Big Valley
GSP

"Set Aside"
Chapters

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Abbreviations and Acronyms

Basin	Big Valley Groundwater Basin
BVGB	Big Valley Groundwater Basin
BVAC	Big Valley Groundwater Basin Advisory Committee
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
DWR	Department of Water Resources
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
MOU	Memorandum of Understanding
SGMA	Sustainable Groundwater Management Act of 2014

1. Introduction to Big Valley Groundwater Sustainability Plan (§ 354.2-4)

1.1 Background

1.1.1 *Overview*

The Big Valley Groundwater Sustainability Agencies (GSAs) are developing this Groundwater Sustainability Plan (GSP) after exhausting its administrative challenges to the California Department of Water Resources (DWR) determination that Big Valley qualifies as a medium-priority basin. The Big Valley GSAs recognize and appreciate the scoring revisions made by DWR for Component 8.b, "Other Information Deemed Relevant by the Department." However, the GSAs continue to firmly believe that the all-or-nothing scoring for Component 7.a, regarding documented declining groundwater levels, is inconsistent with the premise of SGMA: that prioritization levels recognize different levels of impact and conditions across basins. DWR's adherence to treating all declines the same, assigning a fixed 7.5 points for any amount of documented groundwater level decline, renders meaningless the degrees of groundwater decline and penalizes those basins experiencing minor levels of decline.

Additionally, the GSAs recognize the adjustments made to Component 7.d, overall total water quality degradation. Noting that degradation implies a lowering from natural conditions, the Big Valley GSAs urges DWR to further refine the groundwater quality scoring process for Secondary Maximum Contamination Levels (MCLs) - which are not tied to public health concerns, but rather aesthetic issues such as taste, color, and odor. Secondary MCLs which are due to naturally occurring minerals should not be factored into the scoring process. Here, the water quality conditions reflect the natural baseline and are not indicative of degradation and cannot be substantially improved through better groundwater management.

The GSAs also submitted a request to DWR for basin boundary modifications, to integrate planning at the watershed level and leverage a wider array of multi-benefit water management options and strategies within the basin and larger watershed. DWR's denial of the boundary request greatly hampers jurisdictional opportunities to protect groundwater recharge areas in higher elevations. The final boundary significantly curtails management options to increase supply through upland recharge, necessarily requiring that groundwater levels be addressed primarily through demand restrictions. See **Appendix 1A** for communications with DWR regarding basin prioritization ranking and boundary. The GSAs may consider future basin boundary modification requests to DWR.

Development of this GSP by the GSAs, in partnership with the Big Valley Advisory Committee and members of the community, does not constitute agreement with DWR's classification as a medium-priority basin – nor does it preclude the possibility of other actions by the GSAs or by individuals within the basin seeking regulatory relief.

1.1.2 *Timeline*

In September 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA). This law requires medium- and high-priority groundwater basins in California to take actions to ensure they are managed sustainably. The California Department of Water Resources (DWR) is tasked with prioritizing all 515 defined groundwater basins in the state as high, medium, low, and very low priority. Prioritization establishes which basins need to go through the process of developing a Groundwater Sustainability Plan (GSP). When SGMA was passed, basins had already been prioritized under the state's CASGEM program, and that existing ranking process was used as the initial priority baseline for SGMA.

DWR was required to develop its rankings for SGMA based on the first seven criteria listed in **Table 1**. For the final SGMA scoring process (2019), groundwater basins with a score of greater than 14 (up to a score of 21) ranked as medium priority basins. The 2014 ranking put the Big Valley Groundwater Basin (BVGB or Basin) in the Medium category as the lowest ranked basin in the state required to develop a GSP. Lassen County reviewed the 2014 ranking process and criteria that were used and found some potentially erroneous data. They made a request to DWR for the raw data that was used, which they were eventually provided, and verified the error that would have put the BVGB into the Low category. However, because the comment period for these rankings had already expired in 2014 (prior to the passage of SGMA), DWR would not revise their ranking.

Table 1-1 Big Valley Groundwater Basin Prioritization

Criteria	2014	2018	2019	Comment
2010 Population	1	1	1	
Population Growth	0	0	0	
Public Supply Wells	1	1	1	
Total # of Wells	1.5	2	2	
Irrigated Acreage	4	3	3	
Groundwater Reliance	3	3.5	3.5	
Impacts	3	3	2	Declining water levels, water quality
Other Information	0	7	2	Streamflow, habitat, and "other information determined to be relevant"
Total Score	**13.5**	**20.5**	**14.5**	**Medium priority each year**

In 2016, Lassen County submitted a request for a basin boundary modification as allowed under SGMA. The request was to extend the boundaries of the BVGB to the boundary of the watershed. The purpose of the proposed modification was to enhance management by including the volcanic areas surrounding the valley sediments, including federally managed timberlands and rangelands, that have an impact on groundwater recharge. The modification was proposed on a scientific basis but was denied by DWR because the request "…did not include sufficient detail and/or required components necessary…and evidence was not provided to substantiate the connection [of volcanic rock] to the porous permeable alluvial basin, nor were conditions presented that could potentially support radial groundwater flow as observed in alluvial basins."

