Doc No. WRD-ED-0011

SOUTHERN NEVADA WATER AUTHORITY

Water Resources Division

Hydrologic Monitoring and Mitigation Plan for Delamar, Dry Lake, and Cave Valleys

June 2011

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Submitted for Approval to:
Nevada State Engineer

Suggested citation:
Southern Nevada Water Authority, 2011, Hydrologic monitoring and mitigation plan for Delamar, Dry Lake, and Cave valleys: Southern Nevada Water Authority, Las Vegas, Nevada, Doc. No. WRD-ED-0011, 44 p.

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ACRONYMS

BLM	Bureau of Land Management
BRT	Biologic Resources Team
DDC	Delamar, Dry Lake, and Cave valleys
DOI	U.S. Department of the Interior
EC	Executive Committee
HA	hydrographic area
LVVWD	Las Vegas Valley Water District
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NDWR	Nevada Division of Water Resources
NRCS	Natural Resources Conservation Service
NSE	Nevada State Engineer
QA	quality assurance
QC	quality control
SNOTEL	SNOwpack TELemetry
SNWA	Southern Nevada Water Authority
TRP	Technical Review Panel
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WRCC	Western Regional Climate Center

ABBREVIATIONS

amsl	above mean sea level
bgs	below ground surface
cfs	cubic feet per second
ft	foot
in.	inch
m	meter
mi	mile

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1.0 INTRODUCTION

The purpose of this document is to present the proposed Southern Nevada Water Authority (SNWA) Monitoring and Mitigation Plan for Delamar, Dry Lake, and Cave valleys (DDC) hydrographic areas (HA) 182, 181, and 180, respectively. The locations of the DDC hydrographic areas are presented in Figure 1. SNWA proposes that this Monitoring and Mitigation Plan be included by the Nevada State Engineer (NSE) as a permit condition associated with SNWA groundwater permits for applications 53987 through 53992.

1.1 Previous Studies and Reports

Numerous studies related to DDC and adjacent basins have been performed since the late 1940s. These studies have included water resource investigations, geologic and hydrogeologic studies, recharge and discharge estimations, and other hydrologic studies. Studies included Nevada Division of Water Resources (NDWR)/U.S. Geological Survey (USGS) Reconnaissance Investigations, U.S. Air Force MX Missile Siting Investigation-Water Resource Program Study, Basin and Range Carbonate Aquifer System Study, and numerous SNWA and LVVWD studies. These studies are summarized by (Burns and Drici, 2011).

Since the applications were filed in 1989, LVVWD and SNWA have worked to define the basin characteristics and hydrologic baseline conditions in DDC. This has been done by acquiring groundwater and spring discharge data and conducting hydrologic and geologic investigations within DDC and adjacent basins. SNWA has completed numerous hydrologic study reports associated with DDC. Recent reports document results from geophysical studies, SNWA monitor and test well completions, aquifer testing, and hydrologic monitoring.

Additional summary reports were prepared in support of the 2011 water right application hearing. These include *Geology and Geophysics of Spring, Cave, Dry Lake, and Delamar Valleys, White Pine and Lincoln Counties and Adjacent Areas, Nevada and Utah: The Geologic Framework of Regional Groundwater Flow Systems* (Rowley, et al., 2011), *Hydrology and Water Resources of Spring, Cave, Dry Lake, and Delamar Valleys, Nevada and Vicinity* (Burns and Drici, 2011), *Committed Groundwater Resources in four Nevada Hydrographic Areas: Cave, Dry Lake, Delamar, and Spring Valleys* (Stanka, 2011), *SNWA Hydrologic Management Program for Groundwater Development in Spring, Cave, Dry Lake, and Delamar Valleys, Nevada* (Prieur, 2011), and *Environmental Evaluation Regarding SNWA Applications in Spring, Cave, Dry Lake, and Delamar Valleys* (Marshall and Luptowitz, 2011).

