,232	0.31	1,915	6,002	1,183	6,918
202-Basin	Patterson Valley	1,346	1,350	525	0.39	500	2,226	158	2,635
203 Basin	Panaca Valley	18,895	18,868	4,740	0.25	11,174	26,912	8,297	30,499
204 Basin	Clover Valley	5,840	5,244	1,745	0.33	2,405	8,099	1,338	9,509
205 Sub-basin 1	Lower Meadow Valley Wash	1,293	2,935	796	0.27	1,658	4,276	1,174	4,885
205 Sub-basin 2		958	2,182	737	0.34	1,016	3,438	533	3,978
205 Sub-basin 3		3,194	7,252	2,207	0.3	3,786	11,074	2,340	12,663
205 Sub-basin 4		1,216	2,756	763	0.28	1,556	4,051	1,074	4,647
205 Sub-basin 5		3,006	6,801	1,404	0.21	4,548	9,151	3,681	10,168
205 Basin		9,667	21,926	5,907	1	12,564	31,990	8,802	36,341
207 Sub-basin	White River Valley	41,558	43,656	23,682	0.54	10,562	86,243	7,265	105,241
207 Sub-basin		34,888	37,497	15,824	0.42	16,217	67,315	13,213	86,725
207 Basin		76,446	81,153	39,506	1	26,779	153,558	20,478	191,966
209 Sub-basin 1		5,683	5,677	836	0.15	4,334	7,076	3,817	7,728
209 Sub-basin 2		8,701	8,682	2,402	0.28	4,912	12,746	3,382	14,580

Table 2-6
Corrected Table 7-14: Uncertainty on Annual Volumes of Groundwater ET by Sub-Area
(Page 2 of 2)

Forecast Name	HA Name	Groundwater ET Volume (afy)		Standard Deviation (afy)	COV	Groundwater ET Volume Confidence Interval (afy)			
		Deterministic Mean	Monte Carlo Mean			95% Lower	95% Upper	99% Lower	99% Upper
209 Sub-basin 3	Pahranagat Valley	5,865	5,874	829	0.14	4,560	7,267	4,022	7,886
209 Sub-basin 4		3,203	3,193	738	0.23	2,024	4,439	1,544	5,045
209 Sub-basin 5		5,070	5,073	708	0.14	3,923	6,259	3,496	6,796
209 Basin		28,522	28,499	5,513	1	19,753	37,787	16,261	42,035
215 Basin	Black Mountains Area	1,432	1,435	290	0.2	970	1,926	782	2,142
218 Basin	California Wash	4,505	4,505	1,126	0.25	2,698	6,415	2,035	7,270
219 Basin	Muddy River Springs Area	5,988	5,998	1,497	0.25	3,613	8,517	2,725	9,780
220 Basin	Lower Moapa Valley	25,311	25,242	5,878	0.23	15,720	35,148	12,379	39,461
All Basins		**521,758**	**557,638**	**54,984**	**0.1**	**469,806**	**650,950**	**437,930**	**689,576**

COV = Coefficient of Variation

On page 1-6, an error was found in the 3rd paragraph:

> *SNWA (2006) developed a numerical model of predevelopment steady-state conditions in support of the Spring Valley water-right hearing. The model area covers much of the northern part of the current model area. The model was developed to serve as a management tool for planning the development of the water resources of Spring Valley (SNWA, 2006). The initial recharge was derived by applying the standard Maxey-Eakin (Maxey and Eakin, 1949) method to an updated spatial precipitation distribution for Spring Valley. Other components of the groundwater budget were based on the Reconnaissance Series of reports.*

The 4th sentence should be replaced with the following: *"The initial recharge distribution was derived by applying the standard Maxey-Eakin (Maxey and Eakin, 1949) method. However, it was spatially distributed using the recharge-elevation relationships reported in the Reconnaissance series reports and the USGS 30-m Digital Elevation Model. This method was designed to preserve the annual basin recharge volumes reported in the Reconnaissance series reports."*

Table 4-24 on page 4-80 of the numerical model report lists nine historical pumping wells not included in the transient numerical model because they are perched. This table is missing one more pumping well that was excluded from the numerical model. This well, WU_179_MM_2, is located near Duck Creek in Steptoe Valley and is used in mine-related operations. Maps shown in Figures 4-38 and 4-39 do, however, account for all 10 perched wells and do not require revisions. The corrected list is provided in Table 2-7.

Table 2-7
Pumping Wells Not Included in the Numerical Model

Eliminated Pumping Well	HA	Reason
WU_179_MM_1	179 (Steptoe Valley)	Groundwater diversion in Duck Creek for mine related operations.
WU_179_MM_2		
WU194_IRR_1	194 (Pleasant Valley)	Well in perched, unconsolidated deposits not represented in model.
WU194_IRR_2		
WU204_IRR_6	204 (Clover Valley)	
WU204_IRR_8		
WU207_IRR_12	207 (White River Valley)	
WU207_IRR_16		
WU207_IRR_17		
WU207_IRR_19		

Figure 4-40 on page 4-83 of the numerical model report shows the spatial distribution of hydraulic-head observation wells by aquifer- material type from an earlier iteration of the numerical model report. Figure 2-1 is an updated version of that figure and shows the locations of head observations used in the transient numerical model (both original and modified versions). In addition, Figure 2-2 is provided in this addendum to show the locations of drawdown observations. The hydraulic head and drawdown observations are provided in electronic format (see DVD).

Figure 4-41 on page 4-84 shows the distribution of declustered hydraulic-head observation wells. This figure and the corresponding discussion in Section 4.7.3 on page 4- 84 are remnants from an earlier version of the numerical model report and are hereby rendered obsolete, and should be disregarded.

Figure 4-42 on page 4-86 shows the distribution of hydraulic-head observation variances. This figure is also a remnant from a previous version of the numerical model report and should be disregarded. The hydraulic head and drawdown variances for the observation locations over time shown in Figures 2-1 and 2-2 are provided in the form of electronic tables (see DVD in SNWA [2009b]).

On page 9-6, the following citation is in error: *Southern Nevada Water Authority, 2006, Water resources assessment for Spring Valley—Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada, 176 p.* It is replaced by the following citation: *"Southern Nevada Water Authority, 2006, Development and Use of a Groundwater Flow Model for the Spring Valley Area —Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada, 161 p*" (SNWA, 2006).

