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SOUTHERN NEVADA
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Resources & Facilities Department
Water Resources Division

Synoptic Discharge Study Big Springs and Lake Creeks, Snake Valley, Nevada and Utah - March 5, 2014 and September 17, 2014

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ACRONYMS

BLM	Bureau of Land Management
BSLC	Big Springs/Lake Creek
DO	dissolved oxygen
EC	electrical conductivity
NDWR	Nevada Division of Water Resources
NSE	Office of the Nevada State Engineer
NWIS	National Water Information System
TRP	Technical Review Panel
UGS	Utah Geological Survey
USGS	U.S. Geological Survey

ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
afy	acre-feet per year
cfs	cubic feet per second

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1.0 INTRODUCTION

The purpose of this document is to present the results of work performed during the synoptic discharge study of the Big Springs/Lake Creek (BSLC) system, located in Snake Valley Nevada - Utah, to meet the requirements of the Spring Valley Hydrologic Monitoring Plan (SNWA, 2011).

The study utilized six existing continuous gaging stations coupled with ten miscellaneous discharge measurement locations. The study included two field events performed on March 5 and September 17, 2014 during non-irrigation and irrigation seasons, respectively.

1.1 Study Objectives

The Hydrologic Monitoring Plan associated with the Office of the Nevada State Engineer (NSE) Ruling 6164 and the Southern Nevada Water Authority (SNWA) / Department of Interior (DOI) Stipulation Agreement for Spring Valley requires that SNWA collect at least two sets of synoptic-discharge measurements for the BSLC surface water system from Big Springs to Pruess Lake. The plan states these data are to be collected during the irrigation and non-irrigation seasons at least one year prior to the start of groundwater withdrawals by SNWA and again every five years during the irrigation and non-irrigation seasons following the start of water withdrawals by SNWA.

SNWA developed a study work plan in collaboration with the Stipulation Agreement Technical Review Panel (TRP) and NSE which presented the project study plan including background information, aerial imagery of the study area, land ownership, methodologies, and study logistics (SNWA, 2014). Study work plan input was also provided by the Utah Geological Survey and Spring Valley Biological Working Group. The study was implemented according to the plan.

1.2 Report Organization

A summary of background information for the BSLC system including area description and previous studies is presented in Section 2.0. Section 3.0 presents the study work plan, logistics, and methodology. Section 4.0 provides study results and Section 5.0 lists document references.

A site map and land ownership information are presented in Appendix A. Appendix B presents historical groundwater level data from monitor wells in the vicinity of the BSLC system. Appendix C presents aerial imagery of the entire system with measurement site locations. An overview of each aerial image segment location is provided on Figure C-1. Photographs of selected portions of the system are presented in Appendix D. Historical discharge hydrographs from the Utah Geologic Survey (UGS) and United States Geological Survey (USGS) gaging stations are also presented in Appendix D. Measurement site elevations and cross sectional profiles are presented in Appendix E. Discharge measurement procedures are presented in Appendix F. Measurement site attributes and discharge data collected during the study are presented in Appendix G. The irrigation delivery schedule for the Utah ranches is presented in Appendix H. Water-chemistry data collected at measurement sites during the study are presented in Appendix I.

1.3 Acknowledgments

SNWA would like to thank and acknowledge staff from the Nevada Department of Water Resources, Utah Geological Survey, National Park Service including staff at Great Basin National Park, Bureau of Land Management, and US Fish and Wildlife Service for participating in the study.

2.0 BACKGROUND INFORMATION

2.1 Geographic Setting

The BSLC system extends across the Nevada - Utah border, in Snake Valley (Nevada Hydrographic Area - 195 and Utah Water Rights Area 18-1) within the Great Salt Lake Desert Flow System. A map of the study area, surficial geology, and selected monitor wells is presented in Figure 2-1. The BSLC system originates at Big Springs in Nevada and flows northeast to Pruess Lake in Millard County, Utah. The system spans approximately 15 miles and is used heavily for irrigation. The stream is referred to as Big Springs Creek from its headwaters at Big Springs to the NV-UT state line where it becomes known as Lake Creek to its terminus at Pruess Lake. Pruess Lake is utilized as a storage reservoir to provide irrigation water to ranches further to the northeast near Garrison, Utah.

2.2 Land Ownership and Access

Maps depicting land ownership over the system in Nevada and Utah are presented in Figures A-1 and A-2, respectively. Through a collaborative effort with the UGS, written agreements were obtained from Baker and Dearden Ranches for access to their lands during the study. BLM granted access to the lands under their jurisdiction, and the NSE secured a verbal agreement to access the Okelberry property.

2.3 Previous Studies

2.3.1 BSLC System Studies

The earliest report documenting conditions at Big Springs was published by Meinzer in 1911. Below is a description of his observations from the original document:

<u>Big Spring and Lake Creek:</u> *Big Spring is situated in Nevada, about 10 miles up the valley from Burbank. The water issues in large volume from gravel not far from a limestone cliff that borders the valley on the west. This water appears to be of good quality. Its temperature was found to be 63.5° F. The spring gives rise to Lake Creek, which flows northeastward to the Burbank settlement and into the reservoir shown in Plate I* (in the original document). *For some miles below the Big Spring smaller springs well out of the gravel and help to augment the size of the creek. The flow of the creek below these springs is reported to be 18 second-feet. The water is used for irrigation on six ranches at Burbank, above the reservoir, and on five ranches at Garrison, below the reservoir, but its duty is apparently low. A mile or more south of the reservoir a large spring, known as Burbank Spring, issues from the gravelly bench on the east side of the valley and supplies water of good quality, the temperature of which is 57° F. Another spring exists in the same vicinity, but nearer the creek* (Meinzer, 1911).

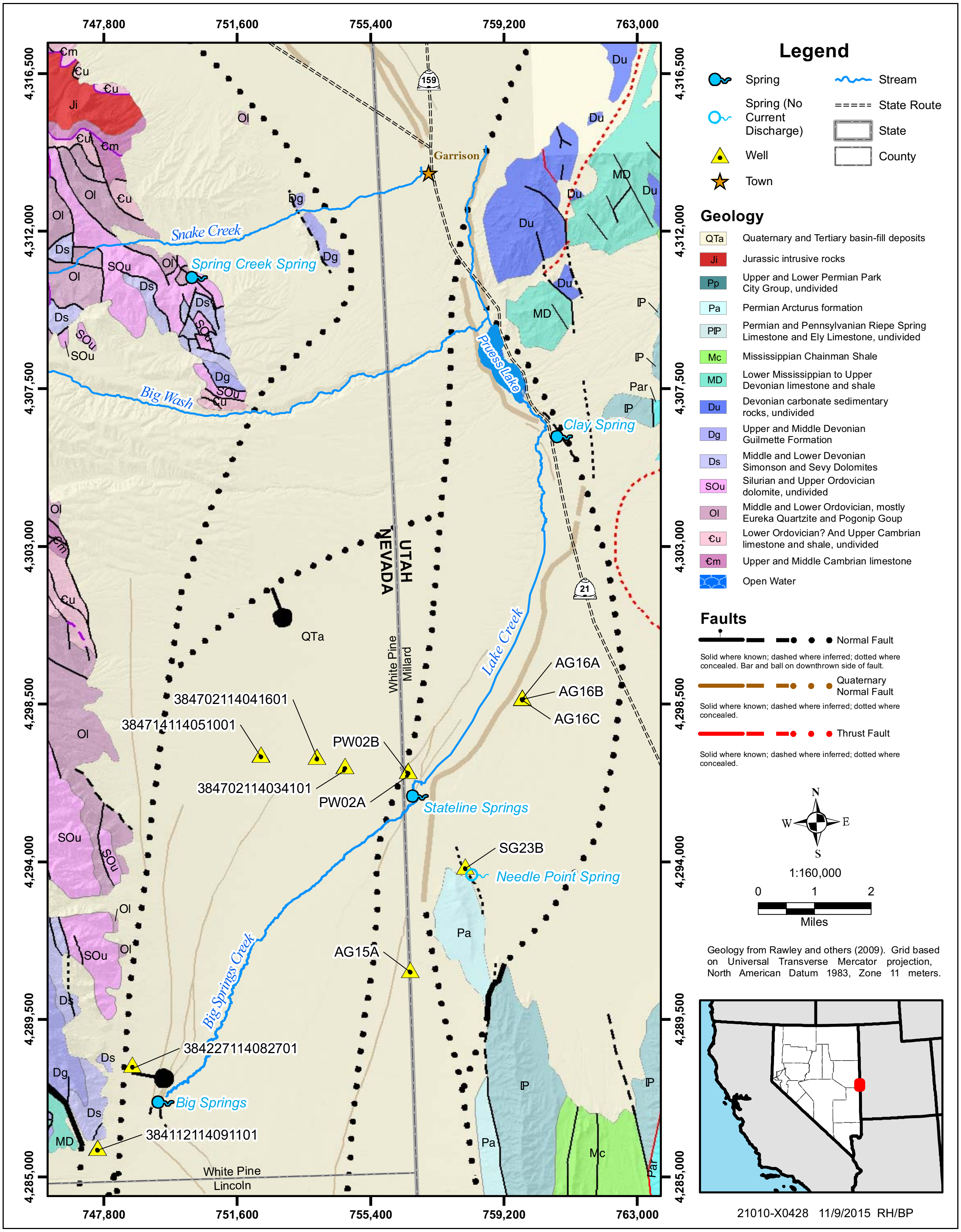

Figure 2-1
Geology and Monitor Well Locations in the Vicinity of BSLC System

Hood and Rush on November 3, 1964 estimated discharge at Big Springs to be approximately 8 cfs. Water samples were collected and a temperature of 64 °F was recorded. Chemical analysis results are presented in Hood and Rush, (1965).

Rodger Walker of the Office of Sevier River Commissioner performed a study of the Big Springs Irrigation Company between June 10 and November 18, 1972. Results of the study are documented in Walker, (1972). The report provides a history of the diversion at Big Springs and measurements at Dearden Ranch.

Squires on October 28, 2004 measured 10.7 cfs below Big Springs (Squires, 2004).

2.3.2 Other Studies

Geologic, hydrogeologic and geophysical investigations have been performed in the vicinity of the BSLC study. A recent evaluation of local geology and hydrogeology in the vicinity of the BSLC system was conducted by Dr. David Prudic and others in 2009 - 2010 as part of the Southern Nevada Public Lands Management Act funded study. This study included an evaluation of the source and characteristics of Big Springs. The source of water to Big Springs is groundwater recharge in the Big Spring Wash drainage basin and in nearby smaller drainage basins at the south end of the Snake Range (Prudic et al., 2015).

Two monitor wells were constructed in carbonate rock and basin-fill material as part of that study. These wells are located southwest and northwest of Big Springs, respectively. These wells were recently incorporated into the SNWA Spring Valley groundwater monitoring program network and water levels are currently recorded hourly. Location of the wells are presented in Figure 2-1. Construction attributes and recent water-level data are summarized in Table 2-1. Historical hydrographs of these two wells are presented in Appendix B on Figures B-1 and B-2.

The UGS installed piezometers in the vicinity of the BSLC system as part of their West Desert groundwater monitoring network. A description of the UGS network along with groundwater level hydrographs are presented on the UGS project web site (UGS, 2015). USGS measures three MX monitor wells located north of BSLC system (Figure 2-1). Hydrographs for the MX wells are available on the USGS NWIS site (USGS, 2015). Historical hydrographs for the wells are presented in Appendix B.

Several other technical reports have been published which discuss the regional and site specific hydrogeology and geology of the study area. These reports include the following:

- Hydrogeologic Studies and Groundwater Monitoring in Snake Valley and Adjacent Hydrographic Areas, West-central Utah and East-central Nevada (Hurlow, 2014).
- Regional Potentiometric-Surface Map of the Great Basin Carbonate and Alluvial Aquifer System in Snake Valley and Surrounding Areas (Gardner et al., 2011).
- Geology and Hydrogeology of the Snake Valley Area, Western Utah and Eastern Nevada (Rowley et al., 2009).

- Characterization of Streams and Springs in the Snake Valley Area (Kistinger et al., 2009).

- Geochemical Characterization of Groundwater and Surface water of Snake Valley and the Surrounding Areas in Utah (Acheampong et al., 2009).

- Audiomagnetotelluric Investigation of Snake Valley, Eastern Nevada and Western Utah (McPhee et al., 2009).

- Geophysical Setting of Western Utah and Eastern Nevada Between Latitudes 37^{o} 45’ and 40^{o} N. (Mankinen and McKee, 2009).

- Geophysical Data from the Spring and Snake Valley Areas, Nevada and Utah (Mankinen et al., 2006).

- Water-Resources Appraisal of the Snake Valley Area, Utah and Nevada (Hood and Rush 1965).

Table 2-1
Monitor Wells in the Vicinity of BSLC System

Well Name	Location		Completion Date	Well Log Number	Borehole Depth (ft)	Well Depth (ft)	Geologic Unit	Screened Interval (ft)	Screened Diameter (in)	Open Interval (ft)	Well[b] Elevation (ft)	Water Level (ft)	Land Stickup (ft)	Water Level Elevation (ft)	Water Level Date
	Northing	Easting													
UGS PW02A[a]	4296602.95	756476.17	6/14/2008	---	998	425	Arcturus FM	405-425	1	398-427	5459.3	30.49	1.43	5428.81	9/8/2014
UGS PW02B[a]	4296602.95	756476.17	6/14/2008	---	998	635	Arcturus FM	615-635	2	605-640	5459.3	28.67	1.41	5430.63	12/8/2014
UGS AG15[a]	4290924.29	756524.92	7/26/2008	---	180	180	Basin Fill	159-179	2	150-185	5528.4	82.51	1.56	5445.89	12/9/2014
UGS AG16A[a]	4298678.53	759728.71	6/25/2008	---	80	80	Basin Fill	50-60	2	46-64	5415.5	19.59	1.98	5395.91	12/9/2014
UGS AG16B[a]	4298692.12	759723.56	7/11/2008	---	317	100	Basin Fill	80-100	2	70-110	5414.5	18.69	1.09	5395.81	12/9/2014
UGS AG16C[a]	4298692.12	759723.56	7/11/2008	---	317	315	Basin Fill	305-315	2	295-317	5414.5	15.51	1.69	5398.99	12/9/2014
UGS SG23B[a]	4293869.12	758103.71	11/16/2008	---	65	65	Basin Fill	55-65	2	50-65	5450.3	6.94	2.43	5443.36	12/8/2014
384227114082701	4288208.30	748609.36	10/13/2009	116598	460	460	Basin Fill	300-460	8	140-460	5815.18	228.82	1.92	5586.36	4/8/2015
384112114091101	4285847.90	747616.56	8/31/2010	112248	700	700	Carbonate	500-700	8	450-700	6019.53	359.66	2.27	5659.87	4/8/2015
384702114034101	4296741.00	754671.00	---	---	101	80	Basin Fill	---	2	---	5535.47	67.59	2.3	5467.88	3/4/2014
384702114041601	4297012.00	753870.00	---	---	101	97	Basin Fill	---	2	---	5581.86	69.52	2	5512.33	3/4/2014
384714114051001	4297066.00	752282.00	---	---	200	147	Basin Fill	---	2	---	5693.14	142.31	2.2	5550.84	3/4/2014

Projection: NAD83 Horizontal Datum: WGS-84 Vertical Datum: NAV88

Water level is from measuring point at top of PVC casing; water level elevation is relative to land surface.

[a] Data from UGS web portal http://geology.utah.gov/resources/data-databases/groundwater-monitoring/

[b] Elevation value given as reported by USGS and UGS

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3.0 STUDY DESCRIPTION

3.1 Study Overview

The synoptic discharge study collected data to characterize and establish the presence or absence of significant gaining and/or losing reaches in the BSLC system by utilizing 16 measurement sites. These 16 sites include six gaging stations; three sites with one or more measurement sections, and seven single-section sites. Aerial imagery of the study area and locations of the measurement sites are presented in Appendix C. An overview of imagery plates is presented in Figure C-1. The first measurements were performed on March 5, 2014 during the non-irrigation season, and a second set of measurements were performed during the irrigation season on September 17, 2014.

Measurement sites were selected based on areas where hydraulically sound discharge measurements could be made. Areas of diffuse discharge or braided channels were not considered reliable measurement sites. Data collected during the study included: discharge, water chemistry, water and air temperature, cross sectional area, bed material description, measurement profile elevation, photos and general site description.

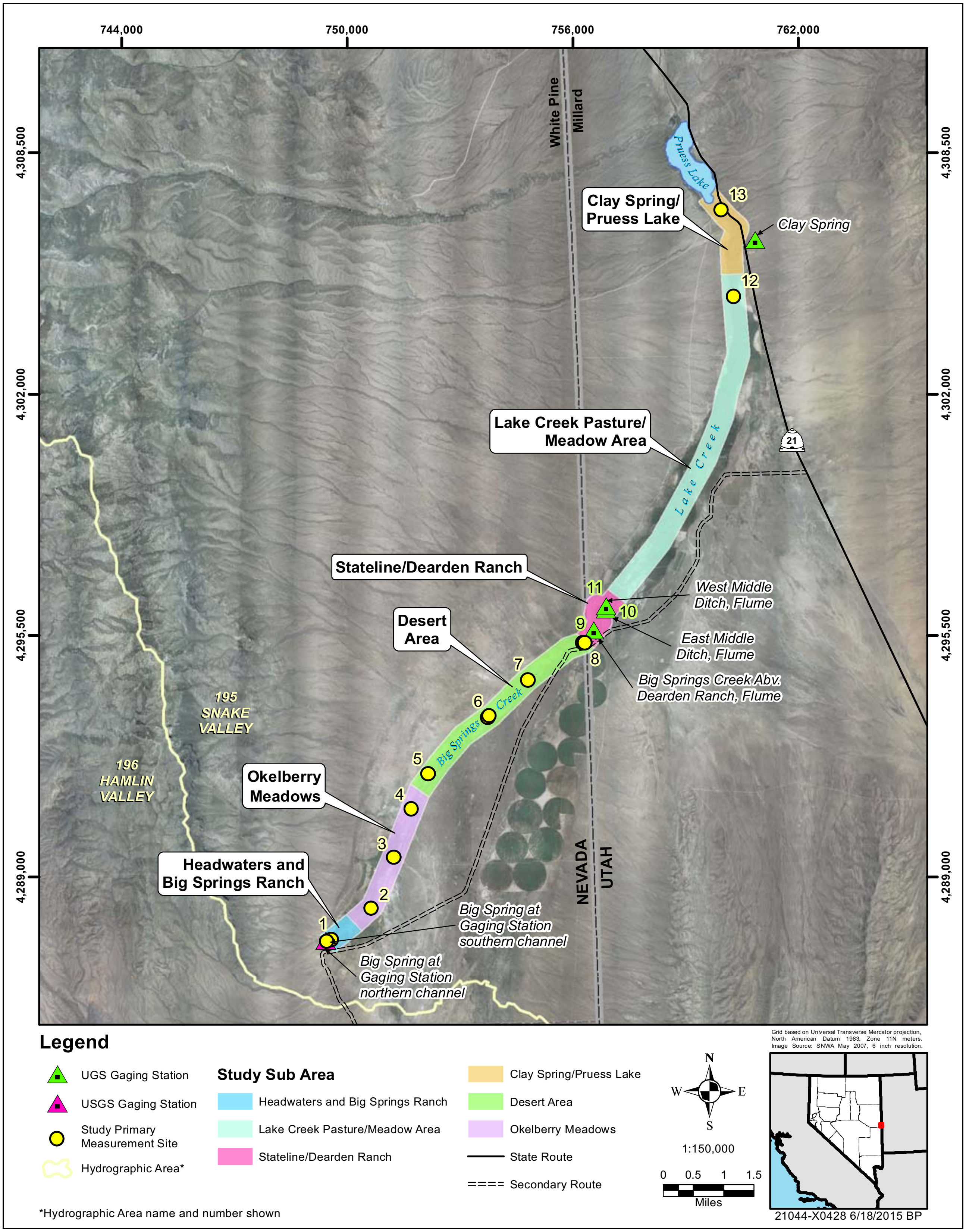
3.2 BSLC System Description

The BSLC system is divided into six sub-areas for the purpose of describing the location and physical attributes of the measurement sites. The sub-areas are Headwaters and Big Springs Ranch, Okelberry Meadows (East and West), Desert Area, State Line/Dearden Ranch Area, Downstream Pastures/Meadows, and Clay Spring/Pruess Lake. These areas are identified in Figure 3-1.

Gains and/or losses of different reaches of the BSLC system were evaluated using ten ungaged physical measurement sites which were established for the study along with six existing gaging stations. Several of these ungaged sites were split into sub-sites to accurately account for diversions. Station information is presented in Table 3-1 and described in detail in Section 3.3.

3.2.1 Headwaters and Big Springs Ranch

Big Springs are located approximately 18 miles southwest of Garrison, Utah at the base of the eastern flank of the southern Snake Range, in Nevada. Spring discharge at Big Springs occurs from two major springheads into two channels, identified as North Channel and South Channel, which are separated by a narrow strip of land approximately 10-15 feet (ft) wide. Two gaging stations are maintained by USGS Water Science Center through a joint funding agreement with SNWA and Nevada Division of Water Resources (NDWR) which measure discharge in the channels. The gaging stations are located approximately 25 ft downstream of the spring orifices. Photos of the South and North Channels downstream of the gages are presented in Figures D-1 and D-2, respectively.



Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

Figure 3-1
Big Springs / Lake Creek Study Area

Table 3-1
Measurement Sites

SNWA ID	Work Plan Site Number	Location	Type	Period of Record	Team Number	Measurement Team Agency	General Coordinates		
							Easting (m)	Northing (m)	Elevation
1951904	1.1	Big Springs at Gaging Station Northern Channel	Continuous	October, 2005 to Present	1	SNWA/NDWR	749,424	4,287,293	5,573
1951911	1.1.2	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing	Miscellaneous	--	1	SNWA/NDWR	749,578	4,287,309	--
1951903	1.2	Big Springs at Gaging Station Southern Channel	Continuous	May, 2005 to Present	1	SNWA/NDWR	749,422	4,287,293	--
1951913	1.2.1	South Channel 14.375 ft Rectangular Suppressed Weir	Miscellaneous	--	1	SNWA/NDWR	749,463	4,287,267	--
1951914	1.2.2	South Channel 4 ft Cippoletti Weir	Miscellaneous	--	1	SNWA/NDWR	749,465	4,287,265	--
1951916	1.2.4	Olkelberry Diversion Ditch downstream of Big Springs Creek Crossing	Miscellaneous	--	1	SNWA/NDWR	749,572	4,287,314	--
1951919	1.3.1	Unnamed Spring Creek upstream of Big Springs Creek	Miscellaneous	--	1	SNWA/NDWR	749,603	4,287,310	--
1951920	2	Big Springs Creek at upperstream Okelberry Meadow	Miscellaneous	--	2	USFWS	750,641	4,288,156	5,502
1951921	3	Big Springs Creek at Mid-Okelberry Meadow	Miscellaneous	--	3	NDWR	751,245	4,289,521	5,488
1951922	4	Big Springs Creek at downstream Okelberry Meadow	Miscellaneous	--	4	NPS	751,706	4,290,830	5,481
1951923	5	Big Springs Creek downstream of Culvert	Miscellaneous	--	5	SNWA	752,154	4,291,770	5,476
1951924	6	Big Springs Creek upstream of Dearden House Ditch	Miscellaneous	--	6	SNWA	753,746	4,293,295	5,467
1951925	6.1	Dearden House Ditch Diversion	Miscellaneous	--	6	SNWA	753,775	4,293,333	5,467
1951926	7	Big Springs Creek at Powerline	Miscellaneous	--	7	NDWR	754,810	4,294,300	5,447
1951927	8	Big Springs Creek upstream of Stateline	Miscellaneous	--	8	SNWA	756,273	4,295,298	5,436
1951928	8.1	Big Springs Creek Highline Ditch upstream of Stateline	Miscellaneous	--	8	SNWA	756,324	4,295,302	5,436
1951905	9	Big Springs Creek above Dearden Ranch	Continuous	2009 to Present	9	UGS	756,556	4,295,638	5,422
1951907	10	East Middle Ditch	Continuous	2009 to Present	9	UGS	756,877	4,296,207	5,414
1951908	11	West Middle Ditch	Continuous	2009 to Present	9	UGS	756,884	4,296,290	5,411
1951929	12	Lake Creek upstream of Clay Spring	Miscellaneous	---	10	SNWA	760,287	4,304,627	5,366
1951930	13	Lake Creek upstream of Pruess Lake	Miscellaneous	--	11	SNWA	759,950	4,306,944	5,361
1951931	14	Clay Spring	Continuous	2009 to Present	9	UGS	760,847	4,306,149	‘--

All coordinates are Universal Transverse Mercator, North American Datum, 1983, Zone 11.

The period of record for the South and North Channel gaging stations are May and October 2005, respectively, to present. Historical hydrographs for the two gages are presented in Figures D-3 and D-4. Data from the sites are provided through the USGS National Water Information System (NWIS).

Downstream of the gaging stations, flow in the South Channel is sub-divided by two weirs. A 14.375-ft rectangular suppressed weir diverts a portion of the discharge into the North Channel, the balance of the flow passes over a 4-ft Cippoletti weir and continues eastward. Approximately 275 ft downstream of the weir, the South Channel can be diverted to the north where it either becomes the Okelberry Diversion Ditch (Site 1.2.4 on Figure C-2) where it can irrigate the Okelberry West Meadows, or it can be diverted to the east where it can be used to irrigate the Okelberry East Meadows. The South Channel discharge can also be augmented with water from the Big Springs Ranch Reservoir. The Big Springs Ranch Reservoir is maintained by a spring located on the southeast corner of the ranch, the discharge of which has not been quantified, however it is minor relative to the discharge of Big Springs.

The North Channel forms Big Springs Creek (Site 1.1.2 on Figure C-2) and flows northeastward dividing the Okelberry Meadows into West and East. High-resolution aerial imagery of Big Springs Creek and diversions on Big Springs Ranch is presented on Figure C-2. Diffuse seepage and overland irrigation practices have been observed on the southern-most Okelberry property, which influence discharge measurements along this segment of the creek.

3.2.2 Okelberry Meadows

Okelberry Meadows is an area of approximately 800 acres of which about half were irrigated meadows during the time of study. As stated previously, the South Channel can irrigate either the east or west Okelberry Meadows. During both of the measurement events the water from this channel, after the weir, was diverted in its entirety to the north into the Okelberry Diversion Ditch. Water from the diversion channel is then diverted at numerous points to flood irrigate the West Okelberry Meadows. An aerial photo showing the irrigated meadows is presented in Figure C-3.

Irrigation water that infiltrates and is not consumed by evapotranspiration (ET) may return to Big Springs Creek as seepage. Water from the Okelberry Diversion Ditch has also been observed in the past returning to Big Springs Creek as overland flow. A photo of Big Springs Creek at the Okelberry upper meadow (Site 2) is presented in Figure D-5.

The Okelberry Meadows is subdivided into three measurement reaches: Upstream, Middle and Downstream. Discharge for these reaches were measured at Site numbers 2, 3, and 4 respectively.

3.2.3 Desert Area

Downstream of the Okelberry Meadows, Big Springs Creek flows relatively unaffected by surface-irrigation practices with the exception of one small diversion at Site 6. A photo of the stream channel at Site 5 is presented in Figure D-6. The diversion at Site 6 known as the “House Ditch” (Site 6.1) continues approximately 3 miles to the northeast where the water is used for irrigation or allowed to return to Lake Creek at the Dearden Ranch House (Figure D-7).

Below the House Ditch diversion, the Big Springs Creek continues to flow in a northeastward direction to Site 8, just upstream of the NV-UT state line, where it can be diverted into what is known as the "High-line Ditch" (Site 8.1 Figure C-8). The UGS maintained a flume and gaging station on the High-line Ditch for a short period of time; however, it was discontinued due to irrigation operational issues affecting the gage record. The High-line Ditch is used intermittently during the irrigation season and conveys the water along the eastern edge of the irrigated area. Downstream of Site 8, Big Springs Creek crosses the NV-UT state line and becomes Lake Creek. Photos of the channels and diversion structure are shown in Figures D-8 and D-9. Aerial images of this area are presented in Figures C-6 through C-11.

3.2.4 Stateline / Dearden Ranch Area

The UGS maintains a continuous gaging station consisting of a 2-ft Parshall flume on the main channel downstream of the stateline called the Big Springs Creek above Dearden Ranch Station (SF28-1). The gage location and site photo are presented on Figure C-9 and Figure D-10, respectively. The period of record for the gaging station is from 2009 to present. The historical discharge records are presented on the UGS portal.

Further downstream, on Dearden Ranch, numerous springs are observed augmenting the flow of Lake Creek. The springs are referred to as Dearden Springs and have also been historically referred to as Stateline, Burbank, and Dearden Ranch Springs. Downstream, northeast of the springs, Lake Creek is diverted into two ditches which parallel the natural channel. The ditches are referred to as the West Middle Ditch and East Middle Ditch and are monitored by two continuous gaging stations operated and maintained by UGS (Figure C-11). The East Middle Ditch is equipped with a 3-ft Parshall flume (SF28-3) and West Middle Ditch, equipped with a 6-ft wide ramp flume (SF 28-4). Photos of the two gaging stations are presented in Figures D-11 and D-12. The period of record for the gaging stations are 2009 to present. The historical discharge hydrographs are presented on the UGS portal.

A hydrograph of Dearden Spring discharge prepared by UGS is presented in Figure D-13. The UGS approximates the discharge of Dearden Springs by Equation 1 (UGS 2015).

$$Q_{DS} = (SF28\text{-}4 + SF28\text{-}3) - SF28\text{-}1 \quad \text{(Eq. 1)}$$

Where:

Q_{DS} = calculated discharge of Dearden Springs

SF28-4 = discharge at West Middle Ditch gaging station

SF28-3 = discharge at East Middle Ditch gaging station

SF28-1 = discharge at Big Springs Creek above Dearden Ranch gaging station

Backwater from the Lake Creek Pasture/Meadow area along the West and East Middle Ditches may influence the accuracy of the discharge records for the SF28-3 and SF28-4 gaging stations.

3.2.5 Lake Creek Pasture/Meadow Area

Lake Creek Pasture/Meadow Area is approximately six miles long and contains about 1,800 acres of flood irrigated land. This area is shown in Figures C-11 to C-14. The area is owned and irrigated by several different property owners. At Dearden Ranch the entire flow of Lake Creek is divided into the East and West Middle Ditches and provides irrigation water to the downstream ranches. The irrigation schedule for the ranches is provided in Appendix G. Each of these ranches has a series of reservoirs, diversions, and flood-irrigation sites. Irrigation practices and channel layout are at the discretion of the individual property owner while it is their “turn” to receive water. This results in difficulty isolating discrete channels for accurate discharge measurements in the area. A single discrete channel was located approximately six miles downstream of the Dearden Ranch, where measurement Site 12 was established as shown on Figure D-14. Approximately 0.6 miles further downstream (north) Lake Creek receives discharge from Clay Spring.

3.2.6 Clay Spring / Pruess Lake

Clay Spring area is depicted on Figure C-14 between sites 12 and 13. North Clay Spring is monitored continuously by UGS using a 90^{o} V-notch weir. A photo of the UGS gaging station is presented in Figure D-15. The station has a period of record of 2009 to 2013. The historical discharge hydrograph is presented on the UGS portal.

A discrete channel is present from south of the confluence with Clay Spring discharge northward to Pruess Lake. Measurement Site 13 is the final measurement site, located approximately 0.4 miles upstream of Pruess Lake. A photo of the channel on BLM-managed land is presented in Figure D-16. Pruess Lake is used as an impoundment to supply irrigation water to ranches downstream near Garrison, UT.

3.3 Measurement Site Locations and Frequency

3.3.1 Gaging Stations

The USGS and UGS operate and maintain six gaging stations which are continuously monitored on Big Springs-Lake Creek and Clay Spring. Two stations are located in Nevada and maintained by the USGS-NV Water Science Center through a funding agreement with SNWA and NDWR. Four are located in Utah and are maintained by the UGS. Station names and periods of record are presented in Table 3-1.

3.3.2 Additional Discharge Measurement Sites

Ten additional sites were established to collect miscellaneous discharge physical measurements for the study to evaluate gains and/or losses of different reaches of the BSLC system. Several of these sites needed to be split into several sub-sites to accurately account for diversions. Study site measurement locations are presented in Appendix C and detailed in Table 3-1. Measurement site elevations and cross sectional profiles are presented in Appendix E.

3.3.3 Measurement Logistics

Prior to the non-irrigation and irrigation season field events, measurement sections were prepared by removing vegetation and bank undercuts. Reference posts were installed at each section prior to the study to measure stage from a consistent point.

Thirteen measurement teams were utilized during the study. Nine teams were assigned to collect discharge measurements at stations along Big Springs-Lake Creek. One team performed verification measurements at the UGS gages. One team performed both verification measurements of Big Springs gages and discharge measurements on diversions on Okelberry Big Springs Ranch. The quality assurance team performed one comparison set of discharge measurements at each measurement site for the purposes of data verification and evaluating equipment variability. One team collected water-chemistry samples and performed water-quality field measurements.

Discharge measurements were performed from 09:00 to 16:00 hours, with one measurement being made every hour on the hour at the miscellaneous discharge measurement sites. Teams stationed at sites with diversions performed measurements in each channel every hour, with the exception of Site 1. Site 1 is made up of numerous sub-sites and each one of these required at least one measurement during the day.

3.4 Methodology

All discharge measurements were performed in accordance with the procedures described in USGS Techniques of Water Resource Investigation Series; USGS Water-Supply Paper 2175 (Rantz and others 1982); American Society for Testing Materials (ASTM) D4409-95 and ASTM D5640-95; and SNWA Field Operating Procedures. Measurement procedures are presented in Appendix F.

Each team made a series of discharge measurements at their assigned site according to the pre-arranged schedule. The equipment used for the discharge measurement included a tag line marked in hundredths of a foot (0.01 ft) and a standard top-set wading rod. Price AA and pygmy vertical-axis current meters were used to perform the measurements. Data were collected using Aquacalc automated data loggers connected to the current meters at most sites. Each team had the ability to record the measurements and calculate the discharge manually should there be a failure with the automated data loggers.

All instruments were inspected, cleaned, and calibrated before being used in the field. All teams met on the day prior to the non-irrigation field event to review the procedures and measurement techniques. Once in the field, the instruments were re-checked to ensure proper operation before and after each measurement.

Each team was assigned to a single station with single or multiple measurement-sections to monitor the entire day. Once at the site, the team located the pre-marked section and stretched the tag line across the channel. At the predetermined time the team executed a discharge measurement. This continued until the final measurement was completed at the pre-determined hour. Air and water temperature were collected along with each discharge measurement.

A Quality Assurance (QA) Team was used during the study to make discharge measurements at each section. The QA Team used their own equipment to verify the measurements made by each team and provide a check on equipment variability.

A water-quality team collected samples for field analysis of water-quality parameters at each site. Water samples were collected for laboratory analysis of general chemistry at selected sites.

A preliminary review of all data was performed at the end of the day, and no obvious erroneous results were identified.

4.0 RESULTS

Results of the discharge measurements collected during the BSLC synoptic discharge study are presented in this section by area from Big Springs to Pruess Lake. Site conditions, non-irrigation season measurements collected on March 5, 2014 and irrigation season discharge measurements collected on September 17, 2014 are presented for the measurement sites. Measurement site locations are presented in Appendix C. Measurement site elevations and cross sectional profiles are presented in Appendix E. Measurement data sets are available in Appendix G. A schematic of the BSLC system summarizing the study results is presented in Figure 4-1. A study result summary table is presented on Table 4-1.

The study discharge results are compared to historical measurements performed on the system in Section 4.2. Water-chemistry results are presented in Appendix H and discussed in Sections 4.3.

4.1 Discharge Measurement Results

4.1.1 Headwaters and Big Springs Ranch

Site 1 is located on the Big Springs Ranch and was divided into eight sub-sites because of multiple channels and numerous diversions. Discharge at six of the sub-sites was measured during the study. The headwaters form two distinct channels known as Big Springs North Channel (Site 1.1) and South Channel (Site 1.2), which are both continuously gaged by the USGS. Downstream of Site 1.2, the South Channel enters a diversion structure where a proportion of the flow is transfered to the North Channel and the remainder stays in the South Channel. Farther downstream the South Channel becomes the Okelberry Diversion Ditch, and the North Channel becomes Big Springs Creek as shown in Figure C-2. Sequential numbering of these additional sites is as follows: 1.1 and 1.1.2 are located on the North Channel; Sites 1.2, 1.2.1, 1.2.2 and 1.2.4 are located on the South Channel and the Okelberry Diversion Ditch.

Study Sites 1.1 and 1.2 are the North and South channels of Big Springs Creek at the USGS gaging stations located downstream of the spring orifice. The channels are characterized by steep grass lined banks with a small berm with dense arboreal growth dividing the North and South Channels. The flow is characterized by clear water and the stream bed is firm gravel. Physical measurements at the sites were rated from fair to poor based on channel conditions observed during the study.

Combined flow of the North and South channels measured during the study at the location of the gaging station during the non-irrigation season measurements was 9.0 cubic feet per second (cfs). Irrigation season discharge measurements, when combined, were 9.2 cfs. Reported combined mean daily discharge for the two channels from the USGS gaging station records are 8.6 and 9.2 cfs for March 5 and September 17, 2014, respectively.