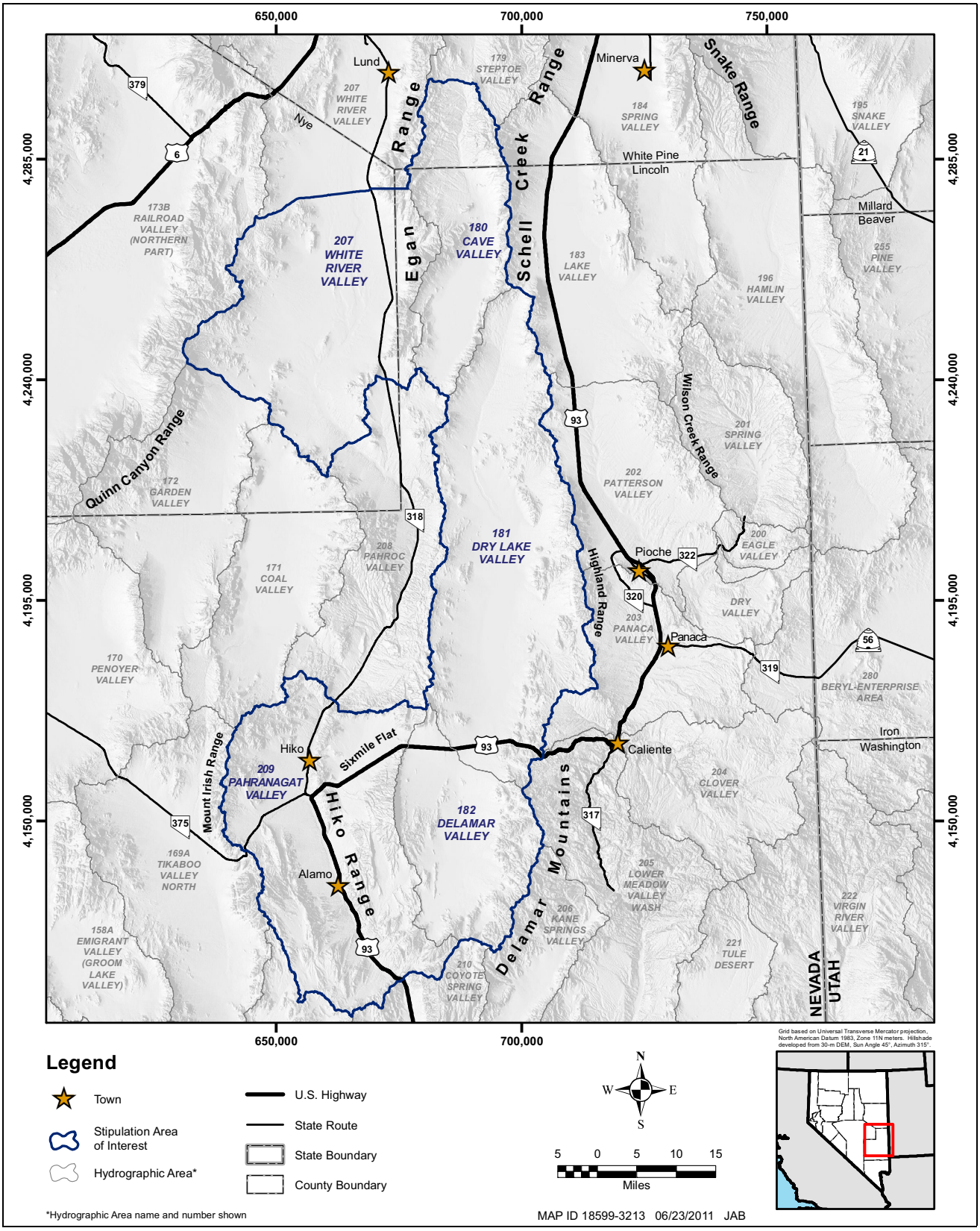

Figure 1
DDC Hydrographic Basins and Stipulation Area of Interest

1.2 Hydrologic Monitoring Data Reports

Data have been provided to the NSE and DOI on a quarterly basis and in annual status and data reports which have been published since 2008. The previously approved monitoring and mitigation plan has been implemented with plan-specific data collection occurring since 2007. This program builds upon available historical hydrologic data. The status and data collected for each element of the approved monitoring plan as of January 2011 is presented in the *2010 DDC Hydrologic Monitoring and Mitigation Plan Status and Data Report* (SNWA, 2011).

The previous annual reports prepared in 2008-2010 are presented in SNWA, 2008, 2009, and 2010. Physical descriptions and background historical hydrologic and water-chemistry data from springs and monitor wells included in the approved monitoring plan network, are presented in the *Delamar, Dry Lake, and Cave Valleys Stipulation Agreement Hydrologic Monitoring Plan Status and Historical Data Report* (SNWA, 2009b).

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2.0 MONITORING AND MITIGATION PLAN REQUIREMENTS

This section summarizes the key objectives and requirements of the monitoring and mitigation plan. The tasks that satisfy these requirements are presented in Section 3.0.

2.1 Stipulation Agreement

On January 7, 2008, a Stipulation for Withdrawal of Protests (Stipulation) was entered into between SNWA and the U.S. Department of the Interior (DOI), on behalf of the Bureau of Indian Affairs, the Bureau of Land Management (BLM), the National Park Service, and the U.S. Fish and Wildlife Service (USFWS) (collectively known as the DOI Bureaus) (Stipulation, 2008). Exhibit A to the Stipulation requires the development of a hydrologic monitoring plan.

The common goals stated in the Stipulation are to manage the development of groundwater by SNWA in the Hydrographic Basins without causing injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and Special Status Species within the Area of Interest as a result of groundwater withdrawals by SNWA in the Hydrographic Basins. The preferred conceptual approach for protecting Federal Water Rights from injury and Federal Resources and Special Status Species from unreasonable adverse effects within the Area of Interest that may be caused by groundwater withdrawals by SNWA in the Hydrographic Basins is through the development of such groundwater in conjunction with the implementation of the monitoring, management, and mitigation plans described in Exhibit A of the Stipulation.

The effects of groundwater withdrawals pursuant to the development of any or all of the SNWA Applications and any future changes in points of diversion and/or rates of withdrawal need to be properly monitored and managed to avoid any injury to Federal Water Rights and unreasonable adverse effects to Federal Resources and Special Status Species within the Area of Interest. There is a need to better understand the response of the aquifers and associated discharge points to pumping stresses from development of permitted quantities of groundwater in accordance with the monitoring, management, and mitigation plans as set forth in Exhibit A to the Stipulation.

The Monitoring and Mitigation Plan consists of three principal components related to the Stipulation:

- *Monitoring Requirements* - including, but not limited to, existing wells, new monitoring wells, water chemistry analyses, spring discharge measurements, quality control procedures and reporting requirements;

- *Management Requirements* – including, but not limited to, creation of a Biologic Resources Team ("BRT") to review biological information collected pursuant to the biological monitoring plan and advise the Executive Committee (Stipulation, 2008); expansion of the

duties of the Technical Review Panel (TRP) (established pursuant to Paragraph 3(C) of Exhibit A of the Spring Valley Stipulation) (Stipulation, 2006) to review information collected under this Plan and advise the Executive Committee; use of an agreed upon transient groundwater flow system numerical model to help predict effects of groundwater withdrawals by SNWA in the Hydrographic Basins; and use of the consensus-based decision making process established in the Spring Valley Stipulation (Stipulation, 2006).

- *Mitigation Requirements* – including, but not limited to the: (1) modification**,** relocation or reduction in points of diversion and/or rates and quantities of groundwater withdrawals, the augmentation of Federal Water Rights, Federal Resources and/or Water Dependent Ecosystems; (2) acquisition of real property and/or water rights dedicated to the protection of Special Status Species; and (3) measures designed and calculated to rehabilitate, repair or replace any and all Federal Water Rights, Federal Resources and Water Dependent Ecosystems if necessary to achieve the Common Goals of the Stipulation.

Some wells in the Monitoring Network will be selected by the TRP to help characterize the movement of groundwater from the Hydrographic Basins to the White River, Pahroc and Pahranagat Valley Hydrographic Basins to the west ("Adjacent Hydrographic Basins"). Other wells in the Monitoring Network will be located throughout the Hydrographic Basins and Adjacent Hydrographic Basins to provide early warning of propagation drawdown toward Federal Water Rights and Federal Resources and provide data for future groundwater model calibration.

To ensure baseline aquifer conditions are established, SNWA will ensure that at least 5 years of monitoring data exists for wells or spring discharge sites that are currently being monitored within the Monitoring Network as of the date of execution of the Stipulation.

SNWA will monitor all new wells in the Monitoring Network at least 2 years prior to any groundwater withdrawals, other than for aquifer tests and construction. SNWA will ensure that at least two (2) years of monitoring is done for the new spring discharge sites in the Monitoring Network before SNWA groundwater withdrawals, other than for aquifer tests and construction.

2.2 Proposed Monitoring Requirements for Non-Federal Water Rights

The requirements for monitoring water rights not subject to the Stipulation (private and other non-Federal water rights regulated by the NSE) may include the following:

- Develop a monitoring and mitigation program which is approved by the NSE.

- Collect a minimum of 2 years of hydrologic baseline data. The baseline monitoring program must be approved by the NSE prior to the export of any groundwater resources from DDC under the permits.