In 2018, DWR released an updated draft basin prioritization based on the eight components shown in **Table 1** using slightly different data and methodology than previously used. For this prioritization, Big Valley's score increased from 13.5 to 20.5, primarily because of an addition of 5 ranking points awarded under the category of "other information determined to be relevant" by DWR. DWR's justification for the five points was poorly substantiated as "Headwaters for Pit River/Central Valley Project – Lake Shasta". Lassen and Modoc Counties sent a joint comment letter questioning DWR's justification and inconsistent assessment of these five points as well as their methodology for awarding the same number of points for water level and water quality impacts to basins throughout the state regardless of the severity of the impacts.

In 2019, DWR released their final prioritization with the BVGB score reduced to 14.5, but still ranked as Medium priority and subject to the development of a GSP. DWR's documentation of the 2019 prioritization can be viewed on their website (DWR 2019).

Meanwhile, throughout this time, Lassen and Modoc Counties began moving forward to comply with the SGMA mandate through a public process that established them as the Groundwater Sustainability Agencies (GSAs) in 2017. The establishing resolutions forming the GSAs adopted findings that it was in the public interest of both counties to maintain local control by declaring themselves the GSA for the respective portion of the basin. The Water Resources Control Board would become the regulating agency if the counties did not agree to be the GSAs since there were no other local agencies in a position or qualified to assume GSA responsibility. The Counties obtained state grant funding to develop the GSP in 2018 and began the GSP development process and associated public outreach in 2019.

1.2 Purpose of the Groundwater Sustainability Plan

Satisfying the requirements of SGMA generally requires four activities:

1. Formation of at least one GSA to fully cover a basin. Multiple GSAs are acceptable and Big Valley has two GSAs.
2. Development of a GSP that fully covers the basin.
3. Implementation of the GSP and management to achieve quantifiable objectives.
4. Regular reporting to DWR.

Two GSAs were established in the Basin: County of Modoc GSA and County of Lassen GSA, each covering the portion of the Basin in their respective jurisdictions. This document is a single GSP, developed jointly by both GSAs for the entire Basin. This GSP describes the Big Valley Groundwater Basin, develops quantifiable management criteria that accounts for the interests of the Basin's beneficial groundwater uses and users, and identifies projects and management actions to ensure sustainability.

1.3 Description of Big Valley Groundwater Basin

The Big Valley Groundwater Basin is identified by DWR in Bulletin 118 as Basin No. 5-004 (DWR, 2016). The basin boundary was drawn by DWR using a 1:250,000 scale geologic map produced by the California Geological Survey (CGS 1958) along the boundary between formations labeled as volcanic and those labeled as alluvial. The Basin is one of many small, isolated basins in the north-eastern region of California, an area with widespread volcanic formations many of which produce large quantities of groundwater and are not included within the defined groundwater basin.

The boundary between Lassen and Modoc Counties runs across the Basin. Each county formed a GSA for its respective portion of the Basin and the counties are working together to manage the Basin under a single GSP. The Basin, shown on **Figure 1-1**, encompasses an area of approximately 144 square miles with Modoc County comprising 40 square miles (28%) on the north and Lassen County comprising 104 square miles (72%) on the south. The Basin includes the towns of Adin and Lookout in Modoc County and the towns of Bieber and Nubieber in Lassen County. The Ash Creek State Wildlife Area is located in both counties and occupies 22.5 square miles in the center of the basin in the marshy/swampy areas along Ash Creek.

The BVGB, as drawn by DWR, is isolated and does not share a boundary with another groundwater basin. However, Ash Creek flows into Big Valley from the Round Valley Groundwater Basin at the town of Adin. The two basins are separated by about a half-mile gap of alluvium which may interconnect the two basins.

The surface expression of the Basin boundary is defined as the contact of the valley sedimentary deposits with the surrounding volcanic rocks. The sediments in the Basin are comprised of mostly Plio-Pleistocene alluvial deposits and Quaternary lake deposits eroded from the volcanic highlands and some volcanic layers interbedded within the alluvial and lake deposits. The Basin is surrounded by Tertiary- and Miocene-age volcanic rocks of andesitic, basaltic and pyroclastic composition. The boundary between the BVGB and the surrounding volcanic rocks generally correlates with a relatively steep change in topography along the margin of the valley.