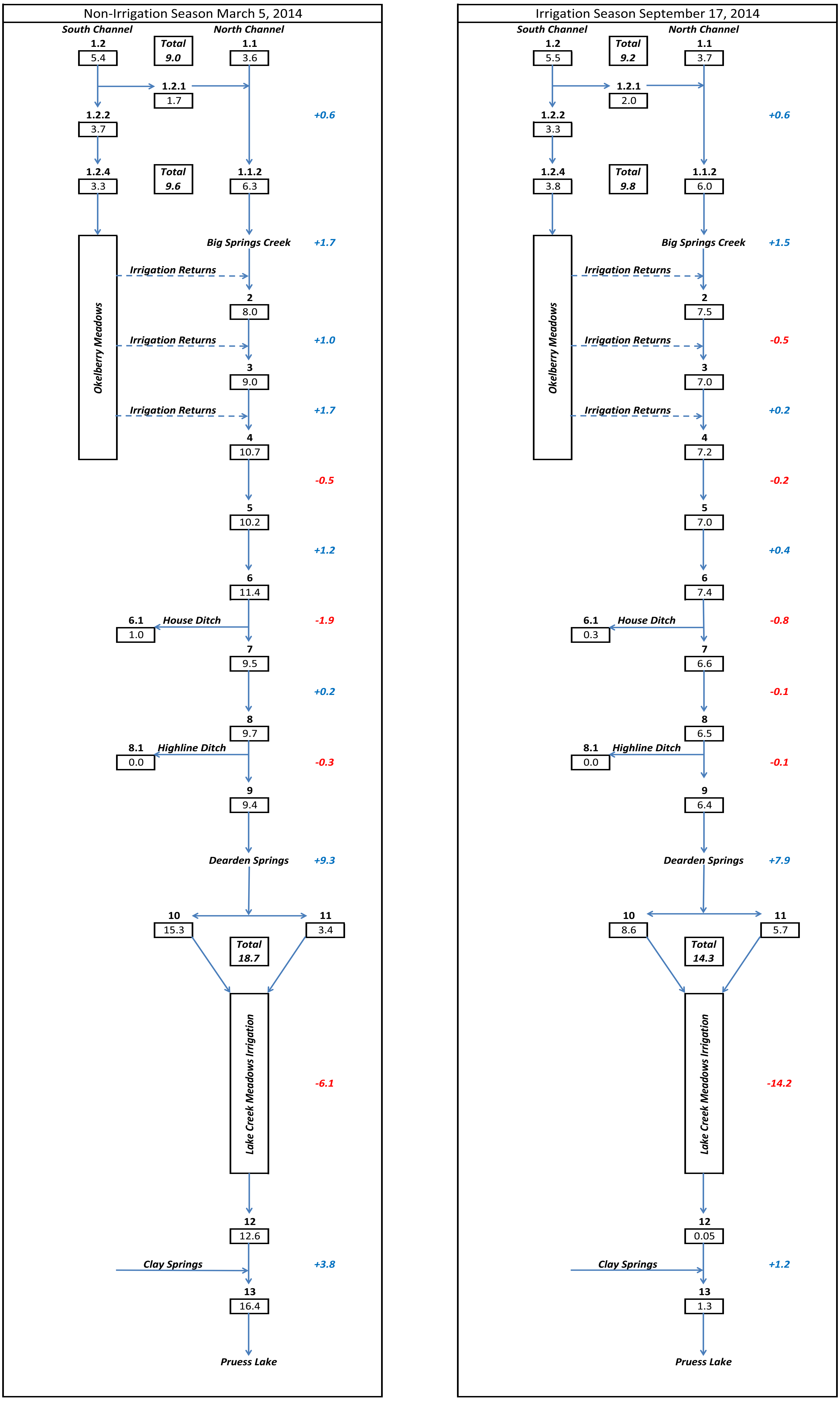


Figure 4-1
Summary of Study Discharge Measurements

Table 4-1
Rate of Discharge Change Table

Reach Description	Length (river miles)	March Measurements			September Measurements		
		Discharge end of reach (cfs)	Total Change over reach (cfs)	Change Rate (cfs/river mile)	Discharge end of reach (cfs)	Total Change over reach (cfs)	Change Rate (cfs/river mile)
Big Springs	-	9.0	-	-	9.2	-	-
Total at Sites 1.2.4 and 1.1.2	0.20	9.6	+ 0.6	3.00	9.8	+0.6	3.00
Okelberry Diversion Ditch Site 1.2.4	-	3.3	-	-	3.8	-	-
Big Springs Creek Site 1.1.2	-	6.3	-	-	6.0	-	-
Site 1.1.2 to Site 2	1.43	8.0	+1.7	1.19	7.5	+1.5	1.05
Site 2 to Site 3	1.74	9.0	+1.0	0.57	7.0	-0.5	-0.29
Site 3 to Site 4	1.22	10.7	+1.7	1.39	7.2	+0.2	0.16
Site 4 to Site 5	0.93	10.2	-0.5	-0.54	7.0	-0.2	-0.22
Site 5 to Site 6	1.77	11.4	+1.2	0.68	7.4	+0.4	0.23
Site 6 to Site 7	1.22	9.5	-0.9[a]	-0.74	6.6	-0.5[b]	-0.41
Site 7 to Site 8	1.36	9.7	+0.2	0.15	6.5	-0.1	-0.07
Site 8 to Site 9	0.41	9.4	-0.3	-0.73	6.4	-0.1	-0.24
Site 9 to Sites 10 and 11	0.78	18.7	+9.3	11.92	14.3	+7.9	10.13
Sites 10 and 11 to Site 12	5.73	12.6	-6.1	-1.06	0.05	-14.2	-2.48
Site 12 to Site 13	1.98	16.4	+3.8	1.92	1.3	+1.2	0.61

[a] Excluding 1.0 cfs diversion to the House Ditch

[b] Excluding 0.3 cfs diversion to the House Ditch

Downstream of Site 1.2 is a diversion box where the flow of the South Channel is split by two weirs, based on water-rights. These two sites, are identified as Sites 1.2.1 and 1.2.2, respectively, are controlled by a 14.375-ft rectangular suppressed weir and a 4-ft Cippoletti weir. Both weirs show signs of pitting and settling which effect their accuracy. Differential leveling was performed to evaluate how much out of level the two weirs were and determined that both are lower by 0.02 ft along their respective right (southeast) banks. Measurements made at Sites 1.2.1 and 1.2.2 are rated as good based on the condition of the weirs observed during the study.

Located approximately 100 yards downstream from Sites 1.2.1 and 1.2.2 are Sites 1.1.2 (North Channel/Big Springs Creek) and 1.2.4 (South Channel/Okelberry Diversion Ditch). Site 1.1.2 measures the total flow of Big Springs Creek and Site 1.2.4 measures the total flow of the Okelberry Diversion Ditch. Both of these channels are located in an active corral and meadow. The banks are grass-lined and heavily trampled by livestock. The bed material at Site 1.2.4 ranges in size from silts along the edges to coarse gravel and large cobbles with a few boulders present. At Site 1.1.2, the channel bed material is coarse gravel with a few large cobbles and small boulders. The crossing of the North and South channels is shown in Figure 4-2. Measurements made at these sites are considered poor based on channel and flow characteristics observed during the measurements.

Figure 4-2
Looking southwest - Site 1.1.2 Big Springs Creek (foreground) and Site 1.2.4 Okelberry Diversion Ditch (background)

The Okelberry Diversion Ditch was in use during both non-irrigation and irrigation season field events. No operational changes for the diversion ditch or irrigation practices were observed between the field events. Between the headwaters (Sites 1.1 and 1.2) and the combined flow in Big Springs Creek and the Okelberry Diversion Ditch (Sites1.1.2 and 1.2.4) the measurement data indicate an increase in discharge of 0.6 cfs was occurring during both the non-irrigation and irrigation seasons.

4.1.2 Okelberry Meadows

Okelberry Meadows are active grazing areas located on the Big Springs Ranch. The meadows are located primarily on the west bank of Big Springs Creek and are approximately 2 miles in length and 800 acres in area with approximately 350 acres being actively irrigated during the studies via the Okelberry irrigation ditch. Okelberry Meadows was divided into 3 reaches: Upper (Site 2), Middle (Site 3) and Lower (Site 4) as shown in Figures C-3 and C-4.

Site 2 is characterized by steep, wet, grassy, sloughing banks. The sloughing has been exacerbated by livestock grazing in the area. Bed materials during the field events were firm, coarse sands and gravel with soft, silty areas along each bank. The control for the measurement section was the bank and stream bed. The stream flow was shallow, fast, turbulent and clear, and discharge measurements were rated as poor to fair based on channel and flow conditions observed during the measurements (Figure 4-3).

Figure 4-3
Site 2 During the Irrigation Season

Discharge measurements at Site 2 made during the non-irrigation season and irrigation season averaged 8.0 and 7.5 cfs, respectively. In comparison to Site 1.1.2, during both seasons an average gain of approximately 1.6 cfs was measured along this reach between measurement sites.

Site 3, located approximately 0.9 miles downstream of Site 2, has steep, soft, silty, sloughing grass-lined banks. Like Site 2, the sloughing has been exacerbated by livestock grazing in the area. Unlike Site 2, the water clarity during the measurements was turbid and velocities slower. Bed material was soft and silty along both banks and became increasingly firm in the center of the channel. Cross section flow control was provided by the channel. Discharge measurements made during both seasons were rated poor based on the conditions observed during the study.

Some additional discharge was observed to be gained by the Okelberry Diversion Ditch by inflow from an unnamed spring located on the western margin of the meadow, north of Big Springs between sites 2 and 3 (Figure C-3). All water in the Okelberry Diversion Ditch is used for overland irrigation of the meadow.

At Site 3 on Big Springs Creek, an average of 1.0 cfs gain was measured as compared to discharge measured at Site 2 during the March field event. However, the September measurement at Site 3 indicate a 0.5 cfs decrease when compared to Site 2.

The Lower Okelberry Meadow was measured at Site 4 located approximately 0.9 miles downstream of Site 3. At Site 4, the banks are steep, silty, and grass-lined with sloughing exacerbated by livestock grazing in the area. During the measurements, the velocities were low and the flow had become increasingly turbid. Bed material was soft and silty along both the right and left banks, and became more firm toward the center of the channel. The flow controls at Site 4 was the channel. Based on the conditions of the flow and channel observed during the study, discharge measurements were rated as poor (Figure 4-4). Measurement during the non-irrigation season indicate an increase in flow along the reach between sites 3 and 4 of 1.7 cfs, and an increase of 0.2 cfs during the irrigation season.

Use of the Okelberry Diversion Ditch was similar during both the March (non-irrigation season) and September (irrigation season) measurements. Observations of the meadow indicated that the meadow grass was active during the September measurements and may account for much of the consumption of irrigation water applied to the meadow from the Okelberry diversion. Less water from the diversion would be consumed in winter and early spring when the meadow grass is less active and a greater volume would be expected to return to Big Springs Creek as overland flow or infiltrate and discharge as shallow groundwater. Water being consumed by the meadow grasses would explain why there is little to no increase in discharge during the irrigation season and larger increases in discharge during the March non-growing season.

4.1.3 Desert Area

The Big Springs Creek flows were measured in the Desert Area at Sites 5, 6, 6.1, 7, 8, and 8.1. The southern part of the Desert Area is characterized by dry meadow grasses at Site 5 with increasing density of shrubs to Site 7 where it has transitioned to solely phreatophitic shrub-land vegetation.

Figure 4-4
Site 3 During the Irrigation Season Measurement Field Event

The measurement section of Site 5 has nearly vertical banks and the channel is typically more than over one foot deep. The bed material is very soft silts becoming increasingly soft from the center of the channel towards the banks. During the measurements the velocity was slow and the water very turbid. Flow control at Site 5 is the stream bed and banks. Measurements made at Site 5 are rated poor based on the channel characteristics and flow conditions observed during the field events. A photo of Site 5 is shown on Figure 4-5. Both during non-irrigation and irrigation seasons small losses of 0.5 and 0.2 cfs respectively were observed along the reach defined by Sites 4 and 5.

Physical characteristics of the channel at Site 6 are similar to those observed at Site 5. The channel becomes increasingly deeper with vertical silty banks and soft silty bed material. At Site 6, an artificial control has been installed across the channel to allow water to be diverted into the House Ditch. The control is stable and made up of tires, plastic tarps, wood, rocks and other debris. As a result, the control velocities during the measurements were slow. The slow velocity resulted in a large silt bar forming along the left bank at the mouth of the House Ditch. The elevation of the control and the large silt bar at Site 6 regulate the amount of water entering the House Ditch. Discharge measurements were rated as poor based on the channel characteristics and flow conditions observed during the field events. A photo of Site 6 is shown on Figure 4-6. The measurements indicate that the reach between Sites 5 and 6 gains 1.2 cfs in the non-irrigation season and 0.4 cfs during the irrigation season.

At Site 6.1, flow is controlled by a 1-ft ramp flume. At the time of measurement. the flume was submerged and ineffective for use as a measuring device. Current meter measurements were made in

Figure 4-5
Site 5 Irrigation Season Measurement

Figure 4-6
Site 6 Looking Downstream at the Control. House Diversion Ditch is on the Left Side of the Photo.

the approach of the flume and are rated as poor. Diversion rates of 1.0 cfs and 0.3 cfs were measured during the non-irrigation and irrigation seasons, respectively. The higher discharge measured at Site 6, during the non-irrigation season (11.4 cfs), compared to the irrigation season (7.4 cfs), results in water breaching the silt bar at the mouth of the House Ditch and allowing more discharge into the ditch.

Phreatophitic shrub-lands with sparse perennial grasses line the steep banks at Site 7. Unlike other locations, Site 7 is deeply incised approximately 6-8 ft below the elevation of the flood plain. During the measurements, velocities were higher, and the depths were shallower when compared to Site 6. Bed material is soft silt along both banks, with firm gravel making up the center of the channel. Measurements were rated from fair to poor based on the channel characteristics of the site and flow conditions observed during the study. A photo of Site 7 is shown on Figure 4-7.

Figure 4-7
NDWR Staff Measuring Site 7 During the Non-Irrigation Season

Discharge losses for the reach defined by Sites 6 and 7 were observed during both seasons. A gross loss of 1.9 cfs (including 1 cfs which was diverted into the House Ditch) was measured during the non-irrigation season, and a gross loss of 0.8 cfs (including 0.3 cfs which was diverted into the House Ditch) was measured during the irrigation season. Factoring out the measured diversion to the House Ditch, the net discharge losses between Sites 6 and 7 during non-irrigation and irrigation seasons were measured as 0.9 and 0.5 cfs, respectively.

Sites 8 and 8.1 are located approximately 1.1 miles downstream from Site 7. Site 8 measures the main channel of Big Springs Creek and Site 8.1 measures the flow in the High-line Ditch. No water was diverted into the High-line Ditch during either field event. Site 8 is a concrete structure similar in design to a modified Parshall Flume and is shown on Figure 4-8. Grooves in the concrete allow the addition or removal of flash boards to modify the volume of water diverted into the high-line ditch. Having shallow depth and a short cross section, measurements made at Site 8 are considered poor. During the measurements, water at the site was turbid.

Figure 4-8
SNWA Staff Inspect Site 8 During February 2014 Pre-Event Field Trip

For the reach defined by Sites 7 and 8, a small gain of 0.2 cfs was measured during the non-irrigation season and a small loss of 0.1 cfs was measured during the irrigation season.

4.1.4 Stateline / Dearden Ranch Area

The Stateline / Dearden Ranch Area is located approximately 0.1 miles downstream of Site 8 at the Nevada-Utah border as shown in Figure 3-1. At this location, Big Springs Creek becomes known as Lake Creek. Site 9 is located approximately 0.25 miles downstream of Site 8 and consists of a gaging station installed with a Parshall flume operated by the UGS. During the study, UGS and NPS personnel made periodic miscellaneous discharge measurements to verify the discharge of the gaging station. Small losses of 0.3 cfs and 0.1 cfs compared to Site 8 were measured at Site 9 during non-irrigation and irrigation seasons, respectively.

Gaging stations at Sites 10 and 11 are also operated by the UGS. The area between Site 9 and Sites 10/11 is characterized by increased discharge associated with a series of observed springs collectively called “Dearden Springs” and coincides with where Lake Creek crosses an outcrop of the

Arcturus Formation and changes direction abruptly from a northeast to a north trend before another sharp bend where the creek turns in an easterly direction. Along both banks in this area, outcrops of the Arcturus Formation are partially covered by basin fill sediments.

At Sites 10 and 11, as shown in Figures C-6 and C-11, the entire flow of Lake Creek is diverted into either the West or East Middle Ditches to be used for irrigation downstream. At Sites 10 and 11, the combined discharge of the East and West Middle Ditches was measured at18.7 cfs and 14.3 cfs during non-irrigation and irrigation season field events compared to the 9.4 cfs and 6.4 measured during those times at Site 9. Based on these sets of measurements, significant gains of 9.3 and 7.9 cfs were observed for the reaches between Site 9 and Sites 10 and 11 during the non-irrigation and irrigation seasons, respectively.

The continuous records from these gaging stations are influenced by irrigation practices downstream that periodically cause backwater conditions in late summer which submerge the flumes resulting in errors in the continuous stage data. As a result of the backwater conditions and submergence of the flumes, seasonal variation of the discharge from the Dearden Springs is difficult to evaluate with the gaging station records. Additional site visits to perform on site discharge measurements, more frequent cleaning of the downstream channel, and possibly modification of the flumes would contribute to a more sound and defensible continuous discharge record.

4.1.5 Lake Creek Meadows Area

Lake Creek Meadows is an approximately 6 mile long, 1,900-acre meadow populated by perennial meadow grass communities with phreatophitic shrub-lands along its borders. At Sites 10 and 11 the entire flow of Lake Creek is diverted into the East Middle and West Middle irrigation ditches and applied as scheduled by the irrigation users. A copy of the irrigation schedule provided by Baker Ranch to Lucy Jordan of UGS for the period of the study is presented in Appendix H.

Due to poor channel conditions, multiple irrigation users and diversions, no discharge measurements were made in the irrigated meadows between Sites 10/11 and Site 12, which is located approximately a quarter of a mile upstream of Clay Spring. No discrete channel sites with a suitable measurement cross section were identified by the TRP between Sites 10 and 11 and Site 12.

Site 12 is located in a discrete channel downstream of the diffuse irrigation areas. A photo of Site 12 is shown on Figure 4-9. It is located in a broad channel heavily overgrown with perennial meadow grasses with a soft, silty bed that has been heavily trampled by livestock. Prior to the measurements, the channel was cleaned and groomed to obtain more accurate results with the conditions present. At the time of the measurements, the control for the channel was a restriction in the channel caused by vegetation. Measurements at the site are considered poor based on the channel conditions.

At site 12, the average of the non-irrigation season measurements was 12.6 cfs which reflects a loss of 6.1 cfs for the reach between Sites 10/11 and 12. The 6.1 cfs loss may result from several factors including actual channel losses, impoundment behind ice-dams and irrigation storage reservoirs, bank storage, and/or other factors. During the irrigation season field event, almost the entire 14.3 cfs measured at Sites 10 and 11 was likely consumed by irrigating meadows, ET, infiltration, possibly impoundments upstream of Site 12 and/or other factors.

Figure 4-9
Site 12 During Non-Irrigation Season

4.1.6 Clay Spring / Pruess Lake

Site 13, located above Pruess Lake, was the last downstream measurement section of the study. The channel changed from a broad meadow at Site 12 to a narrow channel at Site 13 as shown in Figure 4-10. The channel has soft, steep banks and heavy aquatic plant growth that was cleaned out prior to the field events. The control during the non-irrigation season portion of the study was ice, vegetation and debris located downstream. During the irrigation season the channel itself controlled the discharge. Measurements are considered poor based on the channel conditions at the time of each field event.

Approximately 0.25 miles downstream of Site 12 and upstream of Site 13, flow from the Clay Spring area enters the channel. For the reach defined by Sites 12 and 13, a gain of 3.8 cfs and 1.2 cfs were measured during the non-irrigation and irrigation season field events. Downstream of Site 13, the flow of Lake Creek discharges into Pruess Lake.

Figure 4-10
Site 13 During the Pre-Event Field Trip February 2014

4.2 Comparison of Flow with Previous Studies

The results of the synoptic discharge study at selected measurement sites were comparable to previous studies performed by Meinzer (1911), Hood and Rush (1965), and Walker (1972). Comparison of results along with the timing and site location of the measurements are presented in Table 4-2.

Table 4-2
Comparison of 2014 Results with Previous Studies

Area	Sites	Previous Studies		2014 Study	
		Study	Reported Discharge	Non-Irrigation Season	Irrigation Season
Big Springs Ranch	1.1, 1.2	Hood and Rush, 1965	8	9	9.2
Big Springs Ranch	1.1, 1.2	Walker, 1972	8.92		
Dearden Ranch	10, 11	Meinzer, 1911	18	18.7	14.3
Dearden Ranch	10, 11	Walker, 1972[a]	19.1		

[a] Walker reported mean daily discharge values of 15 to 19 cfs

4.3 Water-Chemistry Results

Measurements of electrical conductivity (EC), pH, dissolved oxygen (DO), water temperature, and turbidity were made at each site during both non-irrigation and irrigation seasons. Additionally, water-chemistry samples were collected for laboratory analysis of major ions and metals at each site during the non-irrigation field event, and at selected sites during the irrigation season field event. Samples for analysis of selected isotopes were also collected at several sites during the non-irrigation season event.

Available historic water chemistry data for Big Springs and additional springs and wells in the vicinity of the system are presented in Tables I-5 through I-7 of Appendix I. Big Springs has been sampled approximately 13 times by various organizations from 1964 to 2010. Additional recent water-chemistry data has been collected inthe area by UGS and USGS.

4.3.1 Electrical Conductivity

The EC of water is a function of the types and quantities of dissolved substances in water. EC measurements were recorded in microsiemens per centimeter (uS/cm) at 25 °C with a Hach HQ40D meter which was calibrated according to the manufacturer’s instructions. EC results are presented in Table I-1 of Appendix I and plotted with discharge for both the non-irrigation and irrigation season measurements in Figure 4-11.

During the non-irrigation season the EC increased from Site 1 at Big Springs to Site 4 which is located in the Okelberry Meadows, an active pasture with livestock. The EC values remain relatively stable through Site 8. A significant decrease in EC was observed between Sites 8and Sites 10 and 11 as Dearden and associated observed springs discharge into the channel. A large increase in EC was observed downstream of the irrigated meadows in Utah at Site 12. This upward trend continued at Site 13.

During the irrigation season, EC increases between Sites 1 and 4, although at a much lower level than during non-irrigation season. The EC values again closely follow the discharge trends and continue to increase but at a relatively lower rate. Downstream between Site 8 and Sites 10 and 11, where Dearden and associated observed springs are located, the EC decreased. At Site 12, EC is at its highest observed value and then steeply drops off with the lower EC water added to Lake Creek by Clay Spring. The water at Site 12 was nearly stagnant during the irrigation season measurement.

The historical specific conductance data reported for Big Springs ranged from 370 to 403 µS/cm.

4.3.2 Dissolved Oxygen

Concentrations of dissolved oxygen (DO) were measured using a Hach Luminescent Dissolved Oxygen (LDO) probe. Concentrations were recorded to 0.01 milligrams per liter (mg/L) and reported to the nearest 0.1 mg/L. The DO meter was calibrated according to the manufacturer’s instructions.

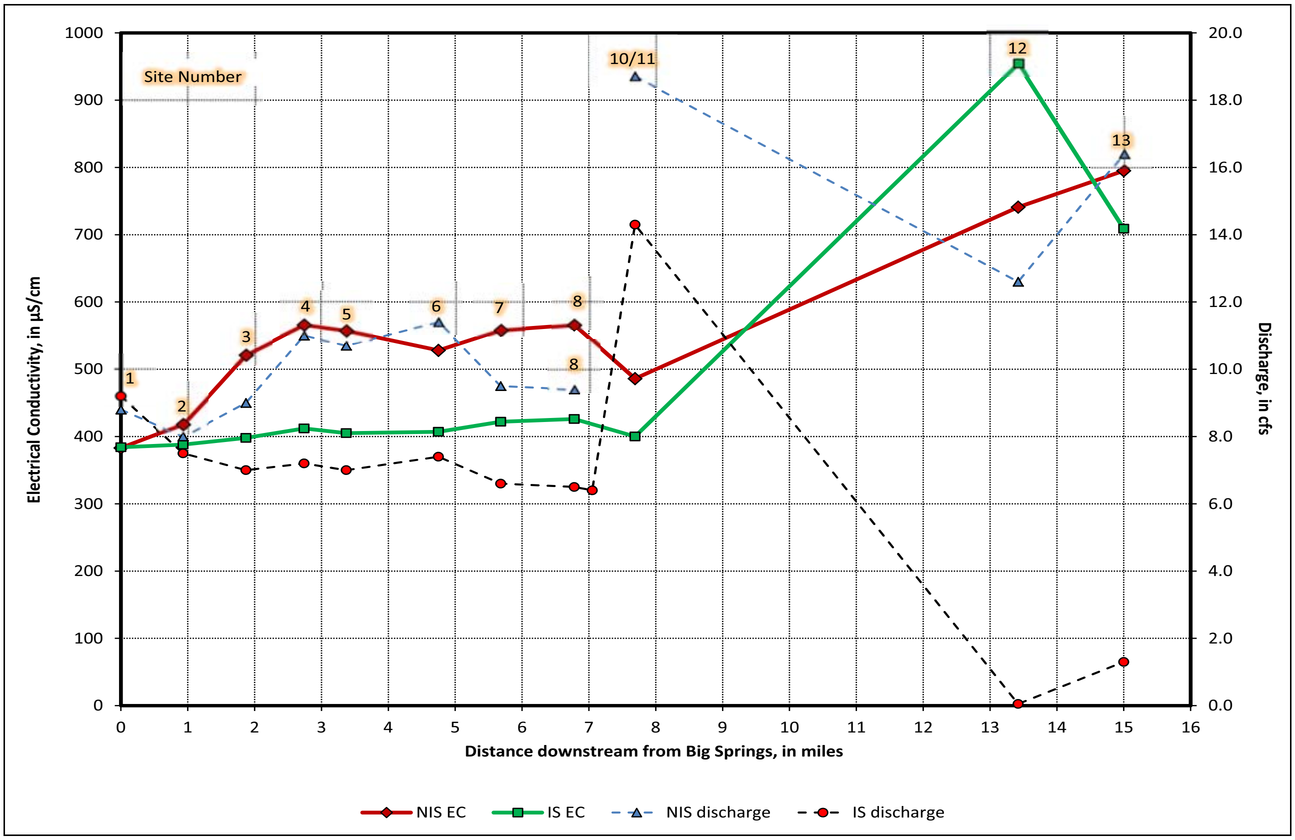


Figure 4-11
Electrical Conductivity and Discharge Measurements During Irrigation and Non-Irrigation Seasons

Concentrations of DO are affected by several factors including temperature, atmospheric pressure, and altitude. Sources of increased DO can include atmospheric aeration (riffles, falls and other turbulent sections) and sources of decreased DO include respiration, decomposition and other chemical and biological reactions (Rounds et al., 2013).

DO values are presented in Table I-1 of Appendix I and graphically in Figure 4-12. DO measurements made at Site 1 were nearly identical during the non-irrigation and irrigation seasons. The DO measurement values increased from approximately 6 mg/L at Site 1 to 9 mg/L at Site 2 during both seasons. Measurement values during the non-irrigation season continued to increase at Site 3 and values were doubled at Site 4 compared to the initial measurements at Site 1. During the irrigation season, the DO values increased from Site 1 to Site 2 and then remained stable through Site 4.

Between Sites 4 and 5 there was a decrease in DO values during both seasons. From Site 5 to Site 6 the DO values were consistent and then increased between Sites 6 and 7. When the discharge data is reviewed the velocities decrease between Sites 4 and 5, are similar between Sites 5 and 6, and increase again between Sites 6 and 7. These higher velocities occur where the water becomes more turbulent allowing aeration of the water, which increased the DO values. From Site 7, downstream, the values remain relatively constant to Site 8. Downstream of Site 8, there is a large decrease in DO

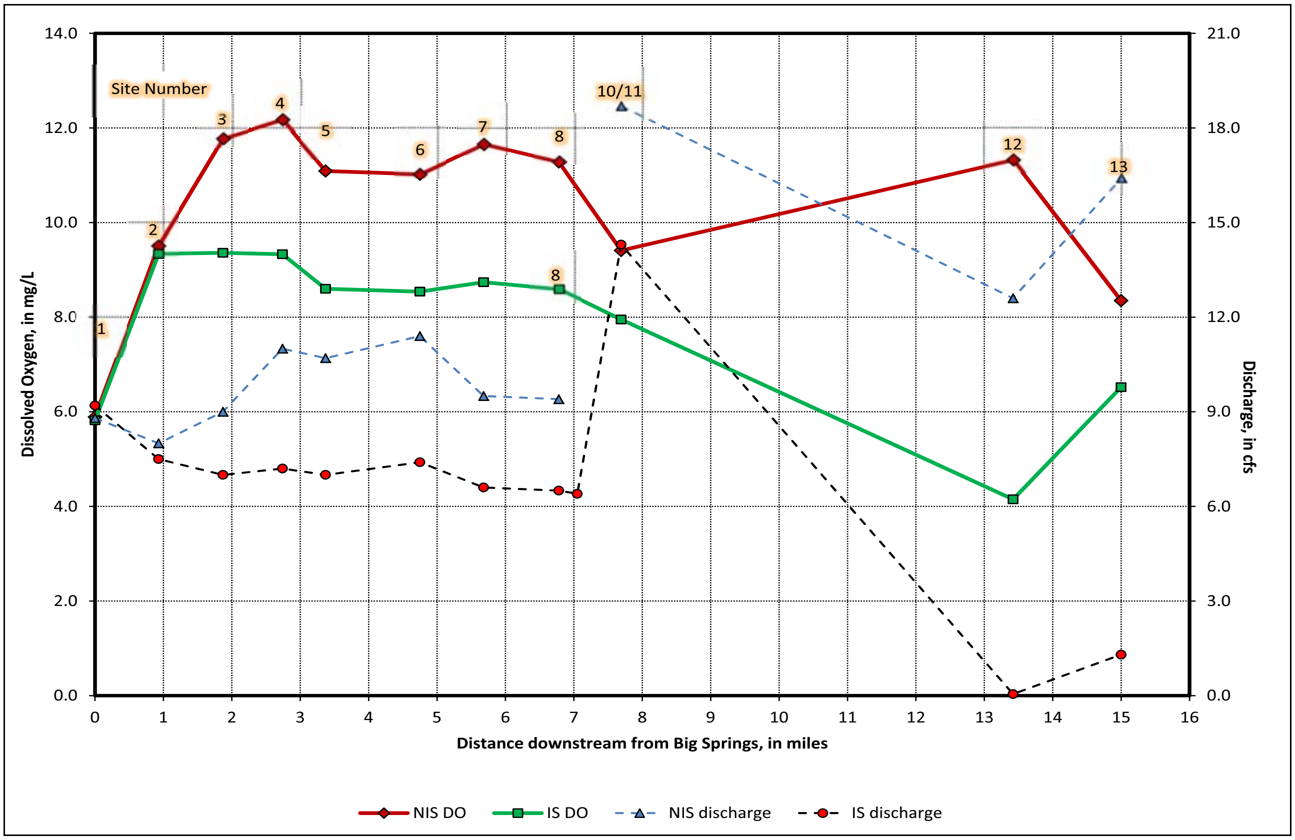


Figure 4-12
Dissolved Oxygen and Discharge Measurements During Irrigation and Non-Irrigation Seasons

measured at Site 10 and 11 during both seasons. This is caused by the observed large inflow of groundwater, which has a much lower DO value, into Lake Creek at Dearden Springs.

DO values measured at Site 12 during the non-irrigation season are similar to those measured at Site 8, and then decrease sharply at site 13. Irrigation season measurements demonstrate a very low DO at Site 12 and a measured increase at Site 13. Velocity measurements at Site 12 indicate a nearly stagnant pool during the irrigation season (0.06 ft/sec), and the inflow of water from Clay Spring and groundwater contributes to the increase in DO observed at Site 13. During the non-irrigation season the inflow of water from Clay Spring and groundwater results in lower DO values.

4.3.3 Temperature

Water temperature measurements are tabulated in Table I-1 of Appendix I. During the non-irrigation season field event, temperature decreased from 17.3^{o} C at Big Springs (Site 1) to 9.0^{o} C at Site 7. Temperature increased slightly to 9.8^{o} C at Sites 10 and 11 then deceased to 5.0^{o} C at Site 13. During the irrigation season field event, temperature increased from 18.1^{o} C at Big Springs (Site 1) to 23.2^{o} C at Site 2 and remained near 22^{o} C to Site 7. Temperature at Sites 7 to 13 ranged from16.7^{o} C to 18.3^{o} C. However, Site 12 with near stagnant water was measured at 19.1 and would not be considered to be representative of the system.

Historic data reported from 1964 to 2010 indicate that water temperature has consistently ranged from 16.8 to 18° C at Big Springs.

4.3.4 Major Ions and Metals

Major ions and metals were sampled during irrigation and non-irrigation season. The samples were collected following standard sampling protocols. Samples were analyzed by the Southern Nevada Water System, River Mountains Water Quality Laboratory. Duplicate samples were collected and analyzed as well. Laboratory results of major ions and metals are presented in Tables I-2 and I-3 of Appendix I. The available historical major ion and metal data are presented in Tables I-5 and I-6 of Appendix I, respectively. Trace element concentrations from all the sites are generally low and mostly below detection limit.

4.3.5 Stable and Radio Isotope Chemistry

Deuterium (^2H), Oxygen 18 (^{18}O) and Tritium (^3H) samples were taken at sites 1.2, 4, 9, 10, 12, and 13 during the March measurements. The results are tabulated in Table I-4 of Appendix I. The available historical stable isotope data for the sites in the vicinity of the study area are presented in Table I-7 of Appendix I.

4.4 Summary of Discharge Trends

Based on the preceding discussion of the data collected for the Big Springs/Lake Creek system, the following general gain-loss observations and trends can be summarized for the system, starting from the headwater area at Big Springs and extending downstream to Pruess Lake.

- Combined discharge at Big Springs was measured at 9.0 cfs and 9.2 cfs, during the non-irrigation and irrigation season, respectively.

- During both the non-irrigation and irrigation season, some of the discharge from Big Springs was diverted via the Okelberry Diversion Ditch to irrigate the Okelberry Meadows area. The measured diversion rate ranged from 3.3 cfs to 3.8 cfs in the non-irrigation and irrigation seasons, respectively. Irrigation returns from the Okelberry Diversion Ditch may influence streamflow of Big Springs Creek between Site 1.1.2 and Site 4.

- Big Springs Creek, between Sites 2 and 6, was gaining during the non-irrigation measurements and unchanged during irrigation season measurements. Between Sites 6 and 9, the stream transitions to a losing reach.

- The discharge of Big Springs/Lake Creek increased by a factor of two in the Dearden Springs area during both measurement periods. However, the additional discharge attributable to inflow from Dearden Springs varied approximately 15 per cent between the two periods, ranging from 9.3 cfs to 7.9 cfs during non-irrigation and irrigation season measurements, respectively.

- Significant losses were observed in the reach between Sites 10 & 11 and Site 12 with losses of 6.1 cfs and 14.2 cfs observed during non-irrigation and irrigation season measurements, respectively. Several factors may be influencing the observed discharge trends including reduced irrigation return flows, evapotranspiration, localized impoundment of irrigation water, local irrigation pumping, and possibly other unidentified factors.

- The lowest reach between Sites 12 and 13, in the area of Clay Springs, was observed to be gaining during both periods with the trend being more pronounced during the non-irrigation season.