- File an annual data report with the NSE by March 31 of each year detailing the findings of the NSE-approved Monitoring Plan. (One combined annual data report which presents all data required by the Stipulation and NSE has been prepared each of the last 4 years).

- Update an NSE-approved groundwater flow model every 5 years after pumping begins and provide predictive results under pumping conditions of 10-, 25-, and 100-year periods.

- Modify or curtail pumping under specific conditions. If pumping effects impact existing rights, conflict with the protectable interests in existing domestic wells, as set forth in Nevada Revised Statutes §533.024, threaten to prove detrimental to the public interest, or are not environmentally sound, SNWA will be required by the NSE to curtail pumping and/or mitigate the impacts to the satisfaction of the NSE.

2.3 Monitoring and Mitigation Plan Elements

The Monitoring and Mitigation Plan was developed to meet Stipulation and non-Federal water right monitoring objectives and requirements. The key elements of the program are presented below with the current status of each element of the monitoring program described in parenthesis.

- General Requirements

  - Design and implement a baseline hydrologic data collection program.

  - Collect at least 2 years of monitoring data prior to groundwater withdrawals from wells and spring discharge sites that are incorporated into the approved monitoring network (started monitoring at various network locations from 2007 and is currently ongoing).

  - Collect at least 2 years of data prior to groundwater withdrawals from new well and spring discharge sites in the monitoring network contingent upon property access and timely issuance of appropriate rights-of-way by various Federal agencies.

- Monitor Well Data Collection

  - Collect quarterly water-level data at 9 existing monitor wells in DDC and adjacent basins (started in 2007 and is currently ongoing).

  - Collect continuous water-level data at 6 existing monitor wells in DDC and adjacent basins (started in 2007 and is currently ongoing).

  - Construct up to 4 new monitor wells located in or around DDC and adjacent hydrographic areas that will be dedicated to long-term monitoring. Collect continuous water-level data from the new monitor wells. (Three well locations have been selected and permitted with installation planned to occur in the future to meet Monitoring and Mitigation Plan timeframe requirements. The fourth well location will be selected after the configuration of production well network is established).

  - Collect quarterly water-level data at SNWA exploratory and test wells located in DDC.

  - Monitor the wells selected to be included in the network to help characterize groundwater movement within DDC and the adjacent HAs of White River, Pahroc, and Pahranagat

valleys. Monitor wells are located throughout DDC and adjacent hydrographic areas to detect and quantify the propagation of drawdown, if any, toward existing water-right holders and areas of interest, including groundwater-dependent areas sustaining critical habitat for endangered and/or threatened species, and to provide observations for future groundwater model calibration.

- Future Production Well Monitoring

  - Record groundwater production and continuous water-level data in all future SNWA production wells in DDC when operational.

- Aquifer Testing

  - Perform a constant-rate aquifer test on all SNWA production and test wells located in DDC.

- Spring Discharge Sites

  - Monitor, or fund a mutually agreed-upon third party to monitor 8 spring locations in White River and Pahranagat valleys. These consist of Flag Springs Complex, Hot Creek, Moorman, Hardy, Hiko, Maynard, Ash, and Crystal springs (currently ongoing).

  - Report and evaluate spring discharge data from Cottonwood Spring, located in Pahranagat Valley, as provided by the USFWS.

  - Perform biannual monitoring of up to 8 springs in DDC (currently ongoing).

- Precipitation Network

  - Select a regional precipitation network from stations with an established historical record in the vicinity of the study area (completed in 2008).

- Baseline Water Chemistry

  - Perform chemical analyses of selected parameters for samples collected from well and spring sites determined by the TRP in cooperation with the NSE. The program will consist of 2 sampling events at 6-month intervals. Samples will be collected at up to 10 locations per event.

  - Perform an additional round of sampling every 5 years after the commencement of groundwater pumping.

- Modeling

  - Update and maintain as required a numerical flow model of the regional groundwater flow system.

- Reporting

  - Provide data collected associated with the monitoring plan as required by the NSE as described in Section 4.2.

  - File an Annual Hydrologic Data Report with the NSE by March 31 of each year detailing the results of monitoring and sampling pursuant to this plan.

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3.0 MONITORING PLAN STRATEGY AND IMPLEMENTATION

The objectives of the Monitoring and Mitigation Plan encompass those set forth by the Stipulation and by the NSE, which focus on the identification and assessment of potential impacts to existing water-right holders and areas of interest within DDC. As changes to the Stipulation monitoring and mitigation requirements occur, the Monitoring and Mitigation Plan will be updated with the approval of the NSE.

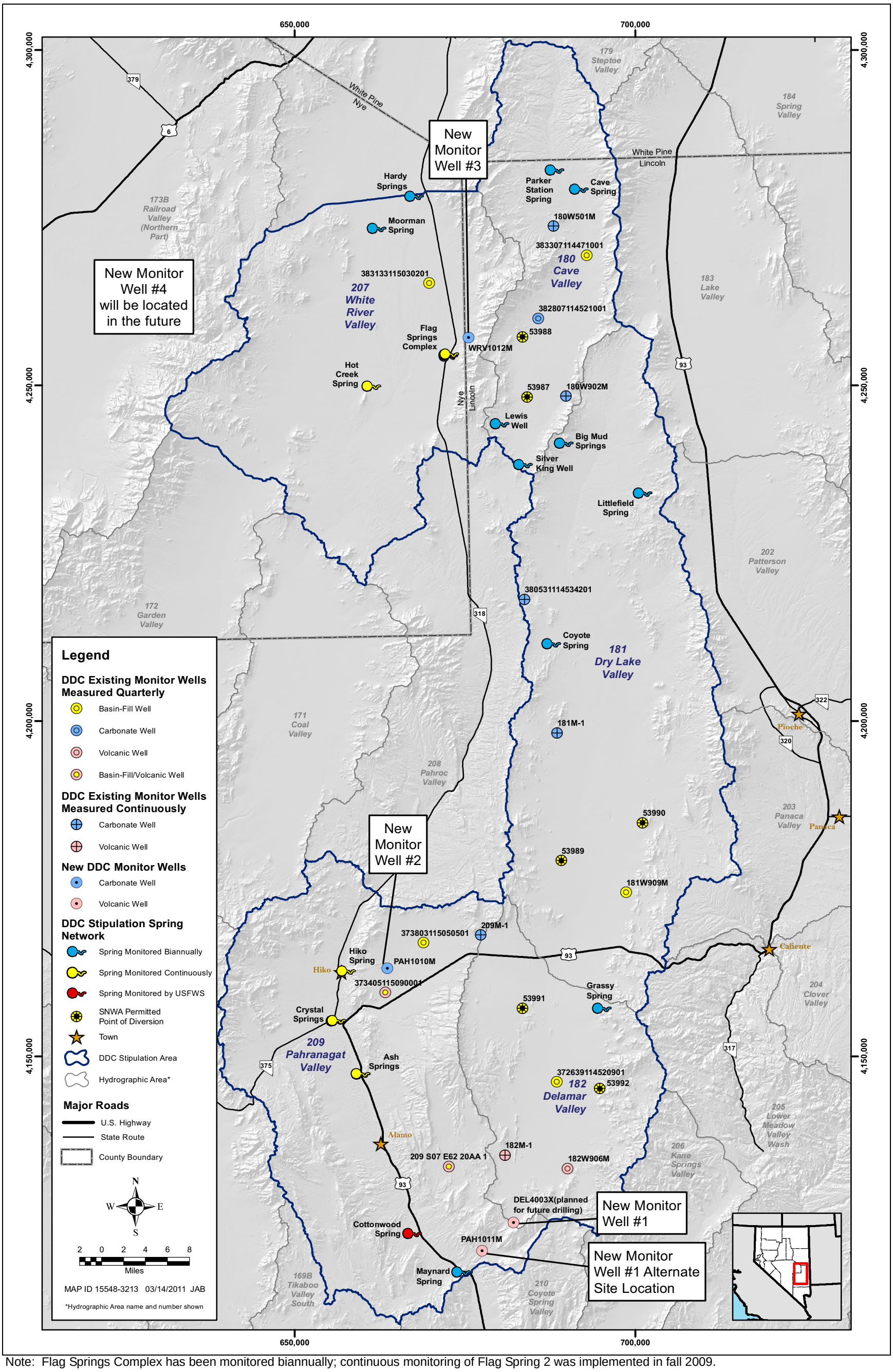
3.1 Baseline Hydrologic Monitoring Program

