# SNWA Hydrologic Management Program for Groundwater Development in Spring, Cave, Dry Lake, and Delamar Valleys, Nevada

**PRESENTATION TO THE OFFICE OF THE NEVADA STATE ENGINEER**

Prepared by

SOUTHERN NEVADA WATER AUTHORITY

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# SNWA Hydrologic Management Program for Groundwater Development in Spring, Cave, Dry Lake, and Delamar Valleys, Nevada

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

June 2011

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6/23/11

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## ACRONYMS

| | |
|---|---|
| BIA | Bureau of Indian Affairs |
| BLM | Bureau of Land Management |
| BRT | Biological Resource Team |
| BWG | Biological Working Group |
| DDC | Delamar, Dry Lake, and Cave valleys |
| DEM | digital elevation model |
| DOI | U.S. Department of the Interior |
| DTW | depth to water |
| EC | Executive Committee |
| GBNP | Great Basin National Park |
| LVVWD | Las Vegas Valley Water District |
| NAD83 | North American Datum of 1983 |
| NAVD88 | North American Vertical Datum of 1988 |
| NPS | National Park Service |
| NRS | Nevada Revised Statutes |
| NSE | Nevada State Engineer |
| POD | point of diversion |
| QA | quality assurance |
| QC | quality control |
| SNPLMA | Southern Nevada Public Lands Management Act |
| SNWA | Southern Nevada Water Authority |
| TRP | Technical Review Panel |
| UGS | Utah Geological Survey |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| UTM | Universal Transverse Mercator |

## ABBREVIATIONS

| | |
|---|---|
| af | acre-foot |
| amsl | above mean sea level |
| bgs | below ground surface |
| ft | foot |
| gpm | gallon per minute |
| in. | inch |

## ABBREVIATIONS (CONTINUED)

| | |
|---|---|
| m | meter |
| mi | mile |
| yr | year |

# 1.0 INTRODUCTION

This report describes the Southern Nevada Water Authority's (SNWA) hydrologic monitoring, management and mitigation programs (Hydrologic Management Program) in the Dry Lake, Delamar and Cave (DDC) and Spring Valley hydrographic basins (Project Basins). The Hydrologic Management Program is intended to support SNWA's groundwater applications that are pending before the Nevada State Engineer (NSE) and is designed to meet the requirements of Nevada Revised Statutes (NRS) and the stipulated agreements between SNWA and the Federal Agencies, which are explained in further detail later in this report. SNWA has implemented many of the elements of the Program described in this report and has committed to constructing and implementing the remaining elements as required prior to development of the pending applications in the Project Basins.

For new applications to appropriate and import water, the NSE is required under NRS 533.370(5); 6(c) to examine potential conflicts with existing rights, weigh the possible benefits and detriments to the public's interest, and analyze whether the interbasin transfer is environmentally sound. The Hydrologic Management Program creates a means for the NSE to meet these obligations by (1) offering a scientifically sound framework to study the groundwater aquifers in the Project Basins; (2) establishing a periodic data reporting process; and (3) collaborating to adapt and change the groundwater development scenario as needed to ensure responsible and sustainable development of the resource. Proposed Hydrologic Monitoring and Mitigation Plans have been prepared for Spring Valley and DDC and will be presented to the NSE concurrent with this report. Those proposed plans may be incorporated into the terms of any groundwater permit granted by the NSE as a condition for groundwater withdrawals.

The Hydrologic Management Program includes specific monitoring and mitigation requirements to protect Federal and non-Federal resources. Federal resources are addressed through stipulation agreements between SNWA and the Department of Interior (DOI). The stipulation agreements' program and structure are explained in Sections 2.1.1 and 3.1.1. Additional monitoring and mitigation measures to protect non-Federal water-right holders previously required by the NSE are described in Section 2.1.2. SNWA also performed substantial supplemental basin characterization and hydrologic monitoring beyond Stipulation and NSE requirements, as explained in Section 4.0, which has increased understanding of regional and Project Basins hydrologic systems.

The NSE and stipulation requirements are included in the Hydrologic Management Program. The Hydrologic Management Program, including specific monitoring and mitigation plans for Spring Valley and DDC and current status are described in Sections 2.0 and 3.0 of this document. These monitoring and mitigation plans were submitted and approved by the NSE on February 9, 2009 and December 22, 2009 for Spring Valley and DDC, respectively, prior to Rulings 5726 and 5875 being vacated. The program may be revised in the future to incorporate requirements associated with the new permits for pending applications and consensus plan modifications associated with the Stipulation Agreements. Additional monitoring may also be required as part of the environmental compliance associated with the right-of-way grants. The Hydrologic Management Program, coupled with the enforcement authority of the NSE, provides an effective mechanism and process to ensure that the rights of existing water-right holders, Federal resources, and areas of interest are protected.

The Spring Valley and DDC Monitoring Plan elements of the Hydrologic Management Program have been successfully implemented and data collection is ongoing. Systematic data collection activities at many locations used in the plans began in 2007, prior to NSE plan approval. Annual hydrologic monitoring program status and historical data reports have been prepared by SNWA and submitted to the DOI and NSE each year between 2008 and 2011 for Spring Valley and DDC. The monitoring plans have established long-term monitoring networks which have enhanced the understanding of basin and regional hydrologic systems within the study areas. The monitoring network has been established over a vast area including remote locations with difficult access. The implementation, maintenance, and on-going monitoring requires significant SNWA resources and manpower.

The Hydrologic Management Program was developed by consensus agreement with NSE and Federal technical expert representatives. The Program is structured as a consensus based adaptive process to evaluate current and direct future activities. The Federal resources are represented through a Technical Review Panel (TRP), established by the stipulation agreements, composed of technical experts from SNWA, U.S. Fish and Wildlife (USFWS), Bureau of Land Management (BLM), National Park Service (NPS), and Bureau of Indian Affairs (BIA). A technical expert from the NSE also participates on the TRP. The stipulation agreements established an Executive Committees (EC), composed of representatives from the signatory parties, to oversee implementation of the agreement. Non-Federal water-right holders and the public's interest are represented through the NSE which has authority over the monitoring and mitigation programs and conditions of the water rights permits.

The Hydrologic Management Program establishes scientifically sound adaptive monitoring and mitigation plans which meet the goals and objectives of the Spring Valley and DDC Stipulation Agreements and vacated NSE Rulings 5726 and 5875. At this stage of development, the program is comparable with other regional groundwater monitoring programs and water development projects as described in Section 4.7. The Hydrologic Management Program is coordinated with biological resource management and monitoring activities required through the Stipulation and vacated Rulings.

The Program builds upon regional hydrologic data collection and basin characterization studies performed by SNWA since the late 1980's and by State and Federal organizations dating back to the early 1900s. It is based upon characterization of the hydrogeologic framework, understanding of the hydrologic system and natural variability, interactions between different elements within the hydrologic system, and pumping stresses on the system. The monitoring network provides representative locations to observe the presence and magnitude of drawdown resulting from project groundwater development and provides an indication of potential influence at locations further from the pumping areas.

The Program uses an adaptive management process for continually improving hydrologic monitoring and predictive management tools. Data derived from the monitoring plans are used to evaluate and enhance the understanding of the regional and local hydrologic systems, determine if monitoring plan objectives are being met, provide data for model refinement, and develop optimal pumping operations while limiting impacts. The adaptive management process recognizes uncertainties associated with predicting future outcomes with limited knowledge of system complexity and behavior. Uncertainty is reduced over time as more baseline and operational data becomes available. The Program integrates monitoring information including hydrologic, biological, and climatological data with groundwater development operations to refine management tools in order to optimize water resource development and minimize impacts in an environmentally sound manner. The basin characterization, monitoring plans, predictive tools, and operations plans provide key elements of the integrated basin hydrologic management strategy.

The Hydrologic Management Program develops and refines predictive tools to assess influence of water resource development operations. Monitoring results provide data for refinement of numerical flow models and other analytical predictive tools which can be used to identify data gaps in the monitoring network as well as be used as an early warning of potential influence at points of interest. The Program incorporates new hydrologic and operational data to refine the model and management program. The regional numerical flow model is at an early stage of development with limited data in the Project Basins and other valleys of interest to predict aquifer response to large scale pumping. As additional basin characterization and direct hydrologic monitoring data is collected over time under a range of varying pumping and climate conditions, the model becomes more useful as a predictive tool.

The adaptive management approach uses hydrologic system and pumping data to structure and refine basin groundwater development operations and monitoring plans in an integrated manner. The Program has structure and flexibility to identify potential influence from pumping and to respond to potential impacts in a responsible and technically sound manner within the context of natural system variations. A mitigation plan is included within the Program which provides for a clear process and action to address potential effects at areas of interest. It also includes, if needed, mitigation alternatives and implementation processes.

The long-term basin Hydrologic Management Program strategy integrates understanding of the hydrologic system, monitoring and mitigation plan results, water development operations, and predictive tools in an adaptive manner. The Program's effectiveness continues to improve over time as new hydrologic and operations data become available to refine the monitoring network, predictive tools, and water development operation plans. The Program's structure provides a clear process for project input, review, and control by stakeholders through the NSE, TRP, and EC. The specific monitoring, management, and mitigation elements of the Hydrologic Management Program for Spring Valley and DDC, along with the enforcement authority of the NSE provides a sound program for water resource development while protecting existing water-right holders, Federal resources, and areas of interest.

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# 2.0 SPRING VALLEY HYDROLOGIC MANAGEMENT PROGRAM

SNWA has developed and implemented a Hydrologic Management Program associated with the groundwater development project in Spring Valley. The Program includes a specific monitoring and mitigation plan which provides a structured process to manage the Spring Valley water development project in a responsible and sustainable manner. This section provides background and a description of the Spring Valley monitoring and mitigation plan.

## 2.1 Monitoring Plan Development and Background

The Spring Valley Stipulation Agreement between SNWA and the DOI along with the vacated NSE (2007) Ruling 5726 present specific monitoring objectives and requirements which are addressed within the Spring Valley Monitoring and Mitigation Plan (Spring Valley Monitoring Plan). The Monitoring Plan was submitted to the NSE and approved on February 9, 2009 prior to Ruling 5726 being vacated. The previously approved monitoring plan is presented in SNWA (2009a). This section summarizes the key hydrologic monitoring requirements of the Spring Valley Stipulation and vacated Ruling 5726, plan development, and implementation status.

SNWA submitted a proposed monitoring and mitigation plan for Spring Valley to the NSE (SNWA, 2011a). SNWA requested that the plan be considered by the NSE for inclusions as a permit condition associated with SNWA groundwater permits for applications 54003 through 54021.

Spring Valley Monitoring Plan data are provided to the NSE and DOI on a quarterly basis and in annual status and data reports which have been published since March 2008. The approved Spring Valley Monitoring Plan has been implemented with plan specific data collection occurring since 2007. This program builds upon historical hydrologic data which dates as far back as 1914 (at Cleve Creek). The most recent data report is the *2010 Spring Valley Hydrologic Monitoring and Mitigation Plan Status and Data Report* (SNWA, 2011b). The previous annual reports prepared in 2008-2010 are presented in SNWA (2008a, 2009b, 2010a).

### 2.1.1 Spring Valley Stipulation Agreement

In 1989, the Las Vegas Valley Water District (LVVWD) filed 19 applications (54003 through 54021) for the appropriation of groundwater resources in Spring Valley (SNWA's Spring Valley Applications). By agreement with LVVWD on December 18, 2003, SNWA assumed full interest in these applications.

Prior to the 2006 NSE hearing on SNWA's Spring Valley Applications, a Stipulation for Withdrawal of Protests (Stipulation, 2006) was entered on September 8, 2006, between SNWA and DOI, on behalf of the BIA, BLM, NPS, and USFWS (also known as the DOI Bureaus). An EC composed of representatives of parties to the Stipulation was established to oversee the implementation of the Spring Valley Stipulation. The Spring Valley Stipulation requires that SNWA implement a hydrologic monitoring, management, and mitigation plan, as described in Exhibit A to the Spring Valley Stipulation. Development and implementation of a biological monitoring, management, and mitigation plan is also required as described in Exhibit B to the Spring Valley Stipulation.