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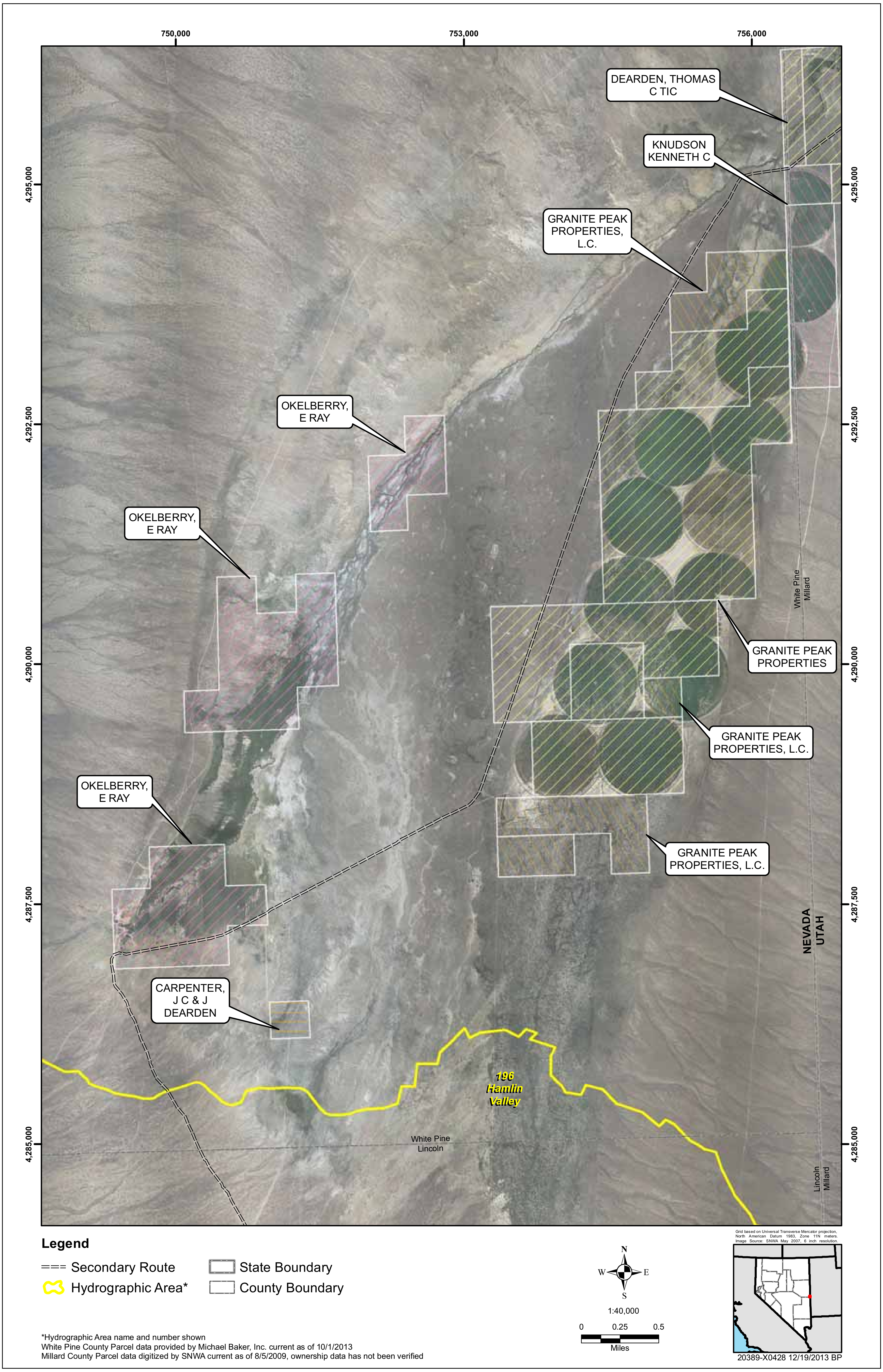
Appendix A

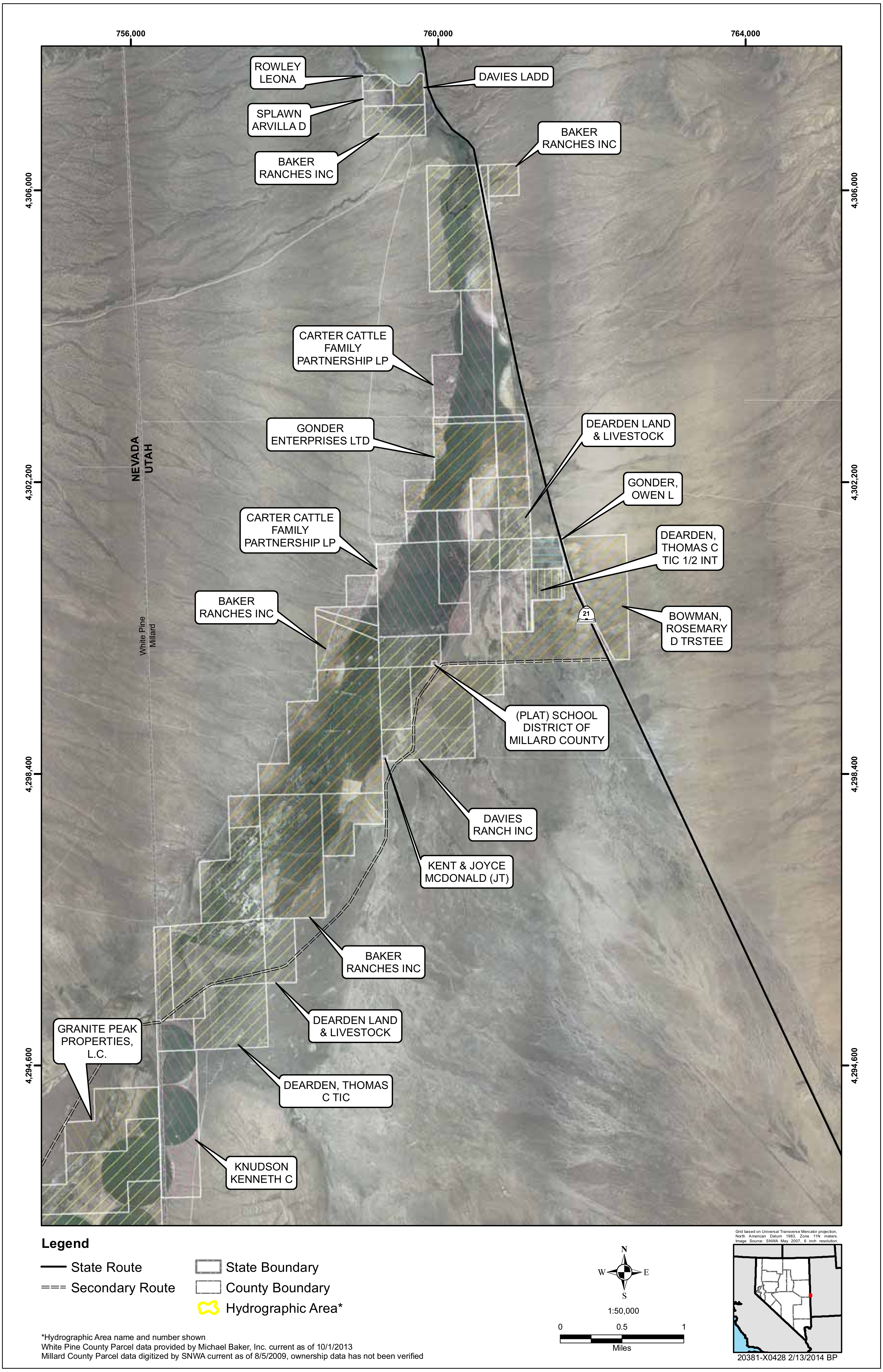
Land Ownership Maps



*Hydrographic Area name and number shown
White Pine County Parcel data provided by Michael Baker, Inc. current as of 10/1/2013
Millard County Parcel data digitized by SNWA current as of 8/5/2009, ownership data has not been verified

20389-X0428 12/19/2013 BP

Figure A-1
Big Springs Seepage Study Land Ownership Nevada



*Hydrographic Area name and number shown
White Pine County Parcel data provided by Michael Baker, Inc. current as of 10/1/2013
Millard County Parcel data digitized by SNWA current as of 8/5/2009, ownership data has not been verified