The Monitoring and Mitigation Plan focuses on establishing a network to collect hydrologic data for the purposes of defining baseline hydrologic conditions prior to SNWA withdrawals in DDC and detecting the effects of these withdrawals as pumping occurs. The network includes the springs and monitor wells within DDC and adjacent hydrographic areas shown on Figure 2. The Monitoring and Mitigation Plan uses existing regional precipitation stations with an extended period of record located in the vicinity of DDC. Data is collected at a frequency designed to meet Monitoring and Mitigation Plan objectives and requirements as well as to provide representative data on temporal fluctuations.

Acquisition of baseline hydrologic and hydrogeochemical data will follow the program presented in the Monitoring and Mitigation Plan with modifications as determined by the NSE. Consensus modifications by the TRP with appropriate approval by the EC will be incorporated into the plan with NSE approval.

3.2 Monitor Wells

Data collected under this Monitoring and Mitigation Plan provides representative hydrologic data on the aquifer systems of the basins. The Monitoring and Mitigation Plan includes monitoring of new and existing wells completed in basin fill, carbonate, and volcanic materials at strategic locations to provide representative data across the study area. Monitor well locations were selected through consensus agreement with the TRP and NSE technical representatives with due consideration to the hydrogeologic conditions at each site, location of potential pumping centers and areas of interest. Geologic reconnaissance, including stratigraphic and structural field mapping and aerial photo analysis, surface geophysics and review of existing hydrogeologic data was performed to assist in well selection. Some sites were selected to provide background data and provide identification and quantification of propagation of drawdown, or early warning, between potential pumping centers and areas of interest.



Note: Flag Springs Complex has been monitored biannually; continuous monitoring of Flag Spring 2 was implemented in fall 2009.

Figure 2
DDC Monitoring Network

Table 1
DDC Existing-Well Monitoring Network

Site Number	Station Local Number	Location[a]		Surface Elevation[b] (ft amsl)	Completion Date	Drill Depth (ft bgs)	Well Depth (ft bgs)	Well Casing Diameter (in.)	Screened Interval (ft bgs)	Open Interval (ft bgs)	Aquifer	Monitor Frequency
		UTM Northing (m)	UTM Easting (m)									
180W902M	180W902M	4,248,355.59	689,816.08	5,984.89	10/19/2005	917	903	12	195-882	77-917	Carbonate	Continuous
382807114521001	180 N07 E63 14BADD 1 USGS-MX	4,259,963.15	685,737.56	6,012.39	9/30/1980	460	460	10	210-250, 375-435	40-460	Carbonate[c]	Quarterly
383307114471001	180 N08 E64 15BCBC1 USBLM (Harris Well)	4,269,378.23	692,859.57	6,162.55	---	---	---	7	---	---	Basin Fill	Quarterly
180W501M	180W501M	4,273,712.79	687,971.03	6,428.63	9/23/2005	1,215	1,212	6	788-1,192	54-1,215	Carbonate	Continuous
182W906M	182W906M	4,133,304.57	690,065.21	4,796.96	9/2/2005	1,735	1,703	6	1,275-1,678	130-1,735	Volcanic	Quarterly
182M-1	182M-1	4,135,293.37	680,867.32	4,597.78	7/10/2005	1,345	1,331	12	1,006-1,290	58-1,345	Volcanic	Continuous
372639114520901	182 S06 E63 12AD 1 USGS-MX	4,146,220.24	688,472.41	4,706.30	5/10/1980	1,215	1,195	10	920-980, 1,040-1,180	40-1,215	Basin Fill	Quarterly[d]
181W909M	181W909M	4,174,462.59	698,676.17	4,799.41	10/16/2007	1,285	1,260	12	637-1,240	183-1,285	Basin Fill	Quarterly
181M-1	181M-1	4,198,199.90	688,534.99	4,963.07	8/30/2005	1,501	1,471	6	765-1,451	58-1,501	Carbonate	Continuous
380531114534201	181 N03 E63 27CAA 1 USGS-MX	4,218,085.09	683,720.32	5,456.35	1/1/1981	2,395	2,395	10	---	775-2,395	Carbonate	Continuous[d]
209 S07 E62 20AA 1	209 S07 E62 20AA 1 (Dean Turley Well)	4,133,610.32	672,648.88	4,082.46	1/10/1981	695	695	8	600-695	55-695	Basin Fill/ Volcanic	Quarterly
373405115090001	209 S04 E61 28CD 1	4,159,504.38	663,314.66	4,230.58	9/19/1968	1,314	1,314	12	1,200-1,300	52-1,314	Basin Fill/ Volcanic	Quarterly
373803115050501	209 S04 E61 01AACB1	4,166,944.29	668,927.03	4,528.90	---	---	700	8	---	---	Basin Fill	Quarterly
209M-1	209M-1	4,168,065.79	677,323.46	5,097.30	8/4/2005	1,616	1,616	6	1,274-1,595	50-1,616	Carbonate	Continuous
383133115030201	207 N08 E62 30CD 1 USGS-MX	4,265,229.62	669,732.25	5,290.20	---	---	101	2	---	---	Basin Fill	Quarterly

[a]Professional survey complete on location and elevation. All coordinates are Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD83), Zone 11.
[b]Elevations are North American Vertical Datum of 1988 (NAVD88).
[c]Carbonate bedrock was encountered at 265 ft bgs according to the well log.
[d]Well is monitored continuously by the USGS.
Well-construction data are based upon best available information from well logs, MX Project Report (Ertec Western Inc., 1981a through d), and direct field measurements.
Monitoring frequency agreed to by the TRP. Additional water-level data in the study area may be collected by SNWA or USGS and reported in future data reports.