A TRP composed of technical experts appointed by each party to the Spring Valley Stipulation and a participating representative of the NSE Office, was established to develop and oversee implementation of the hydrologic monitoring, management, and mitigation plan; to review program data; and to modify the monitoring plans, if necessary. The TRP has had an effective working relationship and has met on numerous occasions including conducting field visits to select well and spring monitoring locations, review various monitoring program elements and applied methodologies, provide program technical updates, and develop water chemistry sampling programs. The TRP has had regular communications via meetings, e-mail, and telephone to provide a responsive forum for any technical hydrologic questions or issues of concern to the parties.

The hydrologic monitoring plan development, implementation, and data evaluation has been performed with direct involvement and consensus of the TRP and the NSE Office. Additional invited participants included the U.S. Geological Survey (USGS), who participated in the selection of some new monitor well sites. SNWA has also worked in cooperative data collection and sharing efforts with the Nevada and Utah offices of the USGS and the Utah Geological Survey (UGS).

A Biological Working Group (BWG) was also established by the Spring Valley Stipulation to oversee the development and implementation of the biological monitoring plan. The TRP worked closely with the BWG to provide hydrologic information during the development and implementation of the biological monitoring plan as well as coordination of field operations.

The goals stated in the Spring Valley Stipulation are: (1) to manage the development of groundwater by SNWA in the Spring Valley hydrographic area without causing injury to Federal water rights and/or unreasonable adverse effects to Federal resources in the area of interest; (2) to accurately characterize the groundwater hydraulic gradient from the Spring Valley hydrographic area to the Snake Valley hydrographic area via Hamlin Valley; and (3) to avoid any effect on Federal resources located within the boundaries of the Great Basin National Park (GBNP) from groundwater withdrawal by SNWA in the Spring Valley hydrographic area.

Additional common goals are: (1) to manage the development of groundwater by SNWA in Spring Valley hydrographic area in order to avoid unreasonable adverse effects to wetlands, wet meadow complexes, springs, streams, and riparian and phreatophytic communities (Water-Dependent Ecosystems) and to maintain biologic integrity and ecological health of the area of interest over the long term; (2) to avoid any effect to Water-Dependent Ecosystems within the boundaries of the GBNP; and (3) to avoid an unreasonable degradation of the scenic values of and visibility from the GBNP due to a potential increase in airborne particulates and loss of surface vegetation that may result from groundwater withdrawals by SNWA in Spring Valley.

### 2.1.2 Proposed Monitoring Requirements for Non-Federal Water Rights

The NSE provided specific monitoring plan requirements in vacated Ruling 5726 (NSE, 2007). The requirements were as follows:

- Develop a monitoring and mitigation program which is approved by the NSE. (A plan was submitted by SNWA and approved by NSE on February 9, 2009).
- Conduct monitoring that will provide data to ensure existing water rights are protected.
- Collect a minimum of 5 years of biological and hydrological baseline data. The baseline monitoring program must be approved by the NSE prior to the export of any groundwater resources from Spring Valley under the permits.
- File an annual data report with the NSE detailing the findings of the NSE-approved Monitoring Plan. (One combined annual data report which presents all data required by the Spring Valley Stipulation and NSE has been prepared each of the last 4 years).
- Update a NSE-approved groundwater flow model every 5 years SNWA will submit the updated groundwater flow model and provide predictive results for 10, 25, and 100 years.
- 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 NRS 533.024, threaten to prove detrimental to the public interest or are found not to be environmentally sound, SNWA will be required to curtail pumping and/or mitigate the impacts to the satisfaction of the NSE.

The Spring Valley Monitoring Plan approved by the NSE includes all the elements required by the Spring Valley Stipulation with three additional elements. The additional elements required by the NSE include additional spring and groundwater monitoring in the vicinity of the Cleveland Ranch (implemented in 2010 and 2011), spring discharge monitoring of Turnley Spring located on Sacramento Pass (implemented in 2008), and an additional monitor well one mile north of the northernmost production well on the east side of Spring Valley based upon the well configuration at time of commencement of water export from the basin (to be implemented in future after initial production well network configuration is complete). A detailed description of each of these three additional elements is presented in the previously approved Spring Valley Monitoring Plan (SNWA, 2009a).

## 2.2 Monitoring and Mitigation Plan Elements

The hydrologic monitoring requirements of the NSE and Spring Valley Stipulation Agreement are summarized in this section. The approved Spring Valley Monitoring Plan was developed to meet these requirements. The current status of each element of the Spring Valley Monitoring Plan is described in parenthesis. The key elements of the program are presented below.

- General Requirements
  - Design and implement a baseline hydrologic data collection program.
- Monitor Well Data Collection
  - The groundwater monitor well network was selected in consensus with the TRP and NSE. Emphasis was placed on selecting wells with known well construction attributes and integrity. Wells were selected to provide spatial and vertical data in varying hydrogeologic conditions in the valley. Wells which are completed in carbonate, basin fill and volcanic materials are included in the network. Current and future planned monitoring wells are presented in Figure 2-1.
  - Collect water-level data at 10 existing monitor wells on a quarterly basis (starting in 2007 and is currently ongoing).
  - Collect water-level data at 15 existing monitor wells on a continuous basis (starting in 2007-2009 and is currently ongoing). The construction attributes of the existing wells are measured quarterly and continuously are presented in Table 2-1.
  - Install two monitor wells SPR7024M and SPR7024M2 in the vicinity of Shoshone Ponds. Water-level data will be collected continuously from each well (installed in 2011). A geologic data analysis report documents its geologic conditions and well construction attributes (Mace, 2011c).
  - The two clustered monitor wells were completed in separate boreholes at different depths. The wells provide data on the local vertical hydraulic gradient.
  - Install two monitor wells between the Interbasin Groundwater Monitoring Zone (Zone), an area located in southeast Spring Valley, eastern Hamlin Valley and southwestern Snake Valley as described in Section 3.2.2.1 of the Spring Valley Hydrologic Monitoring and Mitigation Plan (SNWA, 2009a) and the two SNWA production wells located closest to the Zone. Water-level data will be collected continuously at these near-Zone wells. (The well locations will be determined and installed after the production well network configuration is established).
  - Record quarterly water-level data in all SNWA exploratory wells in Spring Valley. (Started in 2007 and is currently ongoing). The TRP will identify selected exploratory wells for continuous monitoring subsequent to the beginning of groundwater withdrawals should the TRP agree additional monitoring is needed.
  - Install four new groundwater monitoring wells in the vicinity of the Cleveland Ranch as required by NSE (implemented in 2010 and 2011). Locations were selected in consensus with the NSE and the property owner (Corporation of the Presiding Bishop of The Church of Jesus Christ of Latter-Day Saints).