Clarification of calculation of drain conductance: BLM commented that: *Calculation of drain conductance. In the defined terms: GS should be the interpolated field hydraulic head in order to be consistent with the subsequent paragraph which has the correct explanation for calculating initial*

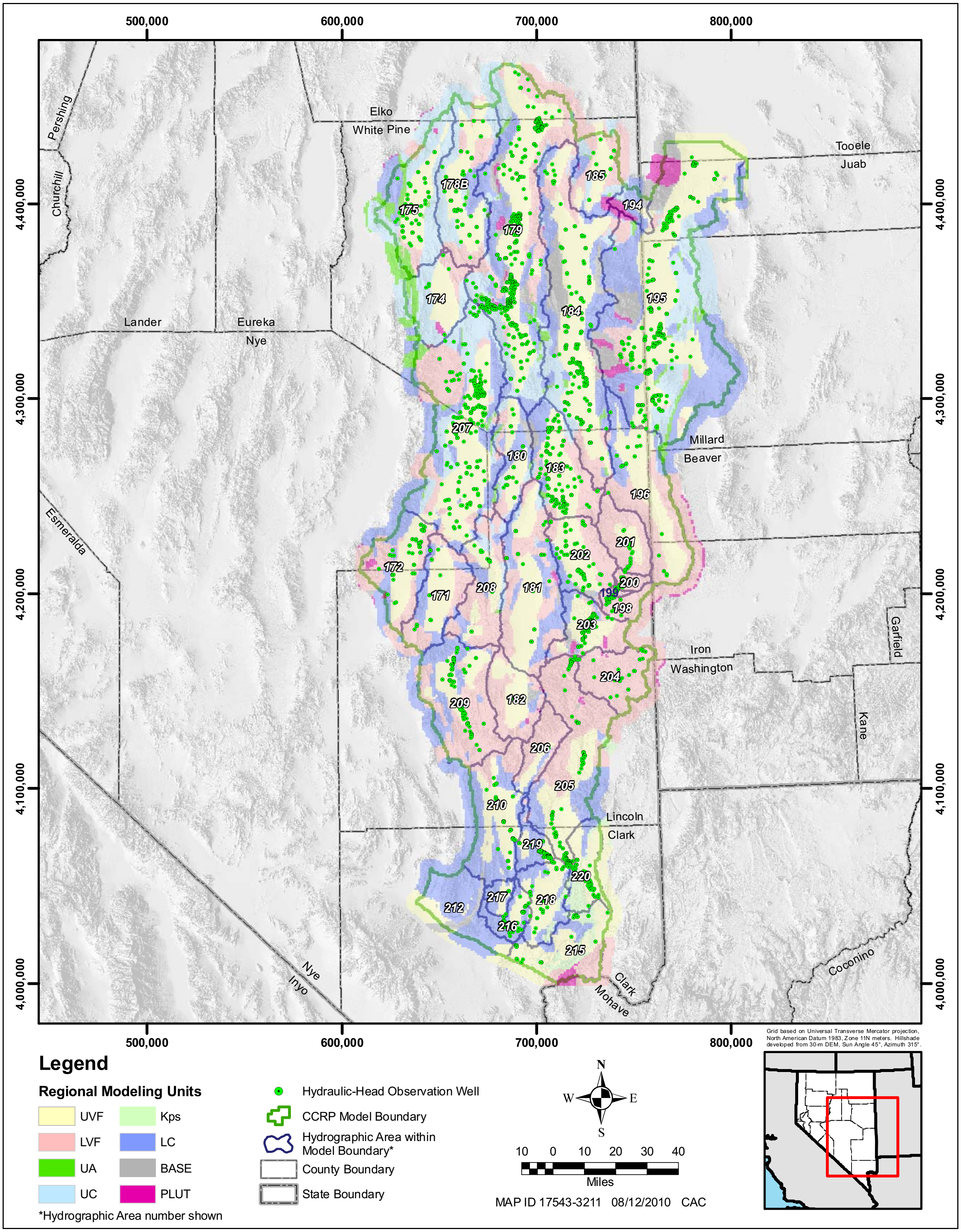

Figure 2-1
Location of Hydraulic Head Observations in Model Area

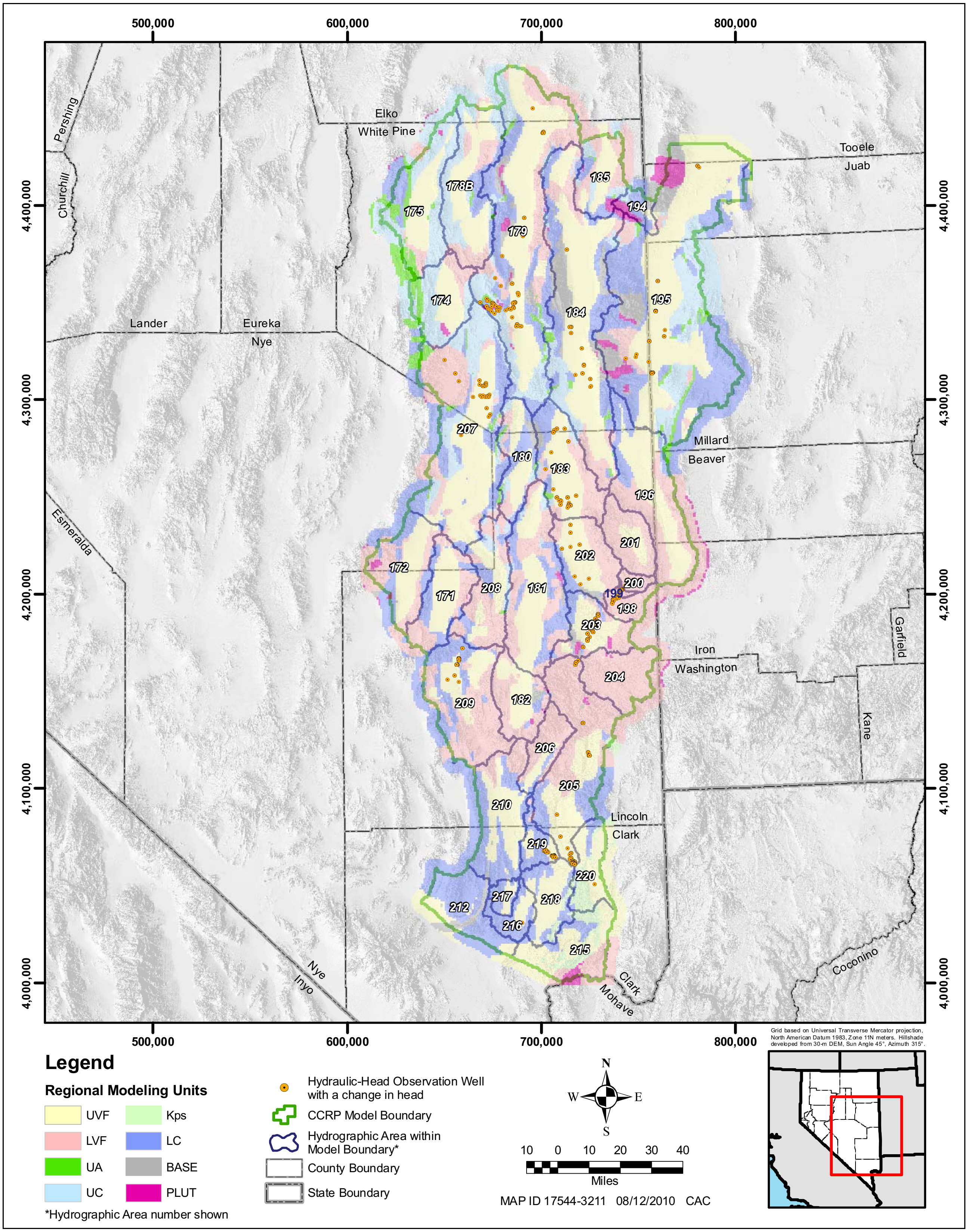

Figure 2-2
Location of Hydraulic Head Observations with Head Change in Model Area

estimates of conductance. The correction made in response to the October 1 comments resulted in a definition that is still in error.

"GS" is actually the ground surface used as an estimate for hydraulic head at the spring location as described in the defined terms. The inconsistency is rather in the subsequent paragraph located on page 4-48 (SNWA, 2009b) (last paragraph of Section 4.4.4.1), which is as follows:

> *Spring conductances were treated as parameters. Initial estimates of drain conductance were calculated as the quotient of measured spring discharge and the difference of interpolated field hydraulic-head and drain elevation. The values of initial estimates of spring conductance are listed in Table 4-11. Individual spring conductances were adjusted during manual portions of the model calibration to better approximate spring discharge. Conductance adjustments are generally limited to within one order of magnitude of the starting value.*

The second sentence should be modified to state the following:

> *Initial estimates of drain conductance were calculated as the quotient of measured spring discharge and the difference between the estimated hydraulic head at the spring location and the spring drain elevation.*

The reason for using land surface elevations as approximation of the hydraulic heads at spring locations is that field-measured hydraulic heads are insufficient to derive interpolated heads at the spring locations.

Clarification about uselessness of estimating screen intervals in this model:

Section 4.6.1.1 (SNWA, 2009b) explains how the pumping well screen intervals were defined. The following paragraph is added to the end of that section as suggested by the BLM reviewers:

> *It is noted that estimating screened intervals for the CCRP model is relatively unimportant because only a limited number of the pumping wells intersect more than one model layer. In addition, most of the multi-node wells likely resulted from the arbitrary vertical discretization of the model with flat-lying layers that arbitrarily range between 0 and 300 m thick at the water table rather than being wells with more than 300 m of screen.*