3.2.1 Existing Well Network

SNWA will record water levels quarterly in nine representative monitor wells and continuously in six representative monitor wells located in DDC and the adjacent White River and Pahranagat hydrographic areas. Well construction data, monitoring frequency, and surveyed location and elevation information for each location are presented in Table 1. The existing well network was selected in consultation with the NSE and TRP to include seven SNWA wells, three private wells, one BLM well and four USGS-MX wells. Wells included in the network are completed in carbonate-rock, volcanic-rock and basin-fill aquifers. Historic water-level data from wells in the network are presented in SNWA, 2011.

The wells were selected to: (1) serve as long-term monitoring points and early warning indicators between SNWA's future production wells and existing water-right holders and environmental resources; (2) provide spatially distributed hydrologic data from aquifers within DDC and adjacent hydrographic areas in order to analyze and produce annual groundwater-level contour and water-level drawdown maps after pumping begins; (3) provide head observations for calibration of the groundwater flow model; and (4) evaluate the effects of SNWA's groundwater withdrawals on local and regional water levels.

Modification of this element of the Monitoring and Mitigation Plan, including any addition, subtraction, or replacement of the wells initially selected by the TRP or changes to the frequency of monitoring for these wells, would be made through consensus recommendations from the TRP, or as required by the NSE. Monitoring locations may be eliminated or alternative locations selected if private property access is restricted.

Seven of the existing monitor wells included in the Monitoring and Mitigation Plan were constructed by SNWA and are located in DDC and Pahranagat Valleys. The SNWA wells were constructed in 2005 and include four 6-in.-diameter and three 12-in.-diameter monitor wells in Delamar, Dry Lake, Cave, and Pahranagat Valleys. Geologic analysis reports for the seven wells are presented in Eastman (2007a through g). Five of the SNWA monitor well locations were selected for continuous monitoring along with one USGS MX monitoring well. The continuous recording instrumentation at the SNWA wells was installed between April and June, 2007. The period of record for the USGS MX well (380531114534201) dates back to the early 1980s. Continuous monitoring of water levels at that location has been conducted periodically, with the most recent period beginning in late 2007. The data collection interval at the continuously monitored locations is hourly. Site visits will be conducted to obtain periodic water-level measurements and download continuous pressure transducer data for processing and analysis.

A professional survey of location coordinates, ground-surface elevation and top-of-casing measuring-point elevations of the network wells was completed. Surveys will be performed on any newly constructed wells upon completion or on existing monitor wells added to the network in the future.

3.2.2 New Monitor Well Locations

SNWA will install four new monitor wells. In 2009, three primary sites and one contingency site were selected in consultation with the NSE and TRP for the installation of three of the monitor wells. The location of the fourth well site will be selected after more information is available on the production network configuration. The coordinates, estimated surface elevations and depth to groundwater for the new monitor wells are presented in Table 2. The locations of these new monitor wells are shown in Figure 2.

Table 2
New DDC Monitor Wells

Well Name	Location[a]		Estimated Surface Elevation[b] (ft amsl)	Estimated Depth to Water (ft)
	UTM Northing (m)	UTM Easting (m)		
WRV1012M	4,257,087	675,519	5,794	420
PAH1010M	4,163,098	663,576	4,380	700
DEL4003X	4,125,223	682,153	4,738	1,450
PAH1011M (alternate site)	4,121,019	677,508	3,727	635

[a]All coordinates are UTM, NAD83, Zone 11.
[b]Elevations are NAVD88.

The northernmost future Monitor Well, WRV1012M, will be located on the west side of the Egan Range northeast of Flag Spring in White River Valley. This well is anticipated to be completed in the Ely Springs Dolomite. The location was selected as a monitoring point and early warning indicator between Flag Springs Complex and Cave Valley. The new well and other existing monitor wells in Cave Valley will provide baseline water-level data to evaluate the hydraulic gradient through Shingle Pass. The depth to groundwater is estimated to be approximately 420 ft bgs at this location.

The second future Monitor Well, PAH1010M, will be located on the east side of the Hiko Range at Sixmile Flat in Pahranagat Valley. The site is located 3.5 mi east of Hiko Spring. The target completion zone is saturated fractured carbonate rocks within the middle to lower units of the Guilmette Formation and possibly the Simonson Dolomite. Carbonate bedrock is anticipated to be encountered within 50 ft of land surface, and it is expected that rocks will be fractured at depth because of the movement along the range-front fault and ancillary normal faults. The depth to water in this area is estimated to be approximately 700 ft bgs.

The third future monitor well will be installed at the well site of a proposed SNWA Test Well, DEL4003X, which is located near the southern boundary of Delamar Valley within a structural feature of the Pahranagat Shear Zone. This well is anticipated to be completed in volcanic materials. An alternative site, PAH1011M, has been identified and will be located along a major structural feature of the Pahranagat Shear Zone southwest of the test well site.

The well sites are located on BLM managed land. The necessary right-of-way applications for these well sites have been submitted and approved by BLM.

3.2.3 Production and Test Well Monitoring

SNWA will record groundwater production and water-level data at all future operational SNWA production wells on a continuous basis. SNWA will record water levels in all existing and future SNWA exploratory and test wells at least quarterly. Two existing SNWA test wells, one 6-in.-diameter Monitor Well (CAV6002M2) and one 20-in.-diameter Test Well (CAV6002X), were installed in southern Cave Valley near Monitor Well 180W902M on October 13 and 28, 2007. A geologic analysis report, containing drilling and downhole geophysical data, lithologic descriptions and structural evaluation, for the wells is presented in Baird (2011). The well-construction attributes of the two wells are presented in Table 3.