20381-X0428 2/13/2014 BP

Figure A-2
Big Springs Seepage Study Land Ownership Utah

Appendix B

Historic Groundwater Hydrographs

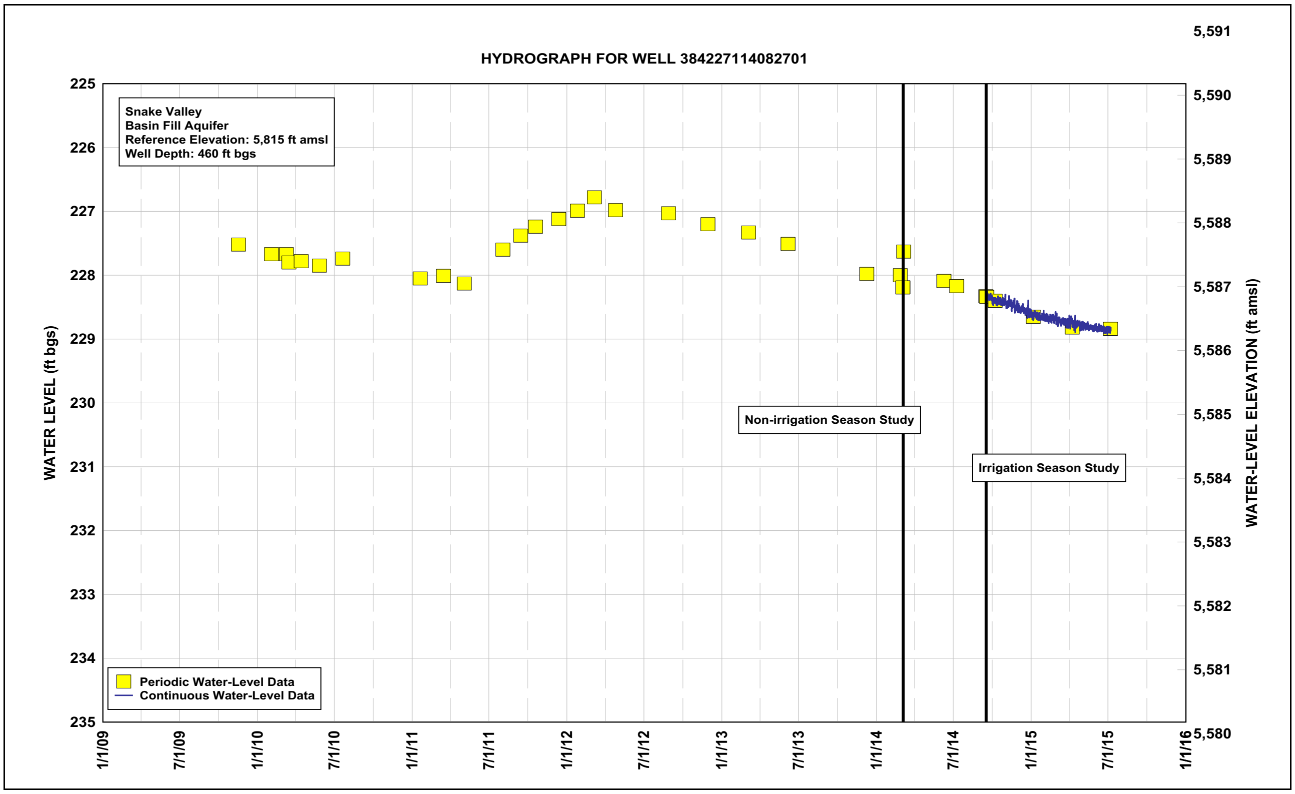


Figure B-1
Big Springs Northwest Monitor Well

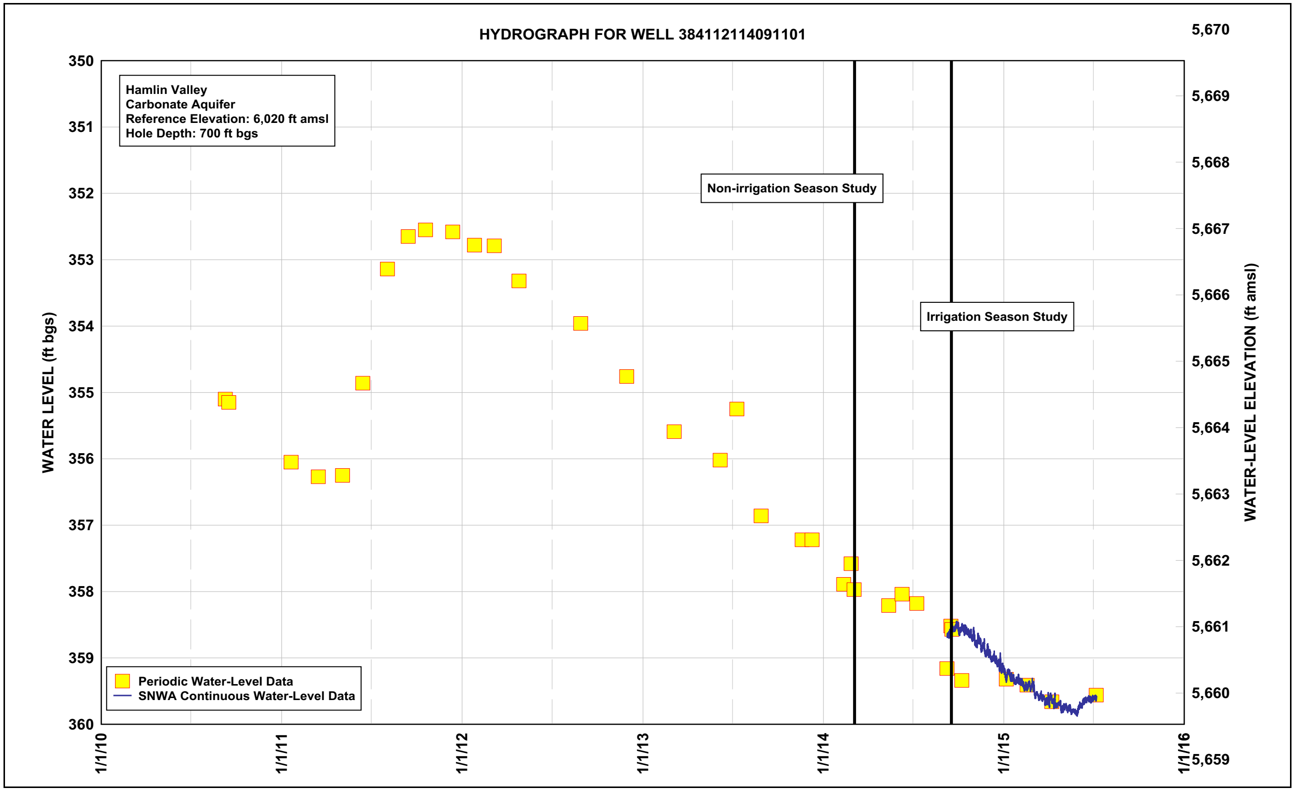


Figure B-2
Big Springs Southwest Monitor Well

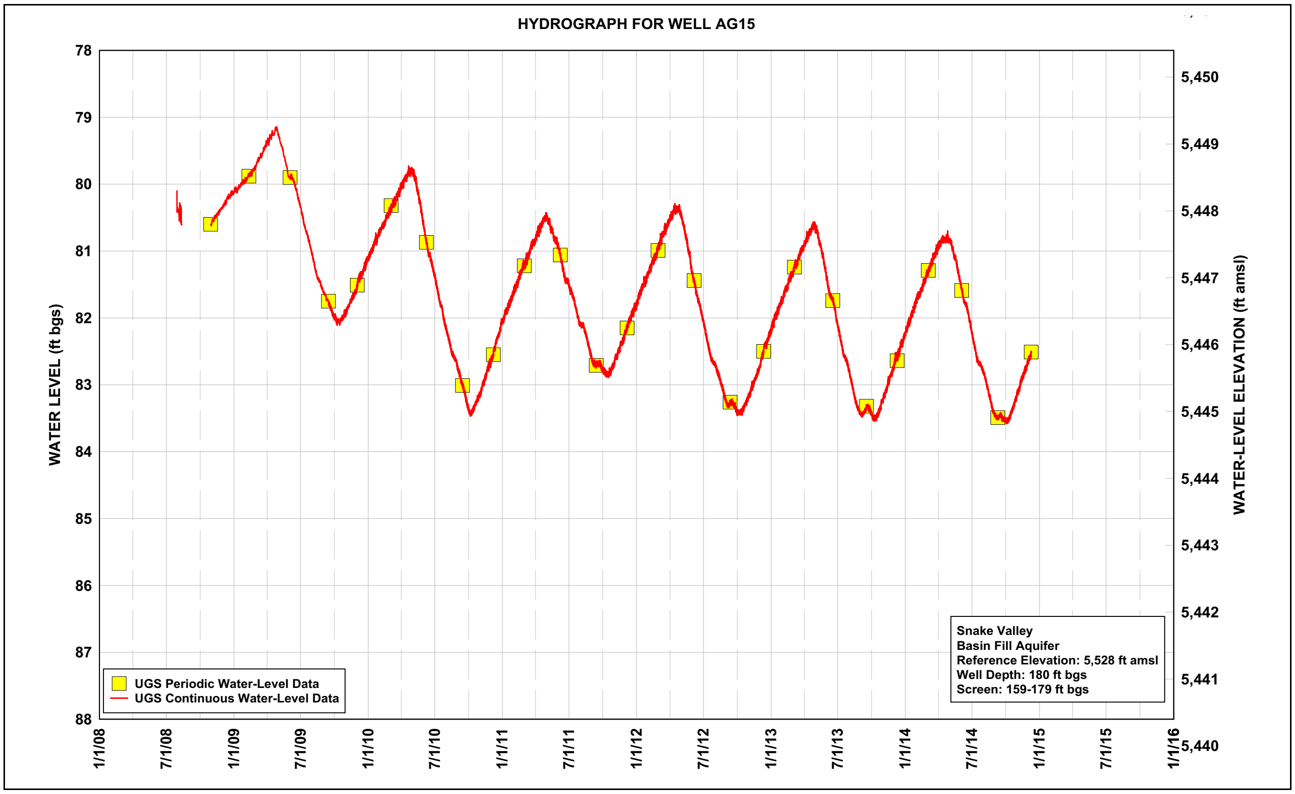


Figure B-3
Historical Hydrograph UGS AG 15A

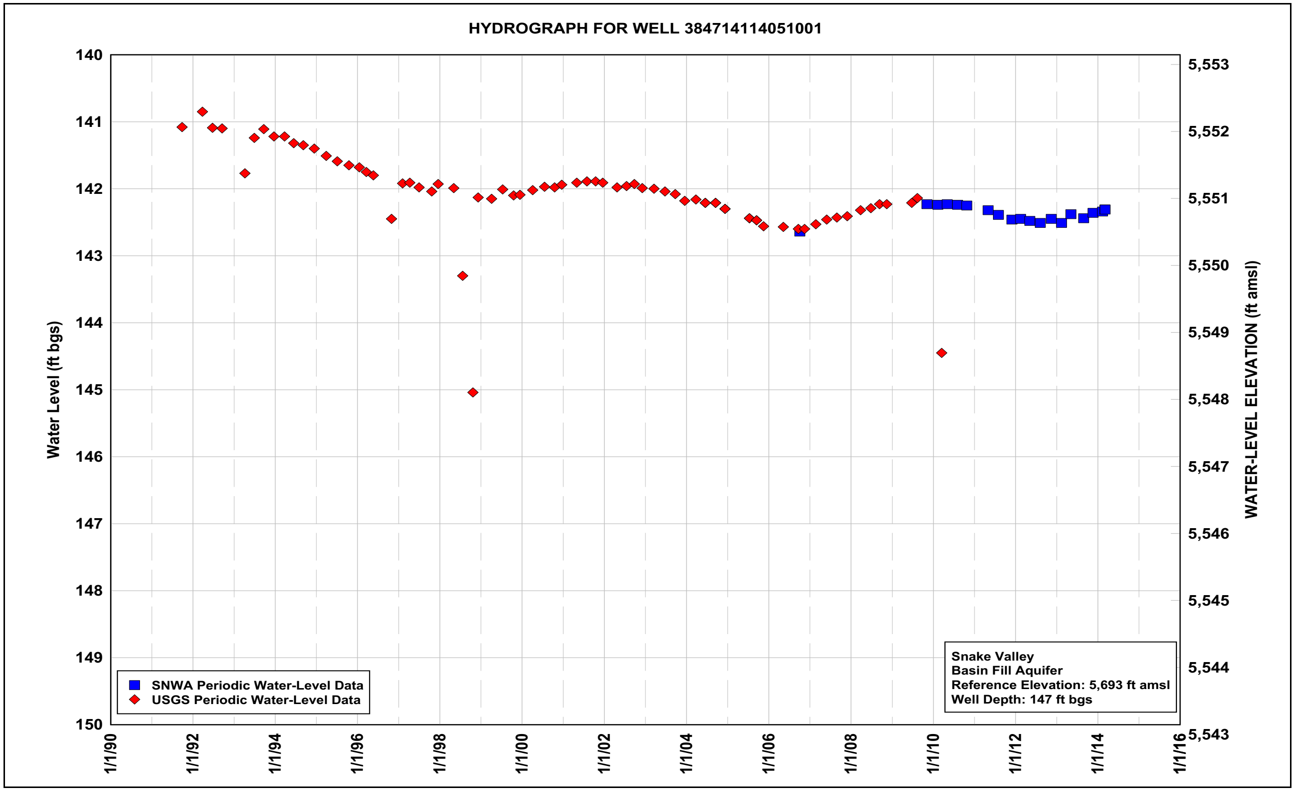


Figure B-4
Historical Hydrograph Well 384714114051001

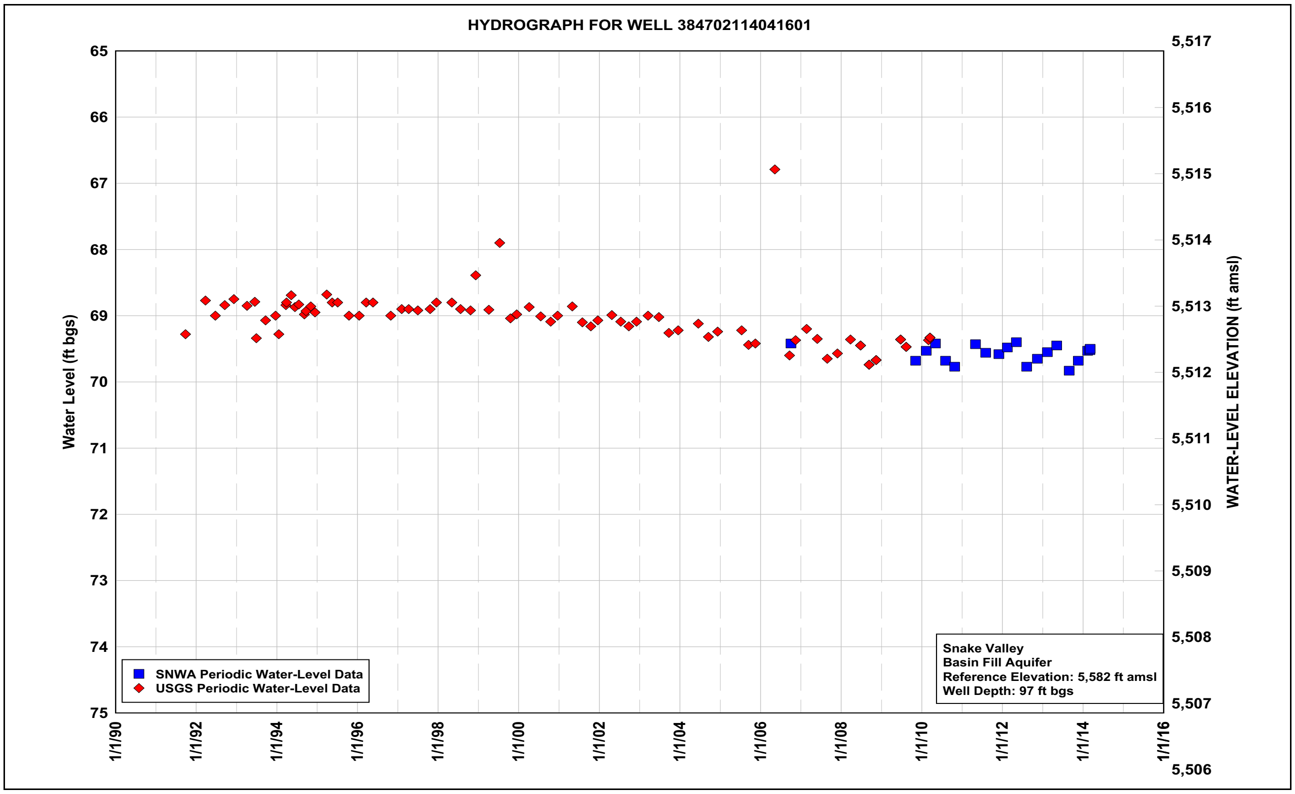


Figure B-5
Historical Hydrograph Well 384702114041601

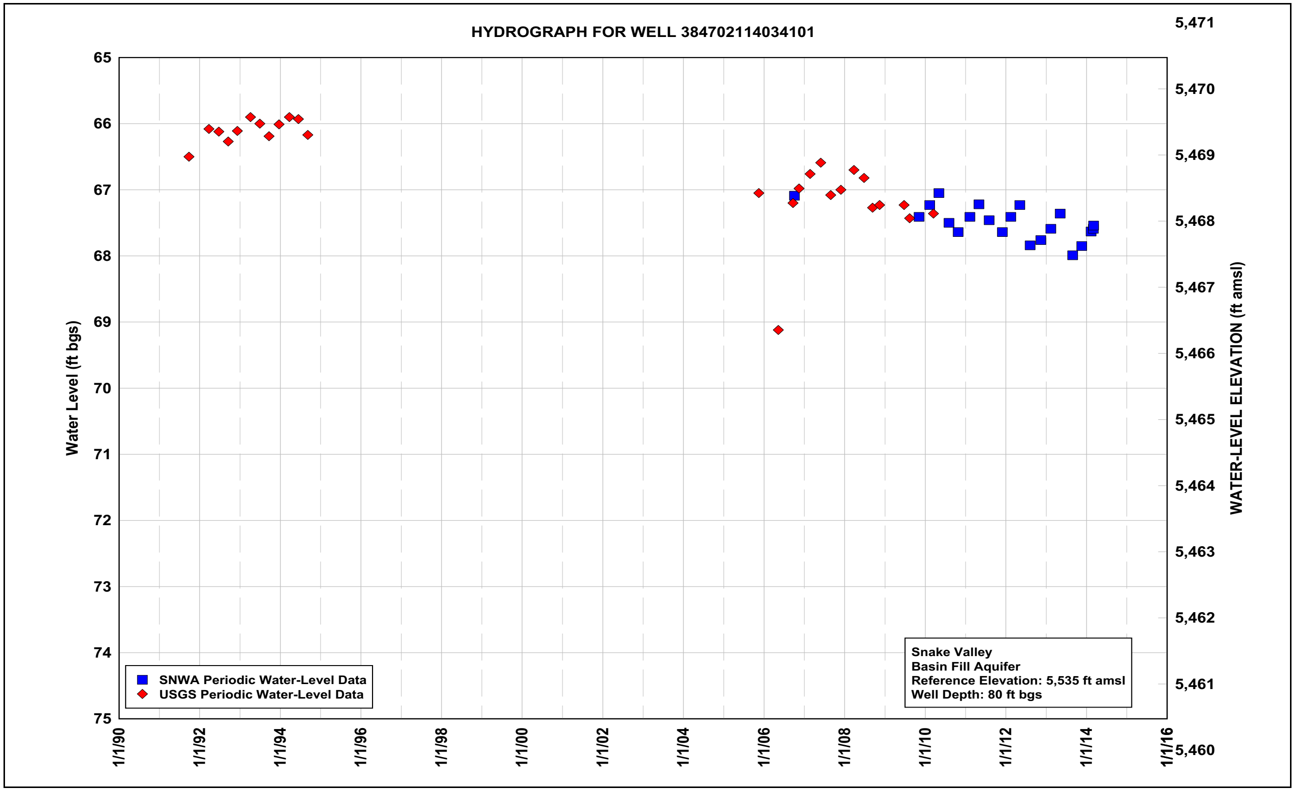


Figure B-6
Historical Hydrograph Well 384702114034101

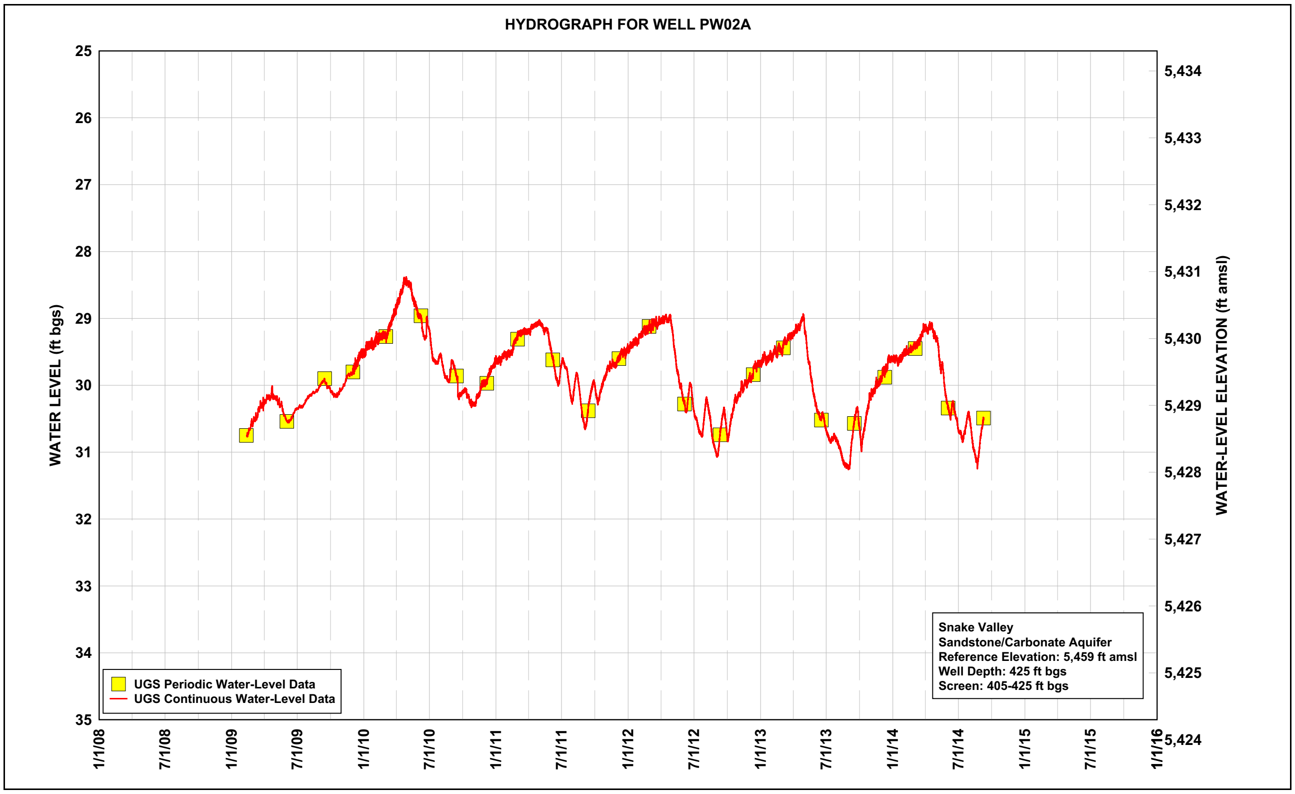


Figure B-7
Historical Hydrograph UGS PW02A

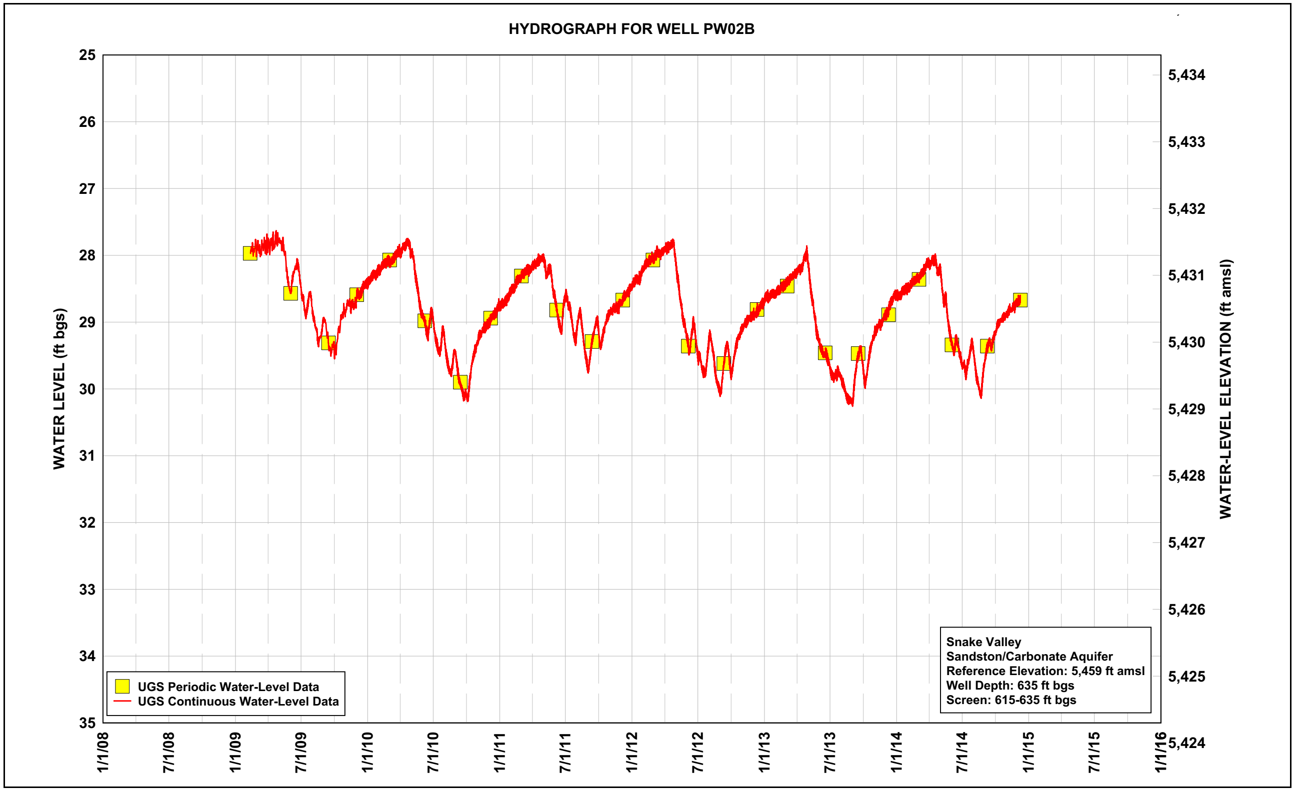


Figure B-8
Historical Hydrograph UGS PW02B

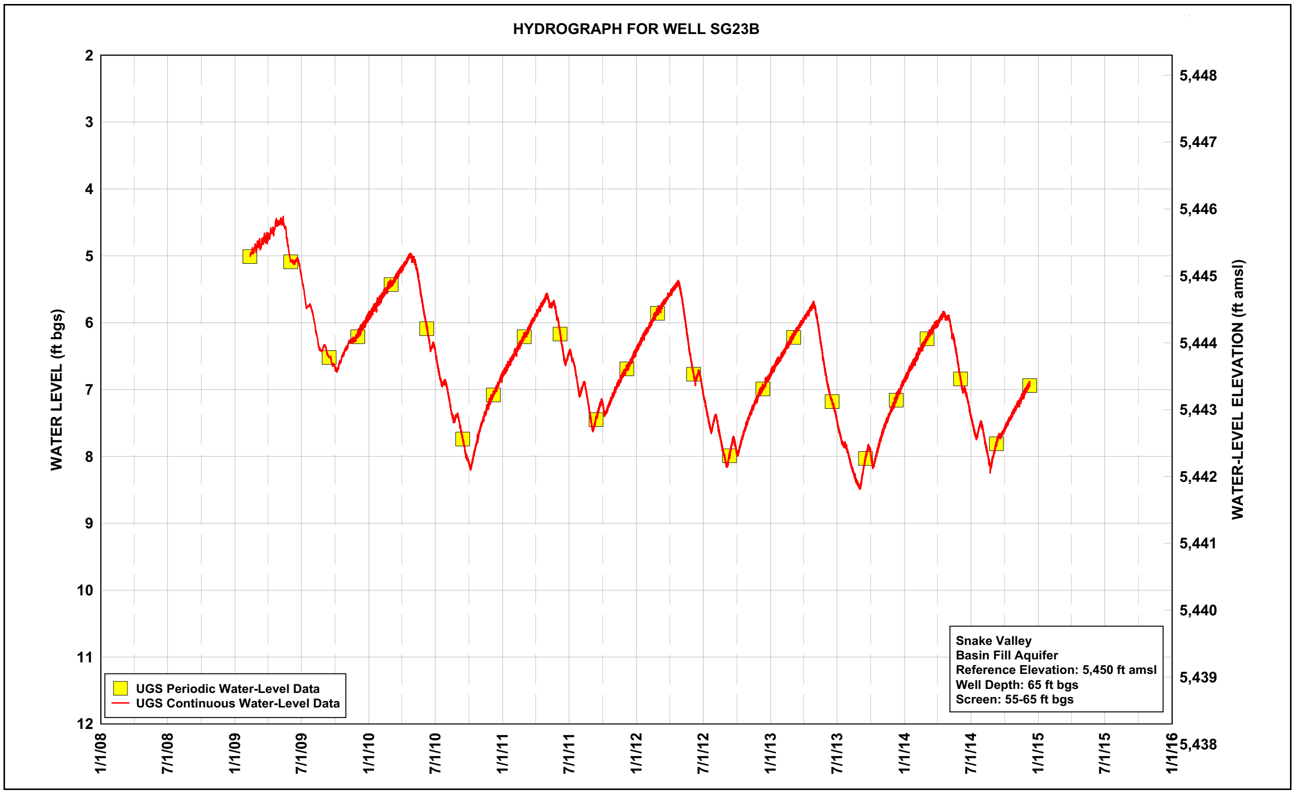


Figure B-9
Historical Hydrograph UGS SG23B Needle Point Spring

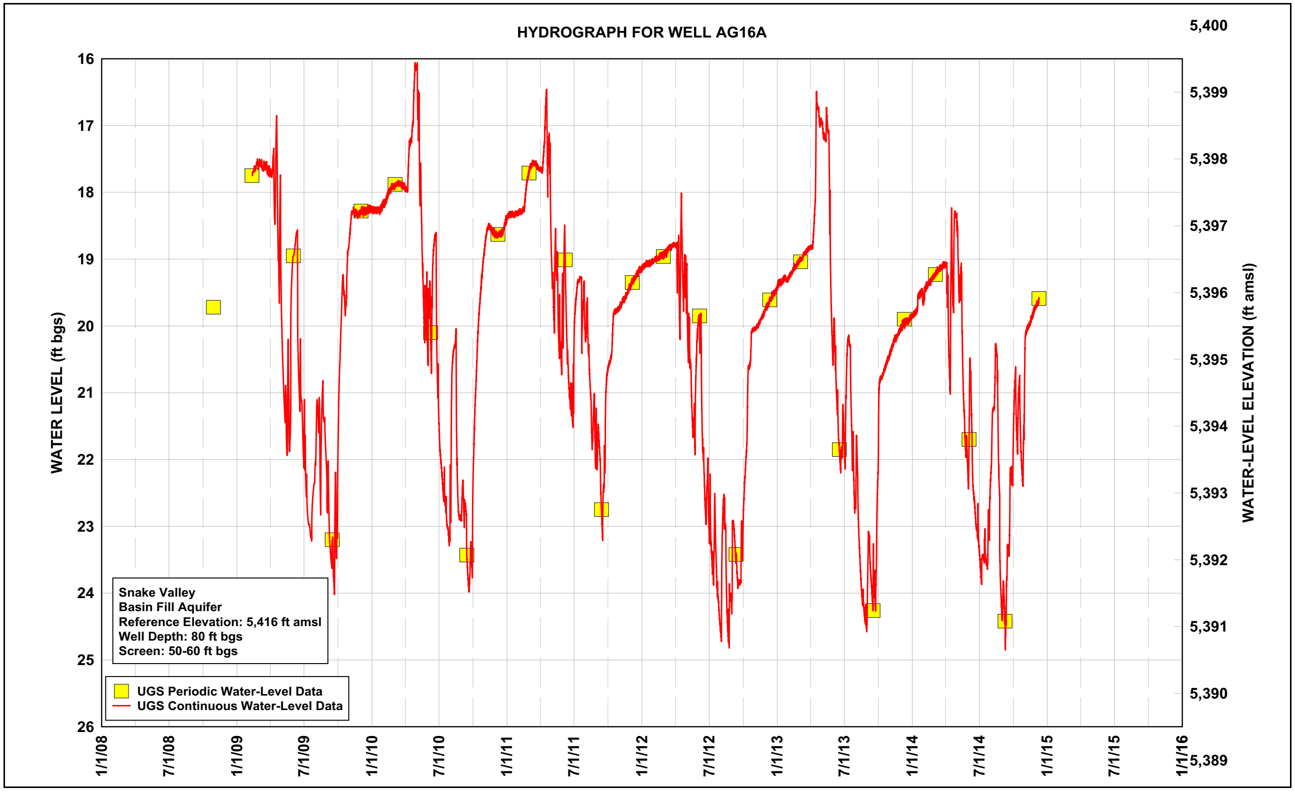


Figure B-10
Historical Hydrograph UGS AG 16A

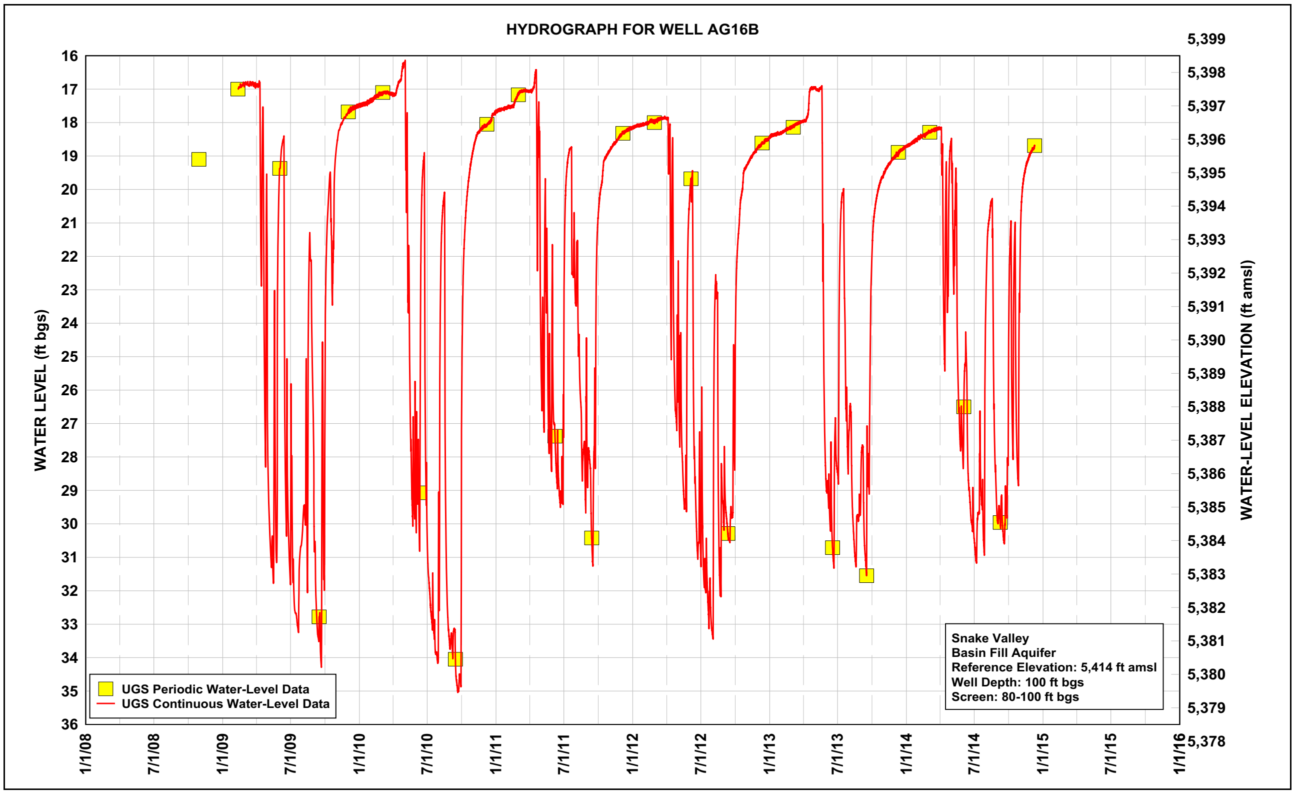


Figure B-11
Historical Hydrograph UGS AG 16B

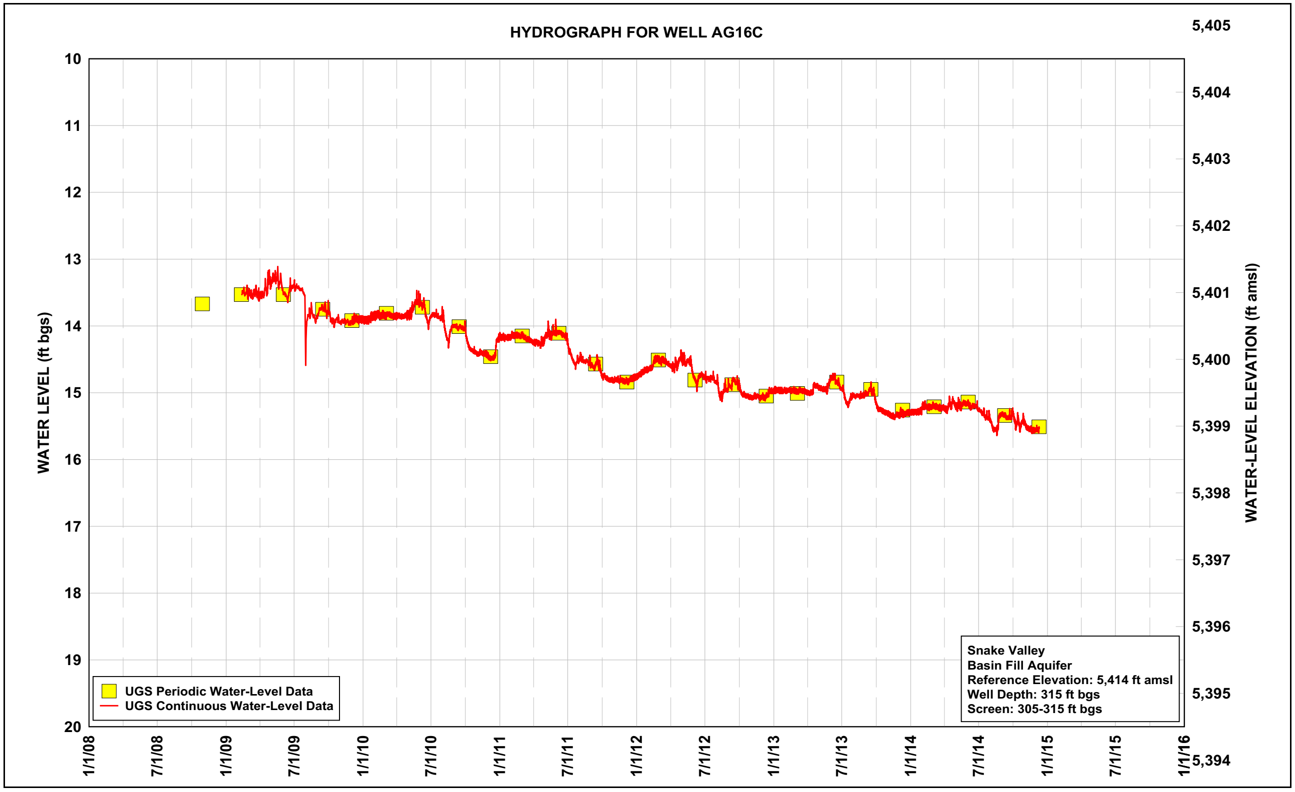


Figure B-12
Historical Hydrograph UGS AG 16C

Appendix C

Aerial Imagery and Measurement Site Locations

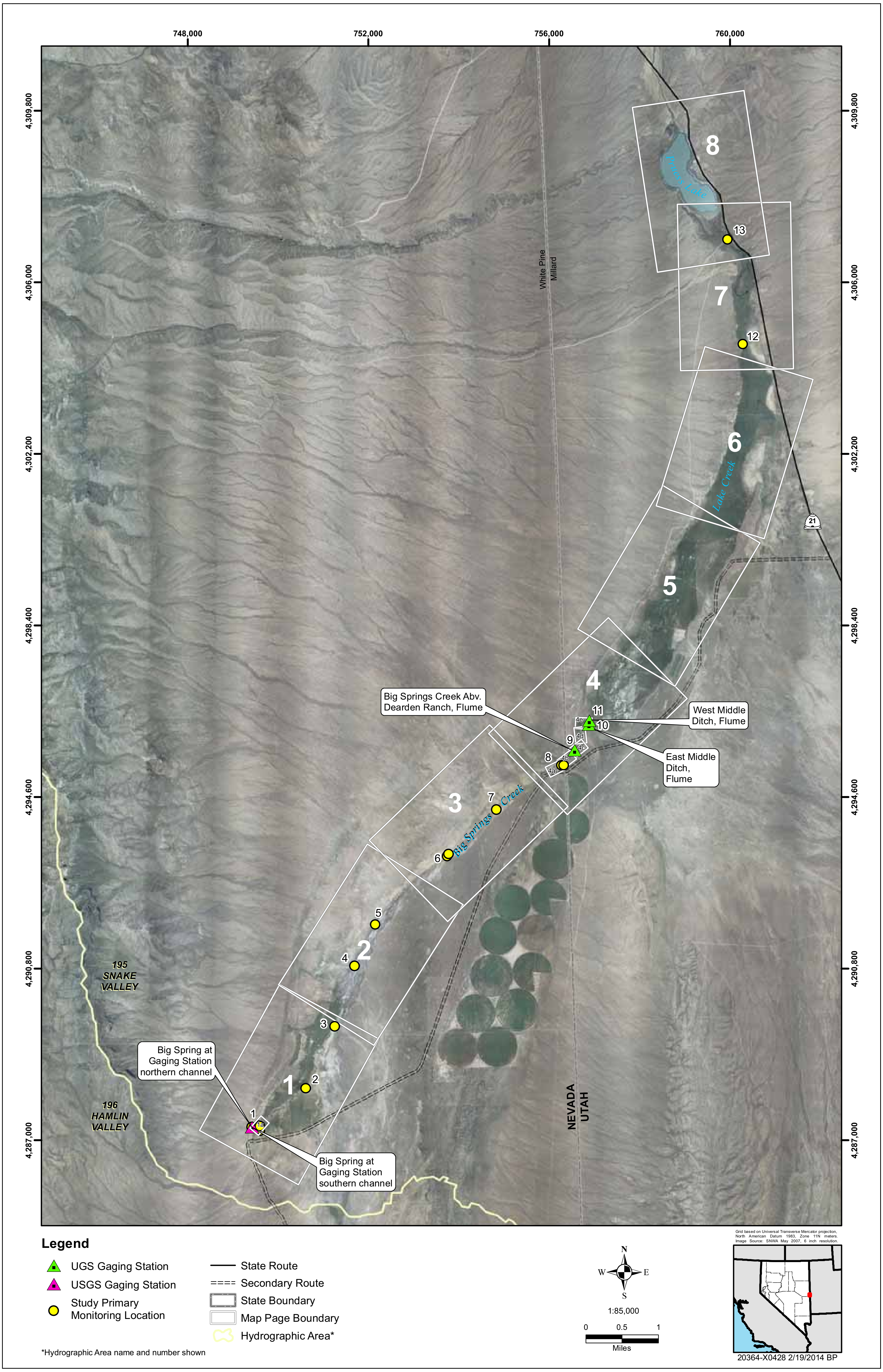


Figure C-1
Aerial Imagery Overview Map

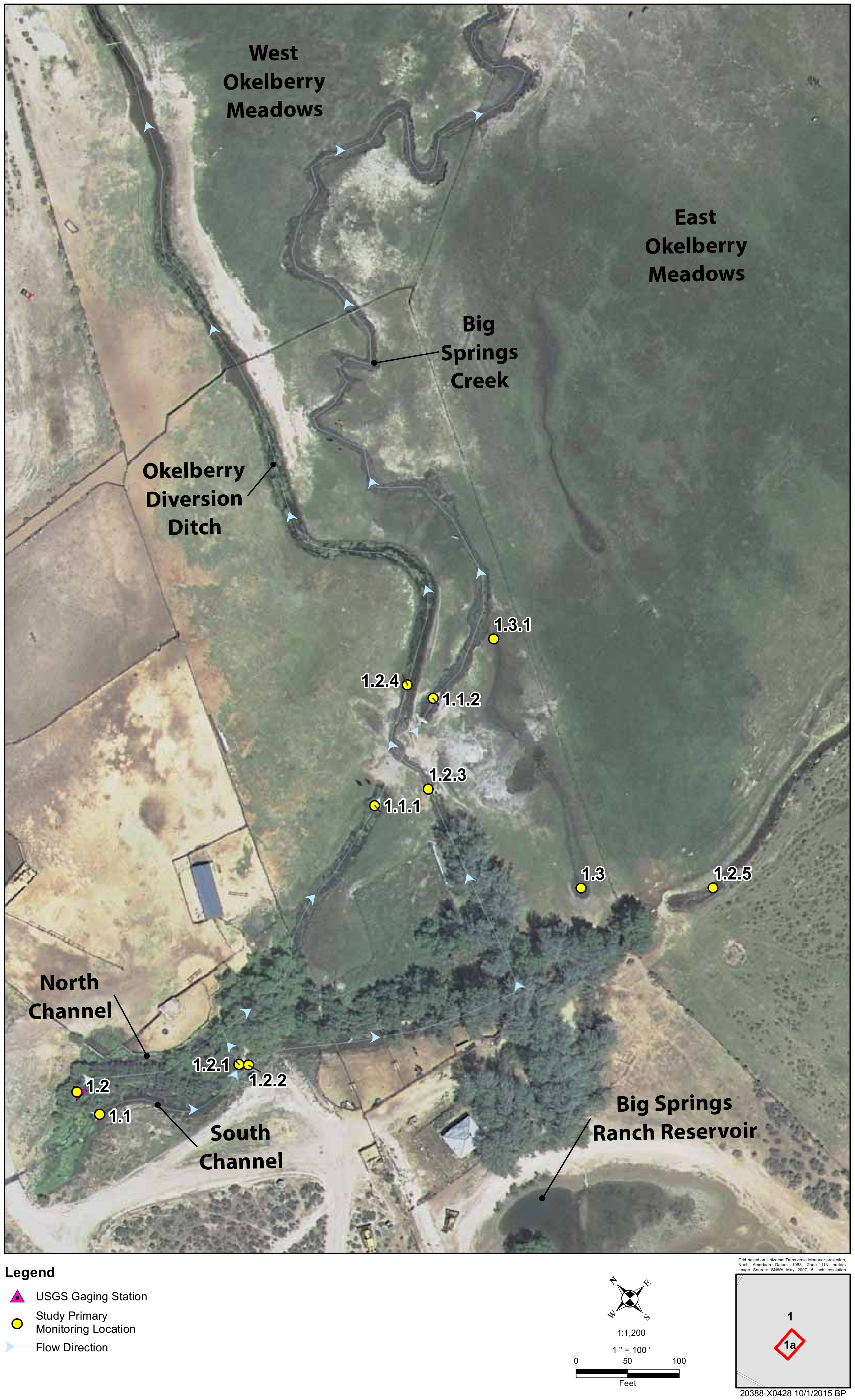


Figure C-2
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 1a

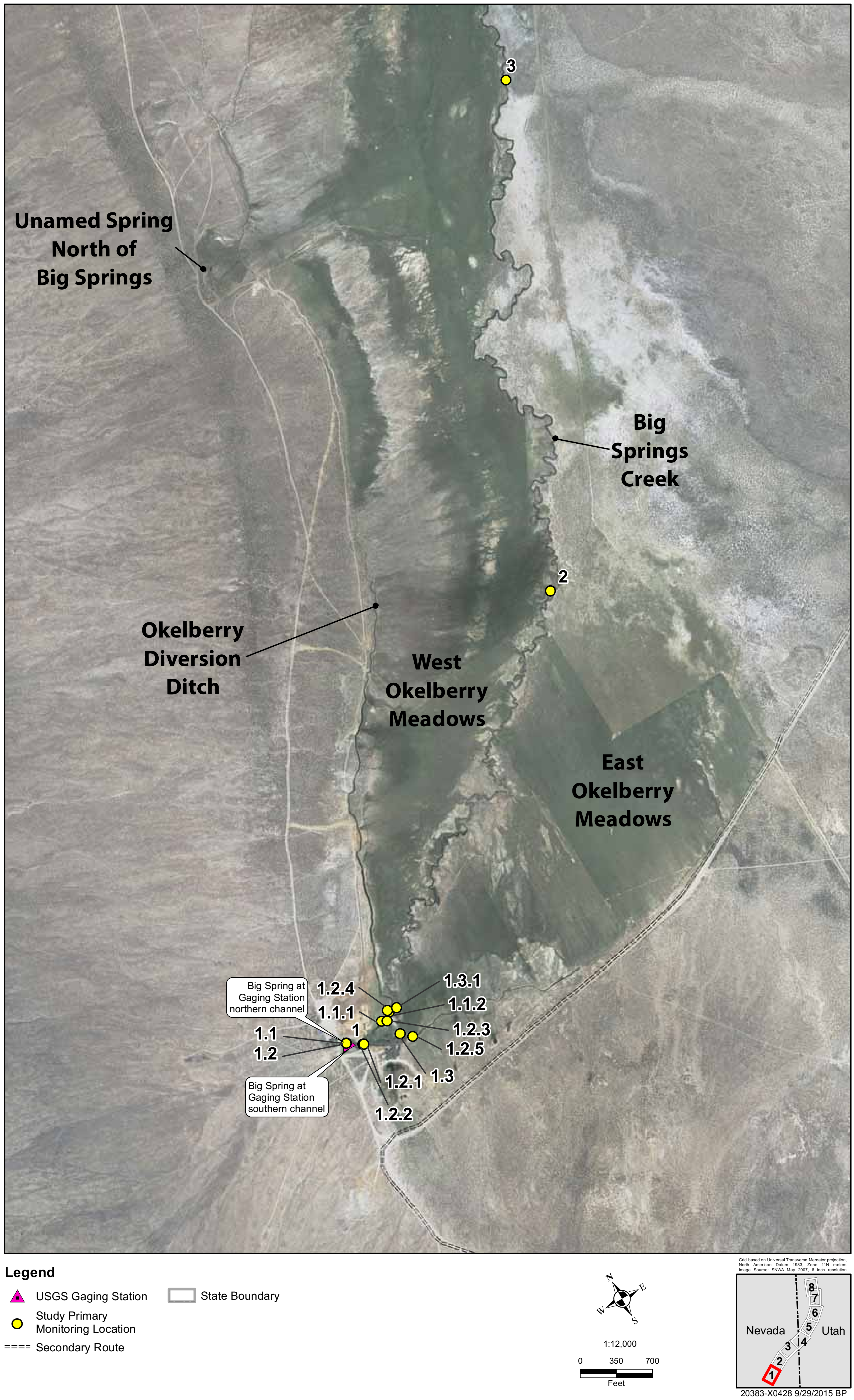


Figure C-3
Big Springs Creek Pruess Lake Synoptic Study Atlas page 1

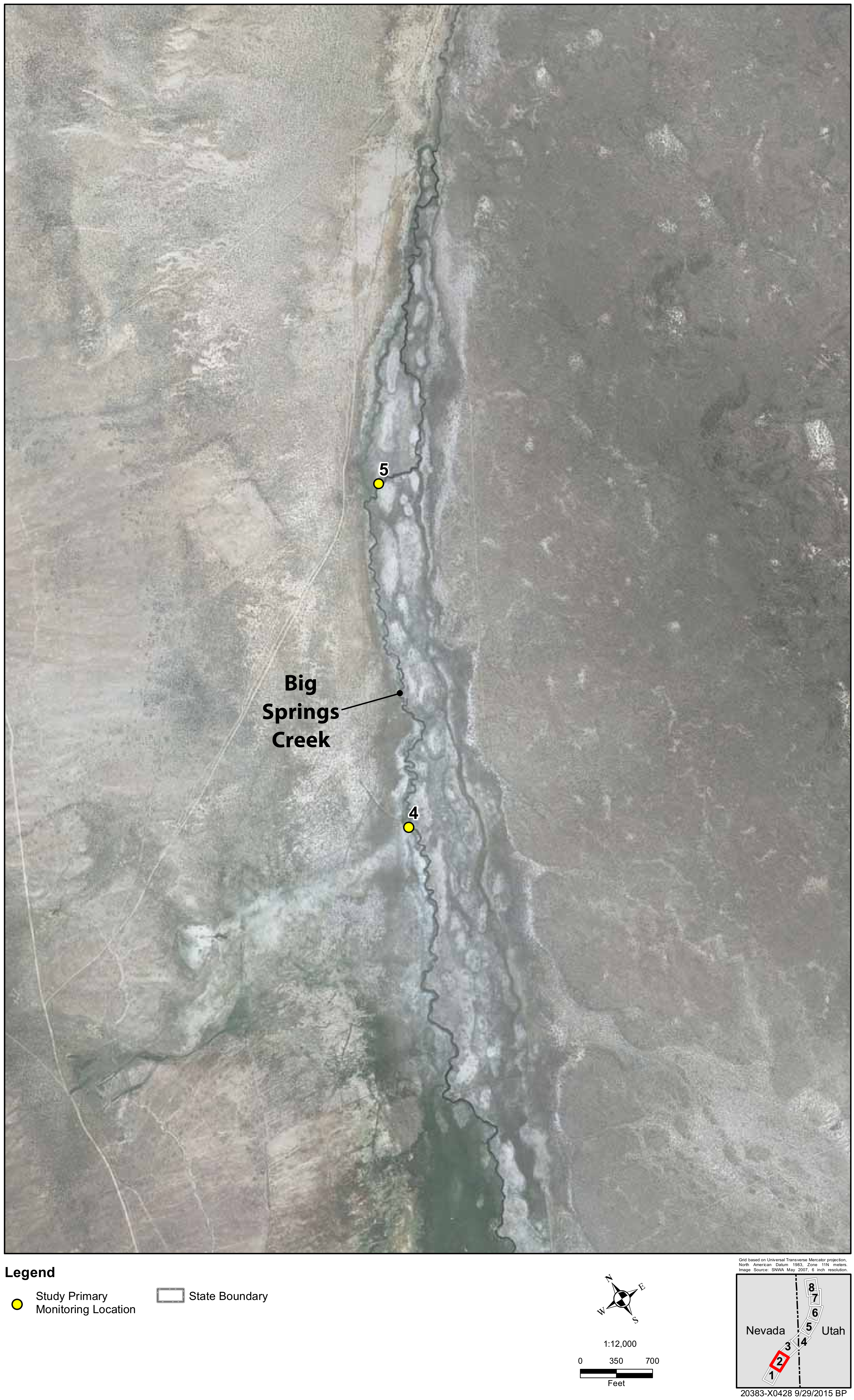


Figure C-4
Big Springs Creek Pruess Lake Synoptic Study Atlas page 2

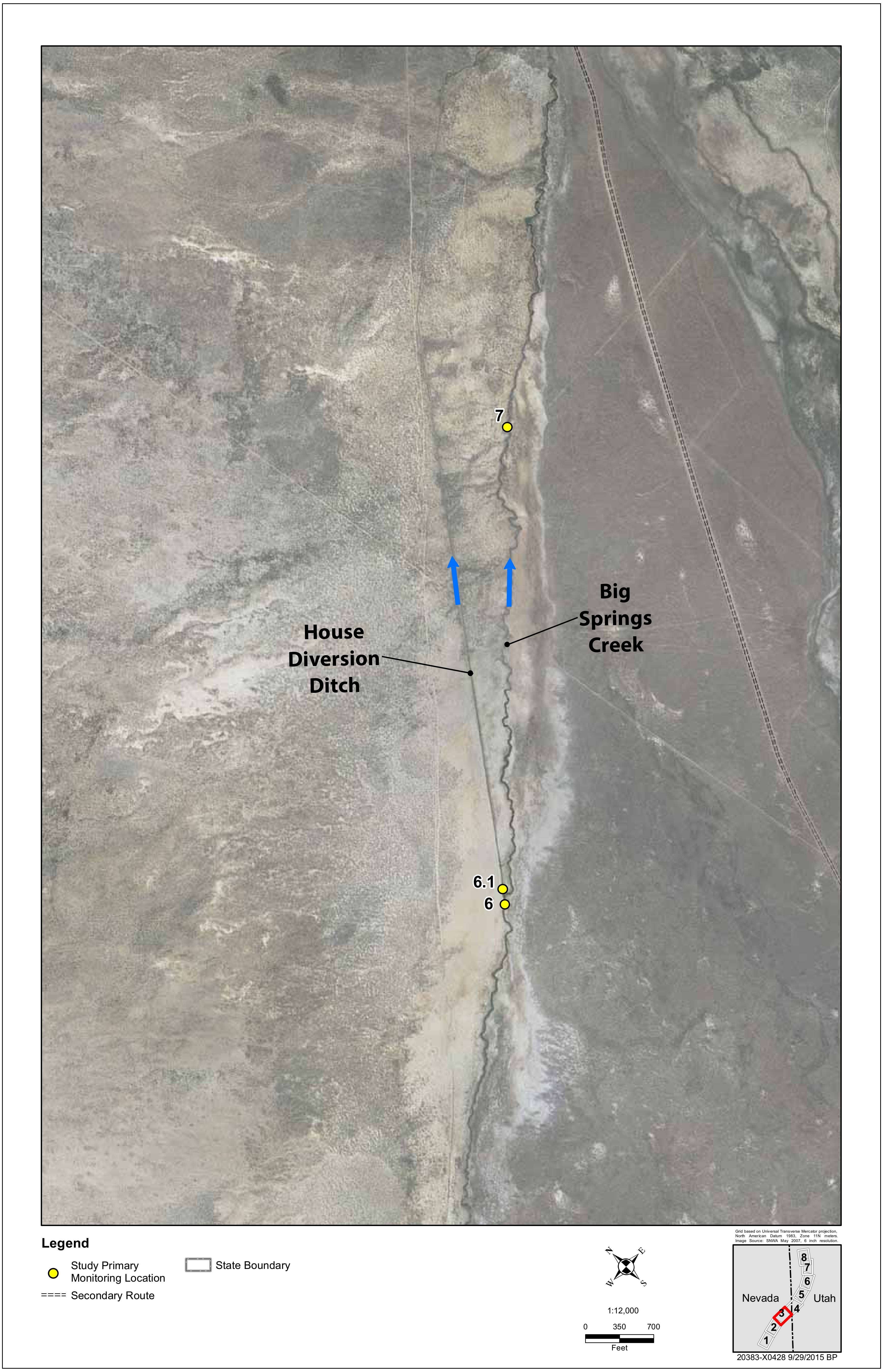
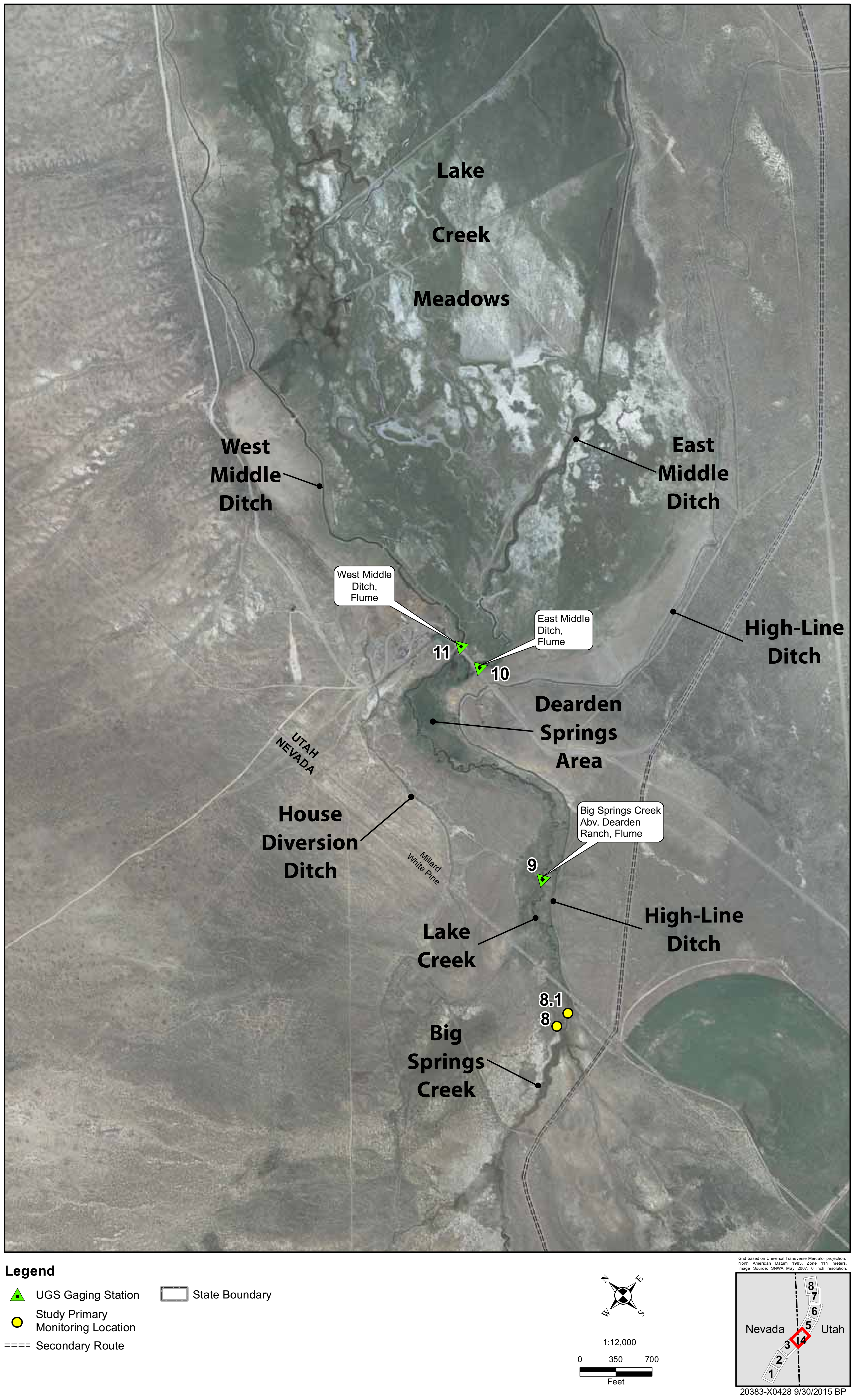


Figure C-5
Big Springs Creek Pruess Lake Synoptic Study Atlas page 3



Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

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Figure C-6
Big Springs Creek Pruess Lake Synoptic Study Atlas page 4

Figure C-7
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 4a

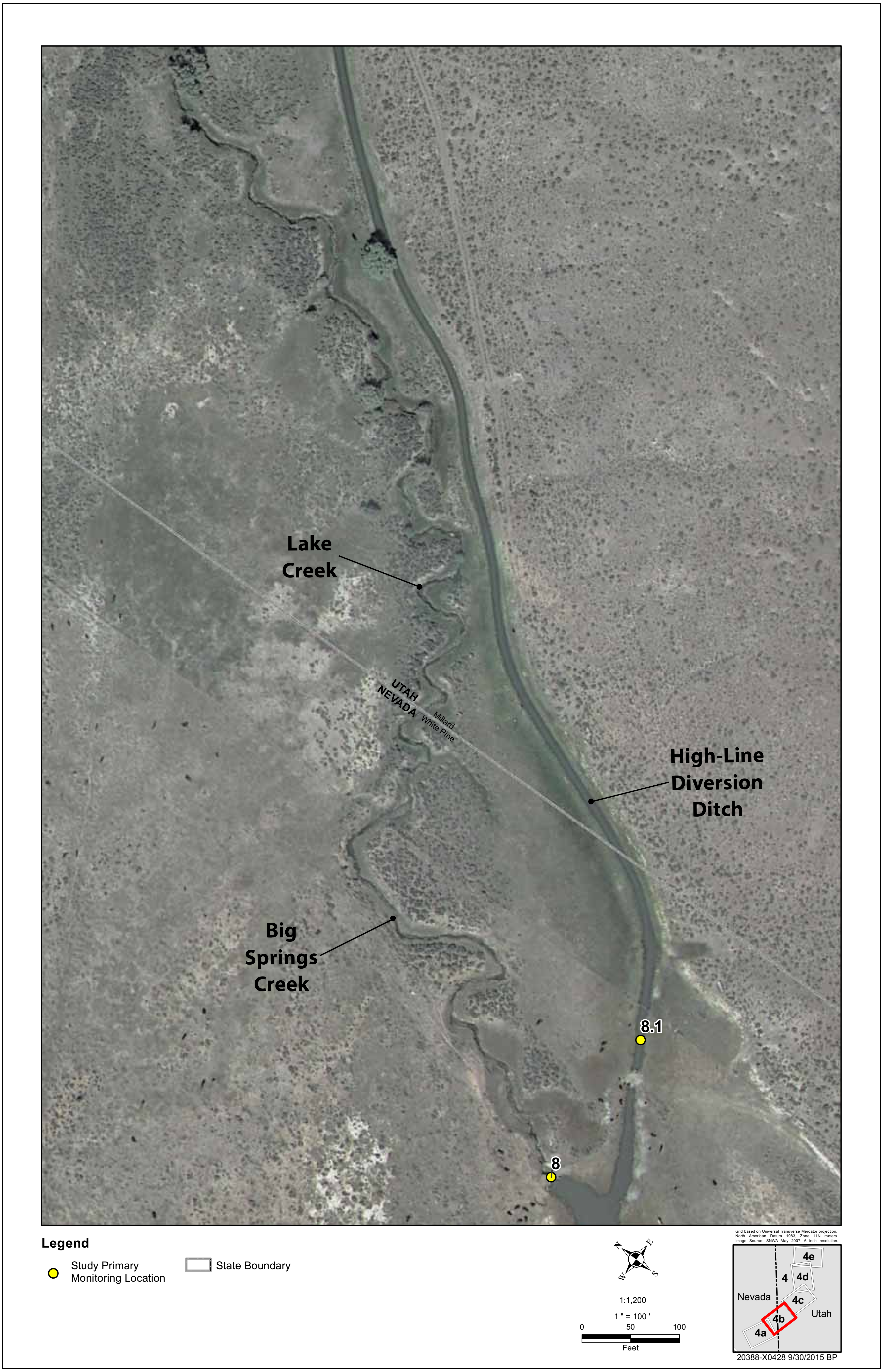

Figure C-8
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 4b

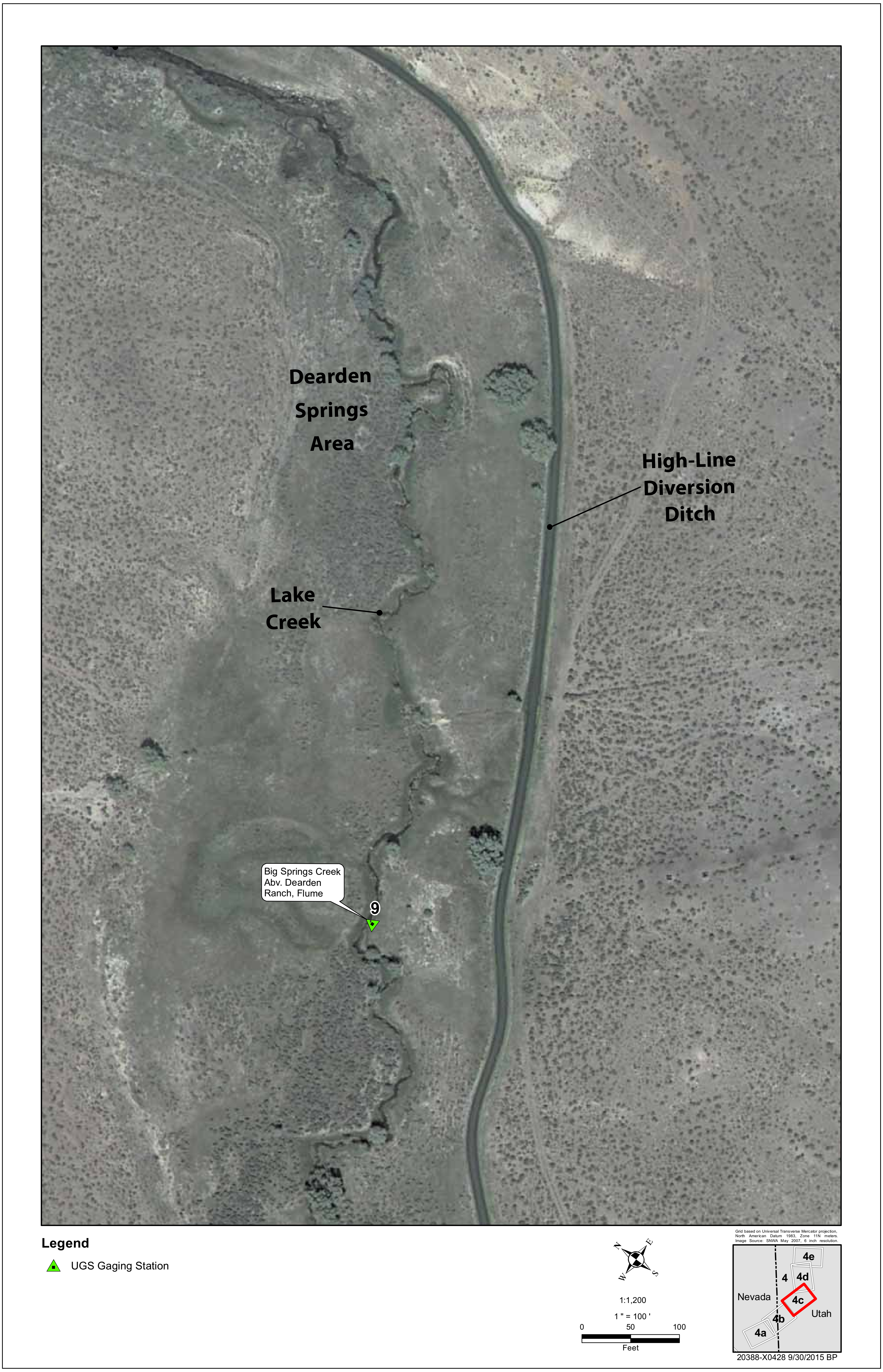

Figure C-9
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 4c

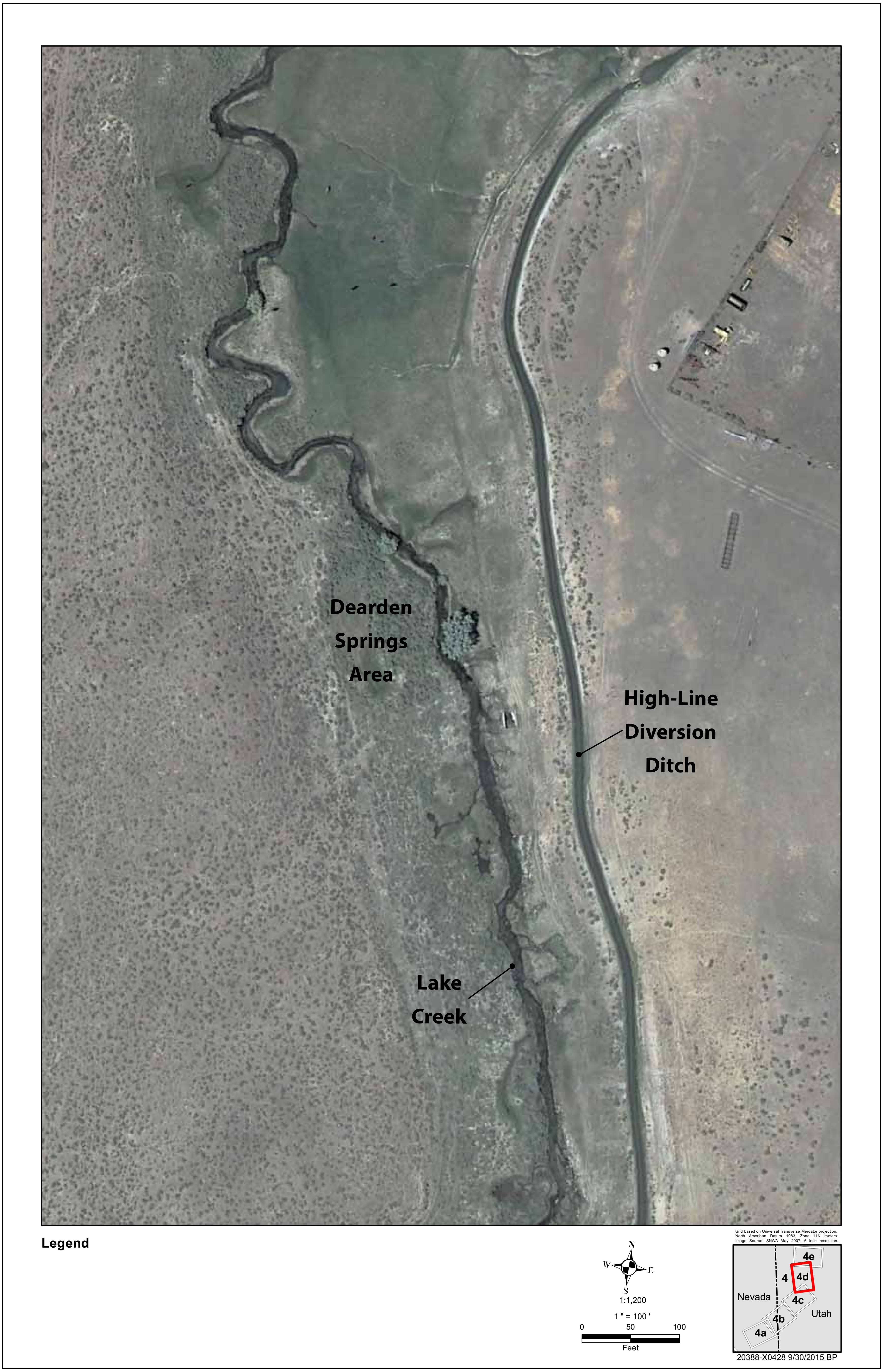

Figure C-10
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 4d

Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

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Figure C-11
Big Springs Creek to Pruess Lake Synoptic Study Large Scale Atlas 4e

Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

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Figure C-12
Big Springs Creek Pruess Lake Synoptic Study Atlas page 5

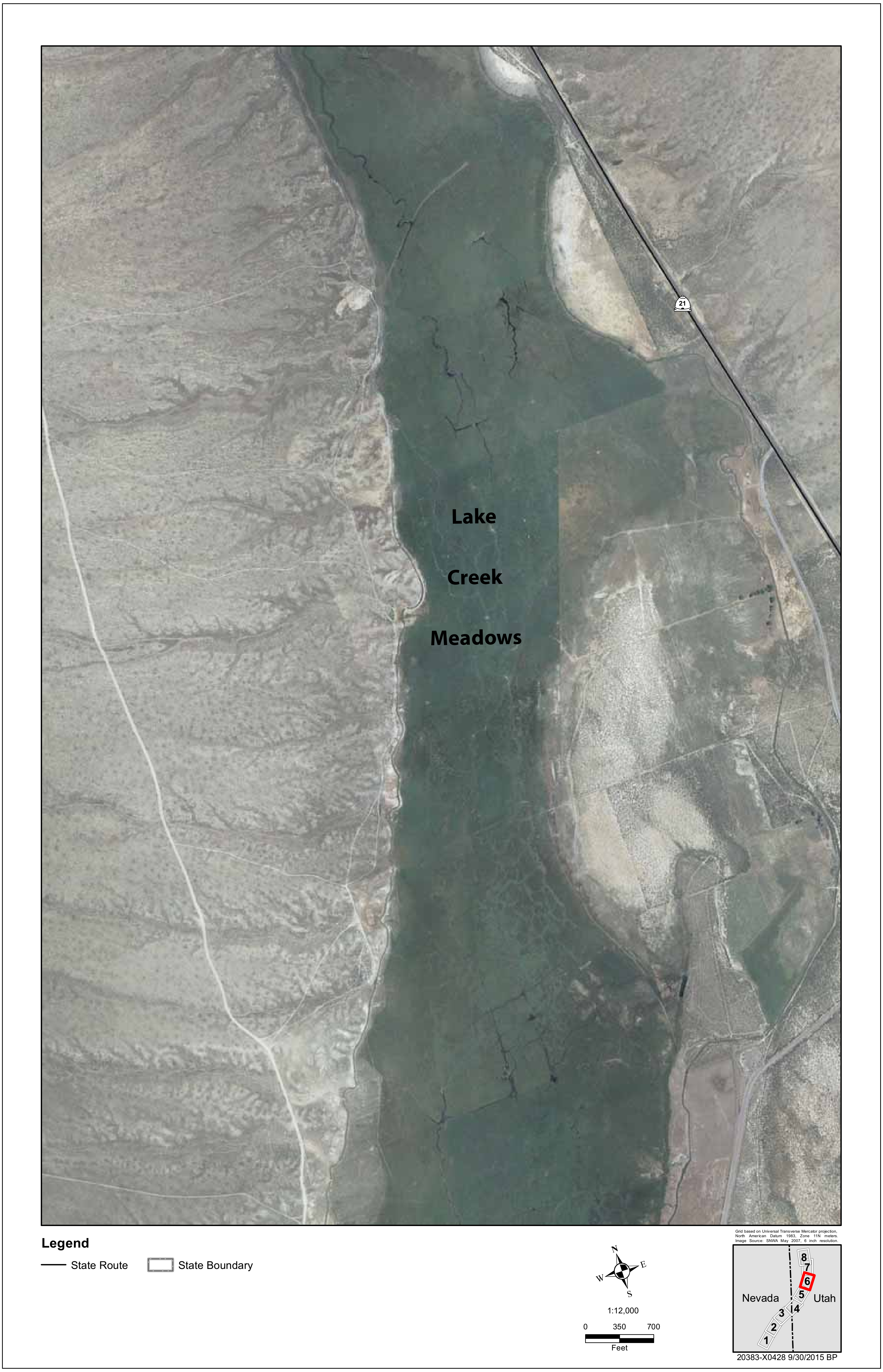
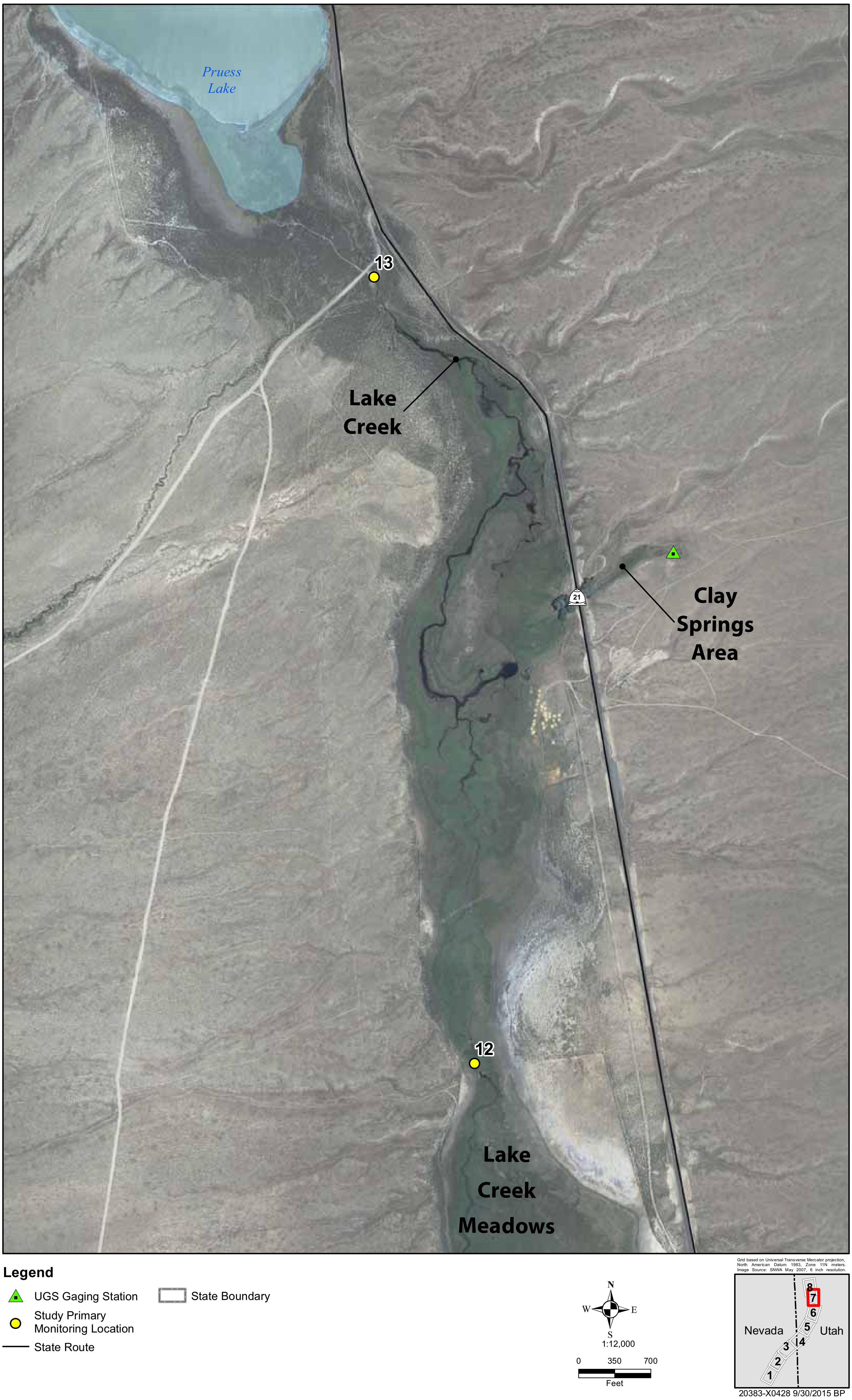


Figure C-13
Big Springs Creek Pruess Lake Synoptic Study Atlas page 6



Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

Figure C-14
Big Springs Creek Pruess Lake Synoptic Study Atlas page 7

Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11N meters. Image Source: SNWA May 2007, 6 inch resolution.

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Figure C-15
Big Springs Creek Pruess Lake Synoptic Study Atlas page 8

Appendix D

Site Photographs and Historic Discharge Hydrographs

Figure D-1
Big Springs South Channel Weirs

Figure D-2
Big Springs North Channel

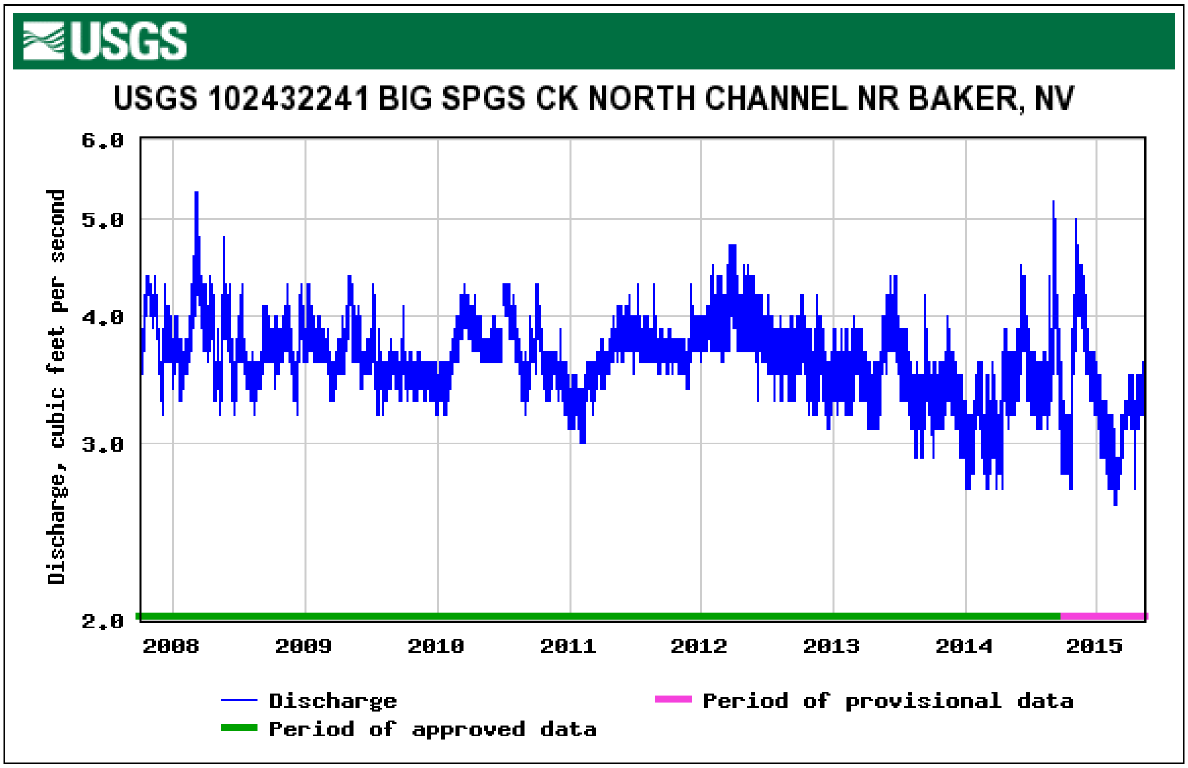


Figure D-3
Big Springs North Channel Hydrograph

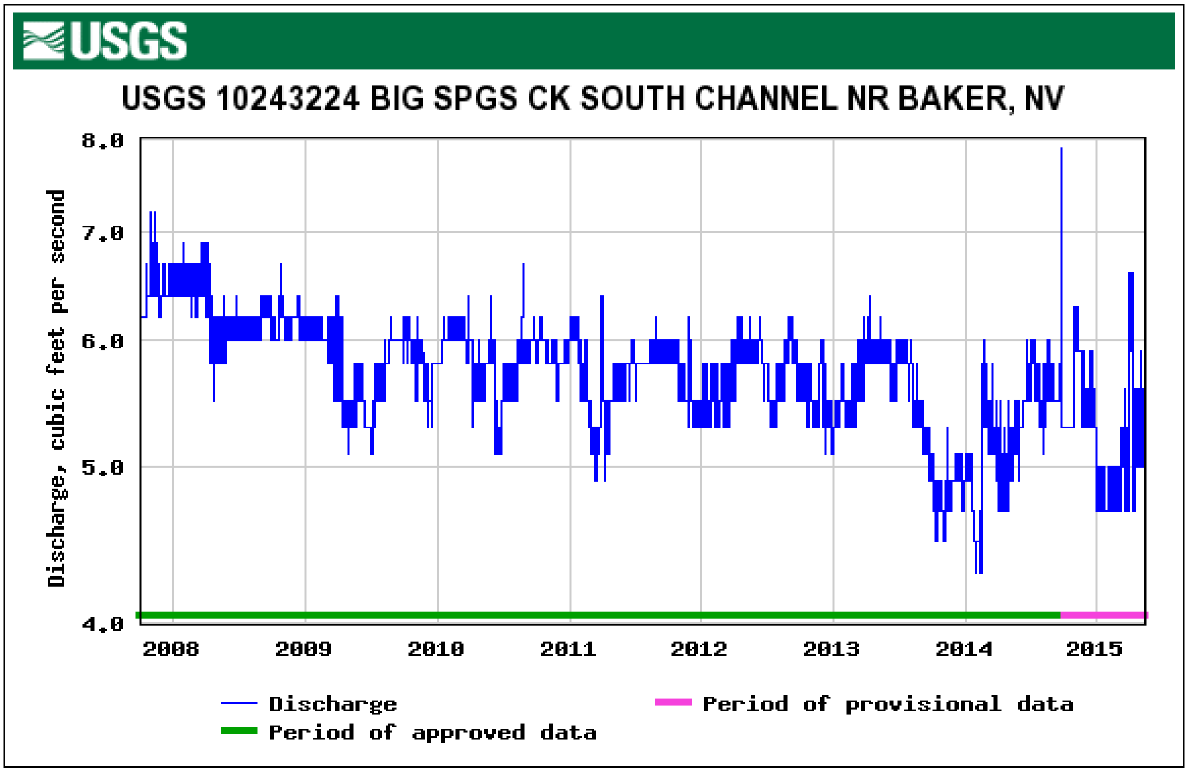


Figure D-4
Big Springs South Channel Hydrograph

Figure D-5
Big Springs Creek at Upstream Okelberry Meadow Site 2

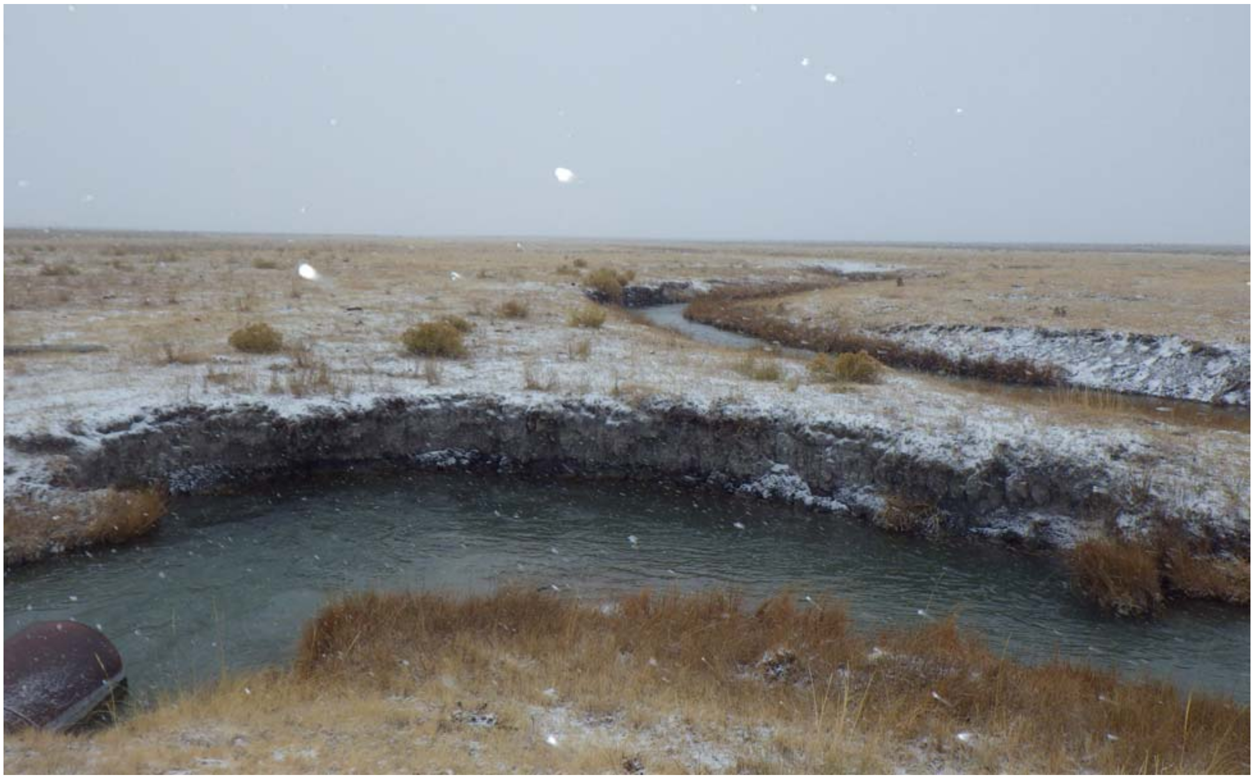


Figure D-6
Big Springs downstream of Culvert, Site 5 (in distance)

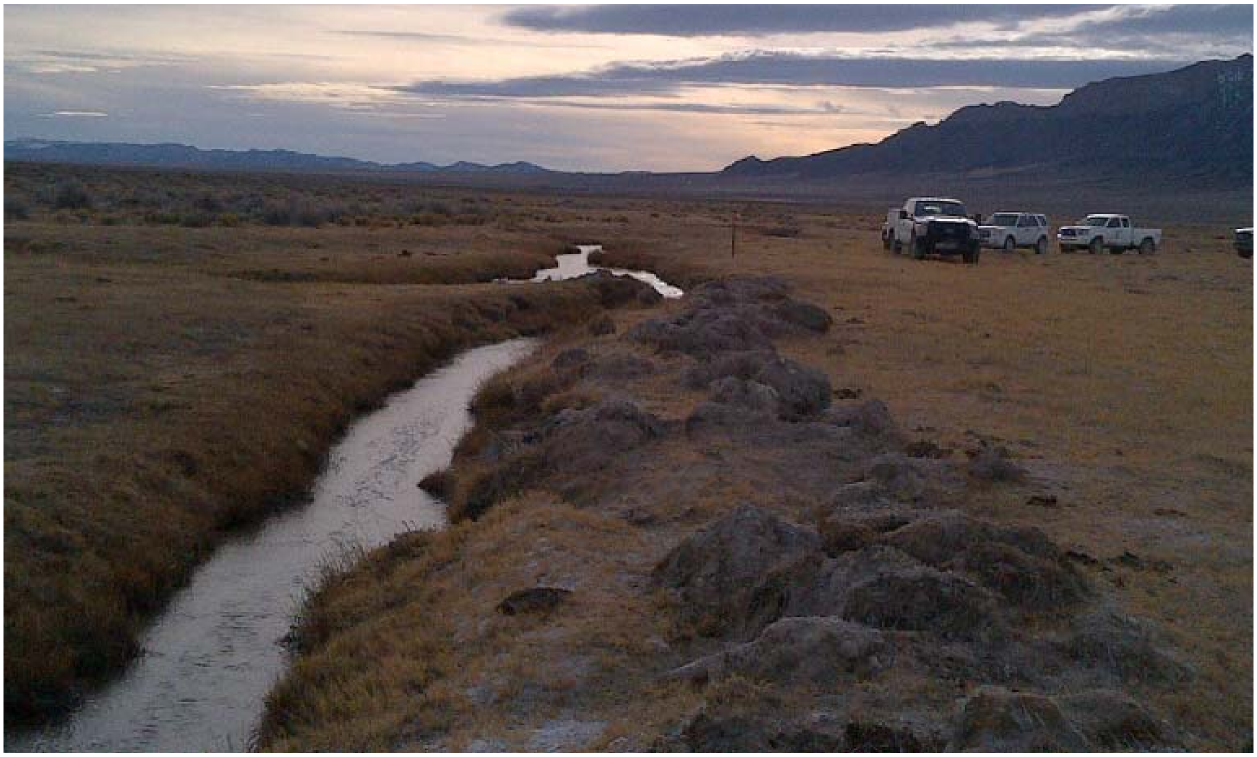


Figure D-7
House Diversion Site 6.1 (Looking South)

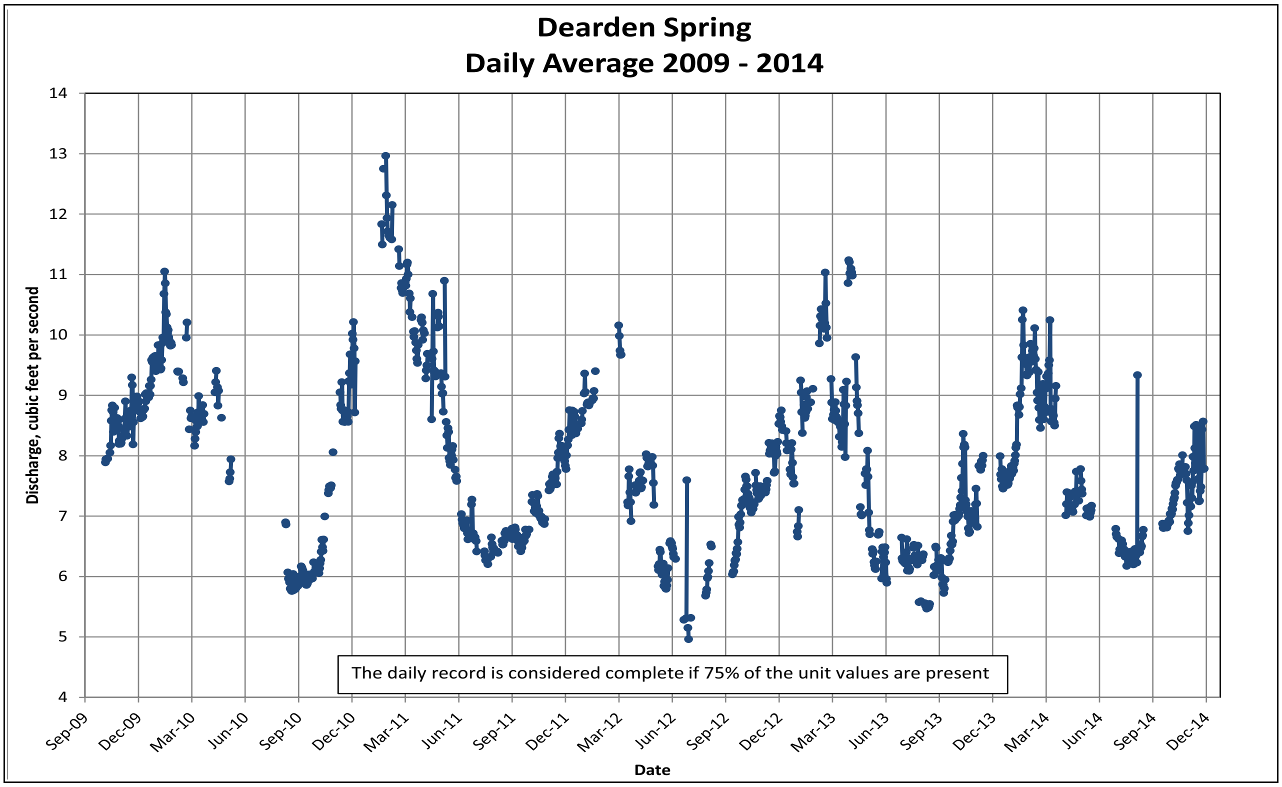
Figure D-8
Main Channel near High Line Diversion at Stateline Site 8 (Looking North)

Figure D-9
High Line Diversion by Stateline Site 8.1

Figure D-10
Big Springs Creek above Dearden Ranch UGS Gaging Station

Figure D-11
East Middle Ditch UGS Gaging Station

Figure D-12
West Middle Ditch UGS Gaging Station



The daily record is considered complete if 75% of the unit values are present

Figure D-13
Dearden Spring UGS Hydrograph

Figure D-14
Lake Creek Upstream of Clay Spring Site 12

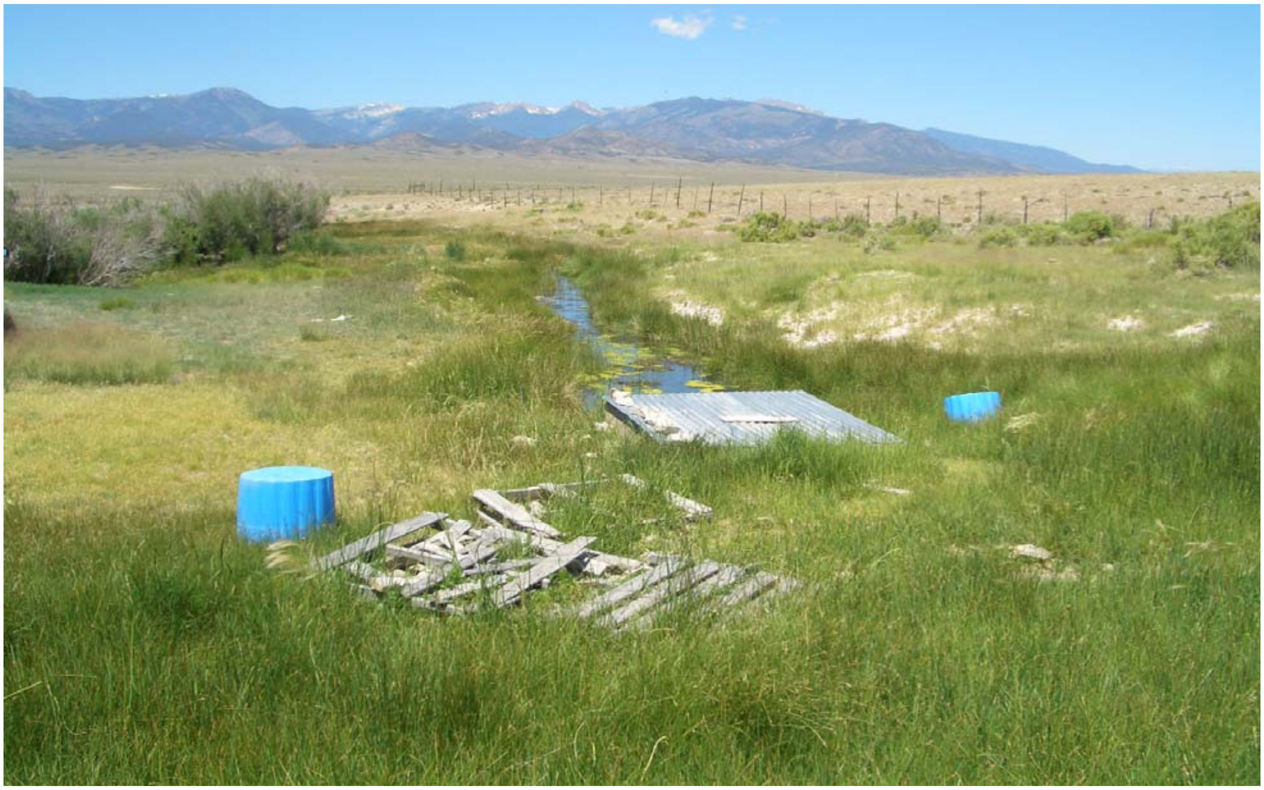


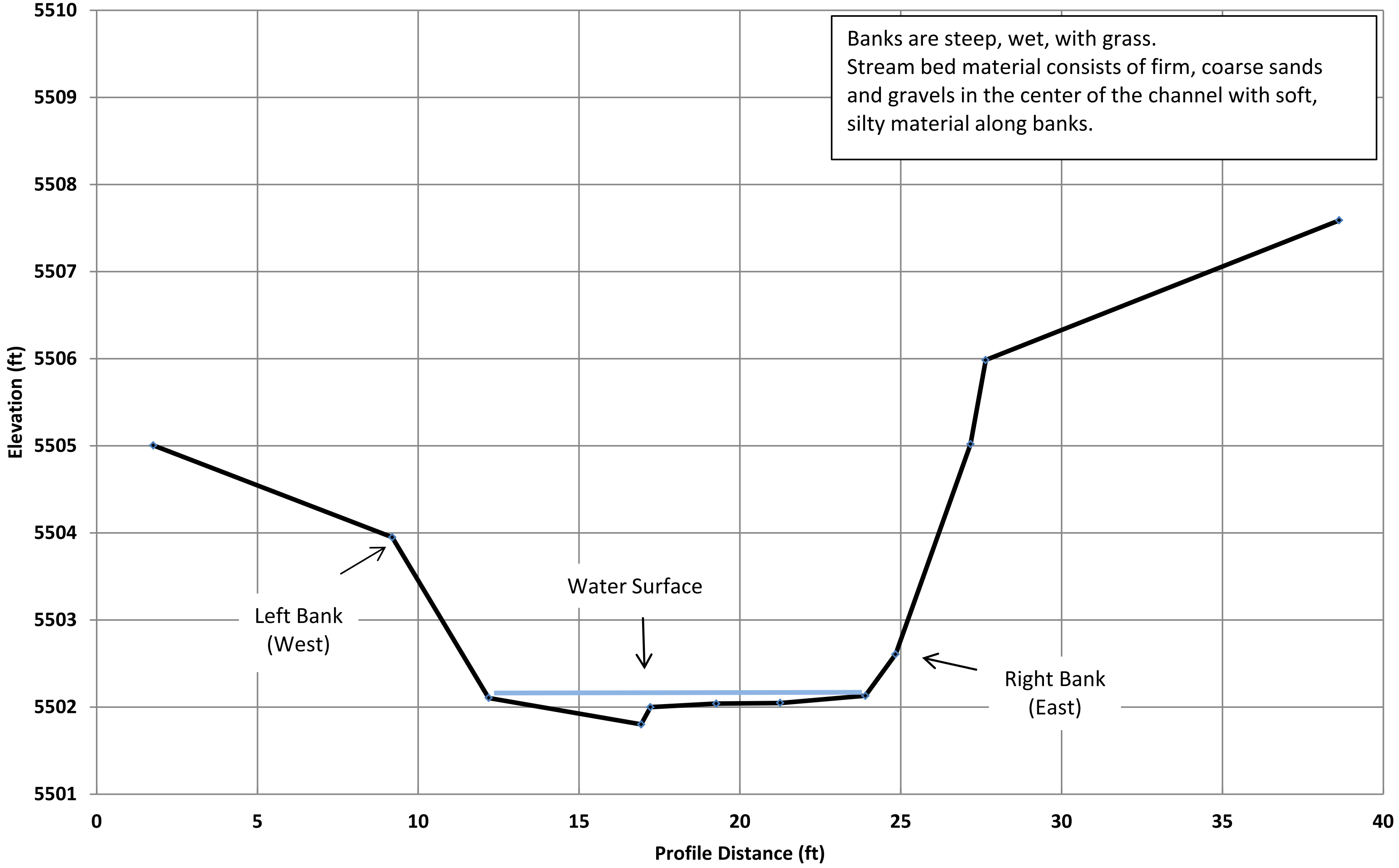
Figure D-15
Clay Spring UGS Gaging Station

Figure D-16
Lake Creek near Pruess Lake Site 13

Appendix E

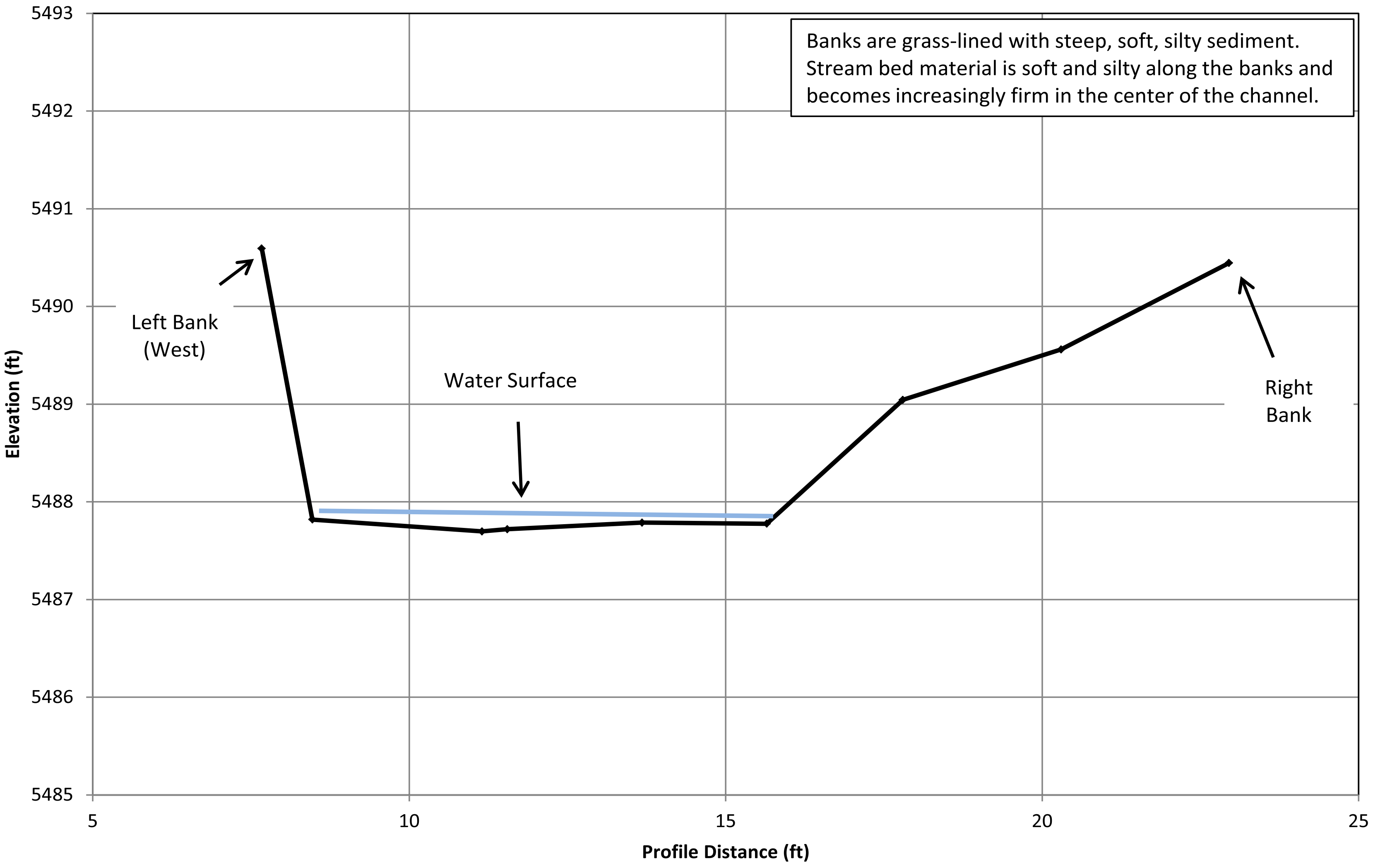
Measurement Site Elevations and Cross Sectional Profiles

Site 2
Upstream Okelberry Meadow

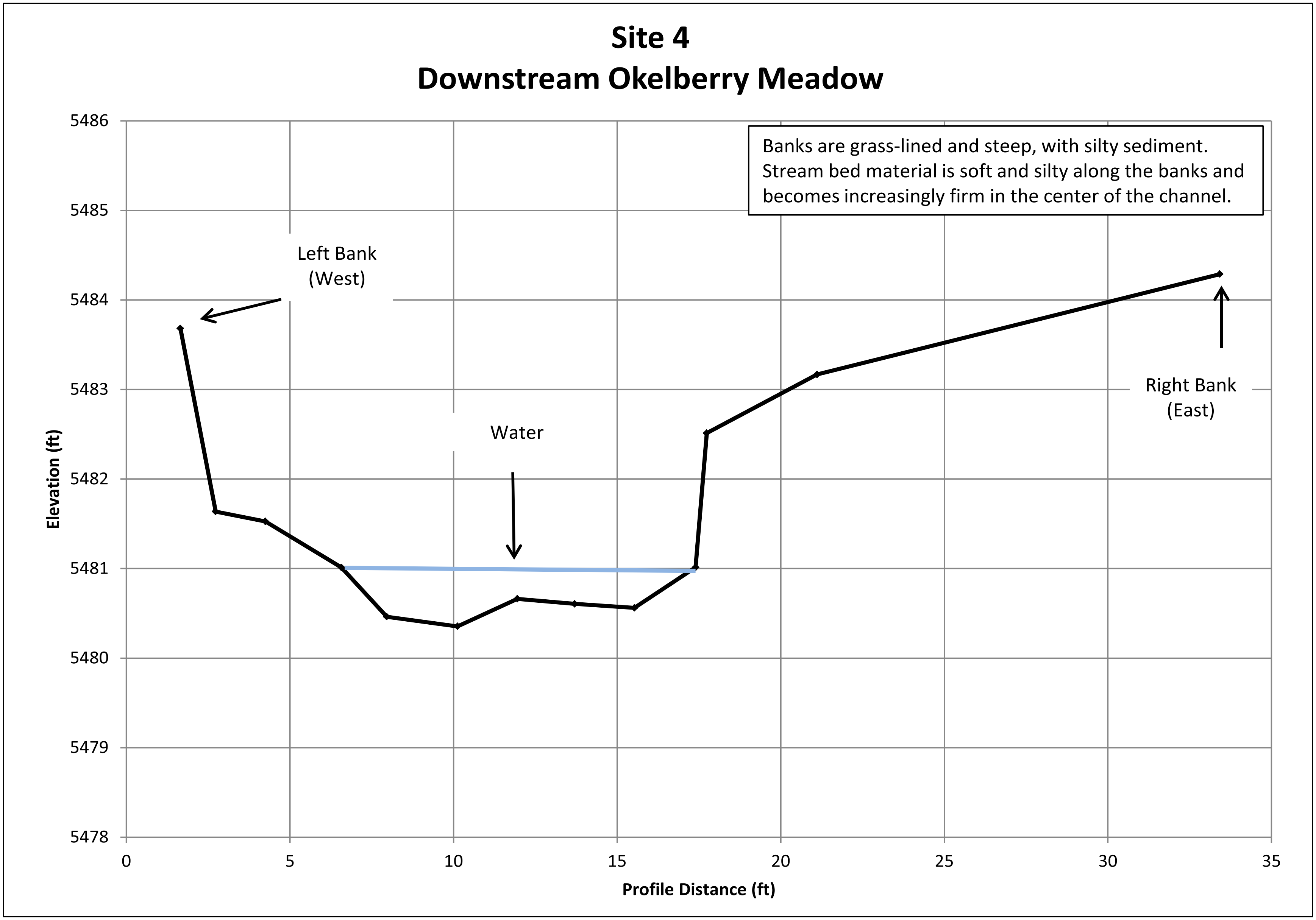


Banks are steep, wet, with grass.
Stream bed material consists of firm, coarse sands and gravels in the center of the channel with soft, silty material along banks.