The addition of a PC version of MODFLOW with standard binary output files for the revised model files and/or a means to convert the unformatted output files to binary format are currently being considered and will be provided with the final version of the reports.

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3.0 MODIFICATIONS TO NUMERICAL MODEL

The modified numerical model has two major changes from the numerical model described in SNWA (2009b): (1) an alternate representation of the Big Springs area of Snake Valley; and (2) fewer number of simulated springs. These changes were requested by the BLM and are described in this section. The calibration of the modified model is discussed in Section 4.0 of this document.

3.1 Alternate Representation of Big Springs Area

BLM requested an alternate representation of the Big Springs area that consisted of shifting the southern Snake Range HFB and modifying the location and properties of the first stream segment representing Big Springs. BLM requested that the calibration statistics be recalculated for the alternate representation of Big Springs. This modified numerical model is identical to the original model described in SNWA (2009b) with the exception of the above changes in the Big Springs area and the omission of small springs as discussed in Section 3.2.

3.1.1 Southern Snake Range Horizontal Flow Barrier

The representation of the faults present in the Big Springs area in Snake Valley was changed in the modified numerical model as shown in Figure 3-1.

The southern Snake Range HFB was previously designed to represent a combination of the range front fault located in that area and the smaller Quaternary faults located downgradient of Big Springs and other smaller springs not simulated in the numerical model. The HFB followed the range front fault located along the length of the southern Snake Range over most of its length. In the area where the Quaternary faults occur, the HFB approximately followed their strikes (Map A in Figure 3-1). This representation was made because: Quaternary faults which correspond to well-defined changes in texture, and therefore, drastic changes in hydraulic properties can be simulated with HFBs and this feature improved the model fit for the flow at Big Springs.

In the modified model, the HFB in the area of Big Springs was moved to the west to match the location of the range front fault (Map B in Figure 3-1), as requested by the BLM. As a result of this move, the Quaternary faults were no longer represented in the numerical model so further changes were required to simulate groundwater discharge from Big Springs which was represented using the SFR2 package. In order to simulate discharge from Big Springs, input to the SFR2 package was modified as described in the next subsection.