Table 3
Existing SNWA DDC Test Wells

Site Number	Station Local Number	Location[a]		Surface Elevation[b] (ft amsl)	Completion Date	Drill Depth (ft bgs)	Well Depth (ft bgs)	Well Casing Diameter (in.)	Screened Interval (ft bgs)	Open Interval (ft bgs)	Aquifer	Monitor Frequency
		UTM Northing (m)	UTM Easting (m)									
CAV6002X	CAV6002X	4,248,307.58	689,819.01	5,987.97	10/28/2007	917	901	20	219-901	50-917	Basin Fill/ Carbonate	Quarterly
CAV6002M2	CAV6002M2	4,248,365.83	689,782.96	5,982.81	10/13/2007	893	885	6	159-882	50-893	Basin Fill/ Carbonate	Quarterly

[a]Professional survey complete on location and elevation. All coordinates are UTM, NAD83, Zone 11.
[b]Elevations are NAVD88.
Note: Well-construction data are based upon best available information from well logs.

3.3 Aquifer Characterization

A constant-rate pumping test will be performed on each future production test well to evaluate aquifer properties. Aquifer-testing results will be used to assess well performance, provide data for the groundwater flow model and assist in evaluating potential future pumping influence.

Well-performance step test and 72-hour constant-rate tests have been performed on SNWA Test Well CAV6002X and Monitor Well 180W902M located in Cave Valley. A hydrologic data analysis report including hydrologic data, well performance and aquifer test analysis and water chemistry results has been prepared for the site (Prieur et al., 2011).

3.4 Spring Discharge Monitoring Network

The Monitoring and Mitigation Plan has two components of spring discharge monitoring. The first component consists of eight springs within DDC that will be monitored biannually for discharge (if measurable), field chemistry and general conditions. The second component consists of nine springs in White River and Pahranagat Valleys that will be monitored for discharge (if measurable). The spring locations and monitoring frequency are presented in Table 4. Available historical data and descriptions of the springs are presented in *Delamar, Dry Lake, and Cave Valleys Stipulation Agreement Hydrologic Monitoring Plan Status and Historical Data Report* (SNWA, 2009b).

3.4.1 DDC Biannual Spring Monitoring

Eight spring monitoring locations were selected within the DDC valleys by the TRP in consultation with the NSE. These springs are generally characterized as sourced in the mountain block and as having no hydraulic connection to the regional aquifer. However, biannual baseline monitoring is being performed to document variability in spring conditions. Springs included in the program are Grassy Spring in Delamar Valley; Coyote, Big Mud and Littlefield springs in Dry Lake Valley; Parker Station and Cave springs in northern Cave Valley; and Lewis Well and Silver King Well in southern Cave Valley. Spring locations are presented in Figure 2.

Several of the springs (Grassy, Big Mud, Coyote and Lewis Well) have been modified in the past with a collector system to transmit water to distribution points away from the spring. Silver King Well is a shallow dug well or modified spring with a gravity discharge line to a stock water area.

Field visits to the sites have been conducted in the spring and fall of each year when site access conditions permit. Wetted area and discharge (if measurable) are documented. Field water-quality is measured including, pH, electrical conductivity and temperature. Photographs are taken to document site conditions. Physical descriptions, photos and historical hydrologic and water-chemistry data for the springs are presented in the annual hydrologic status and data reports.

3.4.2 White River and Pahranagat Valleys Springs

Nine springs located in White River and Pahranagat valleys are included in the monitoring network. Five of these springs are currently being monitored through a cooperative funding arrangement

Table 4
DDC Springs Monitoring Locations and Monitoring Frequency

Basin Number	Station Number	Station Name	Elevation[a]	Location[b]		Monitoring Frequency
				UTM Northing (m)	UTM Easting (m)	
180	1800101	Cave Spring	6,490	4,279,249	691,760	Biannual
	1800301	Parker Station Spring	6,490	4,282,096	688,179	
	381624114540302	USBLM Silver King Well	6,230	4,238,220	683,551	
	381943114562201	Lewis Well	6,260	4,244,297	680,106	
181	1810301	Littlefield Spring	6,150	4,233,949	701,112	Biannual
	1810401	Coyote Spring	5,220	4,211,513	687,693	
	1810501	Big Mud Springs	6,430	4,241,387	689,547	
182	1820101	Grassy Spring	5,790	4,157,193	695,124	
207	2070501	Hot Creek Spring near Sunnyside, NV	5,230	4,249,926	661,290	Continuous
	2071101	Moorman Spring	5,300	4,273,440	662,053	Biannual
	2071501	Hardy Springs	5,350	4,278,196	667,553	
209	2090101	Hiko Spring	3,880	4,162,744	657,549	Continuous
	2090201	Cottonwood Spring	3,240	4,123,643	667,261	Quarterly[c]
	2090801	Maynard Spring	3,110	4,117,909	674,444	Quarterly
Flag Springs Complex						
207	2071301	Flag Spring 3 (South)	5,290	4,254,416	672,579	Biannual
	2071302	Flag Spring 2 (Middle)	5,280	4,254,570	672,576	Continuous
	2071303	Flag Spring 1 (North)	5,290	4,254,696	672,719	Biannual
Crystal Springs						
209	09415589	Crystal Springs Diversion near Hiko, NV	3,820	4,155,336	656,011	Continuous
	2090401	Crystal Springs near Hiko, NV	3,800	4,155,348	656,165	
Ash Springs						
209	09415639	Ash Springs Diversion at Ash Springs, NV	3,600	4,147,415	659,716	Continuous
	2090501	Ash Springs	3,600	4,147,460	659,684	

[a]All elevations are rounded to the nearest 10 ft, NAVD88. High-resolution Global Positioning System will be used to determine elevations at a later date.
[b]All coordinates are UTM NAD83, Zone 11.
[c] Monitoring performed by USFWS. Data provided to SNWA will be presented in the annual data report.

between SNWA, the USGS, and the NDWR. These springs are Flag Springs Complex, Hot Creek, Moorman, Ash, and Crystal Springs. The monitoring frequency of each spring is listed in Table 4. SNWA will monitor, or fund a mutually agreed-upon third party to monitor, these locations.

Hiko spring was evaluated by SNWA and the NSE for technical feasibility of monitoring and property access. A monitoring station was constructed in cooperation with the Hiko Spring Irrigation District and the owners of the Cannon and Whipple Ranches. SNWA monitors discharge at Hiko Spring continuously using a flow meter and data logger installed on the 18-in.-diameter pipe located approximately 0.5 mi southwest of the spring. All work was completed in June 2009. The Hiko Irrigation Company uses a perpetual calendar which assigns irrigation times to each of the twelve members of the company. One complete rotation of the 12 users equates to 11.5 days. There are periods during each rotation when water is diverted above the gage. Daily discharge rates vary

between 4.3 to 8.3 cfs depending upon the season and irrigation needs of the individual users. Data will be further evaluated as more information is collected. A detailed description and photo documentation of Hiko Spring are presented in SNWA (2009b), including a discussion of the historical data collected at the spring complex.