Site 3
Mid-Okelberry Meadow

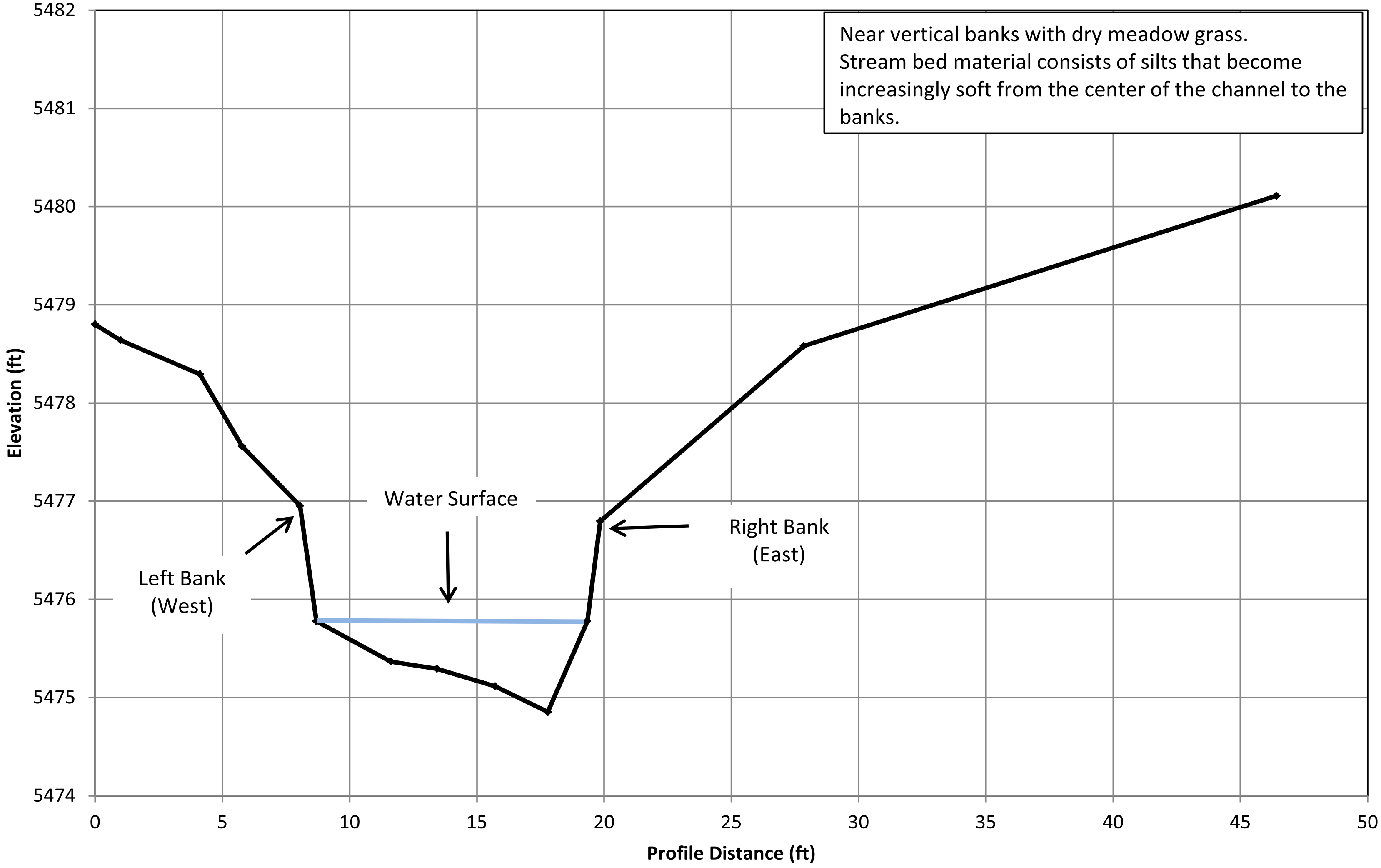


Banks are grass-lined with steep, soft, silty sediment. Stream bed material is soft and silty along the banks and becomes increasingly firm in the center of the channel.



Site 4
Downstream Okelberry Meadow

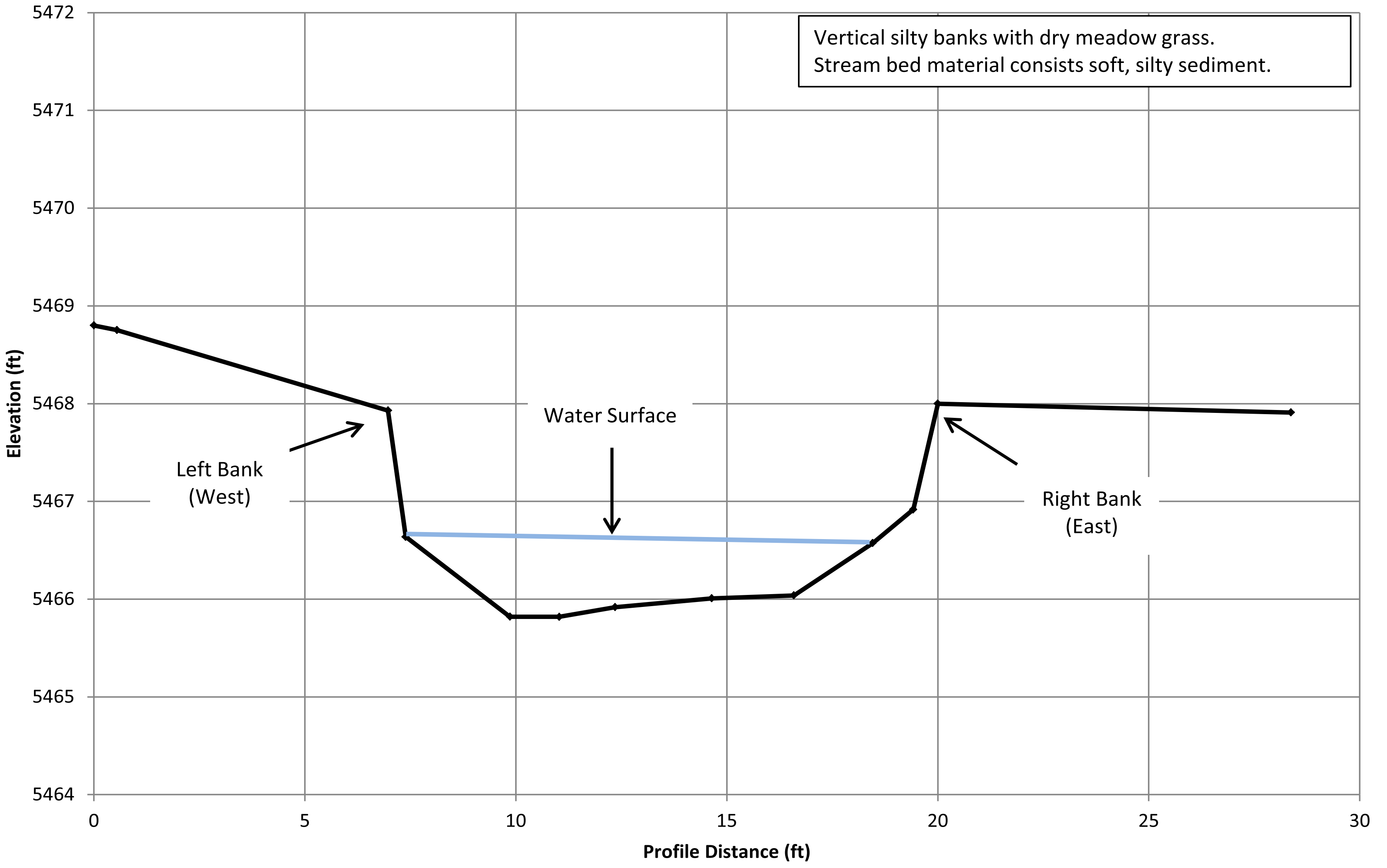
Banks are grass-lined and steep, with silty sediment. Stream bed material is soft and silty along the banks and becomes increasingly firm in the center of the channel.



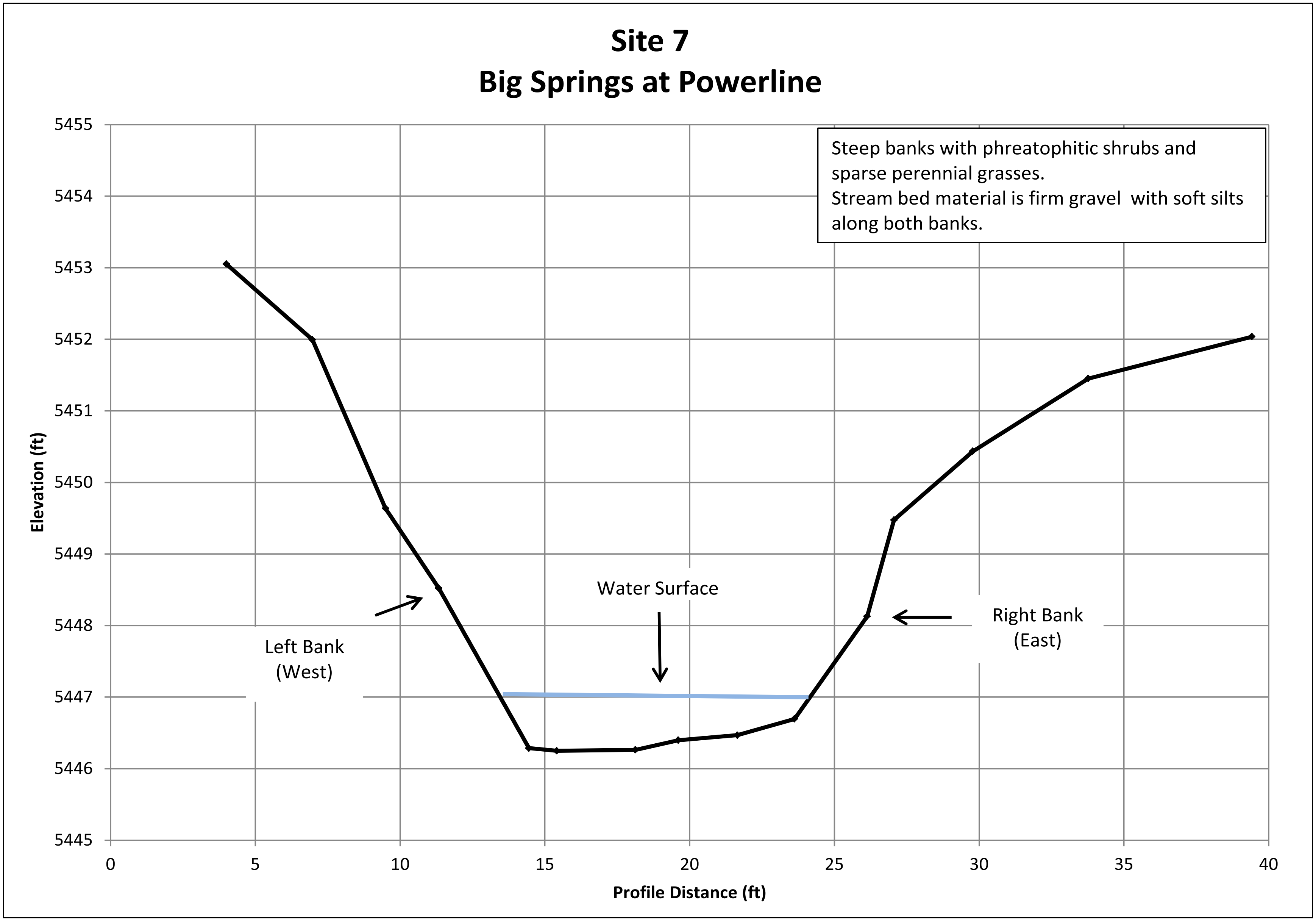
Site 5
Big Spring Creek downstream of Culvert

Near vertical banks with dry meadow grass. Stream bed material consists of silts that become increasingly soft from the center of the channel to the banks.

Site 6
Big Springs Creek upstream of Dearden House Ditch



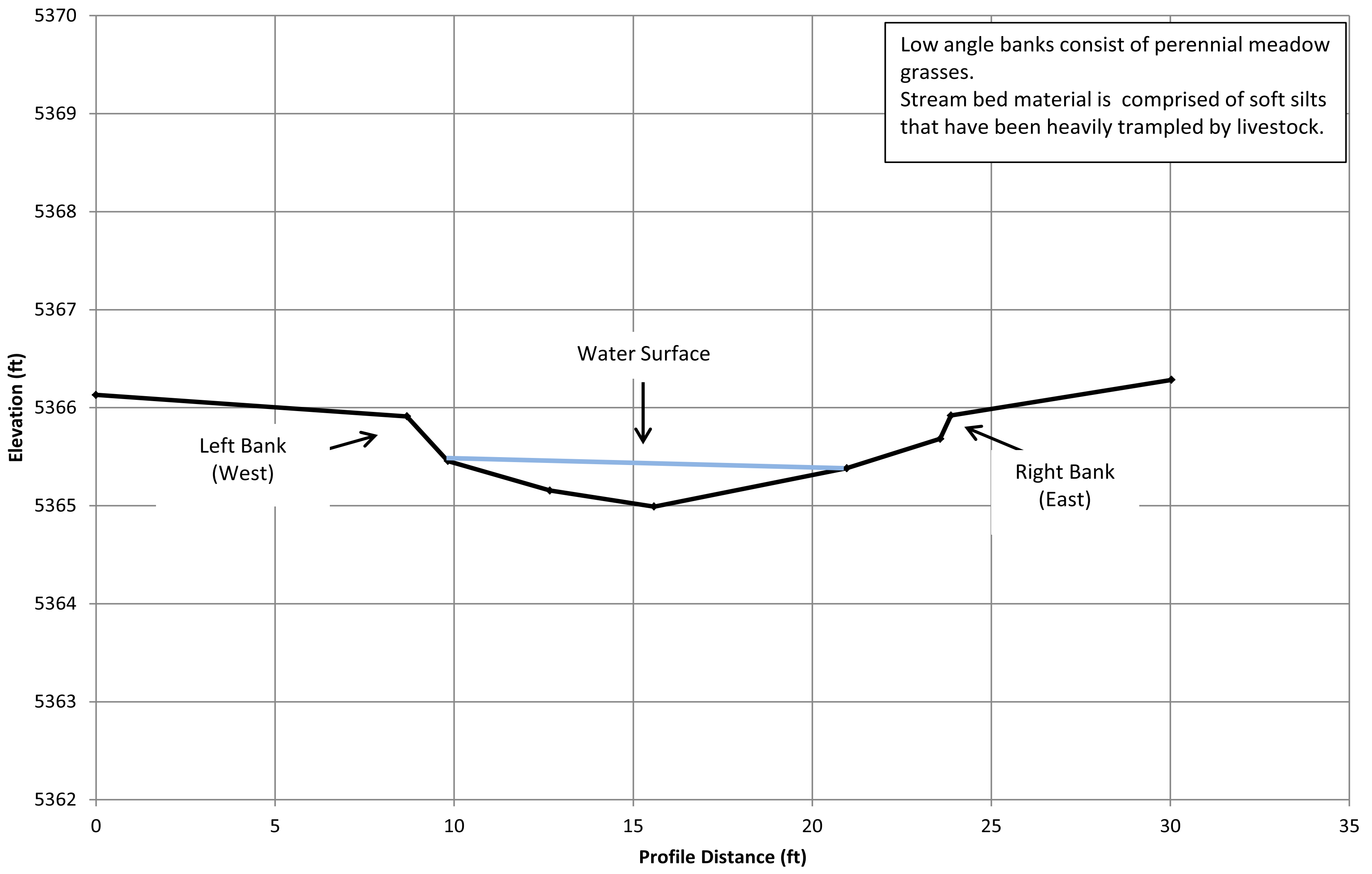
Vertical silty banks with dry meadow grass.
Stream bed material consists soft, silty sediment.



Site 7
Big Springs at Powerline

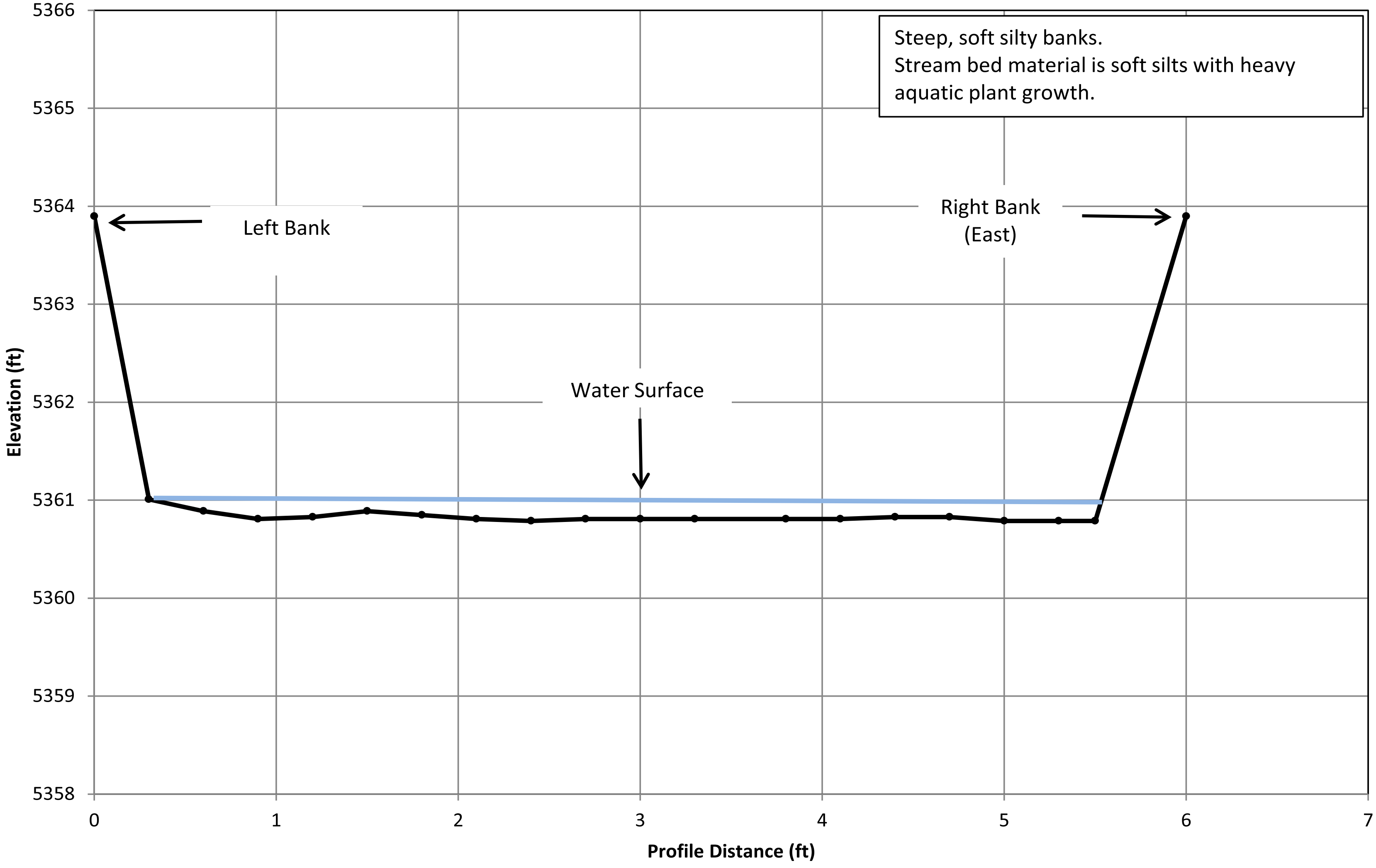
Steep banks with phreatophitic shrubs and sparse perennial grasses.
Stream bed material is firm gravel with soft silts along both banks.

Site 12
Lake Creek upstream of Clay Spring



Low angle banks consist of perennial meadow grasses.
Stream bed material is comprised of soft silts that have been heavily trampled by livestock.

Site 13
Lake Creek upstream of Pruess Lake



Steep, soft silty banks.
Stream bed material is soft silts with heavy aquatic plant growth.

Appendix F

Procedures

SOUTHERN NEVADA
WATER AUTHORITY

Procedure No:	Revision No:	Effective Date:	Review Date:
WRD-FOP-003	1	2-19-2014	2-12-14

WATER RESOURCES DIVISION
FIELD OPERATING PROCEDURE

for

MISCELLANEOUS DISCHARGE MEASUREMENT

Approvals:

Sr. Hydrologist, Data Acquisition and Reporting Section	2/19/14 Date
Sr. Hydrologist, Hydrologic Analysis and Modeling Section	2/18/14 Date
Sr. Hydrologist, Resource Development Section	3/19/14 Date
Division Manager, Water Resources Division	2-19-14 Date

REVISION LOG

Revision No.	Effective Date	Description of Changes	Affected Pages
0	10/01/2007	New Procedure	All
1	2/19/2014	Update	All

CONTENTS

1.0 INTRODUCTION

Stream and spring discharge measurements are fundamental types of hydrologic data used in water-resources investigations. They have a number of uses, including the determination of water budgets, water availability, low-flow characteristics, effects of flow diversions and augmentations, and determining changes in discharge along a stream channel.

2.0 PURPOSE

This procedure documents the activities performed by SNWA to make “miscellaneous” discharge measurements – that is, using volumetric containers, flumes, or conventional current meters (e.g., Price Pygmy or AA). This procedure has been established to provide accurate, reliable, and consistent methods for determining discharge in a stream or a spring.

This procedure also discusses the types of equipment commonly used to measure discharge and identifies the requirements for the proper documentation of collected data.

3.0 SCOPE OF COMPLIANCE

All personnel assigned to the SNWA Water Resources Division who perform surface water and spring discharge measurements shall comply with this procedure. As a result, all discharge measurements will be performed in accordance with this procedure. Before using this procedure, ensure that you have the latest approved revisions, see Section 12.0, Modifications.

4.0 DEFINITIONS

Current Meter – An instrument used to measure the velocity of flowing water.

Discharge – The volume rate of flow of the water, including any sediment or other solids that may be dissolved or mixed with it. Discharge is expressed in cubic feet per second (cfs) or gallons per minute (gpm). Discharge is expressed in gpm for flows less than 0.001 cfs.

Stage -Also known as gage-height. This is the elevation of the stream surface and does not reflect or define the depth of water at the site. It is used to determine relative change over the duration of the measurement. It is measured in hundredths of a foot (0.01 ft).

Tagline - A ruler or measuring tape that is graduated in hundredths of a foot (0.01ft) used for measuring the width of a stream. The distance is read to the nearest tenth of a foot (0.10 ft).

5.0 EQUIPMENT

The following is a list of equipment and materials that are, or may be, necessary for the collection of miscellaneous discharge measurements.

- Location map
- GPS

- Hand tools (e.g., pipe wrench, screw drivers, adjustable wrenches, shovels)
- 3-in. modified Parshall flume
- Volumetric container (use a container of known volume that was checked in the lab before field use)
- Stopwatch
- Taglines (measuring tapes) - graduated in tenths or hundredths of feet
- Folding ruler - graduated in tenths or hundredths of feet
- Top-setting wading rod
- Pygmy or AA current meters
- AquaCalc Pro or AquaCalc Pro Plus
- Chest waders or hip boots
- SNWA Discharge Measurement Notes form
- Standard rating tables for both the pygmy and AA current meters, rated June 1999
- Field notebook
- Copies of all required permits for data collection (ie. National Park Permit)

6.0 APPARATUS BACKGROUND

6.1 Volumetric Containers

The SNWA Water Resources Division staff uses rigid volumetric containers of known volume to measure discharge rates. The discharge is the volume of the container divided by the time it takes to fill the container. The container used should have adequate volume to collect all of the flow for at least 3 seconds.

6.2 Flumes

Flumes measure discharge by creating a contraction in channel width and a drop or a steeping of bed slope to produce critical or supercritical flow in the contracted section of the flume. The height of the water level in the converging section is used in conjunction with a discharge-rating equation to determine the discharge.

When depths are too shallow and velocities too low for a measurement of discharge by current meter, the SNWA Water Resources Division staff uses a 3-in. modified Parshall flume. The modified Parshall flume consists of a standard Parshall flume with the removal of the downstream diverging section of the standard Parshall flume (Kilpatrick and Schneider, 1983). The modification of the standard flume reduces the weight of the flume and makes it easier to install (Kilpatrick and Schneider, 1983).

6.3 Current Meters

Current meters are used to measure the velocity of moving water at a series of points in a stream. The meters consist of a set of cups that rotate horizontally on a sharply pointed pivot as the flowing water drags on the cups (Holmes et al., 2001). The meters are calibrated such that if the number of revolutions of the cups in a certain time is known, then the linear velocity of the water can be determined (Holmes et al., 2001). The two types of current meters currently used by the SNWA Water Resources Division staff are the Price pygmy meter and the Price AA meter.

7.0 ASSUMPTIONS AFFECTING THE PROCEDURE

1. Channel conditions are stable (no rapid change in stage or flow rates).

2. Proper choice of measuring section (no backwater conditions, islands, or eddies).

8.0 LIMITATIONS/ACCURACY

The degree of accuracy for discharge measurements is dependent upon the training, experience, and ability of the hydrographer to maintain the equipment and properly perform discharge measurements following established protocols. Discharge measurements accuracy are rated based on the estimated error - Excellent (2%), Good (5%), Fair (8%) or Poor (>8%). The error is estimated based on the conditions reported in the Flow, Cross-section, and Control portion of the Discharge Measurement Notes.

9.0 SPECIFIC MISCELLANEOUS DISCHARGE MEASUREMENT PROCEDURES

9.1 Volumetric Measurements

1. Verify that you are at the correct measurement location.

2. On a SNWA Discharge Measurements Notes form, fill in the date, time, personnel on site, volume of the container used for measurement, coordinates for the measurement location, description of the outflow being measured, and any other pertinent information.

3. Clean out the volumetric container with water from the discharge source.

4. Ensure that the container opening and volume are large enough to capture the entire discharge for at least three seconds.

5. Practice capturing the flow two or three times while simultaneously starting the stopwatch.

6. Take the discharge measurement by determining the time it takes for the flow to fill the container.

7. Repeat Step 6 a **minimum** of four more times to check for reliability and consistency.

8. If there is a large variation in the time it takes to fill the container, take a sufficient number of additional measurements until you determine an accurate discharge can be obtained from the data collected. At times the highest and lowest measurements may need to be discarded if they are extremely different. Most of the error will be in the accurate timing of the container being filled.

9. The discharge is the volume of the container divided by the time.

10. Average the discharge measurements to obtain the discharge measurement.

9.2 Flume Measurements

1. Verify that you are at the correct measurement location.

2. On a SNWA Discharge Measurements Notes form (see Attachment A), fill in the date, time, personnel on site, coordinates for the measurement location, description of the outflow being measured, and any other pertinent information.

3. Pick a location in the stream that promotes laminar flow conditions at the flume inlet. Conditions such as turns in the stream, elevation drops, or obstructions upstream should be avoided.

4. Place the flume in the stream and ensure that the crest of flume (the floor of the converging section where the depth measurements are made) is level both perpendicular and parallel to the direction of flow using the attached bubble level. If the bubble level is missing or non-functional a carpenters level or torpedo level may be used as a substitute. When using an alternate level make sure the flume is level along both the parallel and perpendicular to the flow axis.

5. Begin the flume installation by building a dam across the channel starting on each bank. Once the dam is complete, set the flume into the dam and proceed to add more material to the dam to keep the pooled water from overflowing the dam. Dam construction materials should consist of fine grained material to adequately seal off the flow of the stream. For a quickly flowing stream, a stockpile of dam material should be dug from the banks to aid in quick repairs to the dam while setting the flume. Should the flume become undermined; one or two quick shovel fulls of material should be placed in immediately upstream of the approach section of the flume. This should stop the leaks. Should any dirt get in the convergent section, gently brush it out of the section before taking a reading. Continuously monitor the flume to ensure that it remains level. After the flume is installed, water will pool upstream from the flume. Read the head in the flume to the nearest 0.01 ft. Careful observations should be made when setting the flume in very flat reaches. The flume must not become submerged.

6. Wait for stabilization of the flow through the flume. This is done by measuring the depth of water in the crest of the flume at 5 minute intervals or until the readings stabilize. Recheck the flume for level before each measurement. Record the head and time of each reading on the Discharge Measurement Notes form. Continue to take head measurements until three consecutive readings are identical. During this period, watch the flow to ensure that it does not

flow around or under the flume. Long flat reaches can take a long time to stabilize, the flume may need to be in-place an hour or more. Additional observations should be made before the readings are called stable.

7. Use the last head value once the flume has stabilized with the volumetric flow equation etched on the flume to determine the miscellaneous discharge.

9.3 Current Meter Measurement

1. Verify that you are at the previously identified measurement location, or select a suitable site for a new measurement. According to Holmes et al. (2001), there are several factors to consider when selecting a suitable measurement site. These include the straightness of the channel, uniformity of the water flow, effects from tributary flow, and velocity of the water being measured.

2. On a SNWA Discharge Measurements Notes form (see Attachment A), fill in the date, time, personnel on site, coordinates for the measurement location, description of the outflow being measured, and any other pertinent information.

3. Determine if the miscellaneous discharge measurement is to be made with a Price pygmy meter or with a Price AA meter. Pygmy meters are used for water depths less than 2.5 ft and water velocities between 0.2 and 2.5 ft/s. AA meters are used in water with depths greater than 1.50 ft and water velocities between 0.2 and 12 ft/s.

4. Assemble the chosen current meter device according to manufacturer’s instructions, and lubricate the pivot pin and contact chamber with mineral oil.

5. Perform a spin test for the assembled instrument. According to Holmes et al. (2001), the spin test is conducted to ensure that the moving parts of the meter are in proper alignment and lubrication and that the meter is functioning similarly to the condition of the meter when it was manufactured and calibrated. The test is performed by either holding the meter level, or placing the meter on a flat surface away from wind effects. The cups (or bucket wheel) are then given a spin while simultaneously starting a stopwatch. The stopwatch is stopped when the bucket wheel quits spinning. This time is recorded on the Discharge Measurement Notes form. SNWA uses a minimum field check spin time for the pygmy meter of 45 seconds while the minimum field check spin time for the AA meter is 2 minutes. If these minimums are not met, then the current meter cannot be used for a discharge measurement. Each type of meter should come to a gradual stop as opposed to an abrupt stop. If the meter passes the spin test but stops abruptly, then the subject meter should be inspected to determine the cause of the abrupt cessation of rotation.

9.4 Discharge Measurement Notes

Currently SNWA uses JBS Instruments AquaCalc Pro and AquaCalc Pro Pus to collect discharge measurement data. The manual for each of these is attached as Attachment B and Attachment C. Staff should be familiar with these two manuals before heading into the field. Regardless if the measurement data is being collected manually or automatically with the AquaCalc the front sheet of the SNWA

Discharge Measurements Notes form (see Attachment A), needs to be completed as follows:

a. Sta. No. - a seven digit number assigned to each site by SNWA. The first three numbers are the Hydrologic Area, the second two are the stream number and the last two digits are the sequential number of the site.

b. Station Name - The full name of the site as given in the SNWA database.

c. Date - Enter the format as Month/Day and the last two digits of the year.

d. Party - The format for Party is first initial, last name, followed by (m) for measurer, (n) for notes, and (o) for observer.

e. Width - This is the total width of the cross section. It is determined subtracting the Right Edge of Water (REW) reading from the Left Edge of Water (LEW) reading and reporting the absolute value. There are no negative cross section widths. This value is recorded after the measurement has been made.

f. Area - Is a calculated value that is recorded after the measurement has been made. The sum of each vertical's area is calculated and recorded on this line.

g. Velocity - Is calculated at the end of the measurement. It is calculated by dividing the Discharge by the Area, and recorded here.

h. GH - This is the gage-height at which the discharge measurement was made.

i. Disch. - Sum all of the verticals' discharges and record the value here.

j. Method - This can be filled out after the measurement. If the method was 0.6 depth method then record 0.6 in the space. If the method was the 0.2/0.8 depth method then record 0.2/0.8 in the space. If both methods were used record the one that was used the most often.

k. No. secs. - Count the number of verticals with measurable discharge and record that value here.

l. GH change - record the total change in gage-height during the measurement, and how long the measurement took to complete.

m. Susp - Enter, rod.

n. Meter No. - The meter number is etched on the side of each meter.

o. Type of meter - Enter either pygmy or AA.

p. Date rated - Enter 6/99.

q. Spin before meas. and after - Enter spin test results either as 63 sec., 63, or 1:03.

r. EC meter no. - record the EC meter’s Equipment Id number here.

s. Turbidity meter no. - record the Turbidity meter’s Equipment Id number here.

t. pH meter no. - record the pH meter’s Equipment Id number here.

u. Meas plots - record the percent difference between the measurement and the discharge from the most current rating table. Then record the rating number used.

v. Levels obtained - This is a yes/no field. Answer yes if station levels were taken during the measurement.

w. Under the GAGE READINGS section, record the Start and End Time. Enter PST for Pacific Standard Time and PDT for Pacific Daylight Savings Time. **Do not use Utah local time for sites located in Utah.** At gaging stations first read the Staff plate and record the value under the heading Outside. Then open the gage house and record the value reported by the data logger under the heading DCP. Include the time each reading was made. If there is greater than 0.02 ft difference, determine the cause and correct the problem. **If unsure of what the problem is record all the values change nothing and report the problem to the Task Lead.** Readings should be taken before and after the flow is measured.

x. If water quality measurements are taken then in the WATER QUALITY MEASUREMENTS section, mark either Yes and record the time or No as appropriate.

y. Samples collected - circle yes or no and record the time. Below that circle the method of collection EDI (Equal Discharge Increment), EWI (Equal Width Increment) or other (grab would be an example).

z. Wading - circle the appropriate adjectives that best describe the location of the measurement cross section relative to the gaging station. Do not forget to estimate the distance and record that in the blank space.

aa. Measurement rated - This is to be filled out based on Flow, Cross Section characteristics and condition of the control.

ab. Flow - briefly describe the flow conditions, noting if it is turbid/clear; fast/slow, laminar/turbulent and other such descriptions.

ac. Cross section - briefly describe the cross section. Note the bed material grain size, the banks, vegetation and other relevant characteristics that would affect the discharge measurement. (Table 1)

Table 1
Bed Material Grain Size Division

Aggregate Type	Aggregate Detail	Size Range	
		Millimeters	Inches (approximate)
Boulder	Coarse	>1,024	>40
	Medium	512 to 1,024	20 to 40
	Fine	256 to 512	10 to 20
Cobble	Coarse	128 to 256	5 to 10
	Fine	64 to 128	2.5 to 5
Gravel	Coarse	16 to 64	0.63 to 2.5
	Medium	8 to 16	0.32 to 0.64
	Fine	2 to 8	0.08 to 0.32
Sand	Coarse	0.5 to 2	0.02 to 0.08
	Fine	0.125 to 0.5	--
Fine material (silts/clays)	--	< 0.125	--

Source: Modified from Buffington and Montgomery, 1999

ad. Control - for miscellaneous sites describe what the feature is that is controlling the discharge at the cross section. At gaging-stations describe the control that is controlling the gage pool elevation. Describe it as clear, the presence of ice, what the structure is made of its stability and other relevant features.

ae. Air Temp - Record the air temperature in degrees C.

af. Weather - Describe the Weather in terms such as Warm, Windy, Cloudy, etc.

ag. Turbidity - If a turbidity meter is present record the value in NTU

ah. Water Temp. - Record the Water Temperature in degrees C.

ai. EC - Record the EC in uS/cm

aj. pH - Record the pH units on the form

ak. Gage operating - Record the difference between the Out side staff and the DCP. Record in ft.

al. File downloaded - Mark Y for yes and N for No.

am. Intake/Orifice cleaned - Mark if it was cleaned. Record the time and gage height change if any in the Remarks section.

an. File name - Record the file name or the name of the data card where the file is stored.

ao. HWM - Describe the High Water Marks here; including quality, type and gage height.

ap. Remarks - Write down any additional information about the site and or measurement that would not fit in the spaces above.

6. Install a ruler or measuring device into the stream channel so that it is partially submerged in the water. Note the elevation of the water (gage-height) from the measuring device on the Discharge Measurement Notes form. This is used to check for changes in stage during the discharge measurement.

7. Install a tag line (or measuring tape) across the channel perpendicular to the flow so that the channel can be divided into subsections. For each subsection, the area and mean in vertical velocity are determined using a top-setting wading rod and current meter. The subsections should be spaced so that no subsection has more than five percent of the total discharge. Determine the width of cross-section where the majority of the flow is present, divide the width by 20. This is a good rule of thumb for determining the width of each interval to not exceed five percent of the total flow. SNWA uses a minimum allowable subsection width for the Price pygmy meter of 0.2 ft, and 0.4 ft for the Price AA meter.

   a. Begin the miscellaneous discharge measurement by noting the initial point of the cross section on the Discharge Measurement Notes form. The initial point should be labeled as either the REW or the LEW. If you are looking downstream, the REW is the right bank of the stream, while the LEW is the left bank of the stream. Note the number from the tag line that corresponds to the bank/water interface in the Dist. from initial point column, the time the discharge measurement began, and the gage height. This number is read to the nearest tenth of a foot (0.1 ft).

   b. For the current observation location, determine the depth of the water using the graduations on the top-setting rod and the value from the tag line for the current location. Record this information in the Depth and Dist. from initial point columns, respectively.

   c. Calculate the width of the subsection. The subsection widths are calculated using the values from the Dist from initial point column. For all observation locations except the first and the last, the width is calculated using the value from the preceding observation and the succeeding observation. The width is the smaller distance subtracted from the greater distance divided by two. For the first observation, the width is calculated using the current observation value and the succeeding observation value. The smaller value is subtracted from the larger value and divided by two. For the last observation, the width is calculated using the next-to-last observation and the last observation. The smaller value is subtracted from the larger value and divided by two. The width for each subsection should be recorded with two significant figures.