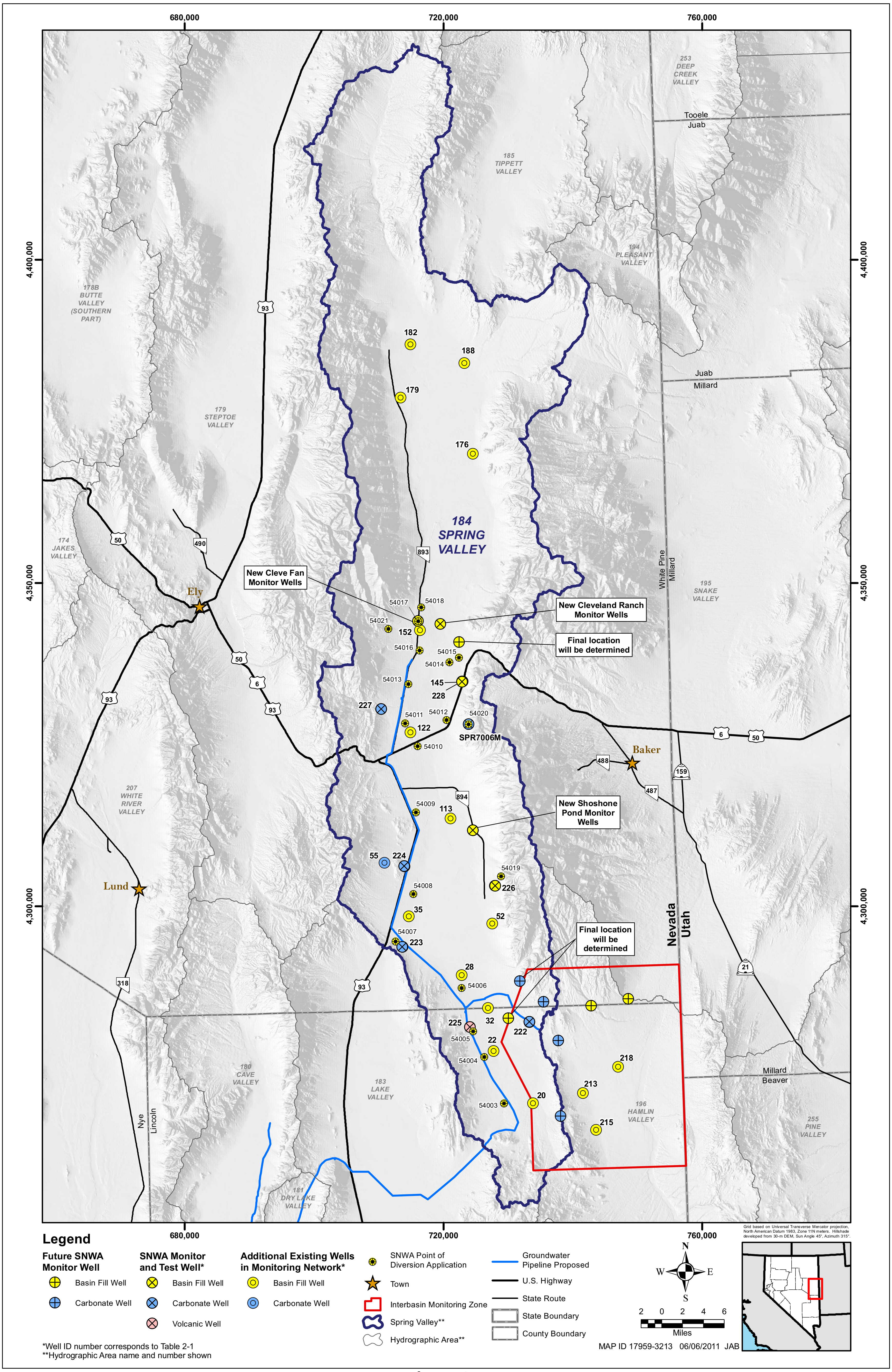



**Figure 2-1**
**Spring Valley Monitoring Plan Well Network**

# Table 2-1
## Spring Valley Existing-Well Monitoring Network

| Map ID | Site Number | Station Local Number | Location[a] | | NDWR Log Number | Surface Elevation (ft amsl) | Completion Date | Drill Depth (ft bgs) | Well Depth (ft bgs) | Well Casing Diameter (in.) | Screened Interval (ft bgs) | Open Interval (ft bgs) | Date of Recent DTW Meas. | Recent DTW Meas. (ft bgs) | Aquifer | Monitor Frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | UTM Northing (m) | UTM Easting (m) | | | | | | | | | | | | |
| 22 | 383704114225001 | 184 N09 E68 30AAAB 1<br>USGS-MX (Spring Valley S.) | 4,277,594.57 | 727,759.99 | 22176 | 6,002.52 | 8/7/1980 | 700 | 679 | 11 | 559 to 679 | 50 to 700 | 9/15/2010 | 224.90 | Basin Fill | Continuous |
| 32 | 384039114232701 | 184 N10 E68 31CD 1 USGS-MX | 4,284,275.68 | 726,871.51 | --- | 5,896.49 | --- | --- | 150 | 2 | --- | 50 to 150 | 9/15/2010 | 118.35 | Basin Fill | Continuous |
| 35 | 384831114314301 | 184 N11 E66 23AB 1 USGS-MX | 4,298,411.13 | 714,633.01 | --- | 5,842.94 | --- | 102 | 102 | 2 | --- | 50 to 102 | 9/14/2010 | 47.52 | Basin Fill | Continuous |
| 52 | 384745114224401 | 184 N11 E68 19DCDC 1<br>USGS-MX (Spring Valley) | 4,297,304.22 | 727,554.19 | --- | 5,900.18 | --- | 200 | 200 | 2 | --- | 50 to 200 | 9/15/2010 | 100.11 | Basin Fill | Continuous |
| 122 | 390352114305401 | 184 N14 E66 24BDDD 1<br>USGS-MX (Spring Valley N.) | 4,326,894.19 | 714,873.84 | --- | 5,846.04 | 1980 | --- | 160 | 2 | --- | 50 to 160 | 9/15/2010 | 38.76 | Basin Fill | Continuous |
| 145 | 390803114251001 | 184 N15 E67 26CA 1 USGS-MX | 4,334,740.47 | 722,963.02 | --- | 5,727.21 | --- | --- | 200 | 2 | --- | 50 to 200 | 9/15/2010 | 40.30 | Basin Fill | Continuous |
| 179 | 393211114320701 | 184 N19 E66 11B 1 | 4,378,627.03 | 713,381.69 | --- | 5,698.43 | 4/22/1960 | --- | 400 | --- | --- | 50 to 400 | 9/15/2010 | 43.12 | Basin Fill | Continuous |
| 215 | 383023114115302 | 196 N08 E69 35DC 2<br>USGS-MX (Hamlin Valley S.) | 4,265,403.02 | 743,597.36 | --- | 5,837.67 | 8/7/1980 | 520 | 435 | 2 | 320 to 420 | 35 to 520 | 9/15/2010 | 174.76 | Basin Fill | Continuous |
| 222 | 184W502M | 184 N09 E68 11 BD 2 | 4,282,116.34 | 733,294.42 | 102843 | 6,189.72 | 1/25/2007 | 1,828 | 1,799 | 8 | 495 to 1,779 | 58 to 1,828 | 9/15/2010 | 482.33 | Carbonate | Continuous |
| 223 | 184W504M | 184 N11 E66 34 DD 2 | 4,293,712.49 | 713,647.12 | 102158 | 5,900.11 | 11/17/2006 | 1,040 | 1,020 | 8 | 309 to 999 | 61 to 1,040 | 9/16/2010 | 100.75 | Carbonate | Continuous |
| 224 | 184W506M | 184 N12 E66 26 BA 2 | 4,306,214.21 | 713,939.81 | 102132 | 6,014.04 | 10/19/2006 | 1,160 | 1,140 | 8 | 430 to 1,120 | 80 to 1,160 | 9/14/2010 | 216.05 | Carbonate | Continuous |
| 225 | 184W508M | 184 N09 E67 11 DB 1 | 4,281,308.68 | 724,070.89 | 102139 | 6,056.19 | 12/15/2006 | 1,180 | 1,160 | 8 | 376 to 1,140 | 241 to 1,180 | 9/15/2010 | 276.79 | Volcanic | Continuous |
| 226 | SPR7007M | 184 N11 E68 05 BC 2 | 4,303,146.59 | 727,976.03 | --- | 6,017.73 | 8/17/2007 | 1,040 | 1,020 | 8 | 300 to 1,000 | 101 to 1,040 | 9/15/2010 | 147.20 | Basin Fill | Continuous |
| 227 | SPR7005M | 184 N14 E66 09 AB 2 | 4,330,471.51 | 710,372.44 | --- | 6,395.68 | 7/10/2007 | 1,412 | 1,404 | 8 | 663 to 1,383 | 439 to 1,412 | 9/15/2010 | 494.24 | Carbonate | Continuous |
| 228 | SPR7008M | 184 N15 E67 26 CD 2 | 4,334,702.61 | 722,865.27 | --- | 5,704.86 | 7/25/2007 | 960 | 946 | 8 | 226 to 926 | 54 to 960 | 9/15/2010 | 14.47 | Basin Fill | Continuous |
| 20 | 383351114180201 | 184 N08 E68 14A 1 USBLM | 4,269,504.76 | 733,845.43 | --- | 6,184.22 | --- | --- | 495 | 6 | 50 to 495 | 50 to 495 | 8/4/2010 | 406.52 | Basin Fill | Quarterly |
| 28 | 384310114261401 | 184 N10 E67 22AA 1<br>USGS-MX (Spring V Central) | 4,289,331.34 | 722,826.33 | --- | 5,853.54 | --- | --- | 100 | 2 | --- | 50 to 100 | 8/3/2010 | 65.58 | Basin Fill | Quarterly |
| 55 | 184 N12 E66 21CD 1 | 184 N12 E66 21CD 1 | 4,306,700.53 | 710,871.15 | 10440 | 6,370.31 | 9/13/1966 | 631 | 631 | 6 | 3 to 631 | 3 to 631 | 8/3/2010 | 570.20 | Carbonate | Quarterly |
| 113 | 385636114265501 | 184 N13 E67 33DDA 1 | 4,313,590.54 | 721,086.82 | --- | 5,769.73 | --- | --- | -- | 36 | --- | --- | 5/5/2010<br>8/4/2010 | 7.47<br>Dry | Basin Fill | Quarterly |
| 152[b] | 391224114293601 | 184 N16 E66 36DBAD 1<br>USBLM - Cleve Creek Well | 4,342,683.25 | 716,362.90 | --- | 5,870.25 | --- | --- | -- | --- | --- | --- | 8/3/2010 | 207.74 | Basin Fill | Quarterly |
| 176 | 392703114230501 | 184 N18 E67 01CCAA 1 | 4,369,956.56 | 724,523.82 | --- | 5,587.78 | --- | --- | 42 | 38 | --- | --- | 8/3/2010 | 35.13 | Basin Fill | Quarterly |
| 182 | 184 N20 E66 13AB 1 | 184 N20 E66 13AB 1 | 4,386,884.19 | 714,871.84 | 9157 | 5,774.93 | 6/26/1966 | 907 | 296 | 16 | 135 to 296 | --- | 8/3/2010 | 125.91 | Basin Fill | Quarterly |
| 188 | 393442114231801 | 184 N20 E67 26ABBD 1 USBLM | 4,383,955.15 | 723,240.35 | --- | 5,708.77 | --- | 130 | 130 | 6 | --- | 50 to 130 | 8/3/2010 | 118.39 | Basin Fill | Quarterly |
| 213 | 383325114134901 | 196 N08 E69 15B 1 | 4,271,103.41 | 741,539.28 | --- | 5,729.98 | --- | --- | 110 | 6 | --- | 50 to 110 | 8/4/2010 | 71.41 | Basin Fill | Quarterly |
| 218 | 383533114102901 | 196 N08 E70 06B 1<br>USBLM - Monument Well | 4,275,166.91 | 747,014.36 | 548 | 5,676.76 | 7/22/1947 | --- | 164 | 6 | 111 to 115/<br>152 to 164 | --- | 8/4/2010 | 89.67 | Basin Fill | Quarterly |

[a]All coordinates are Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD83), Zone 11.
[b]The Cleve Creek well will be replaced by a new monitor well approximately 1 mi to the north.
Well-construction data are based upon best available information from well logs, MX Project Report, and direct field measurements.

- Install an additional monitor well 1 mi north of the northernmost production well on the east side of Spring Valley based upon the well configuration at time of commencement of water export from the basin as required by NSE (to be implemented in future after initial production well network configuration is determined). A geologic data analysis report documents its geologic conditions and well construction attributes (Mace, 2011a and b). The two sets of clustered monitor wells were completed on the Cleve Alluvial Fan (SPR7029M and SPR7029M2) and on Cleveland Ranch. The wells (SPR7030M and SPR7030M2) provide data on the local vertical hydraulic gradient.

- Spring, Hamlin, and Snake valleys Hydrologic Relationship

  - Develop a network of four carbonate and two basin-fill monitor wells to monitor the Zone and characterize the hydraulic gradient from the Spring Valley hydrographic area to the Snake Valley hydrographic area via Hamlin Valley. One of the wells is planned to be installed in the immediate vicinity of Big Springs in southern Snake Valley. (One well is in place and an additional five wells will be installed in the future to meet stipulation timeframe requirements). Two additional monitor wells have been installed by USGS as part of the Southern Nevada Public Lands Management Act (SNPLMA) program in carbonate rock southwest and in basin-fill material northwest of Big Springs.

- Future Production Well Monitoring

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

- Surface Water Streams and Springs

  - Spring and stream monitoring sites were determined by the TRP and NSE. Locations are presented in Figure 2-2. Specific monitoring details of the sites are explained below.

  - Install 12 shallow piezometers adjacent to spring locations determined by the TRP. Piezometer locations are listed in Table 2-2. Water-level data will be collected continuously from each location. One additional mountain block spring (Rock Spring) was added to the Spring Valley Monitoring Plan by the TRP for collection of spring discharge data only (installed in 2009).

  - Spring discharge monitoring of Turnley Spring located on Sacramento Pass as required by NSE (implemented in 2008).

  - Install two flumes and one shallow piezometer at two springs located on Cleveland Ranch as required by NSE (installed in late 2010 and early 2011). Locations were selected in consensus with the NSE and the property owner (Corporation of the Presiding Bishop of The Church of Jesus Christ of Latter-Day Saints).

  - Spring discharge is recorded at locations where discharge is measurable. Current locations are presented in Table 2-3.