SNWA and the NSE also worked together to obtain approval for installation of a flume at Hardy Springs. The Flume was installed in August 2009.

A flume and continuous monitoring instrumentation was installed at Middle Flag Spring through a cooperative project with Nevada Department of Wildlife and SNWA in November 2009. South and North Flag Springs will be measured biannually. SNWA will perform measurements at the sites dependent upon continued property access.

Cottonwood Spring will be monitored by USFWS, and data collected by USFWS and provided to SNWA will be included in the annual SNWA data report. Maynard Spring located on BLM land is monitored by measuring the water level in an existing piezometer in the north pool. No measureable discharge has been observed. SNWA will continue to work with USFWS and BLM in regard to the monitoring of Maynard Spring.

3.5 Precipitation Stations

SNWA will compile and report data from selected precipitation stations with an established historical record in the vicinity of the study area as long as the data is available and the stations are in operation. The precipitation network will assist in assessing climate variability in the vicinity of the DDC Basins. The current precipitation network stations are presented in Table 5 and shown on Figure 3.

The precipitation station network includes the following:

- Eight high-altitude precipitation stations maintained and operated by USGS through a cooperative funding agreement with SNWA and the NDWR.

- Nine National Oceanic and Atmospheric Administration, National Weather Service Stations. Data will be obtained through the Western Regional Climate Center (WRCC).

- One U.S. Department of Agriculture National Resources Conservation Service (NRCS) SNOwpack TELemetry (SNOTEL) site located in the Egan Range. This site provides precipitation and snow-accumulation data.

3.6 Water-Chemistry Baseline Data Monitoring Program

Monitoring of groundwater and surface-water chemistry will be implemented to establish baseline conditions. The sampling program will consist of the collection of 10 samples from representative springs and monitor wells determined by the TRP and NSE. Two sampling events will be performed at 6-month intervals to collect baseline data. The first sampling event will occur after installation of the three new monitor wells. SNWA will collect and submit samples for chemical analysis for the

Table 5
DDC Precipitation-Station Locations

Station Name	Location[a]		Surface Elevation[b] (ft amsl)	Data Source
	UTM Northing (m)	UTM Easting (m)		
Blue Eagle Ranch Hank	4,264,579	626,889	4,780	WRCC
Caliente	4,166,217	719,251	4,400	WRCC
Cave Mountain	4,337,545	706,107	10,650	USGS
Elgin	4,136,286	717,627	3,420	WRCC
Highland Peak	4,196,772	712,963	9,330	USGS
Hiko	4,158,266	656,900	3,900	WRCC
Lund	4,303,974	672,091	5,546	WRCC
McGill	4,365,043	691,693	6,270	WRCC
Mount Irish	4,168,657	641,846	8,607	USGS
Mount Washington	4,309,377	732,764	10,440	USGS
Mount Wilson	4,236,084	728,118	9,200	USGS
Pahranagat Wildlife Refuge	4,126,390	666,716	3,400	WRCC
Quinn Canyon Range	4,228,799	620,297	9,050	USGS
Spring Valley State Park	4,214,070	747,476	5,950	WRCC
Sunnyside	4,254,668	672,599	5,297	WRCC
Unnamed Peak in South Delamar Mountains	4,135,352	701,473	7,800	USGS
Unnamed Peak South of Chokecherry Peak	4,154,830	700,904	7,800	USGS
Ward Mountain	4,333,184	676,331	9,200	NRCS (SnoTel)

[a]All coordinates in UTM, NAD83, Zone 11.
[b]Elevations are NAVD88.

water-chemistry parameters listed in Table 6. Water chemistry parameters may be modified by consensus of the TRP and NSE in consultation with the BRT.

Subsequent sampling will be performed once every 5 years following the start of groundwater production by SNWA.

3.7 Data Collection Methodology and Quality Control Procedures

All data collection and processing will be performed following SNWA procedures. Applicable standards from organizations, such as the American Society for Testing and Materials, the U.S. Environmental Protection Agency, and the USGS, for each element of the program are incorporated as appropriate. A quality assurance/quality control (QA/QC) program will be followed, which includes the following elements: (1) identification of QA/QC procedure and direct organizational