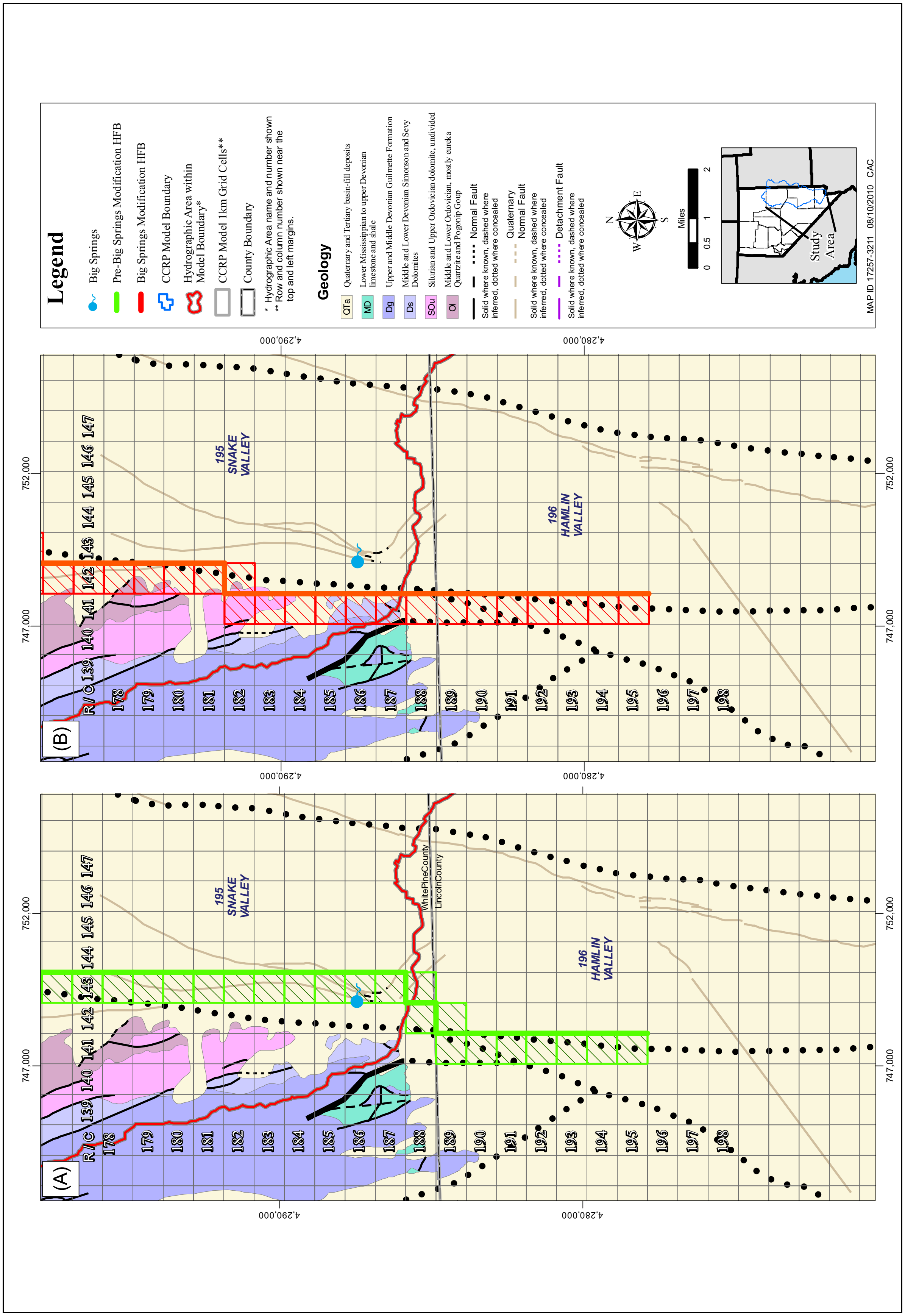

Figure 3-1
Location of Southern Snake Range HFB Relative to Big Springs in Original (A) and Modified (B) Models

3.1.2 Representation of Big Springs

The representation of Big Springs, Big Springs Creek, and Pruess Lake is shown in Figure 3-2 in plan view for the original version of the numerical model (Map A in Figure 3-2) and the modified model (Map B in Figure 3-2).

Only the first SFR2 stream segment, representing Big Springs in the original numerical model was modified. In the original version of the numerical model (SNWA, 2009b), Big Springs was only represented by a vertical stream segment at the location of the spring (single cell in Map A in Figure 3-2). The Big Springs stream segment originated in model layer 7 and extended vertically to layer 2 (top layer in the area). When the HFB was located downgradient of Big Springs (Map B in Figure 3-1) flow was simulated at the spring.

In the modified model, the Big Springs stream segment was modified to extend across the new location of the HFB in the same model layer (see Map B in Figure 3-2). The increased head differential across the HFB would force the model to simulate flow from Big Springs. This produced model instabilities so the representations was slightly modified during localized model calibration. The stream segment was deepened to layer 9 upgradient of the HFB.

3.2 Springs Removed from Numerical Model

BLM noted that small springs could not be simulated adequately by the regional scale model and requested that those springs be removed from the model. The selected springs were removed from the drain input file and the drain observation file. Nineteen springs were removed from the two files because the regional model is not capable of adequately simulating the flow at these local to intermediate springs (Table 3-1 and Figure 3-3).