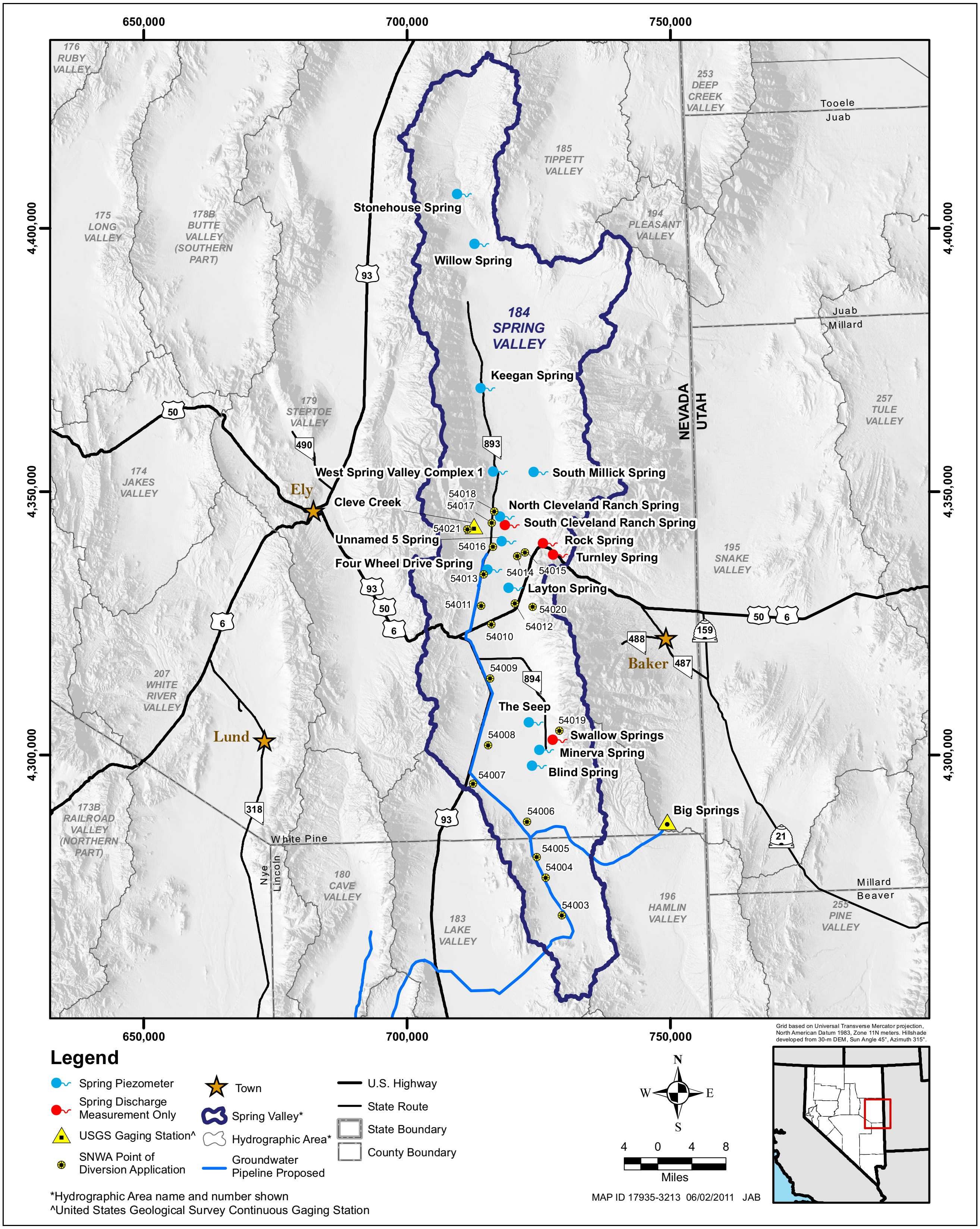



**Figure 2-2**
**Spring Valley Monitoring Plan Spring and Stream Network**

# Table 2-2
## Spring Piezometer Location and Completion Information

| Site Number | Associated Spring | Location[a] | | Surface Elevation (ft amsl) | Completion Date | Drill Depth (ft bgs) | Well Depth (ft bgs) | Well Diameter (in.) | Open Interval (ft bgs) | Screened Interval (ft bgs) | Aquifer | DTW Date | DTW (ft bgs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | UTM Northing (m) | UTM Easting (m) | | | | | | | | | | |
| SPR7007Z | Minerva Spring | 4,301,057.50 | 726,134.41 | 5,828.66 | 1/18/2008 | 35 | 31 | 4 | 12-31.3 | 16-31 | Basin Fill | 10/12/2010 | 10.51 |
| SPR7011Z | Blind Spring | 4,297,998.82 | 724,727.45 | 5,770.00 | 5/6/2010 | 31.3 | 31.3 | 2 | 13-31.3 | 16.1-31.1 | Basin Fill | 10/14/2010 | 7.07 |
| SPR7012Z | 4WD Spring | 4,335,263.42 | 716,235.96 | 5,755.77 | 5/8/2010 | 25 | 25 | 2 | 4-25 | 9.8-24.8 | Basin Fill | 10/14/2010 | 2.36 |
| SPR7013Z | Swallow Spring[b] | 4,302,865.79 | 728,700.19 | 6,133.19 | 5/6/2010 | 65 | 61.2 | 2 | 26-61.2 | 46-61 | Basin Fill | 10/11/2010 | 51.16 |
| SPR7014Z | The Seep | 4,306,272.49 | 724,093.38 | 5,778.93 | 5/7/2010 | 31 | 30.7 | 2 | 6-30.7 | 15.5-30.5 | Basin Fill | 10/12/2010 | 11.65 |
| SPR7015Z | West Spring Valley Complex | 4,353,816.24 | 717,284.40 | 5,602.99 | 5/8/2010 | 40 | 38.2 | 2 | 8-38.2 | 23-38 | Basin Fill | 10/14/2010 | 5.50 |
| SPR7016Z | Unnamed Spring 5 | 4,340,637.22 | 718,885.71 | 5,644.97 | 5/4/2010 | 35 | 32 | 2 | 15-32.0 | 16.8-31.8 | Basin Fill | 10/12/2010 | 1.65 |
| SPR7018Z | S. Millick Spring | 4,353,624.13 | 725,156.83 | 5,587.20 | 5/4/2010 | 31 | 25.2 | 2 | 8-25.2 | 10-25 | Basin Fill | 10/13/2010 | 5.78 |
| SPR7019Z | Layton Spring | 4,331,753.28 | 720,064.23 | 5,688.45 | 5/7/2010 | 35.3 | 35.3 | 2 | 9-35.3 | 20.1-35.1 | Basin Fill | 10/11/2010 | 11.00 |
| SPR7020Z | Stonehouse Spring | 4,406,416.85 | 710,617.98 | 6,264.28 | 5/5/2010 | 9.3 | 9.3 | 2 | 2-9.3 | 4.1-9.1 | Basin Fill | 10/12/2010 | 2.92 |
| SPR7021Z | Keegan Spring | 4,369,692.97 | 714,899.20 | 5,612.85 | 5/8/2010 | 20.7 | 20.7 | 2 | 4-20.7 | 5.5-20.5 | Basin Fill | 10/13/2010 | -2.01 |
| SPR7022Z | Willow Spring | 4,397,090.45 | 713,752.75 | 5,987.40 | 5/5/2010 | 35 | 33.5 | 2 | 7-33.5 | 18.3-33.3 | Basin Fill | 10/12/2010 | 13.79 |

[a]All coordinates are UTM NAD83, Zone 11.
[b]The Swallow Spring piezometer does not appear to be in direct hydrologic connection with the spring. The piezometer is not utilized in the monitoring program at this time. However, spring discharge is monitored.
Note: Piezometer water levels are monitored continuously at 1-hour intervals.

**Table 2-3**
**Current Spring Discharge Monitoring Locations**

| Site Number | Spring Name | Location[a] UTM Northing (m) | Location[a] UTM Easting (m) | Geology | Discharge Monitoring Frequency |
|---|---|---|---|---|---|
| 1848401 | Cleveland Ranch Spring North | 4,345,297 | 718,646 | Basin Fill/Valley Floor | Quarterly |
| 1848501 | Cleveland Ranch Spring South | 4,343,655 | 719,532 | Basin Fill/Valley Floor | Quarterly |
| 1845501 | Willow Spring | 4,397,069 | 713,756 | Basin Fill/Valley Floor | Quarterly |
| 1845702 | South Millick Spring | 4,353,754 | 725,031 | Basin Fill/Valley Floor | Quarterly |
| 1845901 | Layton Spring | 4,331,794 | 720,204 | Basin Fill/Valley Floor | Quarterly |
| 1846201 | Swallow Springs | 4,302,920 | 728,597 | Basin Fill/Range Front | Continuous[b] |
| 1847101 | Keegan Spring | 4,369,664 | 715,050 | Basin Fill/Valley Floor-Fan Margin | Quarterly |
| 1847301 | Rock Spring | 4,340,204 | 726,798 | Carbonate/Mountain Block | Continuous |
| 1848001 | Turnley Spring | 4,338,050 | 728,695 | Carbonate/Mountain Block | Quarterly |

[a]Coordinates are approximate. All coordinates are UTM NAD83, Zone 11.
[b]Continuous at Swallow Spring South Channel and quarterly at North Channel.

- Operate and maintain surface-water gages at Cleve Creek (period of record since 1914) and Big Springs Creek (period of record since 2006) (currently ongoing).

- Collect two sets of synoptic-discharge measurements during irrigation and non-irrigation periods for the Big Springs Creek and Lake Creek surface water system from Big Springs to Pruess Lake. The two sets of measurements will be repeated every 5 years following the start of groundwater withdrawals in Spring Valley hydrographic area by SNWA. (The study will be performed in the future to meet monitoring plan timeframe requirements before water resource development operations begin). The UGS has installed and is operating continuous gaging stations at Stateline and Clay Springs within the complex to provide gain loss data over segments of the streams. Current complex monitoring site locations are presented in Figure 2-3.

• Precipitation Network

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

• Baseline Water Chemistry

- Perform chemical analyses of selected parameters on three rounds of samples collected from wells, piezometers, and surface water sites determined by the TRP. The program will consist of three sampling events at 6-month intervals. (The TRP agreed to perform an

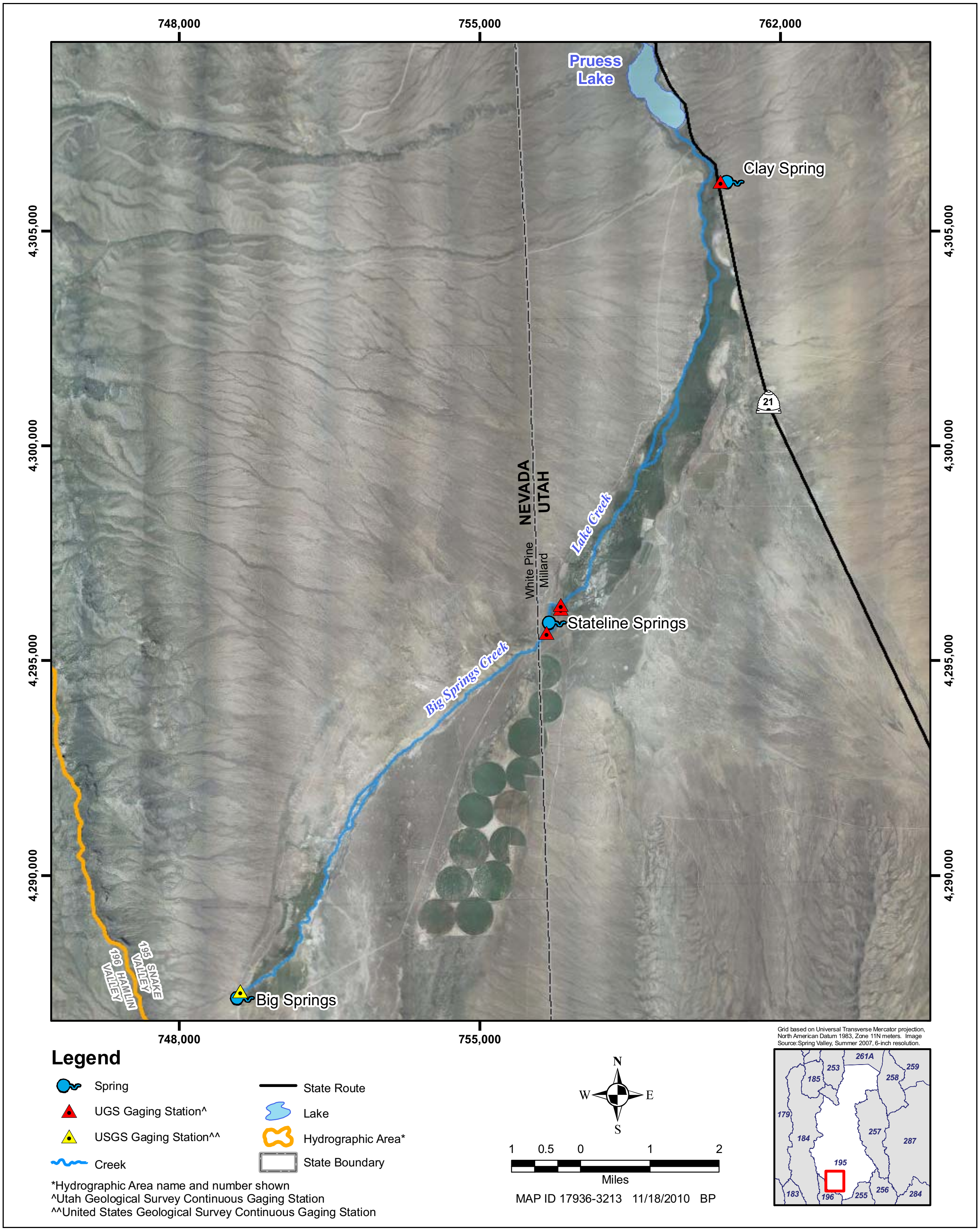



**Figure 2-3**
**Spring Valley Monitoring Plan Big Springs and Lake Creek Complex**

initial round of sampling at 35 locations completed in late 2010 and early 2011. Second and third rounds will be completed after installation of the five Zone monitor wells at 40 locations).

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

- Water chemistry sample site locations are presented in Figure 2-4.

- Modeling

  - Develop and maintain a numerical flow model of the regional groundwater flow system (currently ongoing).

- Reporting

  - Provide collected data associated with the Spring Valley Monitoring Plan to NSE on a quarterly basis. Provide data collected to DOI as required by the Spring Valley Stipulation.

  - File an annual data report with the NSE and DOI by March 31 of each year reporting the results of monitoring and sampling pursuant to this monitoring plan.