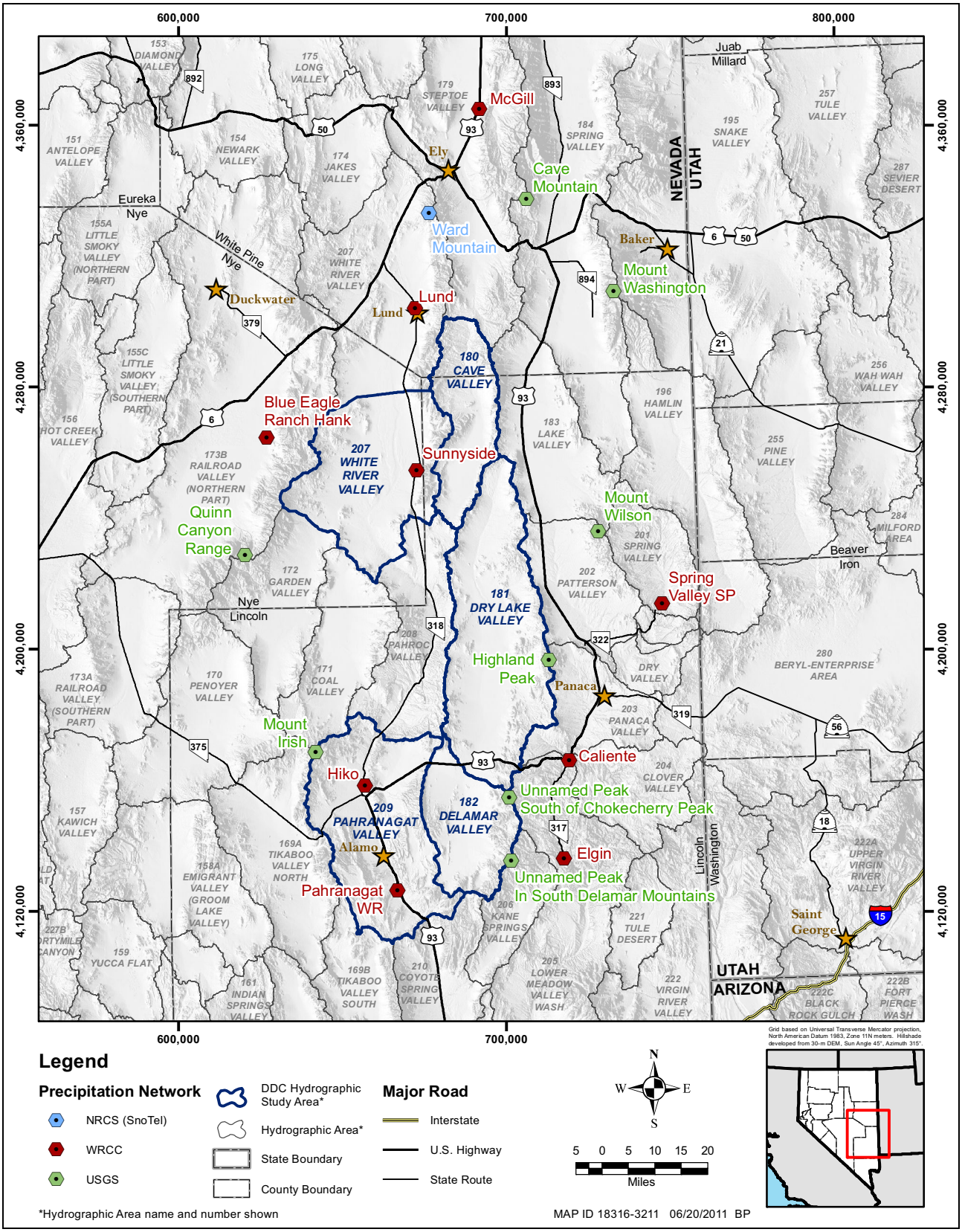


Figure 3
DDC Precipitation-Station Locations

Table 6
Water-Chemistry Parameters

Field Parameters	Major Ions	Isotopes	Minor and Trace Elements
Water temperature	TDS	Oxygen-18	Arsenic
Air temperature	Calcium	Deuterium	Barium
pH	Sodium	Tritium	Cadmium
Electrical conductivity	Potassium	Chlorine-36[a]	Chromium
Dissolved oxygen	Chloride	Carbon-14[a]	Lead
	Bromide	Carbon-13[a]	Mercury
	Fluoride	Strontium-87[a]	Selenium
	Nitrate	Uranium-238[a]	Silver
	Phosphate		Manganese
	Sulfate		Aluminum
	Alkalinity		Iron
	Silica		Bromide
	Magnesium		Fluoride

[a]These parameters will be included only in the first sampling event and will not be included in any further water-chemistry sampling performed pursuant to this Monitoring and Mitigation Plan.

responsibilities; (2) staff training; (3) project work plans and reviews; (4) instrumentation deployment, maintenance and calibration with the use of industry-recognizable standards and traceable to the National Institute of Standards and Technology when appropriate; (5) data collection protocols and documentation; (6) sample collection, chain of custody and laboratory-analysis procedures; (7) data processing and review procedures; and (8) data storage.

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4.0 DATABASE DEVELOPMENT AND REPORTING

4.1 Database Management

All data collected pursuant to this Monitoring and Mitigation Plan will be processed according to the applicable SNWA procedure(s) and stored in an appropriate computerized database and/or physical file. Database quality will be maintained by verifying database input against original data files. Internal cross-checks of new data in the database will be performed at the time of entry to identify anomalous new or existing data. Original data will be maintained in paper or electronic archives to ensure integrity and traceability. Data reviews will be performed to verify that data are collected and entered into the database properly and accurately.

4.2 Reporting

Using data from groundwater-level measurements of all production and monitor wells used in this Monitoring and Mitigation Plan, SNWA will produce groundwater contour maps and water-level change maps for both the basin-fill and carbonate-rock aquifers: (1) at the end of baseline data collection and (2) annually thereafter at the end of each year of groundwater withdrawals by SNWA or as required by the NSE.

Water-level and groundwater-production data will be submitted to the NSE quarterly in an electronic format, as specified by the NSE. Water chemistry laboratory reports will be made available to the NSE within 90 calendar days of receipt or within an alternative time frame required by the NSE.

SNWA will report the results of all monitoring and sampling pursuant to this Monitoring and Mitigation Plan in an annual monitoring data report submitted to the NSE by March 31 for each year that this Monitoring and Mitigation Plan is in effect. The annual monitoring report will include SNWA's proposed schedule of groundwater withdrawals for the immediately succeeding 2 calendar years.

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5.0 NUMERICAL MODELING OF REGIONAL GROUNDWATER FLOW

The Stipulation parties agreed that the Monitoring and Mitigation Plan must include a well-calibrated regional groundwater flow system numerical model. SNWA proposes the use of one model to satisfy the requirements of both the Stipulation and Ruling on SNWA applications. SNWA will maintain, update, and operate the model, in cooperation with the TRP and NSE, and may subcontract this obligation to a third party, if approved by the TRP and NSE.

Numerical groundwater modeling along with the monitoring program are components of the hydrologic adaptive management approach. The model results must be qualified based on a comparison of the accuracy of the model and the capability of the model to predict actual observed conditions. Modification of the numerical model of the regional groundwater flow system may occur based upon additional hydrologic, geologic, geophysical and/or geochemical data collected under the Monitoring Plan. SNWA will update the NSE-approved groundwater flow model every 5 years after pumping begins and submit the updated predictive results.

SNWA will provide model output for evaluation by the NSE or TRP in the form of input files, output files, drawdown maps, tabular data summaries, and plots of simulated water levels through time for the aquifer system, unless otherwise recommended by the TRP. Additional information will be provided as required by the NSE.

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6.0 MANAGEMENT AND MITIGATION ACTIONS

SNWA will implement management and mitigation actions as required by the NSE. The Stipulation presents criteria and a process for the TRP to initiate consultation, management or mitigation actions. The TRP is tasked with reviewing water-level responses and model results to determine if potential injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources are occurring or are predicted to occur due to ongoing or proposed groundwater withdrawals by SNWA in DDC.

SNWA shall mitigate any injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources as agreed upon by the Stipulation parties or as required by the NSE. SNWA shall work with the NSE to implement management and mitigation actions relative to injury to private or non-Federal water-right holders.

Mitigation measures may include, but are not limited to, one or more of the following:

- Geographic redistribution of pumping within the Hydrographic Basins;
- Acquisition of real property and/or water rights dedicated to the recovery of Special Status Species within the current and historic habitat range of each of the Special Status Species. The Parties anticipate that such acquisition of real property and/or water rights may be accomplished prospectively in order to offset future impacts, also known as mitigation banking;
- Augmentation of Federal Water Rights, Federal Resources, and/or Water Dependent Ecosystems and/or provision of resources to restore and enhance habitat on the Pahranagat National Wildlife Refuge;
- Augmentation of water supply for existing water-rights holders using surface and groundwater sources;
- Provision of consumptive water-supply requirements of non Federal water right holders using surface and groundwater sources;
- Reduction or cessation of groundwater withdrawals within the Hydrographic Basins; and
- Other measures as agreed to by the Stipulation Parties and/or required by the NSE.

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