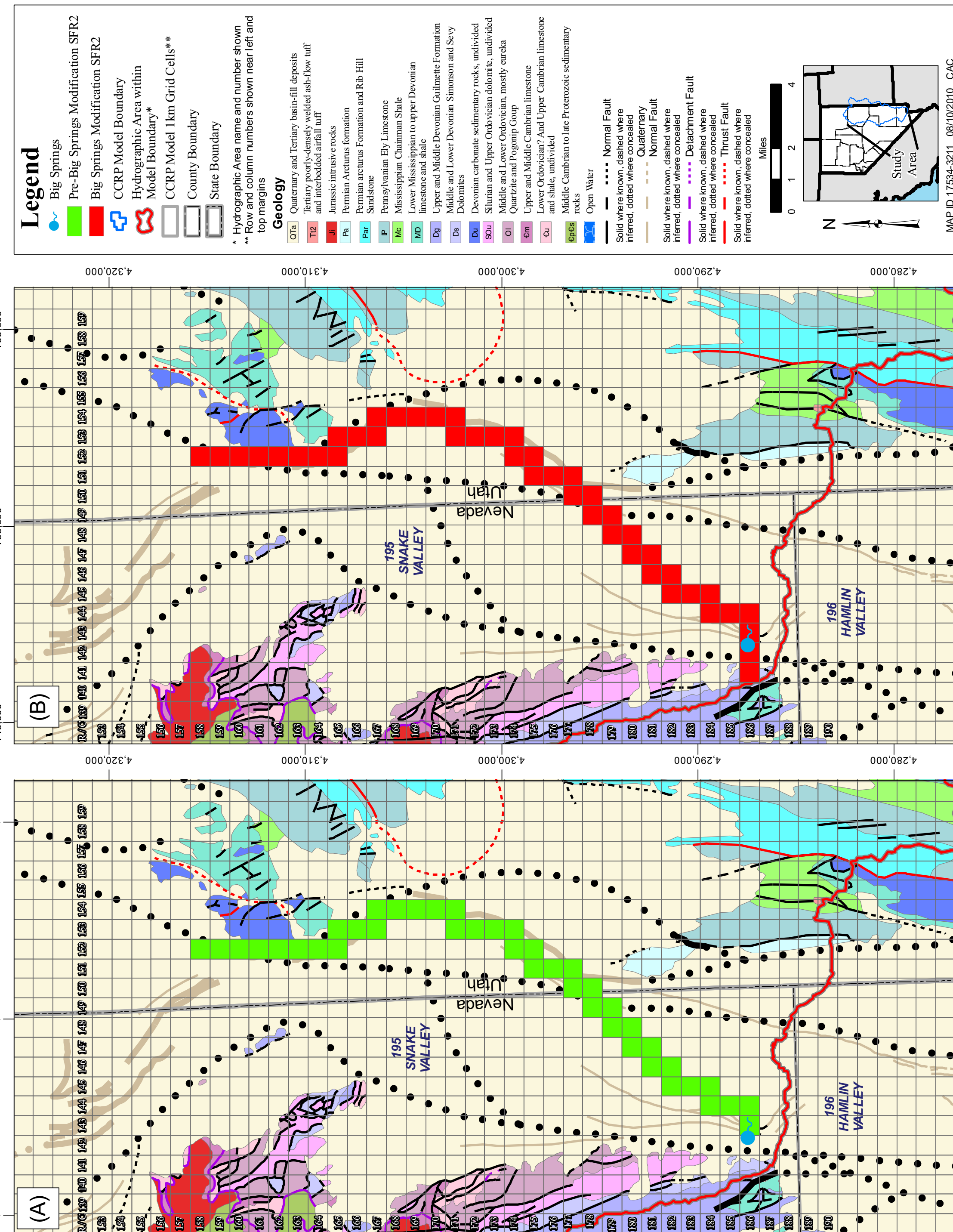

Figure 3-2
Representation of Big Springs in Original (A) and Modified (B) Models (Plan View)

Table 3-1
Springs Removed from Numerical Model in Modified Version

Hydrographic Area	Spring Name	Observation Name	Elevation (ft amsl)	Location[a]	
				UTM Northing (m)	UTM Easting (m)
195	Caine Spring	SPis95_3_01	5,028	4,336,185.72	755,137.91
179	Cherry Creek Hot Springs	SPr79_2_01	6,250	4,417,460.18	679,565.28
179	Cold Spring	SPis79_4_01	5,958	4,396,433.61	688,747.68
207	Emigrant Springs	SPib07_15_01	5,480	4,276,841	669,895
184	Four Wheel Drive Spring	SPis84_11_01	5,754	4,335,256	716,255
195	Knoll Spring	SPis95_4_01	4,869	4,348,105	769,378
184	Layton Spring	SPis84_7_01	5,698	4,331,794.14	720,204.11
184	Minerva Spring	SPis84_13_01	5,825	4,301,025	726,101
184	North Spring	SPiw84_8_01	5,763	4,309,388.29	717,767.63
184	Osborne Springs	SPis84_10_01	6,127	4,398,798	711,959
184	South Bastian Spring	SPis84_5_01	5,660	4,334,864.79	718,387.7
184	South Bastian Spring 2	SPis84_6_01	5,669	4,334,397	718,361
184	Stonehouse Spring	SPis84_14_01	6,256	4,406,507	710,511
184	The Seep	SPiw84_15_01	5,764	4,306,263	724,060
184	Twin Spring	SPib95_15_01	4,827	4,366,196.64	770,137.2
184	Unnamed 5 Spring	SPis84_16_01	5,645	4,340,641	718,911
195	Unnamed Spring	SPis95_14_01	4,853	4,350,397	768,130
184	Willard Springs	SPis84_2_01	5,755	4,323,976.17	718,690.65
184	Willow Spring	SPiw84_1_01	5,982	4,397,068.21	713,829.97