### 2.3 Monitor Well and Spring Network

Monitor well and spring monitoring locations were selected in consensus with the TRP and NSE. The monitor well selection process included evaluation of well integrity, construction completion details, hydrogeologic setting, lithology, and spatial distribution to obtain representative data to meet program objectives. The wells were selected to: (1) serve as monitoring points between SNWA's future production wells and existing water-right holders as well as Federal water rights and Federal resources; (2) calibrate the groundwater flow model; (3) evaluate the effects of SNWA's groundwater withdrawals; and (4) provide spatially distributed hydrologic data from basin-fill, carbonate, and volcanic aquifers within Spring and Hamlin Valleys in order to analyze and produce annual groundwater-level contour and water-level drawdown maps.

Springs were selected based upon hydrologic setting, spatial distribution, biological significance, and spring characteristics. Shallow piezometers were installed near spring locations with hydrologic characteristics indicating a likelihood of hydraulic interconnection between spring discharge and piezometer water level. Due to hydrogeologic conditions, continuous discharge gaging stations were installed at Swallow and Rock Springs instead of utilizing piezometers.

Modification of this element of the Spring Valley Monitoring Plan, including any addition, subtraction, or replacement of the wells and springs initially selected by the TRP or the frequency of monitoring, would be made through consensus recommendations from the TRP, or as required by the NSE.

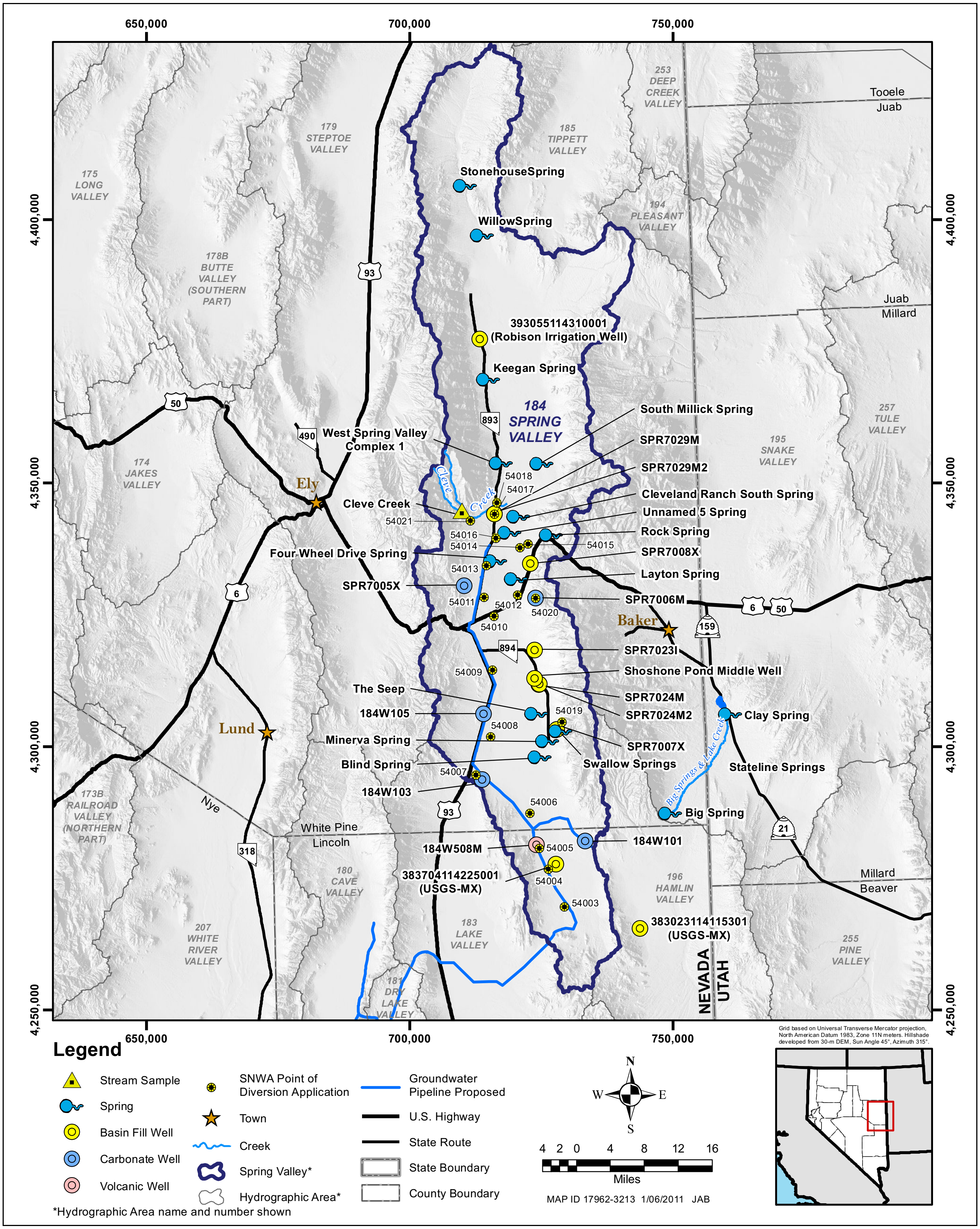



**Figure 2-4**
**Spring Valley Monitoring Plan Water Chemistry Program Sample Locations**

## 2.4 Aquifer Characterization

Aquifer characterization will be performed using constant-rate pumping tests to evaluate aquifer parameters, such as transmissivity (*T*), hydraulic conductivity (*K*), storage coefficient (*S*), and specific yield (*Sy*). The tests may also identify boundary conditions, provide information on aquifer heterogeneity, and evaluate long-term sustainable pumping rates. In fracture-flow systems, depending upon conditions, the tests may estimate fracture and matrix parameters. Aquifer testing results would be used to assess well performance, provide aquifer property data for the groundwater flow model, and evaluate long-term pumping effects.

Well performance step tests and 72- to 120-hour constant-rate tests have been performed on the six SNWA test wells in Spring Valley. These locations (184W101, 184W103, 184W105, SPR7005X, SPR7007X, and SPR7008X) are presented on Figure 6 of the Spring Valley Hydrologic Monitoring and Mitigation Plan (SNWA, 2009a). Hydrologic Analysis Reports, including hydrologic data, test analysis, and water chemistry results, have been prepared for each test well location (Prieur et al., 2009, 2010a through c, 2011a and b). Similar testing may also be performed on selected future test wells. A Geologic Analysis Report, presenting drilling and downhole geophysical data, lithologic descriptions, and structural evaluation, have also been prepared for each location (Eastman and Muller, 2009a through d; Mace and Muller, 2010a through d). These reports have been provided to the NSE and summarized in the annual data reports.

A 120 hour constant-rate test was performed at SPR7029M2 in May 2011. This recently installed well is located on the Cleve alluvial fan. A preliminary data memo was prepared documenting the hydrologic data collected during the hydraulic test (Prieur and Ashinhurst, 2011).

In addition, as required by the Spring Valley Monitoring Plan, one constant-rate aquifer test will be performed by pumping the SNWA basin-fill aquifer production well located closest to the boundary between the Spring Valley and Hamlin Valley hydrographic areas. Similarly, one constant-rate aquifer test will be performed by pumping the SNWA carbonate production well located closest to the boundary between the Spring Valley and the Hamlin Valley hydrographic areas. In the event that SNWA constructs a production well at the point of diversion (POD) specified in Application No. 54019, SNWA will perform one constant-rate aquifer test with parameters determined in consensus with the TRP.

## 2.5 Numerical Modeling of Regional Groundwater Flow

Hydrologic models, including groundwater flow models, are tools used to improve the understanding of hydrologic systems by simulating the natural physical system using mathematical equations. A model is a conceptual description or approximation of natural conditions using a simplified version of those conditions based upon certain underlying assumptions and estimates of system properties. Confidence in the results depend upon how closely the simulation matches the physical system. While such tools are important, it should be emphasized that their predictive capability is limited by the quantity and quality of the data available to construct them. As more data becomes available, a model will better reflect the natural system. However, a model must be viewed as an approximation based upon available data and not an exact replication of the physical system.

Models are most valuable to water managers to compile available data, identify data gaps, and evaluate various scenarios to predict behavior of the system under different conditions and time frames. When data in a hydrographic basin is sparse or unavailable, generalizations and assumptions must be used as estimates for these basin characteristics. These generalizations and assumptions must then be validated through the collection of data from geologic and hydrogeologic studies and hydrologic monitoring. A model becomes more valuable as a predictive tool as new information from data collection programs, exploration programs, and development activities (e.g., aquifer stresses from pumping) is continually added and the model is refined.

SNWA has developed a regional numerical groundwater model of the project area with input and direction from BLM and the associated Hydrology Technical Group and cooperating agencies. The NSE was an observer to the overall model development process and provided input. The model will be refined in an adaptive process to improve the predictive capability as additional basin characterization, pumping, and response monitoring data becomes available.

It needs to be recognized that the numerical model developed for this area is a regional model developed for environmental impact analysis with inherent uncertainties and limitations. There is limited data on human induced influence on groundwater levels in Spring Valley and DDC. Data on aquifer properties such as transmissivity and storativity are generally limited to regional estimates and several local aquifer tests. The current numerical model will be further refined as water resource development activities generate additional data. The established Spring Valley Monitoring Plan provides a long-term network which is generating data to enhance the reliability and predictive capability of the regional groundwater flow model.

SNWA will make the model available to the NSE for his use. SNWA will provide model results for evaluation by the NSE and 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 or required by the NSE.

## 2.6 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 USGS, for each element of the program are incorporated as appropriate. A quality assurance (QA)/quality control (QC) program will be followed, which includes the following elements: (1) identification of QA/QC procedure and direct organizational 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.

## 2.7 Database Management

All data collected pursuant to this 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 in the database properly and accurately.

## 2.8 Reporting

Water-level and production data will be submitted to the NSE quarterly in electronic format as specified by the NSE. Water chemistry laboratory reports will be made available to the NSE within 90 calendar days of receipt.

SNWA will report the results of all monitoring and sampling pursuant to the Spring Valley Monitoring Plan in an annual monitoring report submitted to the DOI and the NSE by March 31 of each year that the Spring Valley Monitoring Plan is in effect. The annual monitoring report will include SNWA's proposed schedule of groundwater withdrawals (testing and production) for the immediately succeeding 2 calendar years. The DOI Bureaus may, at their option, provide comments on the report to the NSE.

Using data derived from groundwater level measurements of all production and monitor wells used in the Spring Valley Monitoring 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 at a frequency agreed upon by the TRP, or as required by the NSE.

## 2.9 Management and Mitigation

The Spring Valley Stipulation explains the criteria and 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 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 Spring Valley.

SNWA shall mitigate any injury to Federal water rights and/or unreasonable adverse effects to Federal resources including within the boundaries of GBNP in accordance with Section 3.E.II of the Spring Valley Stipulation.

SNWA shall follow the same management and mitigation actions relative to any effects or injury to private water-right holders. Additionally, SNWA will implement management and mitigation actions as required by NSE.

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

- Geographic redistribution of groundwater withdrawals.
- Provision of consumptive water supply requirements using surface and groundwater sources.
- Augmentation of water supply for Federal and existing water rights and Federal resources using surface and groundwater sources.
- Reduction or cessation in groundwater withdrawals.
- Other measures as agreed to by the Stipulation parties and/or required by the NSE.

### 2.10 Plan Status

The plan has been implemented with all elements of the monitoring network in place except installation of five interbasin Zone wells (which have been sited and permitted but not installed) and performance of a gain loss study of Big Springs and Lake Creek complex, as described in the Spring Valley Monitoring Plan. Two near-Zone and one monitor well located in the northeast portion of the valley will be located after the production network is determined. These tasks will be performed in the future based upon project schedule.

### 2.11 Summary

The approved Spring Valley Monitoring Plan was developed by consensus agreement of the TRP and NSE representatives. It is a scientifically sound adaptive program which protects Federal and non-Federal water resources and meets the goals and objectives of the Spring Valley Stipulation and vacated NSE Ruling 5726. It provides a structured process to manage the Spring Valley water development program in a responsible and sustainable manner. The Spring Valley Monitoring Plan coupled with the enforcement authority of the NSE provide the NSE with the tools to effectively oversee SNWA's groundwater development project in Spring Valley.