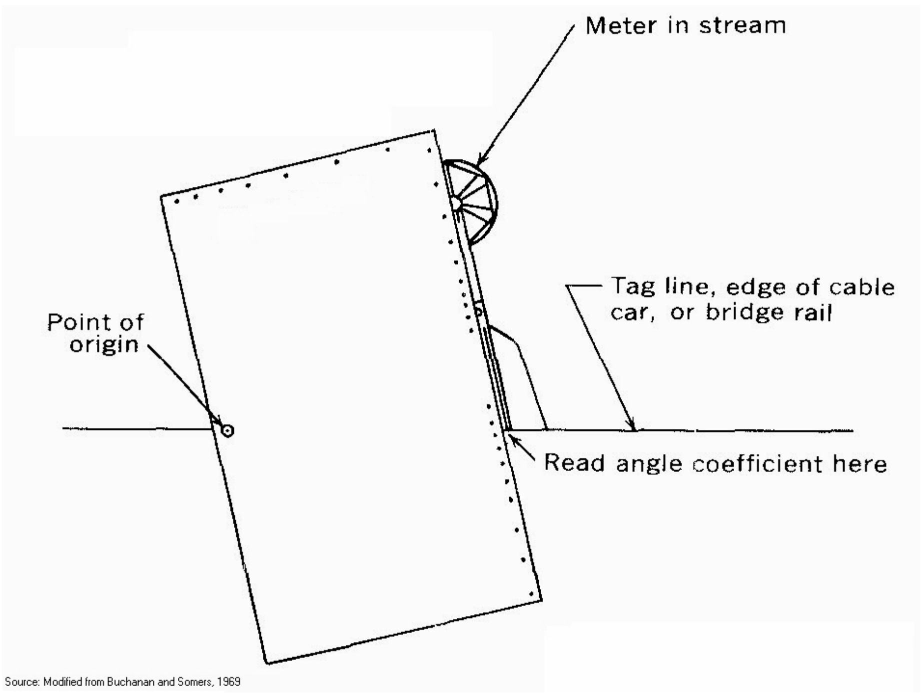
   d. The depth is read off the wading rod. The depth should be read and recorded to the nearest 0.02 ft.

   e. The mean velocity for SNWA miscellaneous discharge measurements is primarily determined using the six-tenths-depth method. The velocity is determined at six-tenths the depth of the water surface. This method is recommended by the USGS for depths between

0.3 and 2.5 ft (Buchanan and Somers, 1969). For depths greater than 2.5 ft or for depths greater than 1.5 ft with velocities greater than three feet per second the AA meter should be used. For depths greater than 2.5 ft, the 0.2/0.8-depth method should be used. The mean-in-vertical velocity is determined by adjusting the height of the bucket wheel on the top-setting wading rod to correspond to the depth of the water. When the top-setting wading rod is adjusted to read the depth of water, the current meter is positioned automatically for the six-tenths-depth method (Buchanan and Somers, 1969). To measure the velocity at 0.2-depth, set the rod on twice the observed depth. To measure the velocity at 0.8-depth, set the rod on one-half the depth. For example, if the observed depth is 1.0 ft, the 0.2-depth is obtained by setting the rod at 2 x 1.0 = 2.0; the 0.8-depth is obtained by setting the rod at 1.0 / 2 = 0.5.

f. A stopwatch is then used to measure a specific number of clicks from the rotation of the bucket wheel. The combination of the specific number of revolutions and the time required correspond to a mean-in-vertical velocity. For each current meter, the specific number of revolutions to be stopped on can be seen on the standard rating table for each of the meters. Each observation should be a minimum of 40 seconds. This mean-in-vertical value which is shown to three significant figures on the chart, is recorded on the Discharge Measurement Notes form in the Velocity column (see Attachment A).

g. When the flow in a particular subsection is not perpendicular to the tag line, the angle of flow must be determined to adjust the velocity observation (Figure 1). This is done by use of the angle coefficients marked on the back of the Discharge Measurement Notes Form. Note the angle of flow on the Adjusted for horizontal angle column on the form.



Source: Modified from Buchanan and Somers, 1969

Figure 1:
Measurement of Horizontal Angles

h. Calculate the area for each subsection. The area is calculated as the width of the subsection multiplied by the depth of the subsection. The area calculations for each subsection are rounded to two significant digits.

i. Calculate the discharge for each subsection. The discharge is calculated as of the vertical velocity multiplied by the area of the subsection. The discharge calculations for each subsection are rounded to three significant digits.

j. Move the top-setting wading rod to the next subsection along the tag line to the nearest 0.1 ft.

k. Repeat Steps 8b through 8k for the entire width of the cross section.

8. Calculate the total discharge for the measurement. The total discharge is the summation of the discharges for all the subsections. The final result should be recorded to three significant figures.

9. Calculate the average velocity using the rounded discharge and rounded area. Record the area, discharge and velocity on the front sheet. Also, record the total width on the front. The subsection widths should be added and compared to the difference between the left and right edges of the water. The final velocity result should be recorded to two significant figures if less than 10 ft per second.

10. If the site is a gaging station, compare the measured discharge to the rating curve. If there is a difference between the staff gage and data logger stage, use the staff gage reading and the effective rating curve stored in the gage house. Subtract the rating curve discharge from the measured discharge and divide the results by the rating curve discharge. Convert the answer to a percentage and record this percentage and the number of the current rating curve on the front page of the Discharge Measurement Notes form.

$$P_D = \left(\frac{Q_m - Q_R}{Q_R}\right) \times 100 \tag{9-1}$$

where,
Q_m = Measured discharge
Q_R = Rated discharge
P_D = Percent difference

11. Rate the miscellaneous discharge measurement (i.e., Excellent, Good, Fair, Poor) to indicate the accuracy of the measurement based on the conditions noted at the time of measurement. The USGS considers an Excellent measurement to be within two percent of the actual discharge, a Good measurement to be within five percent of the actual discharge, a Fair measurement to be within eight percent of the actual discharge, and a Poor measurement to not be within eight percent of the actual discharge (Holmes et al., 2001). These ratings are based on the number of sections, cross section characteristics, and flow conditions.

12. Perform a spin test on the current meter as discussed in Step 4. Note the spin time on the discharge measurement notes form on the Spin after meas. field.

13. Place a dash in all unused blanks on the front of the Discharge Measurement Notes form.

14. Clean the current meter of any material that may have become attached to the meter.

15. Disassemble the current meter according to manufacturer's instructions for travel.

16. An example of a completed SNWA Discharge Measurement Notes form can be found in Attachment A. Place a dash in all unused blanks on the form. The measurement shall be rated using the flow, cross section, and control description in conjunction with the number of verticals. Flow should be described as laminar, turbulent, uniform, nonuniform, center of channel boils, right/left side channel, etc. The cross section should include a description of the banks, including vegetation, general classification of bed material including lithologic description, amount of rounding, and particle distribution. (Table 1)

10.0 MAINTENANCE

The miscellaneous discharge measurement equipment is relatively rugged and easy to use but needs periodic maintenance to maintain peak performance. The following will help in the operation and life of the instrument:

- Keep the current meters and flumes free of mud and dirt.

- Always lubricate the bucket wheel and pivot pins, and check the top-setting wading rod for loose connections, breaks, kinks, and corrosion.

The current meters and flumes are precision instruments and need to be treated with care. The meters, rods, and flumes should be thoroughly cleaned and tested after each field trip. Wiring on the rods should be checked for corrosion, and meters should be tested and repaired, if necessary. Wiring on the rods should be replaced annually or sooner if performance has declined.

11.0 RECORDS

The SNWA Discharge Measurement Notes form and any field notes shall be secured and submitted to the Task Lead. The records will be examined by the Task Lead for completeness and acceptability for incorporation into the official SNWA record. The forms and field notebooks will then be copied and filed for historical traceability. The Task Lead will ensure that the measurements are summarized in an electronic form so that the data can be sent to the appropriate people for entry into the SNWA hydrologic database. The Task Lead will also ensure that the collected data are entered correctly and accurately into the database in a timely manner.

12.0 MODIFICATIONS

If modifications to this field operating procedure become necessary, the Task Lead or Senior Hydrologist will initiate a document review process. This process will consist of a subject matter expert making changes to the field operating procedure, submitting the new field operating procedure for technical as well as editorial review, assigning a new effective date, and assigning a new revision number to the field operating procedure.

13.0 REFERENCES

Buchanan, T.J., and Somers, W.P., 1969, Discharge Measurements at Gaging Stations: U.S. Geological Survey Techniques of Water-Resources Investigations Book 3, Chapter A8, 65 p.

Buffington, J.M., and Montgomery, D.R., 1999, A procedure for classifying textural facies in gravel-bed rivers. Water Resources Research, Vol. 35, No. 6, pp. 1903–1914.

Holmes, Jr., R.R., Terrio, P., Harris, M.A., and Mills, P.C., 2001, Introduction to Field Methods for Hydrologic and Environmental Studies: U.S. Geologic Survey Open-File Report 01-50, 241 p.

Kilpatrick, F.A., and Schneider, V.R., 1983, Use of Flumes in Measuring Discharge: U.S. Geologic Survey Techniques of Water-Resources Investigations Book 3, Chapter A14, 46 p.

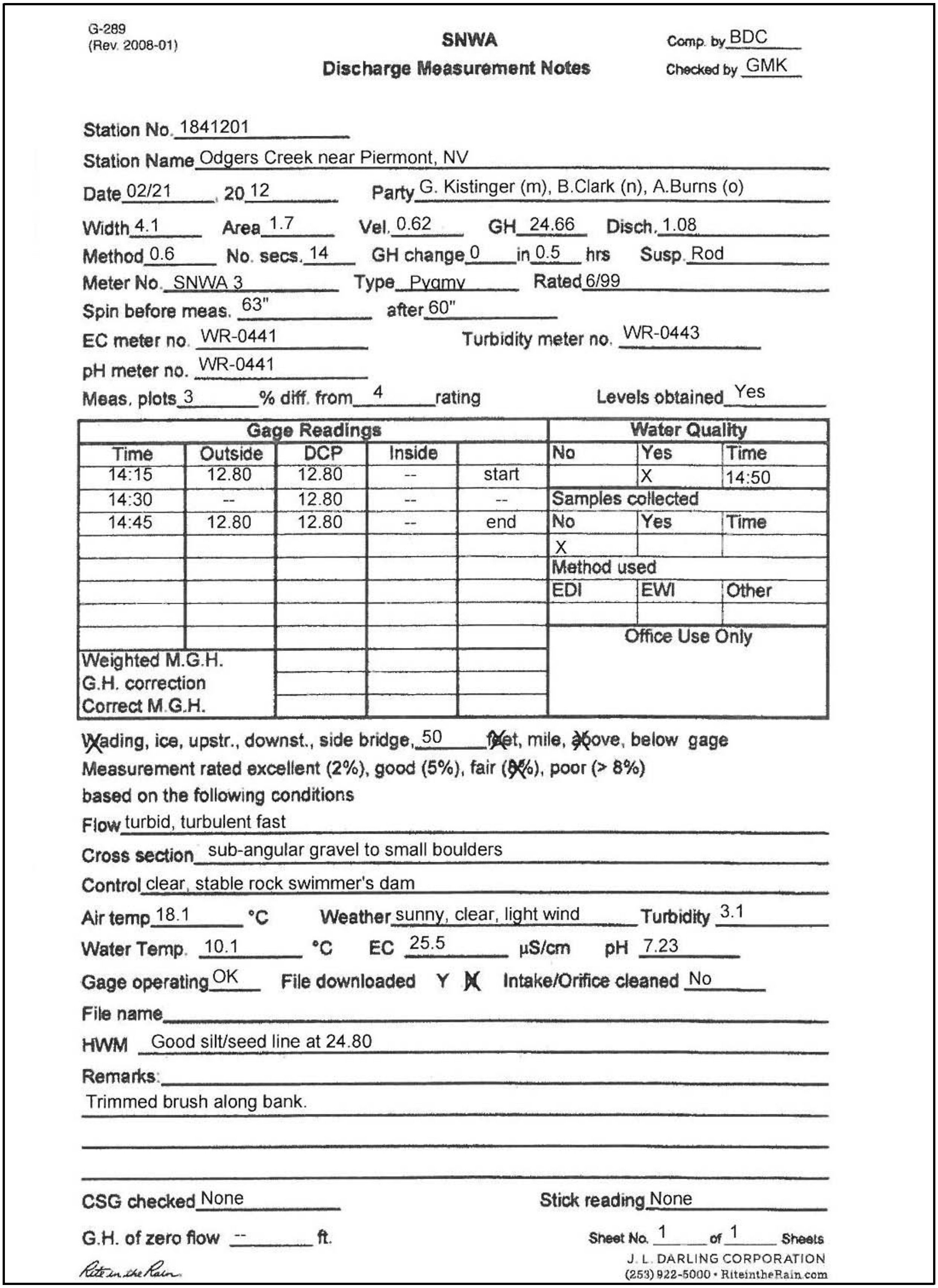
Rantz, S.E., and others, 1982, Measurement and Computation of Streamflow: U.S. Geological Survey Water Supply Paper 2175, V. 1, 2.

14.0 ATTACHMENTS

Attachment A - SNWA Discharge Measurement Notes Form

Attachment B - JBS Instruments AquaCalc Pro Instruction Manual

Attachment C - JBS Instruments AquaCalc Pro Plus Instruction Manual



G-289
(Rev. 2008-01)

SNWA

Discharge Measurement Notes

Comp. by BDC
Checked by GMK

Station No. 1841201
Station Name Odgers Creek near Piermont, NV
Date 02/21, 20 12 Party G. Kistinger (m), B.Clark (n), A.Burns (o)
Width 4.1 Area 1.7 Vel. 0.62 GH 24.66 Disch. 1.08
Method 0.6 No. secs. 14 GH change 0 in 0.5 hrs Susp. Rod
Meter No. SNWA 3 Type Pygmy Rated 6/99
Spin before meas. 63" after 60"
EC meter no. WR-0441 Turbidity meter no. WR-0443
pH meter no. WR-0441
Meas. plots 3 % diff. from 4 rating Levels obtained Yes

Gage Readings

Time	Outside	DCP	Inside	
14:15	12.80	12.80	--	start
14:30	--	12.80	--	--
14:45	12.80	12.80	--	end
Weighted M.G.H.				
G.H. correction				
Correct M.G.H.				

Water Quality

No	Yes	Time
	X	14:50

Samples collected

No	Yes	Time
X		

Method used

EDI	EWI	Other

Office Use Only

[✓ Wading], ice, upstr., downst., side bridge, 50 [✓ feet], mile, [✓ above], below gage
Measurement rated excellent (2%), good (5%), fair [✓ (8%)], poor (> 8%)
based on the following conditions
Flow turbid, turbulent fast
Cross section sub-angular gravel to small boulders
Control clear, stable rock swimmer's dam
Air temp 18.1 °C Weather sunny, clear, light wind Turbidity 3.1
Water Temp. 10.1 °C EC 25.5 µS/cm pH 7.23
Gage operating OK File downloaded Y [✓ N] Intake/Orifice cleaned No
File name
HWM Good silt/seed line at 24.80
Remarks:
Trimmed brush along bank.

CSG checked None Stick reading None
G.H. of zero flow -- ft.

Sheet No. 1 of 1 Sheets

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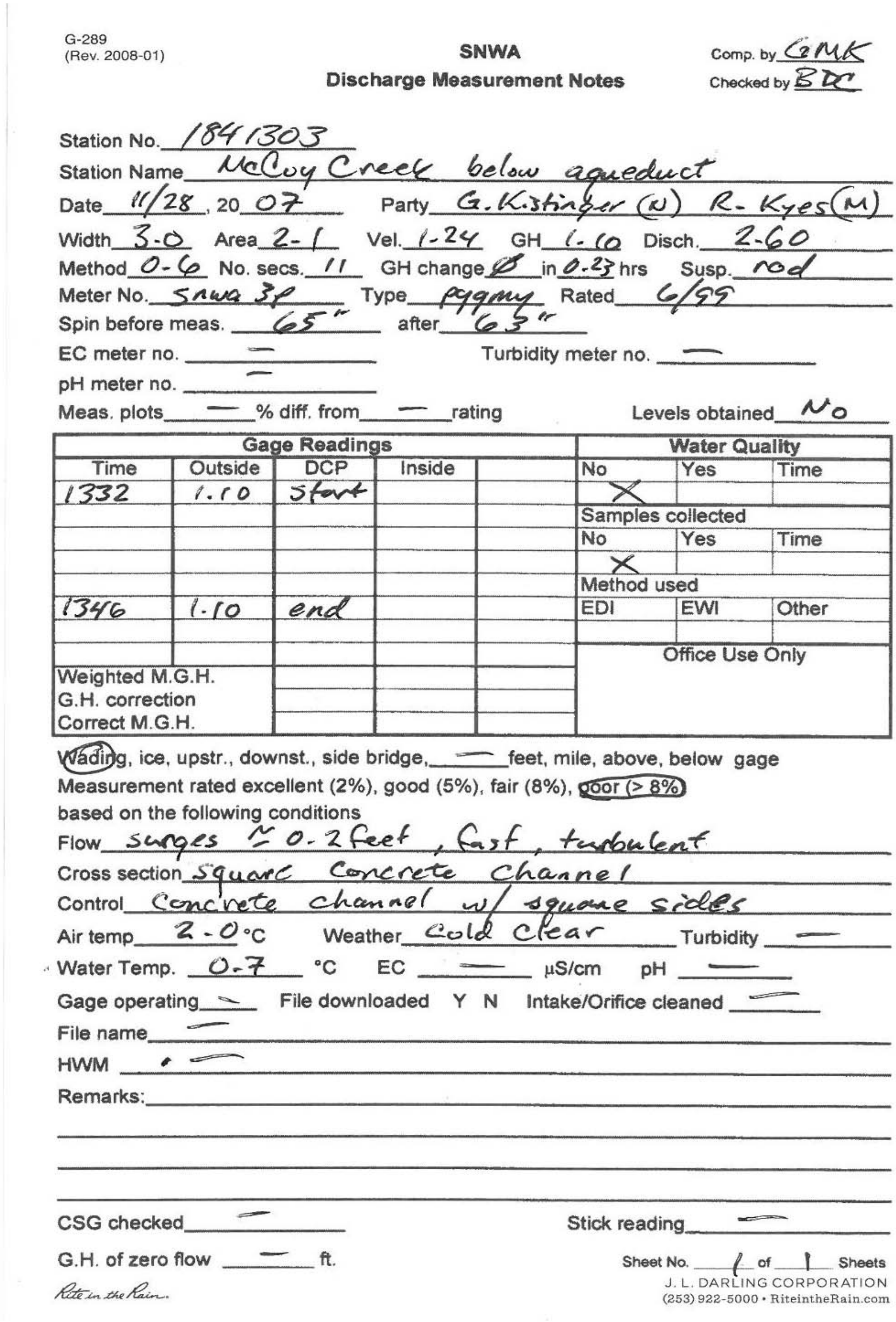

G-289
(Rev. 2008-01)

SNWA
Discharge Measurement Notes

Comp. by GMK
Checked by BDC

Station No. 1841303
Station Name McCoy Creek below aqueduct
Date 11/28, 2007 Party G. Kistinger (N) R. Kyes (M)
Width 3.0 Area 2.1 Vel. 1.24 GH 1.10 Disch. 2.60
Method 0.6 No. secs. 11 GH change 0 in 0.23 hrs Susp. rod
Meter No. snwa 3p Type pygmy Rated 6/99
Spin before meas. 65" after 63"
EC meter no. — Turbidity meter no. —
pH meter no. —
Meas. plots — % diff. from — rating Levels obtained No

Gage Readings				
Time	Outside	DCP	Inside	
1332	1.10	start		
1346	1.10	end		
Weighted M.G.H.				
G.H. correction				
Correct M.G.H.				

Water Quality		
No	Yes	Time
X		
Samples collected		
No	Yes	Time
X		
Method used		
EDI	EWI	Other
Office Use Only		

[✓ Wading], ice, upstr., downst., side bridge, — feet, mile, above, below gage
Measurement rated excellent (2%), good (5%), fair (8%), [✓ poor (> 8%)]
based on the following conditions
Flow surges ≈ 0.2 feet, fast, turbulent
Cross section Square Concrete Channel
Control Concrete channel w/ square sides
Air temp 2.0 °C Weather Cold Clear Turbidity —
Water Temp. 0.7 °C EC — µS/cm pH —
Gage operating — File downloaded Y N Intake/Orifice cleaned —
File name —
HWM • —
Remarks:

CSG checked — Stick reading —
G.H. of zero flow — ft.

Sheet No. 1 of 1 Sheets

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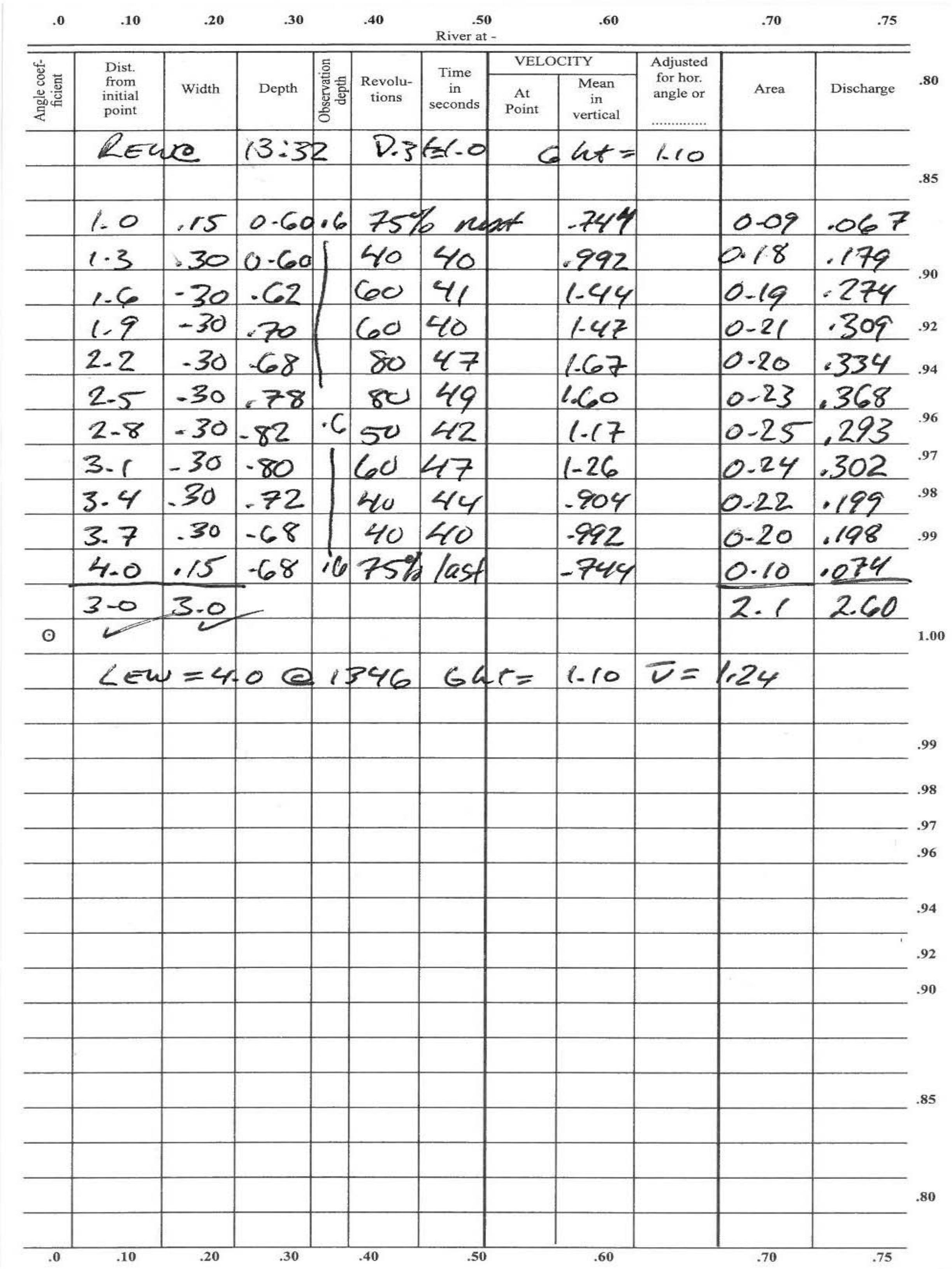

.0 .10 .20 .30 .40 .50 .60 .70 .75

River at -

Angle coef-ficient	Dist. from initial point	Width	Depth	Observation depth	Revolu-tions	Time in seconds	VELOCITY At Point	VELOCITY Mean in vertical	Adjusted for hor. angle or	Area	Discharge	.80
	REWO		13:32		D.3	El.0		GHt =	1.10			
												.85
	1.0	.15	0.60	.6	75% next			.744		0.09	.067	
	1.3	.30	0.60		40	40		.992		0.18	.179	.90
	1.6	.30	.62		60	41		1.44		0.19	.274	
	1.9	.30	.70		60	40		1.47		0.21	.309	.92
	2.2	.30	.68		80	47		1.67		0.20	.334	.94
	2.5	.30	.78		80	49		1.60		0.23	.368	.96
	2.8	.30	.82	.6	50	42		1.17		0.25	.293	
	3.1	.30	.80		60	47		1.26		0.24	.302	.97
	3.4	.30	.72		40	44		.904		0.22	.199	.98
	3.7	.30	.68		40	40		.992		0.20	.198	.99
	4.0	.15	.68	.6	75% last			.744		0.10	.074	
	3.0	3.0								2.1	2.60	
⊙	✓	✓										1.00
	LEW = 4.0 @ 1346				GHt =			1.10	$\bar{v}$ = 1.24			
												.99
												.98
												.97
												.96
												.94
												.92
												.90
												.85
												.80

.0 .10 .20 .30 .40 .50 .60 .70 .75

ATTACHMENTS B AND C

INTENTIONALLY OMITTED

Appendix G

Study Discharge Data

Table G-1
Site Attribute and Discharge Data
(Page 1 of 6)

Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951904	Big Spring at Gaging Station northern channel	102432241	1.1	3/5/2014	--	N	3.60[a]					3.60					Boulder and concrete dam, heavy algae, light to moderate debris.		USGS
1951904	Big Spring at Gaging Station northern channel	102432241	1.1	3/5/2014	10:00	Y	3.47	7.6	2.9	1.18	P		5.68	27	16.0		Boulder and concrete dam, heavy algae, light to moderate debris.		SNWA
1951904	Big Spring at Gaging Station northern channel	102432241	1.1	3/5/2014	16:10	N	3.72[a]	7.7	3.2	1.14	P		5.70	24	16.0		Boulder and concrete dam, heavy moss, light to moderate debris.		SNWA
1951904	Big Spring at Gaging Station northern channel	102432241	1.1	9/17/2014	--	N	3.70[a]					3.91					Concrete and rock riffle with heavy moss and watercress.		USGS
1951904	Big Spring at Gaging Station northern channel	102432241	1.1	9/17/2014	11:03	Y	3.91	7.3	3.9	1.01	P		5.76	25	17.0		Concrete and rock riffle with heavy moss and watercress.		SNWA
1951903	Big Spring at Gaging Station southern channel	10243224	1.2	3/5/2014		N	5.40[a]					5.44					4 ft and 14 ft weirs, clean and clear.		USGS
1951903	Big Spring at Gaging Station southern channel	10243224	1.2	3/5/2014	11:00	Y	5.47	6.5	9.0	0.61	F		8.22	23	15.0		4 ft and 14 ft weirs, clean and clear.		SNWA
1951903	Big Spring at Gaging Station southern channel	10243224	1.2	3/5/2014	16:10	Y							8.22				4 ft and 14 ft weirs, clean and clear.		SNWA
1951903	Big Spring at Gaging Station southern channel	10243224	1.2	9/17/2014	--	N	5.50[a]					5.44					Two downstream weirs, clean and clear.		USGS
1951903	Big Spring at Gaging Station southern channel	10243224	1.2	9/17/2014	10:00	Y	5.39	6.6	9.1	0.59	F		8.20	23	17.0		Two downstream weirs, clean and clear.		SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	3/5/2014	13:02	Y	6.15	9.6	5.0	1.24	P	6.30		33			Boulder riffle with moderate moss.		SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	3/5/2014	14:04	Y	6.21	9.6	4.9	1.26	F			28	16.0		Boulder riffle with moderate moss.		SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	3/6/2014	11:25	Y	6.54	9.9	5.0	1.32	P			30	17.6	17.0	Boulder swimmers dam with heavy moss.	389	SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	9/17/2014	13:03	Y	5.90	9.7	5.2	1.14	P	5.98		25	17.0		Section control, boulder and wood riffle.		SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	9/17/2014	14:00	Y	6.19	9.8	5.1	1.20	P			26	17.0		Section control, boulder and wood riffle.		SNWA
1951911	Big Springs Creek downstream of Okelberry Diversion Ditch Crossing		1.1.2	9/17/2014	16:00	Y	5.84	9.6	5.1	1.14	P			25	17.0		Section control, boulder and wood riffle.		SNWA
1951913	South Channel 14.375 ft Weir		1.2.1	3/5/2014	9:37	Y	1.74				G	1.74	0.11				14.375 ft suppressed weir, clean and clear.		SNWA
1951913	South Channel 14.375 ft Weir		1.2.1	9/17/2014	10:09	Y	1.98				G	1.98	0.12		17.0		14.375 ft suppressed weir, clean and clear.		SNWA
1951914	South Channel 4 ft Cippoletti Weir		1.2.2	3/5/2014	9:37	Y	3.67				G	3.67	0.42				4-ft Cipoletti weir, clean and clear.		SNWA
1951914	South Channel 4 ft Cippoletti Weir		1.2.2	9/17/2014	10:09	Y	3.28				G	3.28	0.39		17.0		4-ft Cipoletti weir, clean and clear.		SNWA
1951916	Okelberry Diversion Ditch downstream of Big Springs Creek Crossing		1.2.4	3/5/2014	12:11	Y	3.16	8.1	3.0	1.05	F	3.26		24	16.0		Grass-lined channel.		SNWA
1951916	Okelberry Diversion Ditch downstream of Big Springs Creek Crossing		1.2.4	3/5/2014	14:58	Y	3.31	8.3	3.1	1.07	P			27	16.0		Grass-lined channel.		SNWA
1951916	Okelberry Diversion Ditch downstream of Big Springs Creek Crossing		1.2.4	3/6/2014	10:54	Y	3.30	8.1	3.0	1.12	P			21	17.2	17.0	Channel with steep grass lined banks.	389	SNWA
1951916	Okelberry Diversion Ditch downstream of Big Springs Creek Crossing		1.2.4	9/17/2014	12:05	Y	3.86	5.7	2.7	1.45	P	3.84		20	18.0		Section control, clean boulder riffle.		SNWA
1951916	Okelberry Diversion Ditch downstream of Big Springs Creek Crossing		1.2.4	9/17/2014	15:03	Y	3.82	5.7	2.6	1.46	P			19	17.0		Section control, clean boulder riffle.		SNWA

[a] Gaging station data reported by USGS.

Table G-1
Site Attribute and Discharge Data
(Page 2 of 6)

Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951917	Big Springs South Creek E of Big Springs Ranch		1.2.5	9/17/2014	12:40	Y	0.057				E	0.06					3 -inch mod Parshall flume, clean and clear.		SNWA
1951919	Unamed Spring Creek upstream of Big Springs Creek		1.3.1	3/5/2014	12:55	Y	0.009				E	0.01					3-inch modified Parshall flume.		SNWA
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	7:45	Y	7.05	9.7	4.4	1.60	F	7.97		18	12.9		Channel with soft banks.	437	SNWA
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	9:59	Y	8.32	10.3	5.1	1.65	F			30	12.5	8.5	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	11:08	Y	8.45	10.3	5.2	1.64	F			30	14.0	9.5	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	12:10	Y	8.28	10.3	5.1	1.61	F			29	14.0	14.0	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	13:07	Y	8.01	10.3	5.2	1.55	F			30	15.0	13.5	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	14:10	Y	7.92	10.3	5.1	1.54	F			30	15.0	12.5	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	15:10	Y	7.83	10.3	5.2	1.51	F			29	14.0	11.5	Grassy, near vertical banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	3/5/2014	16:09	Y	7.87	10.3	5.1	1.53	F			30	13.0	8.5	Grass lined banks.		FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	8:03	Y	6.36	9.7	4.3	1.48	F	7.50		21			Channel with steep banks.		SNWA
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	10:05	Y	7.49	9.5	5.3	1.42	F			20	19.2	22.0			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	11:01	Y	7.94	9.5	5.5	1.45	F			20	20.8	24.9			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	12:01	Y	7.74	9.5	5.5	1.41	F			20	22.2	26.0			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	12:59	Y	7.75	9.5	5.5	1.41	F			20	22.5	23.2			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	13:55	Y	7.65	9.5	5.5	1.40	F			20	23.0	22.5			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	15:06	Y	7.57	9.5	5.5	1.38	F			20	22.8	24.0			FWS
1951920	Big Springs Creek at Upstream Okelberry Meadow		2	9/17/2014	15:58	Y	7.46	9.5	5.4	1.37	F			20	20.8	22.5			FWS
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	8:40	Y	8.56	9.2	7.2	1.19	F	8.98		24	10.0		Channel with steep sides and soft edges.	536	SNWA
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	9:55	Y	9.10	9.7	8.2	1.10	G			25	11.0		Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	10:58	Y	8.84	9.7	8.2	1.08	F			25			Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	12:00	Y	9.09	9.7	8.2	1.11	G			25			Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	12:58	Y	9.25	9.7	8.2	1.13	G			25	15.0		Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	13:58	Y	9.15	9.7	8.1	1.13	G			25	15.0		Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	14:55	Y	9.04	9.7	8.1	1.12	G			25	15.0		Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	3/5/2014	15:55	Y	8.77	9.7	8.0	1.10	F			25	15.0		Channel with steep sides and soft edges.		NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	10:00	Y	7.07	9.4	5.7	1.24	F	7.02		25	14.0				NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	11:00	Y	6.95	9.4	5.7	1.21	F			25					NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	11:58	Y	6.90	9.4	5.8	1.20	F			25					NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	13:01	Y	7.08	9.4	5.8	1.23	F			25					NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	13:58	Y	6.93	9.4	5.6	1.25	F			25					NDWR
1951921	Big Springs Creek at Mid-Okelberry Meadow		3	9/17/2014	14:58	Y	7.19	9.4	5.8	1.25	F			25					NDWR
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	9:38	Y	9.91	10.6	8.8	1.12	F			23	10.0		Grass lined banks and channel.	563	SNWA
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	10:12	Y	11.2	10.6	9.1	1.24	P			23			Channel with steep grass banks.		NPS

Table G-1
Site Attribute and Discharge Data
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Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	11:08	Y	10.6	10.6	9.3	1.14	P	10.74		23	12		Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	12:03	Y	11.0	10.6	9.3	1.19	P			23	12		Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	13:00	Y	10.8	10.6	9.1	1.18	P			23	13		Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	14:00	Y	10.8	10.6	9.2	1.17	P			23	14		Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	15:00	Y	10.8	10.6	9.1	1.18	P			23	14		Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	3/5/2014	15:59	Y	10.8	10.6	9.1	1.19	P			23			Channel with steep grass banks.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	9:38	Y	6.73	11.0	6.5	1.04	F	7.16		23	17.0	26.0	Channel with debris downstream.		SNWA
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	10:22	Y	7.38	11.0	6.4	1.15	F			23	26.0	17.0	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	11:06	Y	7.00	11.0	6.3	1.11	F			23	18.7	29.0	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	12:06	Y	7.25	11.0	6.4	1.14	F			23	20.3	30.0	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	13:07	Y	7.23	11.0	6.3	1.14	F			23	21.6	31.5	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	14:07	Y	7.31	11.0	6.4	1.14	F			23	22.6	30.2	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	15:12	Y	7.21	11.0	6.3	1.14	F			23	22.6	26.6	Channel with debris downstream.		NPS
1951922	Big Springs Creek at Downstream Okelberry Meadow		4	9/17/2014	16:06	Y	7.20	11.0	6.4	1.13	F			23	23.7	30.0	Channel with debris downstream.		NPS
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	9:58	Y	9.89	10.9	12.0	0.82	P	10.23		28		15.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	11:00	Y	9.72	11.1	12.3	0.79	P			24	10.0	14.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	11:59	Y	10.3	11.1	12.5	0.82	P			24	10.0	19.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	12:59	Y	10.5	11.1	12.6	0.83	P			24	11.0	23.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	14:00	Y	10.1	11.0	12.5	0.81	P			24	12.0	20.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	14:59	Y	10.1	11.0	12.3	0.82	P			24	13.0	18.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/5/2014	16:00	Y	10.3	11.0	12.4	0.83	P			24	13.0	14.0	Steep grass lined banks.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	3/6/2014	9:34	Y	10.9	11.1	13.2	0.83	P			24	8.8	18.0	Channel with steep grass lined banks.	501	SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	10:06	Y	6.77	11.1	9.1	0.74	F	6.97		24	16.0	27.0	Grass-lined channel.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	11:07	Y	6.77	11.1	9.0	0.75	F			26	19.0	30.0	Grass-lined channel.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	12:09	Y	7.08	11.1	9.2	0.77	F			26	19.5		Grass-lined channel.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	13:10	Y	6.98	11.1	9.2	0.76	F			27	20.5		Grass-lined channel.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	14:09	Y	7.00	11.1	9.0	0.78	F			26	22.0	28.0	Grass-lined channel.		SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	15:12	Y	7.13	11.1	9.2	0.78	F			26	22.2	30.0	Grass-lined channel.	405	SNWA
1951923	Big Springs Creek downstream of Culvert		5	9/17/2014	16:07	Y	7.03	11.1	9.0	0.78	F			26	23.0	31.0	Grass-lined channel.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	9:55	Y	11.6	12.1	13.4	0.86	F	11.39		28	7.1	10.5	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	11:00	Y	11.8	12.1	14.1	0.84	F			20	9.1	14.8	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	12:00	Y	10.7	12.1	13.6	0.79	F			21	9.3	14.7	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	13:03	Y	11.4	12.1	14.1	0.81	F			23	11.5	19.5	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	14:00	Y	11.7	12.1	14.2	0.83	F			21	11.9	18.7	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	15:00	Y	11.7	12.1	14.2	0.82	P			22	12.5	17.1	Debris swimmers dam.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	3/5/2014	16:05	Y	10.8	12.1	13.4	0.81	F			25			Boulder and debris pile with eroding banks.		SNWA

Table G-1
Site Attribute and Discharge Data
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Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	10:08	Y	7.27	11.0	8.5	0.86	F	7.37		25	16.1		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	11:00	Y	7.27	11.0	8.7	0.84	F			23	17.2		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	11:55	Y	7.15	11.0	8.6	0.83	F			22	21.1		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	12:59	Y	7.26	10.8	8.6	0.84	F			27	20.0		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	14:04	Y	7.63	11.0	8.7	0.88	F			28	20.0		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	15:05	Y	7.60	11.0	8.9	0.86	F			24	21.1		Downstream boulder swimmers dam diversion.		SNWA
1951924	Big Springs Creek upstream of Dearden House Ditch		6	9/17/2014	16:01	Y	7.38	11.0	8.6	0.85	F			24	21.1	26.6	Downstream boulder swimmers dam diversion.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	10:45	Y	0.96	1.0	0.94	1.03	P	1.04		6	4.3	14.6	Submerged 1 ft ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	11:35	Y	1.04	1.0	0.94	1.11	P			6	9.3	15.0	Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	12:43	Y	1.06	1.0	0.94	1.12	P			6	10.8	18.1	Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	13:43	Y	1.05	1.0	0.94	1.12	P			6	11.8	18.6	Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	14:38	Y	1.05	1.0	0.94	1.12	P			6	12.3	17.4	Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	15:39	Y	1.08	1.0	0.94	1.15	P			6	12.3	15.4	Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	3/5/2014	16:35	Y	1.01	1.0	0.95	1.06	P			6			Submerged 1 foot ramp flume.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	10:43	Y	0.34	1.0	0.48	0.71	P	0.33		5	16.1		Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	11:28	Y	0.35	1.0	0.48	0.73	P			5	17.2		Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	12:29	Y	0.33	1.0	0.48	0.69	P			5	21.1		Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	13:42	Y	0.34	1.0	0.48	0.71	P			4	20.0		Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	14:42	Y	0.31	1.0	0.48	0.65	P			5	20.0	28.9	Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	15:35	Y	0.30	1.0	0.48	0.62	P			5	21.1	23.3	Grass lined channel.		SNWA
1951925	Dearden House Ditch Diversion		6.1	9/17/2014	16:33	Y	0.31	1.0	0.48	0.65	P			5	21.1	26.7	Grass lined channel.		SNWA
1951926	Big Springs Creek at Powerline		7	3/5/2014	10:00	Y	9.10	10.6	6.4	1.42	F	9.51		22	8.0	5.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	11:00	Y	8.84	10.6	6.4	1.38	F			22	9.0	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	11:35	Y	9.49	10.9	6.3	1.51	F			22	9.5		Channel with steep grass lined banks.	555	SNWA
1951926	Big Springs Creek at Powerline		7	3/5/2014	12:00	Y	9.45	10.6	6.3	1.50	F			22	9.5	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	13:00	Y	10.2	10.6	6.6	1.55	F			22	9.5	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	14:00	Y	10.2	10.6	6.5	1.57	F			22	11.0	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	15:00	Y	9.01	10.6	6.4	1.41	F			22	11.0	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	3/5/2014	16:00	Y	9.80	10.6	6.4	1.53	F			22	11.0	7.0	Channel with steep grass lined banks.		NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	10:00	Y	6.46	10.5	4.8	1.35	F			22	17.0	29.0			NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	11:00	Y	6.39	10.5	4.8	1.33	F			22	17.0	29.0			NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	12:00	Y	6.47	10.5	4.8	1.35	F			22	18.0	32.0			NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	13:00	Y	6.06	10.5	4.9	1.24	F			21	23.0	32.0			NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	14:00	Y	7.04	10.5	5.0	1.41	F			22	25.0				NDWR