[a]Universal Transverse Mercator, North American Datum of 1983, Zone 11N, Meters

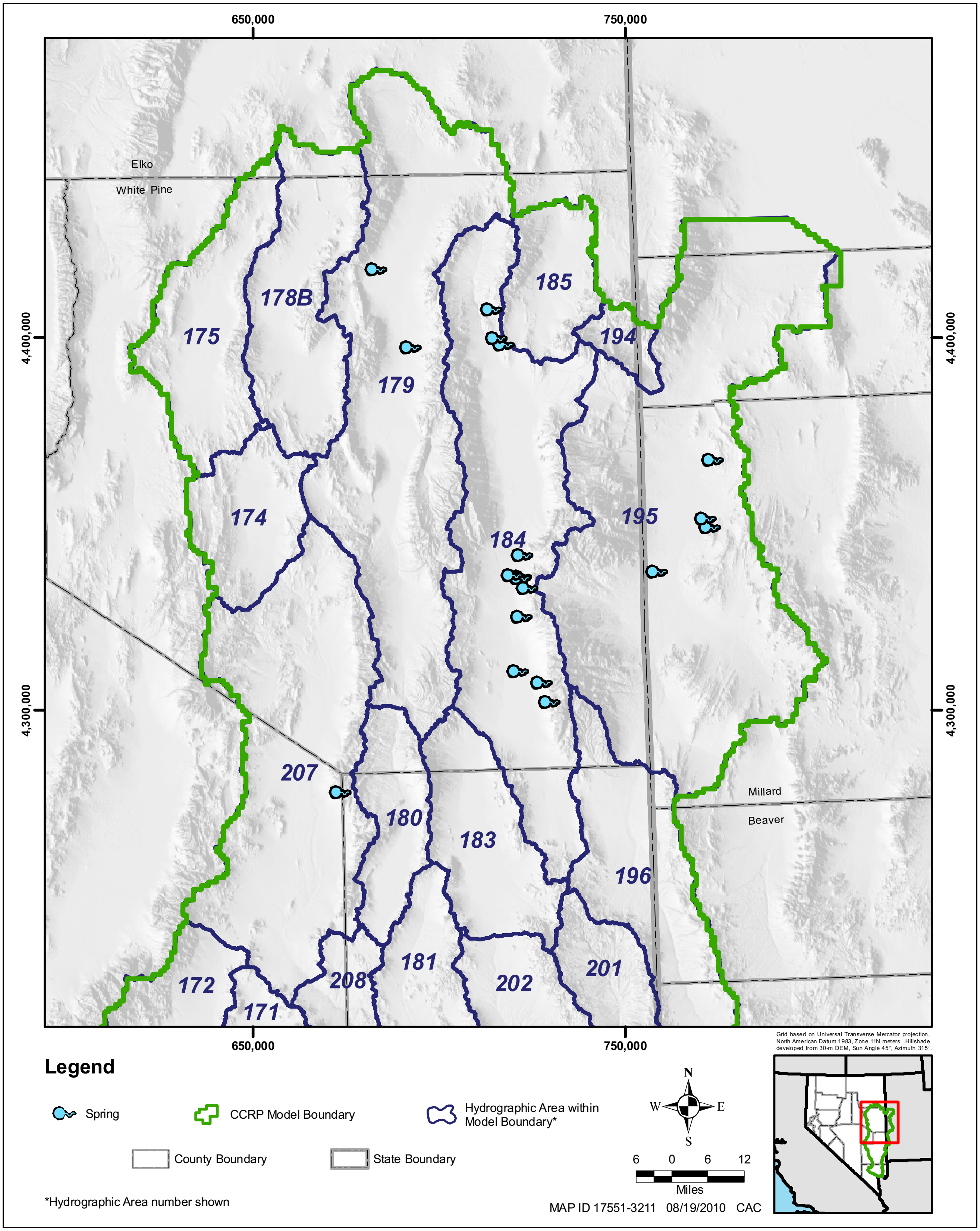

Figure 3-3
Springs Removed from Numerical Model in Modified Version

4.0 Modified Model Calibration

The calibration of the modified Central Carbonate-Rock Province (CCRP) numerical model is presented in this section, followed by a description of the results.

4.1 Model Calibration

BLM indicated it was acceptable for calibration of the modified numerical model described in Section 3.0 to be limited to adjustments in the representation and properties of Big Springs and removal of the smaller springs because they were relatively small changes at the scale of this model. The modifications to the model were evaluated as described in this section. The starting model was the original numerical model described in SNWA (2009b).

The location of the Southern Snake Range HFB was changed as shown in Figure 3-1 and a simulation was conducted without any other model modifications. As expected, this resulted in a zero discharge from Big Springs because there was no barrier to force flow from the spring. Several configurations of the stream representing Big Springs were tested as described below.

The first Big Springs configuration tested consisted of extending the stream segment across the Southern Snake Range HFB within model layer 7. This caused the model to simulate some discharge from Big Springs, but not as much as the predevelopment steady-state discharge observed in the field. Increasing the stream conductance increased the discharge rate closer to the observed value. However, unexplained fluctuations occurred in the discharge with time (transient).

Subsequent simulations consisted of extending the stream segment into deeper model layers. Once the segment extended to layer 9 or deeper the fluctuations were eliminated. Deepening the stream segment also increased discharge from Big Springs. Although extending the stream segment to model layers deeper than layer 9 increased the simulated spring flow, the layer 9 configuration was selected to be consistent with the temperature and chemistry of the Big Springs water source. Consequently, this configuration, which simulates discharge of about one-half of the observed discharge at Big Springs, was used in the modified numerical model. It was not possible to simulate a larger spring discharge without additional changes to the numerical model. This fit to the observed discharge is similar to the quality of fit at other intermediate spring locations represented in the model. The modified numerical model files are provided on the DVD under simulation ucth935.

4.2 Calibration Results

The results of the calibrated modified numerical model (ucth935) are presented in terms of model fit and overall groundwater water budget. The results are compared to those of the original numerical model (ucth814), as documented in SNWA (2009b).

4.2.1 Model Fit

A comparison of the overall fit of the two calibrated transient models is made be comparing their SoSWR values. This value increased from 30,772 for the original model (ucth814) to 41,464 for the modified numerical model (ucth935); or an increase of about 35 percent. The detailed statistics for the unweighted observations are presented in Table 4-1.

Table 4-1
Unweighted Observation Statistics for Modified Numerical Model

Observation Type	Unit	Number of Samples	Mean Error	Mean Absolute Error	Root Mean Square Error	Standard Deviation	Target Data Range	RMSE/ Range (%)	Expected Error Size with Increasing Target Size[a]
Boundary Flux	afy	16	1,173	1,707	2,275	2,013	20,000	11	Increasing
Gage Flow[b]	afy	140	255	1,211	1,687	1,674	35,672	5	Increasing
Ground Surface[c]	ft	2,145	-0	0	5	5	---	NA	Constant
Regional ET Discharge	afy	108	-250	1,765	2,908	2,910	69,431	4	Increasing
Spring Flow[d]	afy	29	-1,146	1,293	2,208	1,921	12,833	13	Increasing
Well Drawdown	ft	4,301	-1	4	9	9	238	4	Constant
Well Head	ft	2,707	15	45	92	90	6,461	1	Constant

[a]The error associated with head would be expected to be constant with elevation. The error associated with spring flow would be expected to increase with larger flows.
[b]Ash, Big Springs, Crystal, and Hiko Spring measurements removed from gage statistics.
[c]Because all ground surface measurements were expected to be 0.0 (no mounding), the target data range is 0.0, and RMSE/Range cannot be calculated.
[d]Ash, Big Springs, Crystal, and Hiko Spring measurements added to spring statistics.

A comparison of the statistics of the unweighted residuals calculated as the difference between the original (SNWA, 2009b) and modified numerical models (Figure 4-1) is presented in Table 4-2. As shown in this table. The comparison of the two models is also shown in graphical form displaying the simulated versus observed values (Figure 4-1). This figure shows that the fit of the modified model is essentially identical to the fit of the original model.

4.2.2 Calibrated Parameters

Characteristics of the stream segment used to simulate Big Springs were changed, but no changes were made to other parameters. As the stream segment conductance is unknown, the values used in both models are arbitrary.

As requested by the BLM reviewers, a map of the total transmissivity of the model including the effect of the decrease of horizontal hydraulic conductivity with depth is presented in Figure 4-2.