The Spring Valley Monitoring Plan established an extensive hydrologic monitoring network which includes wells and springs spatially located across Spring Valley in varying hydrologic conditions. The program also includes stream and regional precipitation monitoring as well as water chemistry data collection. The Spring Valley Monitoring Plan has been successfully implemented and is currently providing baseline hydrologic data and basin characteristics information to improve the understanding of the hydrologic system and document system response to varying climate conditions.

# 3.0 DDC Hydrologic Management Program

SNWA has developed and implemented a Hydrologic Management Program associated with the groundwater development project in DDC. The Program includes a specific monitoring and mitigation plan. The Program is a consensus based adaptive plan similar in approach and structure to the Spring Valley Management Program. The Program is designed to meet the monitoring objectives of the NSE and TRP and provide data to manage the DDC water development program in a responsible and sustainable manner. This section provides background and a description of the DDC Hydrologic Monitoring and Mitigation Plan (DDC Monitoring Plan) and will focus on elements of the Plan which are different from the Spring Valley Monitoring Plan.

## 3.1 Monitoring Plan Development and Background

The DDC Stipulation Agreement between SNWA and DOI, along with the vacated NSE Ruling 5875, present specific monitoring objectives and requirements which are addressed within the DDC Monitoring Plan. The DDC Monitoring Plan was submitted to the NSE and approved on December 22, 2009, prior to Ruling 5875 being vacated. This section summarizes the key hydrologic monitoring requirements plan and implementation status. The previously approved DDC Monitoring Plan is presented in SNWA (2009c).

SNWA submitted a proposed monitoring and mitigation plan for DDC to the NSE (SNWA, 2011c). SNWA requested that the plan be considered by the NSE for inclusion as a permit condition associated with SNWA groundwater permits for applications 53987 through 53992.

The DDC Monitoring Plan data are provided to the NSE and DOI on a quarterly basis and in annual status and data reports which have been published since July 2008. The approved DDC Monitoring Plan has been implemented with plan specific data collection occurring since 2007. This Plan builds upon available historical data collected prior to 2007, which has been included in the annual reports. The most recent data report is the *2010 Delamar, Dry Lake, and Cave Valleys Hydrologic Monitoring and Mitigation Plan Status and Data Report* (SNWA, 2011d). The annual reports prepared in 2008-2010 are presented in SNWA (2008b, 2009d, and 2010b).

### 3.1.1 DDC Stipulation Agreement

Prior to the 2008 NSE hearing on SNWA's DDC Applications, a Stipulation for Withdrawal of Protests was entered on January 7, 2008, between SNWA and DOI, on behalf of the DOI Bureaus (Stipulation, 2008). The DDC Stipulation requires that SNWA implement a hydrologic monitoring, management, and mitigation plan, which is presented in Exhibit A of the DDC Stipulation. Similar to the Spring Valley Stipulation, an EC was established to oversee its implementation. A DDC TRP was also established to develop and oversee the implementation of the hydrologic monitoring, management, and mitigation plan, review program data, and modify the plan, if needed. The TRP operates in a similar manner to that described for the Spring Valley Monitoring Plan. A Biological Resource Team (BRT) was also established to develop and implement a biological monitoring plan.

### 3.1.2 Proposed Monitoring Requirements for Non-Federal Water Rights

A summary of the hydrologic monitoring requirements specified by NSE in the vacated Ruling 5875 (NSE, 2008) are presented below.

- Develop a hydrologic monitoring and mitigation program 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. Data collected prior to approval of the DDC Monitoring Plan qualify as baseline data, provided the data were collected in accordance with the approved DDC Monitoring Plan.

- File an annual data report with the NSE by March 31 of each year detailing the findings of the DDC Monitoring Plan.

- 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 NRS 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.

## 3.2 Monitoring and Mitigation Plan Elements

The hydrologic monitoring requirements of the NSE and DDC Stipulation are summarized in this section. The approved DCC Monitoring Plan was developed to meet these requirements. The current status of each element of the DDC Monitoring Plan is described in parenthesis. The key elements are presented below.

- 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 to the present).

- 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 nine existing monitor wells in DDC and adjacent basins (started in 2007 to the present).

  - Collect continuous water-level data at six existing monitor wells in DDC and adjacent basins (started in 2007 to the present).

  - The groundwater monitor well network was selected in consensus with the TRP and NSE. Emphasis was placed on selecting wells with known well construction attributes and integrity. Wells were selected to provide spatial distribution across the valleys and in varying hydrogeologic conditions. Wells which were completed in carbonate, basin fill and volcanic materials are included in the network. Current and future planned monitor well locations included in the DDC Monitoring Plan are presented in Figure 3-1. The construction attributes and monitoring frequency of the existing monitor wells are presented in Table 3-1.

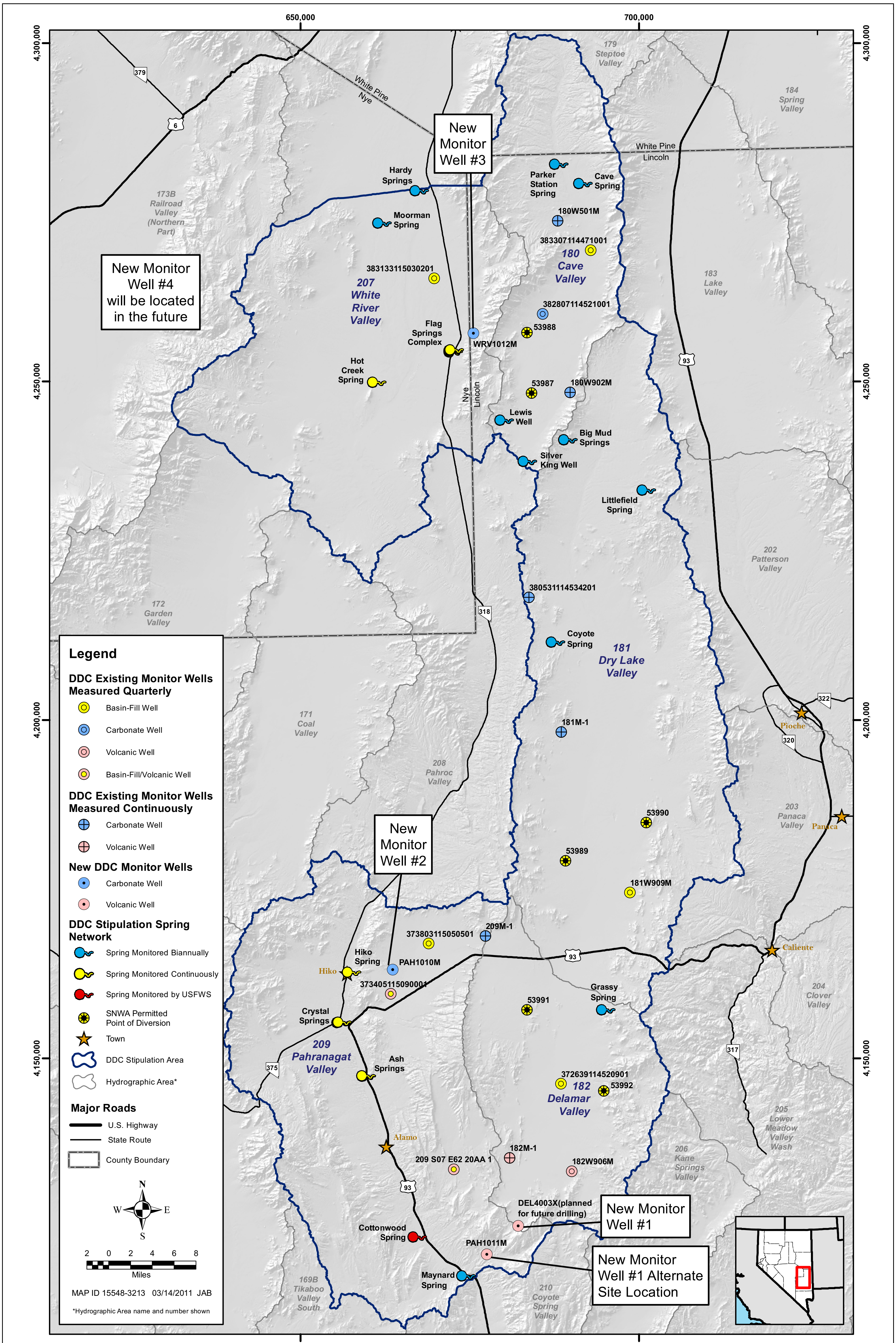
  - Install up to four new monitor wells located in or around DDC and adjacent hydrographic areas that will be dedicated to long-term monitoring. Collect continuous water-level data from the new monitor wells. Three well locations have been selected and permitted with installation planned to occur in the future. The fourth well location will be selected after the production well network configuration is established.

  - Collect quarterly water-level data at SNWA exploratory and test wells located in DDC (2007 to the present). Two existing SNWA exploratory wells, which were installed in 2007, are located in southern Cave Valley near Monitor Well 180W902M.

  - Monitor the wells selected for inclusion in the network to help characterize groundwater movement within DDC and the adjacent hydrographic areas of White River, Pahroc, and Pahranagat Valleys. Monitor wells are located throughout DDC and adjacent hydrographic areas to detect and quantify the propagation, if any, of drawdown toward existing water-right holders and groundwater-dependent areas sustaining critical habitat for endangered and/or threatened species and to provide observations for future groundwater model refinement.

- Future Production Well Monitoring

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




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

**Figure 3-1**
**DDC Monitoring Plan Well and Spring Network**

# Table 3-1
# DDC Existing-Well Monitoring Network

| Site Number | Station Local Number | Location[a] UTM Northing (m) | Location[a] UTM Easting (m) | Surface Elevation (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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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[b] | 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[c] |
| 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[c] |
| 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 | --- | --- | >780 | 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 UTM NAD83, Zone 11.
[b]Carbonate bedrock was encountered at 265 ft bgs according to the well log.
[c]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., 1981), 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.

- 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 eight spring locations in White River and Pahranagat Valleys. These consist of Flag Springs Complex, Hot Creek, Moorman, Hardy, Hiko, Maynard, Ash, and Crystal Springs (started in 2009 and is 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 eight springs in DDC (started in 2009 and is currently ongoing).
  - DDC Monitoring Plan spring sites and monitoring frequency are presented on Figure 3-1 and Table 3-2.
- Precipitation Network
  - Select a regional precipitation network from stations with 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 SNWA in cooperation with the NSE and TRP. The Plan will consist of two 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 a numerical flow model of the regional groundwater flow system.

**Table 3-2**
**DDC Springs Monitoring Locations and Monitoring Frequency**

| Basin Number | Station Number | Station Name | Elevation[a] | Location[b] UTM Northing (m) | Location[b] UTM Easting (m) | Monitoring Frequency |
|---|---|---|---|---|---|---|
| 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, UTM North American Vertical Datum of 1988 (NAVD88). High-resolution Global Positioning System will be used to determine elevations at a later date.
[b]All coordinates are UTM North American Datum of 1983, Zone 11.
[c]Monitoring performed by USFWS. Data provided to SNWA will be presented in the annual data report.

- Reporting
  - Provide collected data associated with the monitoring plan to NSE on a quarterly basis. Provide data collected to DOI as required by the DDC Stipulation
  - File an annual data report with the NSE and DOI by March 31 of each year reporting the results of monitoring and sampling pursuant to this plan.

### 3.3 Monitor Well and Spring Network

Monitor well and spring monitoring locations were selected in consensus with the TRP and NSE. The wells were selected to: (1) serve as long-term monitoring points between SNWA's future production wells and existing water-right holders and environmental resources, thus providing an early warning system of the presence and degree of drawdown occurring at points between pumping areas and locations of concern such as regional springs and environmentally sensitive areas; and (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 refinement of the groundwater flow model; and (4) evaluate the effects of SNWA's groundwater withdrawals on local and regional water levels.

SNWA constructed seven of the monitoring wells which are included in the DDC network. Geologic Data Analysis Reports presenting drilling and downhole geophysical data, lithologic descriptions, and structural evaluation, were prepared for each location (Eastman, 2007a through g).