Table G-1
Site Attribute and Discharge Data
(Page 5 of 6)

Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951926	Big Springs Creek at Powerline		7	9/17/2014	15:00	Y	6.68	10.5	5	1.34	F	6.57		22	25.0	34.0			NDWR
1951926	Big Springs Creek at Powerline		7	9/17/2014	16:00	Y	6.89	10.5	5	1.38	F			22	25.0	34.0			NDWR
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	9:04	Y	9.63	4.6	3.1	3.08	P	9.73		13	7.0	8.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	9:58	Y	9.85	4.6	3.1	3.17	P			13	7.0	11.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	10:51	Y	10.6	4.6	3.3	3.21	P			13	7.0	13.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	11:58	Y	9.64	4.60	3	3.18	P			13	8.0	13.5	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	12:38	Y	8.64	4.7	3	2.93	P			13	10.3	15.0	Concrete diversion structure.	570	SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	13:03	Y	9.70	4.60	2.9	3.33	P			13	9.0	14.5	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	13:59	Y	9.63	4.60	3	3.25	P			13	9.0	15.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	14:25	Y	9.78	4.5	2.9	3.35	P			13		13.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	14:58	Y	9.92	4.60	3	3.33	P			13	10.0	15.5	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	3/5/2014	15:58	Y	9.90	4.60	3	3.27	P			13	10.0	15.0	Cement flume, light moss and algae.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	9:53	Y	6.42	4.7	4.5	1.43	P	6.50		17		26.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	10:56	Y	6.49	4.7	4.5	1.46	P			17		28.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	12:02	Y	6.38	4.7	4.5	1.42	P			17		30.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	13:01	Y	6.67	4.7	4.5	1.49	P			17		30.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	14:01	Y	6.51	4.7	4.5	1.46	P			17		29.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	15:02	Y	6.52	4.7	4.4	1.48	P			17		26.0	Cement diversion with 2x4 wood weir.		SNWA
1951927	Big Springs Creek upstream of Stateline		8	9/17/2014	16:01	Y	6.51	4.7	4.4	1.46	P			17		28.0	Cement diversion with 2x4 wood weir.		SNWA
1951928	Big Springs Creek Highline Ditch upstream of Stateline		8.1	3/5/2014	9:00	Y	0.00				E	0.00				8.0			SNWA
1951928	Big Springs Creek Highline Ditch upstream of Stateline		8.1	9/17/2014	10:30	Y	0.00				E	0.00				26.0			SNWA
1951905	Big Springs Creek Abv. Dearden Ranch, Flume		9	3/5/2014	10:32	Y	9.56	4.0	5.2	1.84	P	9.36	1.24	14	7.0		2 ft Parshall flume.		UGS
1951905	Big Springs Creek Abv. Dearden Ranch, Flume		9	3/5/2014	13:05	Y	9.15	3.9	5.0	1.82	P		1.22	15	10.0		2 ft Parshall flume.		UGS
			9																
1951905	Big Springs Creek Abv. Dearden Ranch, Flume		9	9/17/2014	11:41	Y	6.42	3.9	3.9	1.63	P	6.42	0.95	15			2 ft. Parshall flume.		UGS
1951907	East Middle Ditch, Flume		10	3/5/2014	9:21	Y	15.4	5.2	6.0	2.59	F	15.30	1.06	18	8.5		3 ft Parshall flume.		UGS
1951907	East Middle Ditch, Flume		10	3/5/2014	12:02	Y	15.2	5.2	5.8	2.63	F		1.06	19	11.5		3 ft Parshall flume.		UGS
1951907	East Middle Ditch, Flume		10	9/17/2014	13:09	Y	8.65	4.8	3.9	2.26	P	8.65	0.73	18			3 ft. Parshall flume.		UGS
1951908	West Middle Ditch, Flume		11	3/5/2014	11:08	Y	3.47	6.0	3.9	0.89	F	3.38	0.33	21	11.0		6 ft ramp flume.		UGS
1951908	West Middle Ditch, Flume		11	3/5/2014	14:12	Y	3.29	6.0	3.8	0.86	F		0.33	22	11.5		6 ft ramp flume.		UGS
1951908	West Middle Ditch, Flume		11	9/17/2014	10:01	Y	5.65	6.0	4.6	1.22	F		0.46	22			20 cfs ramp flume.		UGS

Table G-1
Site Attribute and Discharge Data
(Page 6 of 6)

Station Number	Station Name	Other Agency ID Number	Project Site Number	Date	Time	Measured	Discharge (cfs)	Width (ft)	Area (Sq ft)	Velocity (ft/sec)	Accuracy Code	Average Discharge	Outside GHT (ft)	Number of Sections	Water Temp (°C)	Air Temp (°C)	Control	Electrical conductivity (µS/cm)	Measurement Agency
1951908	West Middle Ditch, Flume		11	9/17/2014	10:54	Y	5.81	6.0	4.6	1.25	F	5.68	0.46	22			20 cfs ramp flume.		UGS
1951908	West Middle Ditch, Flume		11	9/17/2014	12:26	Y	5.56	6.0	4.6	1.21	F		0.455	22			20 cfs ramp flume.		UGS
1951908	West Middle Ditch, Flume		11	9/17/2014	14:07	Y	5.69	6.0	4.6	1.23	F		0.46	22			20 cfs ramp flume.		UGS
1951908	West Middle Ditch, Flume		11	9/17/2014	15:52	Y	5.71	6.0	4.6	1.23	F		0.46	22			20 cfs ramp flume.		UGS
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	10:00	Y	12.8	12.5	10.8	1.18	P	12.61		26	6.0	12.0	Shallow vegetated bank.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	11:00	Y	13.3	12.5	11.1	1.19	P			25	6.0	15.0	Grassy low angle banks.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	12:00	Y	13.0	12.0	10.8	1.21	P			25	9.0	16.0	Grassy low angle banks.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	13:00	Y	12.7	12.0	10.4	1.21	P			25	9.5	16.0	Grassy low angle banks.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	13:57	Y	11.6	12.0	10.5	1.11	P			25	9.3	16.0	Channel with grass lined banks and vegetation.	746	SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	15:01	Y	12.7	12.0	10.8	1.17	P			25		14.0	Grassy low angle banks.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	3/5/2014	16:01	Y	12.2	12.0	10.8	1.13	P			25			Grassy low angle banks.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	10:09	Y	0.00	4.9	0.90	0.00	P	0.05		17	19.1	26.0	Stream ponded above and below measured section.	954	SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	11:01	Y	0.08	4.9	0.90	0.09	P			16		28.0	Stream ponded above and below section.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	12:01	Y	0.07	4.9	0.88	0.08	P			16	25.0	30.0	Ponded water above and below section.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	13:01	Y	0.07	4.9	0.88	0.08	P			17	28.0	30.0	Ponded water above and below section.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	14:00	Y	0.06	4.9	0.87	0.07	P			17	28.0	31.0	Ponded water above and below section.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	15:02	Y	0.06	4.9	0.81	0.07	P			14	29.0		Ponded water above and below section.		SNWA
1951929	Lake Creek upstream of Clay Spring		12	9/17/2014	16:02	Y	0.03	4.9	0.76	0.04	P			15	28.0	29.0	Ponded water above and below section.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	9:05	Y	16.3	7.8	12.7	1.28	P	16.43		20		11.0	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	9:59	Y	16.4	7.8	13.3	1.24	P			20		10.0	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	11:00	Y	16.3	7.8	13.1	1.25	P			20		16.1	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	12:02	Y	16.4	8.0	13.4	1.22	P			20		17.3	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	13:00	Y	16.9	7.8	13.1	1.24	P			20		17.3	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	14:00	Y	16.8	7.8	13.2	1.28	P			20		17.4	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	15:05	Y	15.9	7.5	13.5	1.18	P			16			Aquatic debris DS and channel banks.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	3/5/2014	16:00	Y	16.4	7.5	13.2	1.24	P			20		15.7	Bullrush downstream.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	9:04	Y	1.23	5.5	3.4	0.36	P	1.31		19	17.1	24.0	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	9:57	Y	1.37	5.5	3.9	0.35	P			18	19.7	27.4	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	11:06	Y	1.31	5.5	4.0	0.33	P			19	19.0	28.8	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	12:01	Y	1.31	5.5	4.1	0.32	P			17	19.9	32.8	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	13:04	Y	1.36	5.5	4.2	0.33	P			18	20.8	34.2	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	14:01	Y	1.16	5.5	4.3	0.27	P			18	21.6	36.0	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	14:58	Y	1.33	5.5	4.3	0.31	P			18	21.9	32.7	Grass-lined channel.		SNWA
1951930	Lake Creek upstream of Pruess Lake		13	9/17/2014	16:05	Y	1.40	5.5	4.2	0.33	P			18	22.4	33.6	Grass-lined channel.		SNWA

Appendix H

Irrigation Schedule

Fax cover sheet Baker Ranches inc.

Pages including cover sheet 5

ATTN: Lucy Jordan

Subject: 2nd Big springs irr. Co. Schedule. The water may be Diverted Down the highline Ditch During Deardon or Baker Turns. Deardon has taken it in the highline once so far. I think. Bakers will take it on the 5/10 turn for the first time this season. We will prob have it in there for a couple of Days & won't take it in the highline for several Turns. I installed a ramp flume in the house Ditch. There was about 1.6 CFS Diverted Down that Ditch on 5/5.

Thanks

Craig Baker

2nd Big Springs Irr. Co.
Includes all water except House Ditch
* UTAH Times

4/7 - turn water down
4/8 - Carter - lone tree; 5 AM, 30 hr.
4/9 - Gonder; 11 AM, 30 hr.
4/10 - Carter at Wheelers; 5 PM, 41.5 hr
4/12 - Baker; 10:30 AM, 72.5 hr.
4/16 - Dearden; 1:00 PM, 29 hr.
4/17 - Ditch; 6 PM
4/18 - Carter; 5 AM
4/19 - Gonder; 11 AM
4/20 - Carter; 5 PM
4/22 - Baker; 10:30 AM
4/26 - Dearden; 1 PM
4/27 - Ditch; 6 PM
4/28 - Carter; 5 AM
4/29 - Gonder; 11 AM
4/30 - Carter; 5 PM
5/2 - Baker; 10:30 AM
5/6 - Dearden; 1 PM
5/7 - Ditch; 6 PM
5/8 - Carter; 5 AM
5/9 - Gonder; 11 AM
5/10 - Carter; 5 PM
5/10 - Baker; 10:30 AM
5/16 - Dearden; 1 PM
5/17 - Ditch; 6 PM

*UTAH TIMES

5/18 - Carter ; 5 AM
5/19 - Gonder ; 11 AM
5/20 - Carter ; 5 PM
5/22 - Baker ; 10:30 AM
5/26 - Dearden ; 1 PM
5/27 - Ditch ; 6 PM
5/28 - Carter ; 5 AM
5/29 - Gonder ; 11 AM
5/30 - Carter ; 5 PM
6/1 - Baker ; 10:30 AM
6/5 - Dearden ; 1 PM
6/6 - Ditch ; 6 PM
6/7 - Carter ; 5 AM
6/8 - Gonder ; 11 AM
6/9 - Carter ; 5 PM
6/11 - Baker ; 10:30 AM
6/15 - Dearden ; 1 PM
6/16 - Ditch ; 6 PM
6/17 - Carter ; 5 AM
6/18 - Gonder ; 11 AM
6/19 - Carter ; 5 PM
6/21 - Baker ; 10:30 AM
6/25 - Dearden ; 1 PM
6/26 - Ditch ; 6 PM
6/27 - Carter ; 5 AM
6/28 - Gonder ; 11 AM
6/29 - Carter ; 5 PM

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*Utah Times

7/1 - Baker: 10:30 AM
7/5 - Dearden: 1 PM
7/6 - Ditch: 6 PM
7/7 - Carter: 5 AM
7/8 - Gonder: 11 AM
7/9 - Carter: 5 PM
7/11 - Baker: 10:30 AM
7/15 - Dearden: 1 PM
7/16 - Ditch: 6 PM
7/17 - Carter: 5 AM
7/18 - Gonder: 11 AM
7/19 - Carter: 5 PM
7/21 - Baker: 10:30 AM
7/25 - Dearden: 1 PM
7/26 - Ditch: 6 PM
7/27 - Carter: 5 AM
7/28 - Gonder: 11 AM
7/29 - Carter: 5 PM
7/31 - Baker: 10:30
8/4 - Dearden: 1 PM
8/5 - Ditch: 6 PM
8/6 - Carter: 5 AM
8/7 - Gonder: 11 AM
8/8 - Carter: 5 PM
8/10 - Baker: 10:30 AM
8/14 - Dearden: 1 PM
8/15 - Ditch: 6 PM

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Utah Times

8/16 - Carter; ~~Am~~ 5 AM
8/17 - Gonder; 11 AM
8/18 - Carter; 5 PM
8/20 - Baker; 10:30 AM
8/24 - Dearden; 1 PM
8/25 - Ditch; 6 PM
8/26 - Carter; 5 AM
8/27 - Gonder; 11 AM
8/28 - Carter; 5 PM
8/30 - Baker; 10:30 AM
9/3 - Dearden; 1 PM
9/4 - Ditch; 6 PM
9/5 - Carter; 5 AM
9/6 - Gonder; 11 AM
9/7 - Carter; 5 PM
9/9 - Baker; 10:30 AM
9/13 - Dearden; 1 PM
9/14 - Ditch; 6 PM
9/15 - Carter; 5 AM
9/16 - Gonder; 11 AM
9/17 - Carter; 5 PM
9/19 - Baker; 10:30 AM
9/23 - Dearden; 1 PM
9/24 - Ditch; 6 PM
9/25 - Carter; 5 AM
9/26 - Gonder; 11 AM
9/27 - Carter; 5 PM

Appendix I

Water-Chemistry Data

Table I-1
Study Field Chemistry Results

Site Data				Non-Irrigation Season					Irrigation Season				
Site Number	Distance (miles)	River Miles	Total Distance	Date	Time	EC (µS/cm)	Temp (°C)	DO (mg/L)	Date	Time	EC (µS/cm)	Temp (°C)	DO (mg/L)
1.1, 1.2	0	--	0	3/5/2014	15:00	383	17.3	5.89	9/17/2014	13:40	384	18.1	5.82
2	0.83	1.63	0.93	3/5/2014	14:20	418	16.4	9.51	9/17/2014	13:10	388	23.2	9.34
3	0.94	1.74	1.87	3/5/2014	13:30	521	15.3	11.77	9/17/2014	12:45	398	22.1	9.36
4	0.87	1.22	2.74	3/5/2014	12:40	566	12.8	12.17	9/17/2014	12:22	412	21	9.33
5	0.63	0.93	3.37	3/5/2014	15:30	557	13.4	11.09	9/17/2014	14:40	405	22.2	8.6
6	1.38	1.77	4.75	3/5/2014	16:00	528	12.5	11.02	9/17/2014	14:20	407	22	8.54
7	0.93	1.22	5.68	3/5/2014	11:50	558	9.0	11.66	9/17/2014	11:30	422	18.1	8.74
8	1.1	1.36	6.78	3/5/2014	11:25	566	9.3	11.28	9/17/2014	11:15	426	18.3	8.59
10,11	1.04	1.19	7.82	3/5/2014	9:50	486	9.8	9.41	9/17/2014	10:40	400	16.8	7.95
12	5.73	--	13.53	3/5/2014	10:30	741	5.1	11.32	9/17/2014	9:50	954	19.1	4.15
13	1.58	1.98	15.11	3/5/2014	8:45	795	5.0	8.35	9/17/2014	9:00	709	16.7	6.52

Table I-2
Study Water Chemistry Data - Major Ions

Samples Taken March 5, 2014

Sample Reference ID	Chain of Custody	Sample Date	Station Number	Alkalinity, CO3 (mg/L)	Alkalinity, HCO3 (mg/L)	Alkalinity, OH (mg/L)	Alkalinity, Total (mg/L)	Boron (mg/L)	Bromide (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Conductivity (uS/cm)	Fluoride (mg/L)	Hardness, Total (mg/L as CaCO3)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	o-Phosphate as P (mg/L)	Potassium (mg/L)	Silica, Total (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	T-Phosphate as P (mg/L)	TDS (mg/L)	Total Susp. Solids (mg/L)
14030089-016	14030089	3/5/2014 15:00	1	0	198	0	198	<.1	0.0327	48	5.2	393	0.15	200	0.48	<.02	0.0028	1.2	13	5	8.3	0.0055	205	<5
14030089-015	14030089	3/5/2014 14:20	2	3.88	219	0	223	<.1	0.0356	49	5.9	428	0.17	230	0.32	<.02	0.002	1.7	16	5.9	9.1	0.014	226	11.5
14030089-014	14030089	3/5/2014 13:30	3	12.4	267	0	279	<.1	0.0426	49	11	521	0.17	280	0.18	<.02	0.0073	3.4	20	13	13	0.024	292	10
14030089-013	14030089	3/5/2014 12:40	4	11.6	287	0	299	<.1	0.0511	50	15	566	0.17	300	0.15	<.02	0.0048	3.9	20	15	15	0.024	336	11.5
14030089-017	14030089	3/5/2014 15:30	5	14.8	281	0	296	<.1	0.0501	50	15	557	0.17	300	0.1	<.02	0.0043	3.9	20	15	15	0.021	322	16.5
14030089-019	14030089	3/5/2014 15:30	5 Dup	14.4	281	0	295	<.1	0.0414	50	15	557	0.17	300	0.093	<.02	0.0043	3.8	20	15	15	0.025	328	14.8
14030089-018	14030089	3/5/2014 16:00	6	12.1	279	0	292	<.1	0.0431	52	15	528	0.17	310	0.12	<.02	0.0065	3.6	20	15	15	0.028	328	27.2
14030089-005	14030089	3/5/2014 11:50	7	6.35	286	0	292	<.1	0.0507	53	16	558	0.17	310	0.19	<.02	0.0055	3.5	20	15	15	0.023	331	<5
14030089-004	14030089	3/5/2014 11:25	8	6.16	286	0	292	<.1	0.0531	56	18	586	0.17	320	0.17	<.02	0.008	3.6	21	16	16	0.037	327	38.6
14030089-002	14030089	3/5/2014 9:50	10	0	221	0	221	<.1	0.0692	46	20	486	0.35	240	0.65	<.02	0.0075	3.3	27	17	23	0.024	280	19.9
14030089-003	14030089	3/5/2014 10:30	12	0	310	0	310	0.12	0.151	56	42	770	0.62	330	<.02	<.02	0.022	4.4	23	36	52	0.068	447	6
14030089-001	14030089	3/5/2014 8:45	13	0	316	0	316	0.13	0.153	65	43	795	0.89	370	<.02	<.02	0.026	4.7	23	36	78	0.069	502	8.7

Samples Taken September 17, 2014

Sample Reference ID	Chain of Custody	Sample Date	Location	Alkalinity, CO3 (mg/L)	Alkalinity, HCO3 (mg/L)	Alkalinity, OH (mg/L)	Alkalinity, Total (mg/L)	Boron (mg/L)	Bromide (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Conductivity (uS/cm)	Fluoride (mg/L)	Hardness, Total (mg/L as CaCO3)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	o-Phosphate as P (mg/L)	Potassium (mg/L)	Silica, Total (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	T-Phosphate as P (mg/L)	TDS (mg/L)	Total Susp. Solids (mg/L)
14090249-007	14090249	9/17/2014 13:40	1	0	197	0	197	<.1	0.0236	49	5.1	386	0.15	200	0.48	<.02	0.0035	1.2	13	4.9	8.2	0.0069	220	<5
14090249-006	14090249	9/17/2014 12:45	3	7.38	200	0	207	<.1	0.029	51	6	396	0.17	220	0.25	<.02	0.0019	1.5	15	6.1	9.1	0.033	232	35.4
14090249-009	14090249	9/17/2014 14:40	5	7.12	198	0	205	<.1	0.03	48	7.3	399	0.17	220	0.24	<.02	0.0014	1.6	15	6.3	9.6	0.054	230	62.5
14090249-008	14090249	9/17/2014 14:20	6	6.35	202	0	208	<.1	0.0308	51	7.4	406	0.17	220	0.25	<.02	0.0012	1.6	14	6.3	9.6	0.072	238	71.9
14090249-004	14090249	9/17/2014 11:15	8	5.55	212	0	218	<.1	0.0302	51	8.9	423	0.17	230	0.25	<.02	<.001	1.6	15	7	10	0.092	246	92.1
14090249-005	14090249	9/17/2014 11:20	8 Dup	5.36	212	0	217	<.1	0.0274	48	8.9	424	0.17	220	0.25	<.02	0.0011	1.5	15	7	10	0.095	246	91.9
14090249-003	14090249	9/17/2014 10:40	10	2.52	171	0	173	<.1	0.0574	43	16	402	0.37	200	0.75	<.02	0.0027	2.2	25	12	20	0.056	237	53.6
14090249-002	14090249	9/17/2014 9:50	12	0	429	0	429	0.14	0.229	80	54	954	0.91	440	<.02	<.02	0.058	8.7	45	41	33	0.14	600	9.5
14090249-001	14090249	9/17/2014 9:00	13	0	176	0	176	<.1	0.0496	79	14	712	2	360	<.02	<.02	0.0037	1.8	11	12	190	0.04	473	19.3

Table I-3
Study Water Chemistry Data - Metals

Samples Taken March 5, 2014

Sample Reference ID	Chain of Custody	Sample Date	Site Number	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
14030089-016	14030089	3/5/2014 15:00	1	<.005	<.0006	0.0026	0.11	<.0004	<.0005	<.003	<.005	<.05	<.001	20	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-015	14030089	3/5/2014 14:20	2	0.042	<.0006	0.0047	0.12	<.0004	<.0005	<.003	<.005	0.052	0.0028	26	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-014	14030089	3/5/2014 13:30	3	0.048	<.0006	0.01	0.12	<.0004	<.0005	<.003	<.005	0.063	<.001	39	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-013	14030089	3/5/2014 12:40	4	0.037	<.0006	0.011	0.12	<.0004	<.0005	<.003	<.005	0.069	<.001	44	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-017	14030089	3/5/2014 15:30	5	0.062	<.0006	0.012	0.12	<.0004	<.0005	<.003	<.005	0.098	<.001	43	0.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-019	14030089	3/5/2014 15:30	5 Dup	0.055	<.0006	0.011	0.12	<.0004	<.0005	<.003	<.005	0.092	<.001	43	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-018	14030089	3/5/2014 16:00	6	0.091	<.0006	0.011	0.13	<.0004	<.0005	<.003	<.005	0.11	<.001	43	0.006	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-005	14030089	3/5/2014 11:50	7	0.075	<.0006	0.0099	0.13	<.0004	<.0005	<.003	<.005	0.11	<.001	42	0.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-004	14030089	3/5/2014 11:25	8	0.083	<.0006	0.0098	0.13	<.0004	<.0005	<.003	<.005	0.22	<.001	43	0.0057	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14030089-002	14030089	3/5/2014 9:50	10	0.06	<.0006	0.0085	0.084	<.0004	<.0005	<.003	<.005	0.12	<.001	32	<.005	<.0002	<.005	<.005	0.0011	<.005	<.0002	<.005	<.005
14030089-003	14030089	3/5/2014 10:30	12	0.094	<.0006	0.017	0.085	<.0004	<.0005	<.003	<.005	0.14	0.0023	46	0.041	<.0002	0.0058	<.005	0.0011	<.005	<.0002	0.0067	<.005
14030089-001	14030089	3/5/2014 8:45	13	0.089	<.0006	0.017	0.075	<.0004	<.0005	<.003	<.005	0.11	0.0015	50	0.037	<.0002	0.0067	<.005	0.0014	<.005	<.0002	0.0078	<.005

Samples Taken September 17, 2014

Sample Reference ID	Chain of Custody	Sample Date	Site Number	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
14090249-007	14090249	9/17/2014 13:40	1	<.005	<.0006	0.0028	0.11	<.0004	<.0005	<.003	<.005	<.05	<.001	20	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-006	14090249	9/17/2014 12:45	3	0.055	<.0006	0.0046	0.12	<.0004	<.0005	<.003	<.005	0.056	<.001	23	0.0053	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-009	14090249	9/17/2014 14:40	5	0.075	<.0006	0.0047	0.12	<.0004	<.0005	<.003	<.005	0.066	<.001	23	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-008	14090249	9/17/2014 14:20	6	0.087	<.0006	0.0046	0.13	<.0004	<.0005	<.003	<.005	0.072	<.001	24	0.0066	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-004	14090249	9/17/2014 11:15	8	0.099	<.0006	0.0044	0.13	<.0004	<.0005	<.003	<.005	0.079	<.001	25	0.0066	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-005	14090249	9/17/2014 11:20	8 Dup	0.075	<.0006	0.0043	0.12	<.0004	<.0005	<.003	<.005	0.066	<.001	25	<.005	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	0.0064
14090249-003	14090249	9/17/2014 10:40	10	0.075	<.0006	0.0058	0.076	<.0004	<.0005	<.003	<.005	0.069	<.001	21	0.0057	<.0002	<.005	<.005	<.001	<.005	<.0002	<.005	<.005
14090249-002	14090249	9/17/2014 9:50	12	0.055	<.0006	0.018	0.13	<.0004	<.0005	<.003	<.005	0.12	<.001	58	0.018	<.0002	<.005	<.005	0.0013	<.005	<.0002	<.005	<.005
14090249-001	14090249	9/17/2014 9:00	13	0.078	<.0006	0.0016	0.03	<.0004	<.0005	<.003	<.005	0.1	<.001	41	0.017	<.0002	0.0058	<.005	0.0021	<.005	<.0002	<.005	<.005

Table I-4
Study Water Chemistry Data - Isotopes

Site Number	Date	$\delta^{18}O$ (per mil)	$\delta^{2}H$ (per mil)	^{3}H (TU)	±σ
1.2	3/5/2014	-15.1	-111	1.5	0.4
4	3/5/2014	-14.6	-109	1.4	0.4
8	3/5/2014	-14.6	-109	<0.8	0.4
10	3/5/2014	-14.6	-110	1.0	0.4
12	3/5/2014	-13.7	-105	1.1	0.4
13	3/5/2014	-13.4	-103	1.4	0.4

Table I-5
Historic Water Chemistry Results - Major Ions

Site Name	Data Source	Location	Sample Collection Date	Water Temp (°C)	pH	Conductivity (uS/cm)	DO (mg/L)	K (mg/L)	Mg (mg/l)	Na (mg/L)	Ca (mg/l)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO^3 (mg/L as N)	HCO^3 Lab (mg/L as HCO^3)	SiO^2 (mg/L)	Charge Balance Lab (%)
Big Spring	Hood & Rush (1965)	Snake Valley	11/3/1964	17.8	7.8	401	---	---	20	5.9	47	8.0	3.7	0.2	2.20	238	---	-1.8
Big Springs	USGS NWIS	Snake Valley	6/15/1983	18	8.0	370	5.9	1.5	20	5.4	48	8.7	5.6	0.1	---	240	12	9.2
Big Spring	Hershey and Mizell (1995)	Snake Valley	6/19/1992	17.6	7.7	378	---	1.53	19.9	5.54	46.6	7.3	5.1	0.15	0.35	244	10.6	-1.0
Big Spring	Hershey et al. (2007)	Snake Valley	7/13/2005	17.5	7.0	403	5.3	1.6	22.6	6.07	51.3	8.7	6	0.13	---	226	12.4	7.6
Big Springs	DRI Data	Snake Valley	1/22/2005	17.2	7.5	387	5.3	1.51	20.3	5.5	47.8	8.5	5.1	0.13	0.49	228	12.6	2.8
Big Springs	DRI Data	Snake Valley	5/20/2005	17	6.9	398	5.5	1.48	19.9	5.38	47.3	8.3	5.7	0.13	0.49	228	13.5	1.9
Big Springs	DRI Data	Snake Valley	8/13/2005	17.7	7.1	385	5.1	1.54	19.5	5.28	48.3	8.5	5.5	0.13	0.49	234	12.7	0.9
Big Springs	DRI Data	Snake Valley	11/8/2005	17.2	7.5	389	4.9	1.51	20.2	5.34	42.9	8.5	5.8	0.13	0.47	229	12.7	-0.7
Big Springs	DRI Data	Snake Valley	2/25/2006	16.8	7.6	393	5.2	1.5	19.6	5.32	47.5	8.6	5.5	0.13	0.48	229	12.5	1.5
Big Springs	DRI Data	Snake Valley	5/21/2006	17.2	7.4	384	5.3	2.61	20.3	6.18	49	9.3	7.3	0.13	0.45	232	12.8	2.4
Big Springs	DRI Data	Snake Valley	8/24/2006	17.3	7.5	383	5.4	1.42	20.4	5.2	47.7	8.8	5.33	0.12	0.47	232	12.7	1.7
Big Springs	DRI Data	Snake Valley	10/29/2006	17	7.4	384	4.8	1.45	20.3	5.93	49.7	8.5	6.1	0.13	0.44	232	12.9	3.0
Big Springs -USGS by gate	USGS	Snake Valley	11/2/2010	17.2	7.4	382	4.7	1.42	19.7	5	47.6	8.5	5.1	0.15	0.39	168	11.9	---
Big Spring NW Well	USGS NWIS	Snake Valley	10/4/2010	12.8	7.4	445	6.1	0.98	28.6	8.73	53.9	5.8	11.7	0.06	4.05	245	10.7	0.3
Big Spring SW Well	USGS NWIS	Snake Valley	11/3/2010	15.8	7.5	328	4.6	1.27	18.5	3.98	46.9	7.4	4.03	0.13	2.09	172	11	4.2
Big Springs South	SNWA Data	Snake Valley	11/2/2010	17.4	7.1	373	5.3	1.5	21	4.8	51	8.3	5	0.15	0.49	188	13	5.0
Clay Spring	SNWA Data	Snake Valley	10/12/2006	13.6	7.7	520	---	1.8	36	12	70	140.0	14	1.8	< 0.1	220	14	0.1
Clay Spring	SNWA Data	Snake Valley	11/2/2010	13.7	7.2	642	2.0	2.1	39	11	74	150.0	13	1.8	0.19	172	15	2.8
Hamlin MX	SNWA Data	Hamlin Valley	11/2/2010	19.2	7.3	404	3.6	5.2	19	24	37	31.0	17	0.77	0.62	157	28	2.9
Knoll Spring	Hood & Rush (1965)	Snake Valley	10/15/1964	19.4	7.6	688	---	---	28	57	63	58.0	52	---	0.30	317	---	---
Knoll Spring	SNWA Data	Snake Valley	10/12/2006	19.7	7.5	650	---	4.8	26	48	61	54.0	51	0.54	ND	290	19	0.3
Needle Spring Well	USGS NWIS	Snake Valley	9/1/2005	15.2	8.0	383	6.5	3.93	19.4	23	35.1	30.0	23.2	0.1	---	128	37.4	---
Spring Creek Spring	Hershey et al. (2007)	Snake Valley	7/16/2005	---	---	---	---	1.07	8.44	6.85	64.4	11.0	---	---	---	---	11.5	---
Spring Creek Spring	Hershey et al. (2007)	Snake Valley	7/16/2005	12.9	7.3	380	8.1	1.22	7.85	6.94	64.2	12.5	6.7	0.11	0.35	227	11.1	-0.2
Stateline Spring	SNWA Data	Snake Valley	11/2/2010	13.8	7.3	366	5.2	3.5	18	17	34	27.0	23	0.49	1.6	122	39	3.9

Table I-6
Historic Water Chemistry Results - Metals

Station Name Units	Site Number	Sample Date	Source	Al ug/L	Sb ug/L	As ug/L	Ba ug/L	Be ug/L	Bi ug/L	Cd ug/L	Cr ug/L	Co ug/L	Cu ug/L	F mg/L	Fe ug/L	Li ug/L	Pb ug/L	Mn ug/L	Mo ug/L	Ni ug/L	Ag ug/L	Se ug/L	Sr ug/L	Tl ug/L	V ug/L	Zn ug/L
Big Springs		06/15/1983	USGS																							
Big Springs		07/13/2005	USGS		0.30	3.1	112	< 0.05		< 0.02	2.9		< 0.5		0.03	9.0	< 0.05	< 0.2		< 0.4	< 0.3		0.13		2.2	0.8
195 N10 E70 33ACBB1 Big Spring	384152114075001	06/19/1992	NV-UNDRI				0.1	< 0.001		< 0.005		< 0.01	< 0.005		< 0.01		< 0.001	< 0.005	< 0.02						< 0.02	< 0.005
195 N10 E70 33ACBB1 Big Spring	384152114075001	07/13/2005	USGS-WRD	< 2		3.1	112	< 0.05	< 0.2	< 0.02		< 0.02	< 0.5		< 50		< 0.05	< 0.2	< 2	< 0.4	< 0.3	< 1	130	0.2	2.2	
195 N10 E70 32A 1 Big Springs	384158114075201	06/15/1983	USGS-WRD				120	< 0.5		< 1		< 3	< 10	0.1	10	10	< 10	30	< 10				280		< 6.0	
195 N10 E70 32A 1 Big Springs	384158114075201	01/22/2005	NV-UNDRI																							
195 N10 E70 32A 1 Big Springs	384158114075201	05/20/2005	NV-UNDRI																							
195 N10 E70 32A 1 Big Springs	384158114075201	08/13/2005																								
195 N10 E70 32A 1 Big Springs	384158114075201	11/8/2005																								
Big Springs South Channel		11/2/2010		0.89	0.14	2.6	110	0		0	0.17		0.26				0.013	0.79	1.3	0.11	0.049	0.36	0	0.13	1.1	1.8
Clay Spring		10/12/2006	SNWA																							
Clay Spring		11/2/2010	SNWA	0.52	0.02	1	20	0		0	0.46		0.39				0.059	0.04	5	0.27	0.022	2.2	0.00	0	3.8	1.5
Hamlin MX Well		11/2/2010	SNWA	0.62	0.51	8	92	0		0	0.42		0.17				0.37	18	4.4	0.82	0.022	0.41	0.00	0.018	6.1	25
Knoll Spring		10/12/2006	SNWA																							
Clay Spring		10/12/2006	SNWA																							
Needle Springs Well		09/1/2005	USGS		< 0.3	5.8	14.6	< 0.05		< 0.02	5.7		< 0.5	0.39	0.10	18.1	< 0.05	0.9		< 0.4	< 0.3		239		9.0	1.4
195 N12 E70 15CB 1 Spring Creek Spring (D8)	385434114063901	07/16/2005	USGS-WRD	4	< 0.3	< 1.0	68.2	< 0.05	< 0.2	< 0.02		< 0.02	< 0.5	0.11	< 50		< 0.05	< 0.2	< 2	< 0.4	< 0.3	< 1	210	< 0.1	1	
Stateline Spring		11/2/2010	SNWA	0.60	0.13	4.8	10	0	0	0	2.2	0	0.16	0	0	0	0.023	1.1	1.5	0.16	0.025	1.2	0	0	6.4	2.2

Table I-7
Historic Water Chemistry Data - Isotopes

Site Name	Data Source	HA	Sample Collection Date	$\delta^{18}O$ (per mil)	$\delta^{2}H$ (per mil)	^{14}C pmc (%)	$\delta^{13}C$ (per mil)	^{3}H (TU)	±σ
Big Spring	Hershey and Mizell (1995)	195	6/19/1992	-14.9	-111				
Big Spring	Hershey et al. (2007)	195	7/13/2005	-15	-112.2				
Big Springs	USGS NWIS	195	6/15/1983	-15	-115				
Big Springs	SNWA Data	195	6/22/2004	-14.85	-112.35				
Big Springs	SNWA Data	195	6/22/2004		-113.08				
Big Springs	DRI Data	195	1/22/2005	-15.14	-112.2				
Big Springs	DRI Data	195	5/20/2005	-15.15	-109.8				
Big Springs	DRI Data	195	8/13/2005	-15.22	-112.2				
Big Springs	DRI Data	195	11/8/2005	-15.1	-110.3				
Big Springs	DRI Data	195	2/25/2006	-15.17	-111.6				
Big Springs	DRI Data	195	5/21/2006	-15.1	-112.6				
Big Springs	DRI Data	195	8/24/2006	-15.15	-111.8				
Big Springs	DRI Data	195	10/29/2006	-15.2	-111.1				
Big Springs South	SNWA Data	195	11/2/2010	-14.98	-111.9	31	-8	2	0.4
Big Springs -USGS by gate	USGS	195	11/2/2010	-15	-111	31.2	-7.1	1.5	
Big Spring NW Well	USGS NWIS	195	10/4/2010	-14.66	-108	58.02	-9.17	<0.8	
Big Spring SW Well	USGS NWIS	195	11/3/2010	-15.09	-111	33.61	-7.2	<0.8	
Clay Spring	SNWA Data	195	10/12/2006	-15.06	-111.65				
Clay Spring	SNWA Data	195	10/12/2006	-15.08	-111.15				
Clay Spring	SNWA Data	195	11/2/2010	-14.98	-112.8	5	-7	<0.8	0.3
Hamlin MX Well (10")	SNWA Data	196	11/2/2010	-14.96	-114.2	6.8	-6	<0.8	0.3
Knoll Spring	SNWA Data	195	10/12/2006	-14.29	-109.09				
Knoll Spring	SNWA Data	195	10/12/2006		-109.27				
Needle Springs Well	Hershey et al. (2007)	195	9/1/2005	-14.43	-109.8				
Stateline Spring	SNWA Data	195	11/2/2010	-14.59	-110.7	24.1	-11	<0.8	0.3