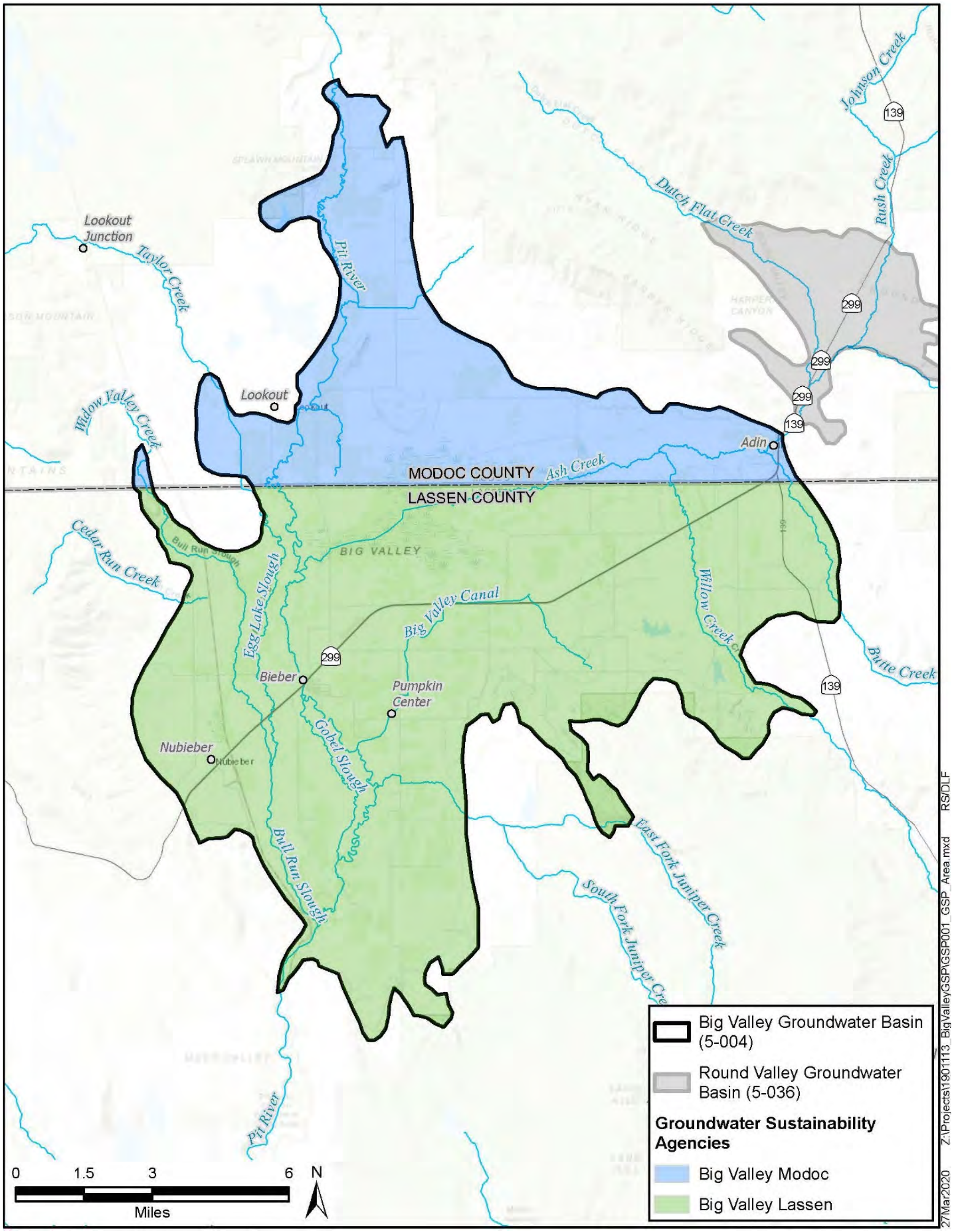

Figure 1-1 Big Valley Groundwater Basin, Surrounding Basins, and GSAs

2. Agency Information (§ 354.6)

The two Big Valley GSAs were established for the entire Big Valley Groundwater Basin to jointly develop, adopt, and implement a single mandated GSP for the BVGB pursuant to SGMA and other applicable provisions of law.

2.1 Agency Names and Mailing Addresses

The following contact information is provided for each GSA pursuant to California Water Code §10723.8.