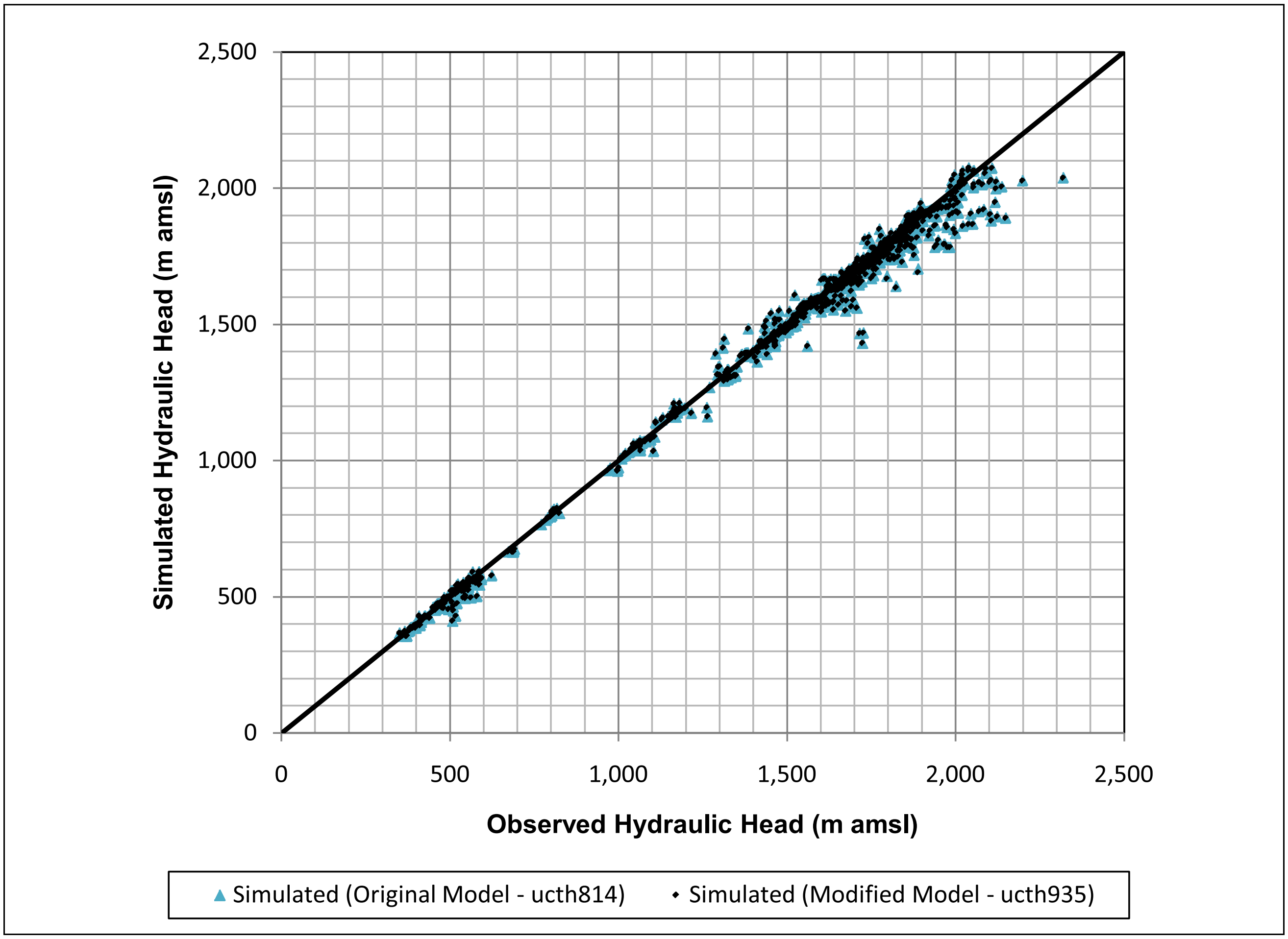

Figure 4-1
Simulated Versus Observed Unweighted Hydraulic Head Values in Original (ucth814)and Modified (ucth935) Numerical Models

Table 4-2
Comparison of Unweighted Observation Statistics for Original and Modified Models

Observation Type	Units	Number of Samples	Mean Error	Mean Absolute Error	Root Mean Square Error	Standard Deviation	Target Data Range	RMSE/ Range
Boundary Flux	afy	---	-4	-4	-2	0	---	---
Gage Flow	afy	---	-0	0	0	0	---	---
Ground Surface	ft	---	-0	0	0	0	---	NA
Regional ET Discharge	afy	---	-0	4	5	5	---	---
Spring Flow	afy	19	461	-477	-543	-387	194	---
Well Drawdown	ft	---	-0	0	0	0	---	---
Well Head	ft	---	-0	-0	-0	-0	---	---