The DDC Monitoring 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 as listed in Table 3-2. The springs in DDC are local and primarily occur in the mountain block. They are not in hydrologic connection with the principal aquifer. This is evident by the local hydrogeologic conditions and elevation at the springs, depth to water at the valley floor and water chemistry. The second component consists of nine springs in White River and Pahranagat valleys which were specifically listed in the DDC Stipulation and will be monitored for discharge. The listed springs are also presented in Table 3-2. SNWA has installed a flume at Hardy Spring and a flow meter on the discharge line from Hiko Spring. SNWA also worked with the Nevada Department of Wildlife to install a flume and continuous monitoring instrumentation at Flag Spring No. 2. USGS has established gages at Crystal, Ash, and Hot Creek springs. Available historical data and descriptions of selected springs are presented in *Delamar, Dry Lake, and Cave Valley Stipulation Agreement Hydrologic Monitoring Plan Status and Historical Data Report* (SNWA, 2009d).

### 3.4 Aquifer Characterization

A constant-rate pumping test will be performed on each future production and test well to evaluate aquifer properties. The test results may also identify boundary conditions and provide information on aquifer heterogeneity. Hydraulic-testing data will be evaluated to assess well performance and will be analyzed to provide aquifer-property data to constrain groundwater flow model calibration and to evaluate long-term pumping effects.

Step-drawdown and 72-hour constant-rate tests have been performed on SNWA Test Well CAV6002X and Monitor Well 180W902M located in Cave Valley. A geologic data analysis report including drilling, geophysical, and well completion data has been prepared for this site (Baird, 2011). A Hydrologic Analysis Report, including hydrologic data, test analysis, and water-chemistry results has also been prepared for the site (Prieur et al., 2011c).

Results of drilling, well construction, geophysics and hydraulic testing of Lincoln County Water District and Vidler Water Company Well PW-1 located in Dry Lake Valley is presented by Feast Geosciences, LLC (2011). The PW-1 well is completed in the carbonate aquifer.

### 3.5 Numerical Modeling of Regional Groundwater Flow

SNWA will continue to maintain, update, and operate the same regional groundwater flow system numerical model for DDC as used for Spring Valley.

### 3.6 Data Collection, Management, and Reporting

Data collection methodology, quality control procedures, database management and reporting for the DDC Monitoring Plan are similar to those described for Spring Valley.

### 3.7 Management and Mitigation Plan

SNWA will implement management and mitigation actions as required by the NSE. The DDC stipulation presents criteria and a process for the TRP to initiate consultation, management or mitigation actions (Stipulation, 2008). This process is similar to the Spring Valley Stipulation process as described in Section 2.9. Management and mitigation actions are explained in more detail in Section 6.0 of the DDC Monitoring and Mitigation Plan (SNWA, 2011c).

### 3.8 Plan Status

The DDC Monitoring Plan has been initiated with all elements of the monitoring network in place with the exception of three new monitor wells, which have been sited and permitted but not installed. One additional new monitor well will be located after production well network configuration is established. These wells will be installed based upon project schedule.

### 3.9 Summary

The approved DDC Monitoring Plan was developed by consensus agreement from the TRP and NSE representatives in a manner similar to the Spring Valley Monitoring Plan. The DDC Monitoring Plan is a scientifically sound adaptive program which protects Federal and non-Federal water resources and meets the goals and objectives of the DDC Stipulation and vacated NSE Ruling 5875.

The Plan established an extensive hydrologic monitoring network which includes wells and springs spatially located across DDC in varying hydrologic conditions. The program also includes springs in White River and Pahranagat Valleys and a regional precipitation monitoring network. A water chemistry data collection program is also included in the DDC Monitoring Plan.

The DDC Monitoring Plan has been successfully implemented with the Plan data collected and reported beginning in 2007. The Plan is currently providing baseline hydrologic data and basin characteristics information to improve the understanding of hydrologic system and document system response to varying climate conditions.

The DDC Monitoring Plan provides a structured process to manage the DDC water development program in a responsible and sustainable manner. The DDC Monitoring plan coupled with the enforcement authority of the NSE provide the NSE with the tools to effectively oversee SNWA's groundwater development program in DDC.

# 4.0 SNWA SUPPLEMENTAL HYDROLOGIC MANAGEMENT ACTIVITIES

This section presents SNWA's activities related to hydrologic management and basin characterization supplemental to the established Monitoring Plans for Spring Valley and DDC presented in Sections 2.0 and 3.0, respectively. The supplemental activities in addition to the established monitoring and mitigation plans provide the elements of the integrated Hydrologic Management Program for the Project Basins.

## 4.1 Hydrologic Management Program Elements

The SNWA Hydrologic Management Program activities, including those which are supplemental to the Monitoring Plans, consists of the following components:

Basin characterization and monitoring:

- Basin Geologic Framework and Hydrologic Characterization;
- Water Resources Assessment;
- Monitoring, Testing and Exploratory Well Development Programs;
- Implementation of the Hydrologic Monitoring Plans.

Hydrologic management tools:

- Regional Groundwater Flow Model and Potential Water-Related Effects Analysis;
- Groundwater Augmentation/Vegetation/Maintenance Programs;
- Groundwater Development and Operations Programs;
- Long-Term Integrated Basin Management.

## 4.2 Basin Characterization

The objective of the basin geologic and hydrologic characterization is to develop a framework as a basis for further defining local, basin, and regional groundwater flow system properties and characteristics. This information is used as a foundation for water resource development, establishment of hydrologic monitoring plans, and improving the predictive capabilities of modeling tools. This information is obtained through the implementation of geologic and hydrologic investigations and monitoring plans.

### 4.2.1 Basin Geologic Framework Characterization

Extensive geologic investigations have been conducted in the area of the Project Basins to define the geologic framework. SNWA investigations included exploratory drilling, surface geophysical profiles, and geologic mapping. Historical data and recent studies performed by other organizations such as UGS, USGS, and through SNPLMA-funded studies are incorporated into the characterization.

Surface geophysical audiomagnetotelluric profiles have been completed by SNWA within the Project Basins to evaluate basin geology and structure. These studies are used to define basin geology and structure which influence groundwater flow and aquifer characteristics. The studies include 25 profiles over a total of 74,064 m within Spring Valley. In DDC, 13 profiles were performed over 23,675 m including three profiles in Delamar Valley over 2,865 m, nine profiles in Dry Lake Valley over 17,420 m, and one profile in Cave Valley over 3,390 m. Additional gravity and magnetic geophysical surveys have been performed by USGS in the study area (Rowley et al., 2011).

Other activities have included regional geologic mapping and hydrogeologic evaluations of the study area including proposed PODs.

### 4.2.2 Monitoring and Testing Program

SNWA has installed 30 wells and 13 piezometers to date in Spring Valley and DDC associated with the monitoring plans and basin characterization studies. These wells provided information on the geologic framework as well as local aquifer characteristics through hydraulic testing, groundwater elevation levels, and water chemistry data. The new SNWA wells are incorporated into the monitoring plans along with selected existing wells to provide long-term monitoring. The new wells installed by SNWA include 23 monitor wells, 7 test wells, and 13 shallow piezometers associated with springs. The test wells are 20-in.-diameter wells ranging in depth between 900 and 1,760 ft bgs. The costs associated with each test well generally are over a $1 million dollars each. The monitor wells range from 4 to 8-in.-diameter and are completed between 100 and 1,830 ft bgs. The costs associated with the installed monitor wells range from $50,000 to $500,000 dollars. The wells were installed as follows:

- Spring Valley: 6 test wells, 14 monitor wells, and 13 spring piezometers
- DDC: 1 test well, 8 monitor wells
- Additional testing wells are currently being considered, including two wells in Delamar Valley and four in Dry Lake Valley to further define hydrogeologic conditions. Additional exploratory drilling and studies are expected to occur in the future as the project proceeds.
- Geologic Data Analysis Reports have been prepared for most locations which present site lithology, downhole geophysical data, and drilling parameters

SNWA performed seven step-drawdown and 72 to 120-hour constant-rate aquifer tests in Spring Valley (described in Section 2.4) and two in Cave Valley (described in Section 3.4) at pumping rates ranging from 550 to 3,000 gpm to determine hydraulic properties and characteristics of the aquifer. The test wells were also sampled for an extensive suite of parameters for chemical analysis to assist in understanding the hydrologic system. Testing results were reported in technical memos and Hydrologic Data Analysis Reports for the test wells. Additional future planned aquifer testing is presented in the Spring Valley and DDC Monitoring Plans.

### 4.2.3 Water Resource Assessments

SNWA performed assessments of water resources and identification of water-rights holders (Stanka, 2011) for Spring Valley (Burns and Drici, 2011). The assessment included characterization of streams and associated watersheds, springs, existing wells, water users, and water-right holders. This information builds upon the basin characterization to allow evaluation of the general hydrologic interconnection between various hydrologic features and water uses and other areas of interest. The water resource assessment was used during the development of hydrologic monitoring plans to identify key areas for monitoring of baseline conditions and future effects, if any, from pumping operations.

## 4.3 Additional Supplemental SNWA Hydrologic Monitoring

In addition to the SNWA Spring Valley and DDC Monitoring Plans, regional hydrologic data in east-central Nevada and western Utah is being collected by SNWA, Federal and State agencies, and other private water-right holders. SNWA provides funding to USGS and the Nevada Division of Water Resources for the monitoring of certain springs, streams, and wells in east-central Nevada and to the USGS Salt Lake City Office for monitoring of wells and streams in western Utah. UGS also performs monitoring within Snake Valley.

Outside of existing monitoring plans, SNWA currently monitors numerous streams, springs, wells, and precipitation stations in the project areas. SNWA also performs evapotranspiration studies in Spring, Snake, and White River valleys. SNWA has been collecting regional data in the area of the Project Basins since the late 1980s.

## 4.4 Groundwater Augmentation

In addition to refining the hydrologic and hydrogeologic parameters of the basin, the integrated hydrologic management approach addresses the importance and recognition of surface water interaction with both vegetation and groundwater in Spring Valley. SNWA will evaluate the potential to increase infiltration into the groundwater system through various enhanced recharge strategies.

A key to managing the water resources in Spring Valley is to ensure that surface runoff continues to successfully enter the groundwater system through the natural grassland areas and irrigated fields. SNWA will evaluate the augmentation of the natural recharge system in Spring Valley to increase the infiltration to the groundwater system of mountain front surface water run-off, by intercepting this flow and developing a system to enhance the capability for additional recharge into the groundwater system. SNWA will work with the appropriate parties for the possible approval of an appropriate recharge recovery program and evaluate the development of such facilities that will increase the quantity of water reaching the groundwater system. SNWA may also acquire surface water rights to aid in this effort.

### 4.5 Groundwater Development and Operations Plan

SNWA will use basin characterization information, baseline monitoring data, and predictive tools in the development of water resource operations plans. The plans' objectives are to optimize development of water resources permitted by NSE while not causing injury to Federal and non-Federal water rights and unreasonable adverse effects to Federal resources, special status species, and areas of interest. Concurrent with development of PODs, SNWA will continue to monitor streams, springs, and wells included in the hydrologic monitoring plans. The basin characterization information derived from POD site development and additional hydrogeologic investigations, coupled with operations data from production wells and the monitoring network will further refine the predictive capability of the numerical groundwater model to further improve the operations plan.

### 4.6 Integrated Basin Hydrologic Management

The components of the monitoring and mitigation plans and supplemental activities are integrated together in an adaptive manner to provide effective management of basin water resources. Understanding of the geologic framework and hydrologic system, identification of areas of interest, and water-right holders, and establishment of long-term monitoring networks allows for development of an effective monitoring program. Predictive tools such as regional groundwater numerical models and analytical methods will improve in effectiveness and capability as the baseline and operational monitoring database becomes larger and extends through periods of climate variation in the hydrologic system such as wet and dry years. The process will allow identification of data gaps which could be used to modify the monitoring program, and, in turn, provide more information to further refine the model. Data would be incorporated into the operations plans in order to optimize development and system operations while minimizing impacts within project constraints. The Hydrologic Management Program includes a clearly defined process for review of potential effects and, if needed, initiation of mitigation actions.

### 4.7 Monitoring Plan Effectiveness

The Hydrologic Management Program is consistent with the management structure and approach of other approved regional groundwater and water resource development monitoring and management programs. The technical content of the SNWA Programs is appropriate for the hydrologic conditions present and for meeting Program monitoring objectives. The Hydrologic Management Program at this stage of project implementation is effective in meeting monitoring objectives.