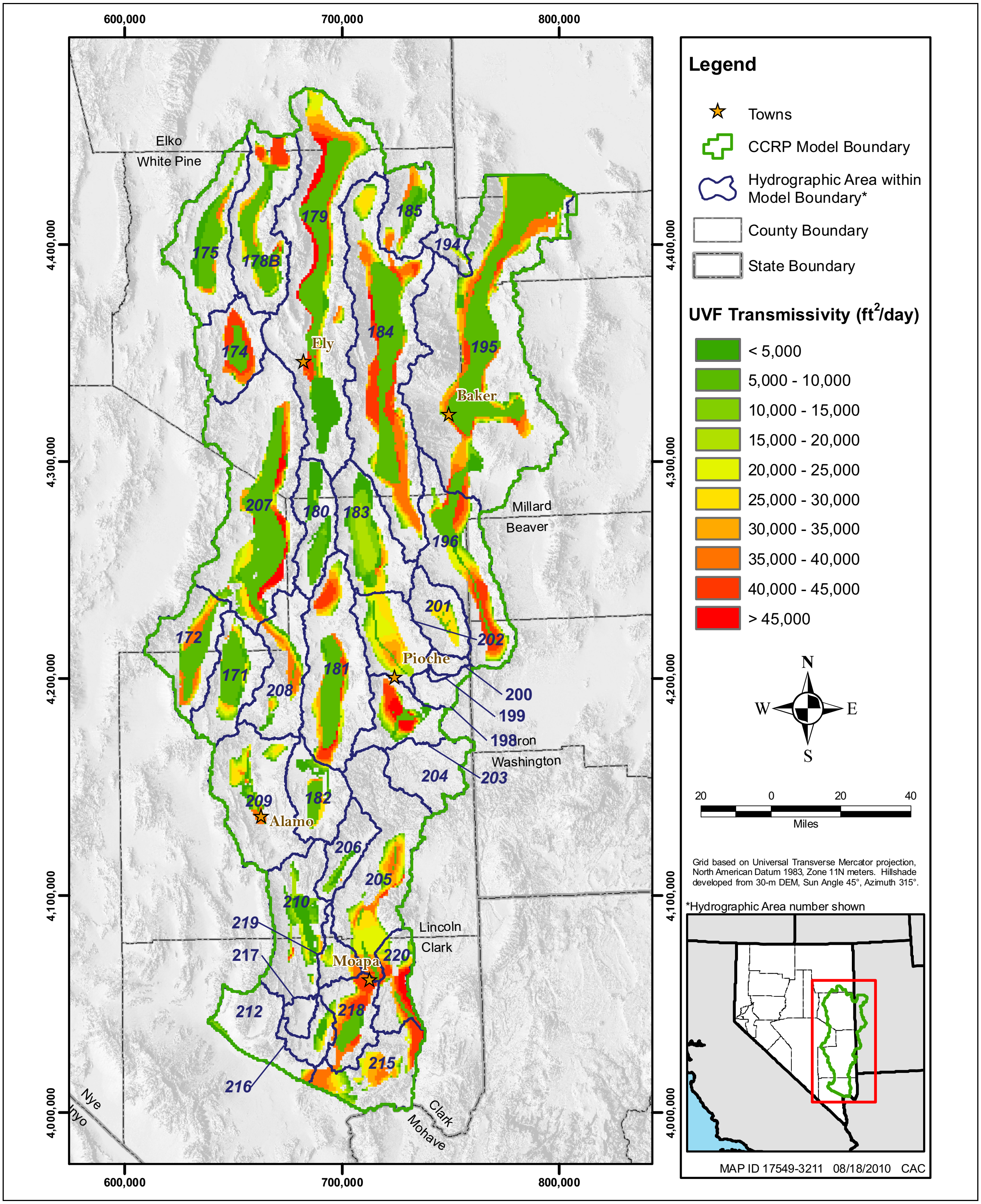

Figure 4-2
Spatial Distribution of Upper-Valley-Fill Transmissivity Simulated by the Modified Numerical Model

4.2.3 Simulated Discharge

The simulated groundwater discharges are the same as in the transient calibrated model (ucth814 in SNWA, 2009b), except in areas affected by the changes made in the Big Spring area. The effects of these changes are mostly noticeable in the water budgets and the spring discharge from Big Springs.

4.2.4 Water Budgets

Water budgets simulated by the modified numerical model (ucth935) for all flow systems and basins in the model area are presented in pdf files located on the DVD. Changes from the original model (ucth814) are presented below.

Water budgets for all basins except the ones located in the Meadow Valley and Great Salt Lake Desert flow systems are the same as in the original numerical model (ucth814 in SNWA, 2009b). For the Meadow Valley flow system, the only changes are in Lake Valley: (1) the net interbasin flow increased by 100 afy from the 5,000 afy simulated by the original model; and (2) the groundwater discharge by ET and springs decreased by 100 afy from the 2,400 afy simulated by the original model. The changes in the Great Salt Lake Desert Flow System are larger. The simulated values for the water budget components of this flow system are presented in Table 4-3. A comparison (Table 4-4) is presented to show the differences between the results of the modified numerical model (ucth935) as compared to the original model (ucth814). As can be seen from Table 4-4, the differences are relatively small. The large absolute change (1,100 afy) occurs in the ET value simulated for Snake Valley. This change represents an increase from the 104,700 afy simulated by the original model (ucth814).

Table 4-3
Simulated Groundwater-Budget Components for the Great Salt Lake Desert Flow System in afy for 2004

HA Number	HA Name	Net Interbasin Flow	Change in Storage	Groundwater Withdrawals	Constant Head	ET and Springs	Recharge	Stream Flow
184	Spring Valley	-5,300	2,000	-5,600	0	-73,700	82,600	0
185	Tippett Valley	-1,600	0	0	-4,200	0	5,700	0
194	Pleasant Valley	-4,400	0	0	0	0	4,400	0
195	Snake Valley	49,500	3,000	-21,600	-31,900	-105,800	106,900	-100
196	Hamlin Valley	-21,500	600	0	0	-200	21,100	0
258	Fish Springs Flat	-2,300	0	0	2,200	0	100	0
	Totals	**14,400**	**5,600**	**-27,200**	**-33,900**	**-179,700**	**220,800**	**-100**

Table 4-4
Comparison Between Water Budget Components as Difference in afy Between Values Simulated by Original (ucth814) and Modified (ucth935) Models

HA Number	HA Name	Net Interbasin Flow	Change in Storage	Groundwater Withdrawals	Constant Head	ET and Springs	Recharge	Stream Flow
184	Spring Valley	400	0	0	0	-400	0	0
185	Tippett Valley	0	0	0	0	0	0	0
194	Pleasant Valley	0	0	0	0	0	0	0
195	Snake Valley	-900	-200	0	100	1,100	0	-100
196	Hamlin Valley	500	0	0	0	-500	0	0
258	Fish Springs Flat	0	0	0	0	0	0	0
	Great Salt Lake Desert Totals	**0**	**-200**	**0**	**100**	**200**	**0**	**-100**

4.2.5 Big Springs Discharge

Input for the two numerical models (original and modified) is the same, except for the HFB in the Big Springs area, the location and properties of the first Big Springs stream segment, and the omission of the inadequately simulated springs. The most significant difference in the calibration is the simulated discharge from Big Springs. Only one observed discharge value is available for this spring: 7,431 afy with an uncertainty range of 6,609 to 8,252 afy. The original numerical model (ucth814) simulated a value of 7,192 afy. The modified numerical model (ucth935) simulated a discharge of only 3,170 afy, a value that is outside of the uncertainty range. Whereas the original model simulated the historical discharge of Big Springs rather closely, the modified model simulates approximately only half of the historical discharge. This fit to the observed discharge is similar to the quality of fit at other intermediate spring locations represented by this regional model.

5.0 SUMMARY

A numerical groundwater flow model was developed for the CCRP in Nevada and Utah. This numerical flow model and supporting information have been documented in a set of four reports: Baseline Report (SNWA, 2008), Conceptual Model Report (SNWA, 2009a), Numerical Model Report (SNWA, 2009b), and a draft scenario simulation report. These reports were submitted to the Bureau of Land Management for review. Major review comments have been addressed in this addendum.

Issues addressed in this addendum were organized into 3 categories: (1) revisions and updates to the first three reports, (2) development of an alternate representation of the Big Springs area in a modified version of the numerical model, and (3) calibration of the modified numerical model. The scenario simulations using the modified numerical model are documented in a separate report.

The numerical model (SNWA, 2009b) was modified: the representation of the Big Springs area was changed and selected springs were removed as requested by BLM. The calibration only consisted of adjustments to the representation of Big Springs in the model. Difficulties during calibration including instabilities in the simulated spring discharge led to a simulated spring discharge that is only about half the observed value. Except for the reduced simulated discharge and the effect of removing selected springs, the two models are, otherwise, the same.

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6.0 REFERENCES

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