The primary focus of the Hydrologic Management Program at this stage of implementation is providing background and baseline data in the region and at specific areas of interest as well as providing additional information on the geologic framework and hydrologic system. The scale and distribution of the current monitoring network as well as data collection at the future pumping centers, use of early warning monitoring wells, and predictive tools provide the ability to identify unreasonable drawdown propagation toward areas of interest.

The next stages of the project include aquifer configuration of the production network, followed by initiation of operations and collection of response data. The adaptive management process allows the hydrologic monitoring plans to be reevaluated as additional information becomes available to effectively meet project objectives. The NSE has the authority to require modifications to the monitoring program in the future.

Throughout my professional career since 1979, I have prepared, implemented, or reviewed hundreds of hydrologic monitoring plans and performed hydrologic or remedial investigations at locations throughout the United States and internationally. The plans I was involved with were developed or implemented primarily for private industry, utilities, state environmental agencies, and Federal government Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (commonly known as SUPERFUND) sites. The project sites and facilities were located in a wide variety of hydrogeologic conditions and program scales ranging from local to regional in scope.

I am currently responsible for supervising the monitoring programs in the Las Vegas Valley associated with the LVVWD artificial recharge program and production wells and SNWA regional and shallow monitoring networks. I supervise the groundwater monitoring for water systems in Searchlight, Jean, Kyle Canyon, and Blue Diamond, Nevada. I also supervise and am responsible for DDC and Spring Valley hydrologic monitoring plans and aquifer testing and analysis. I oversee the SNWA joint funding agreements with Nevada Division of Water Resources and USGS Nevada office for hydrologic monitoring in east-central and southern Nevada and the SNWA-USGS Salt Lake City office for hydrologic data collection in western Utah.

I have recently reviewed numerous water resource management plans and regional groundwater monitoring programs developed by other organizations for locations in Nevada, across the United States, and internationally for comparability with the approach and technical content to the Spring Valley and DDC Management Programs.

The comparison of elements of the various regional management and monitoring programs, demonstrate that the SNWA Hydrologic Management Program is comparable with other plans at this stage of implementation and is appropriate and effective for the conditions encountered and monitoring objectives. The key elements of the Program include the following:

- Clear monitoring objectives which have been identified and used as the foundation for monitoring plan development;
- Understanding of the regional and basin geologic framework and hydrologic system. This was defined through the collection and evaluation of time independent data using methods such as geophysical surveys, geologic mapping, test drilling, aquifer testing, and previous report and log reviews;
- Establishment of a regional monitoring network to document baseline conditions through collection of representative time dependent data such as water levels, spring discharge, streamflow, and precipitation data over varying climatological periods, including wet and dry periods. The groundwater network includes existing and new monitor wells which have been professionally surveyed and have known construction attributes and integrity;

- Identification of specific monitoring locations of interest including existing water rights holders, groundwater influenced ecosystems, aquatic species of interest and other areas of interest. Locations were identified through water resource and biological resource inventories and selected by consensus with the TRP;

- Effective data collection and management system to insure that all monitoring points are constructed or selected to provide representative data and station integrity is maintained throughout the Program's life. Data is collected in a consistent manner which follows approved field procedures and QA/QC protocols. Data is processed and stored in an approved and secure manner;

- The Program has flexibility through adaptive management practices to utilize monitoring data to refine the Program in an iterative process. The monitoring plans data is used to refine predictive tools such as numerical flow modeling. The predictive tools, in turn, are used to evaluate monitoring network effectiveness, identify data gaps or modifications to the network or monitoring frequency to improve Program performance;

- The management and data review process has input from stakeholders, including NSE and TRP, to refine or modify the plans based upon scientifically sound data and current conditions.

- The monitoring plan results, predictive tools, and water development operations plan are integrated to provide for optimal operations while minimizing and managing potential impacts.

- The specific technical content is site specific and tailored to the local hydrologic and hydrogeologic conditions, areas of interest, scale, and monitoring objectives. The site specifics such as monitoring density, frequency of measurements, and location are determined in consensus with local technical experts such as the NSE, TRP, and SNWA representatives who developed the technical specifics of the Program to meet project monitoring objectives.

Programs recently reviewed include those with comparable or more complex technical and management issues. Groundwater monitoring and management plans throughout the nation address a variety of issues on a regional and local scale. They involve municipal and agricultural water development and usage, mining dewatering, coal bed methane producer impacts, and regional water resource management plans. These include identification and evaluation of the influence of water development and pumping on regional aquifers. Issues of concern include management of sole-source aquifers, production well interference, control and movement of contaminant plumes, salt water intrusion, and long term sustainability of water resources and groundwater influenced ecosystems. Plans also include wellfield development projects and regional pipeline distribution systems located in various parts of the country.

A few examples include successful water management programs administered by the Florida Water Management Districts which consider large urban water supplies, regional population growth, agricultural usage, sensitive ecological systems (including the Everglades) and regional carbonate springs, surface water usage and recreation, and coastal saltwater intrusion issues.

In the central plain states, overdrafting of regional aquifers by irrigation usage is a major water resource management issue. County and groundwater conservation district groundwater management plans have been established to develop regional monitoring programs to assess and manage the influence of current and future pumping on the sustainability of the regional aquifer.

In California, irrigation and water district groundwater management programs have been established to manage multiple water uses, implement long term monitoring networks, and develop strategies to sustain the aquifer systems. In Nevada, multiple large scale monitoring programs have been established to evaluate the influence of dewatering activities at mining operations as well as development of water resources.

There are well established and successful groundwater management programs in the United States which deal with complex technical and management issues on a regional scale. The programs balance water development with monitoring and management of potential impacts to provide responsible development and resource sustainability. Successful elements of these programs have been incorporated into the Hydrologic Management Programs for Spring Valley and DDC. Other programs can continue to be observed and evaluated to adapt appropriate successful management strategies into the DDC and Spring Valley Programs as well as to provide benchmarks for Program comparison.

The SNWA Monitoring Program approach is also consistent with international hydrologic guidelines and publications. An example is: *Guideline on: Groundwater monitoring for general reference purposes* published by International Groundwater Resources Assessment Centre (Jousma, 2006). The organization, based in the Netherlands, is an initiative of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and World Meteorological Organization.

## *4.8 SNWA Hydrologic Management and Monitoring Experience and Expertise*

SNWA has proven experience with integrated basin hydrologic management within the Las Vegas Valley where 40,600 af/yr of groundwater is produced through 75 production wells and through the operation of a major aquifer recharge program. The artificial recharge program, operated since 1987, is one of the largest direct injection programs in the world. Over 360,000 af of water has been recharged over the history of the program with an annual maximum of 32,061 af in 1999. SNWA uses hydrologic monitoring locations throughout the Las Vegas Valley to track natural variations in aquifer water levels and influences of pumping and recharge. Monitoring data is integrated into the operations plans to determine location and volume pumped and recharged within the system. Groundwater data is regularly reported to the NSE and USGS.

A basin groundwater flow model was developed and used as a management tool during the development and implementation of the artificial recharge program. SNWA also has established effective conservation and public outreach programs in the Las Vegas Valley which demonstrate a respect for other water users and the hydrologic system. SNWA will continue to apply this experience and expertise to the management of the Spring Valley and DDC Programs.

SNWA has demonstrated the ability to effectively implement and operate the Hydrologic Management Programs in DDC and Spring Valley. It has the resources, experience and technical expertise to apply the Program. SNWA has worked collaboratively with the NSE and the TRP in the process of development, implementation, and operation of the monitoring programs. SNWA has implemented the Hydrologic Management Program and has already met applicable reporting requirements.

# 5.0 CONCLUSIONS

Scientifically sound Hydrologic Monitoring Plans for Spring Valley and DDC were developed and implemented while working closely with expert technical representatives of the NSE and TRP. The Monitoring Plans meet the objectives of vacated Rulings 5726 and 5875 and the Spring Valley and DDC Stipulations. These Plans were submitted and approved by the NSE on February 9, 2009 and December 22, 2009 for Spring Valley and DDC, respectively, prior to the Rulings being vacated.

The Hydrologic Management Program has been implemented in Spring Valley and DDC to collect data on each element of the hydrologic system. Extensive study and monitoring employing advanced technical tools and methods were used in implementing the Monitoring Plans. The monitoring network provides spatial and temporal data for evaluation of natural variation in the hydrologic system, assessing aquifer response to local pumping, and providing monitoring at early warning locations and areas of interest. The monitor networks were designed to identify and quantify propagation of drawdown from water resource development. Monitoring during operations will provide data to refine predictive tools which will enhance the monitor network and optimize pumping operations while minimizing impacts. Operational monitoring at selected network locations and use of refined predictive tools will provide early indication of potential future impacts at areas of interest. The projections and monitoring data may be used to develop appropriate mitigation measures including modification of pumping operations.

The Hydrologic Management Program was developed by identifying the groundwater monitoring objectives including those presented in the vacated Rulings and Stipulations. Specifications on representative data needed to meet these objectives were developed and used as the foundation of the plan. Monitoring components, such as type, location, density, frequency of monitoring, QA/QC requirements (such as field protocols, instrumentation, and data processing), data analysis, and program reporting requirements were then designed and implemented to meet the specifications.

The Hydrologic Management Program objectives include: documenting baseline and operational hydrologic conditions, variability, and trends; detecting hydrologic system responses to water development; assisting in determining if unexpected changes in the ecosystem are hydrologically derived, supporting scientific investigations designed to increase understanding of the hydrologic system and ecosystem; assisting in evaluating cause and effect of changes in the system; and evaluating effectiveness of appropriate mitigation action to unreasonable impact responses from water development if they occur.

The Program provides quantitative data for: evaluation of natural background conditions, including influence of variation in precipitation; increasing the understanding of the regional and basin hydrologic system; refinement of the regional numerical flow model; and monitoring aquifer stresses in the vicinity of future pumping operations and areas of interest. The monitoring network distribution and pumping center data will provide early warning identification of unreasonable drawdown propagation if present. Additional Spring Valley and DDC hydrologic monitoring-related goals and objectives are presented in Sections 2.0 and 3.0, respectively.

The Hydrologic Management Program, as discussed further in Section 4.7, is consistent with the management structure and approach of other approved regional groundwater and water resource development monitoring programs located in other areas of the country and internationally. The Program is appropriate and effective for the hydrologic conditions present and monitoring objectives at this stage of development. The scale and distribution of the monitoring network as well as data collection at the future pumping centers and use of predictive tools provide the ability to identify unreasonable drawdown propagation in a timely manner. The NSE has the authority to require modifications to the monitoring program in the future as conditions warrant.

SNWA has demonstrated successful management of resource operations and monitoring in the Las Vegas Valley through the artificial recharge program and water use permits. SNWA has also demonstrated successful development and implementation of the Spring Valley and DDC Hydrologic Management Program. SNWA has the technical knowledge and management ability to successfully implement and manage an effective and technically sound hydrologic monitoring and management program associated with groundwater development in an environmentally sound manner. SNWA has demonstrated the ability to work effectively with a variety of technical teams from government and other organizations, implement hydrologic monitoring programs, meet permit requirements, and provide timely reporting. SNWA maintains an extensive staff of professional geologists, hydrologists, engineers, and chemists with technical resources and commitment to establish and maintain scientifically sound hydrologic management and monitoring programs during baseline and water resource development operations.

The long-term basin Hydrologic Management Program strategy integrates understanding of the hydrologic system, monitoring and mitigation program, water development operations, and predictive tools in an adaptive manner. The Program's effectiveness continues to improve over time as new hydrologic and operations data become available to refine predictive tools and water development operation plans. The Hydrologic Management Program provides the structure and content for effective hydrologic monitoring with a clear process for project input, review, and control by stakeholders through the NSE, TRP, and EC. The Hydrologic Management Program and the authority of the NSE to modify and enforce the program provide the tools to proceed with the development of SNWA's applications in an environmentally sound and responsible manner while protecting existing water-right holders, Federal resources, and areas of interest.

# 6.0 References

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