Modoc County
204 S. Court Street
Alturas, CA 96101
(530) 233-6201
tiffanymartinez@co.modoc.ca.us

Lassen County
Department of Planning and Building Services
707 Nevada Street, Suite 5
Susanville, CA 96130
(530) 251-8269
landuse@co.lassen.ca.us

2.2 Agency Organization and Management Structure

The two GSAs, Lassen and Modoc Counties, were established in 2017 to comply with the SGMA, mandated legislation. **Appendix 2A** contains the resolutions forming the two agencies. Each GSA is governed by a five-member Board of Supervisors. In 2019, the two GSAs established the Big Valley Groundwater Basin Advisory Committee (BVAC) through a Memorandum of Understanding (MOU), included as **Appendix 2B**. The membership of the BVAC is comprised of:

- One member of the Lassen County Board of Supervisors selected by said Board
- One alternate member of the Lassen County Board of Supervisors selected by said Board
- One member of the Modoc County Board of Supervisors selected by said Board
- One alternate member of the Modoc County Board of Supervisors selected by said Board
- Two public members selected by the Lassen County Board of Supervisors. Said members must either reside or own property within the Lassen County portion of the Big Valley Groundwater Basin
- Two public members selected by the Modoc County Board of Supervisors. Said members must either reside or own property within the Modoc County portion of the Big Valley Groundwater Basin

The decisions made by the BVAC are not binding, but the committee serves the important role of providing formalized, local stakeholder input and guidance to the GSA governing bodies, GSA staff, and consultants in developing and implementing the GSP.

2.3 Contact Information for Plan Manager

The plan manager is from Lassen County and can be contacted at:

Gaylon Norwood
Assistant Director
Lassen County Department of Planning and Building Services
707 Nevada Street, Suite 5
Susanville, CA 96130
(530) 251-8269
gnorwood@co.lassen.ca.us

2.4 Authority of Agencies

The GSAs were formed in accordance with the requirements of California Water Code §10723 *et seq*. Both GSAs are local public agencies organized as general law counties under the State Constitution and have land use responsibility for their respective portions of the Basin. The resolutions of formation for the GSAs are included in **Appendix B**.

2.4.1 *Memorandum of Understanding*

In addition to the MOU establishing the BVAC, the two GSAs may to enter into an agreement to jointly implement the GSP for the Basin. However, this agreement is not a requirement of the SGMA.

2.5 References

California Department of Water Resources (DWR), 2019. Basin Prioritization Website. Available at: https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization.

California Geological Survey (CGS) (Gay, T. E. and Aune, Q. A.), 1958. Geologic Map of California, Alturas Sheet. 1:250,000. Olaf P. Jenkins Edition.

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Abbreviations and Acronyms

Basin	Big Valley Groundwater Basin
bgs	below ground surface
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMO	Basin Management Objective
BVGB	Big Valley Groundwater Basin
BVWUA	Big Valley Water Users Association
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CIMIS	California Irrigation Management Information System
CWC	California Water Code

DDW	Division of Drinking Water, State Water Resources Control Board
DWR	Department of Water Resources
ETo	Evapotranspiration
°F	degrees Fahrenheit
ft	feet
GAMA	Groundwater Ambient Monitoring and Assessment Program
GP	General Plan
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IRWMP	Upper Pit Integrated Regional Water Management Plan
LMFCWCD	Lassen-Modoc Flood Control and Water Conservation District
MCL	Maximum Contaminant Level
NCNRCDC	North Cal-Neva Resource Conservation and Development Council
NOAA	National Oceanic and Atmospheric Administration
RWMG	Regional Water Management Group
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act of 2014
SWQL	Secondary Water Quality Limits
SWRCB	State Water Resources Control Board
USFS	United States Forest Service
USGS	United States Geologic Survey

3. Description of Plan Area (§ 354.8)

3.1 Area of the Plan

This Groundwater Sustainability Plan (GSP) covers the Big Valley Groundwater Basin (BVGB or Basin), which is located within Modoc and Lassen Counties and is approximately 92,000 acres (144 square miles). The Basin is a broad, flat plain extending about 13 miles north to south and 15 miles east to west and consists of depressed fault blocks surrounded by tilted fault-block ridges. The BVGB is designated as basin number 5-004 by the California Department of Water Resources (DWR) and was most recently described in the 2003 update of Bulletin 118 (DWR 2003):

> *"The basin is bounded to the north and south by Pleistocene and Pliocene basalt and Tertiary pyroclastic rocks of the Turner Creek Formation, to the west by Tertiary rocks of the Big Valley Mountain volcanic series, and to the east by the Turner Creek Formation.*
>
> *The Pit River enters the Basin from the north and exits at the southernmost tip of the valley through a narrow canyon gorge. Ash Creek flows into the valley from Round Valley and disperse into Big Swamp. Near its confluence with the Pit River, Ash Creek reforms as a tributary at the western edge of Big Swamp. Annual precipitation ranges from 13- to 17-inches."*

Communities in the Basin are Nubieber, Bieber, Lookout, and Adin which are categorized as census-designated places. Highway 299 is the most significant east to west highway in the Basin, with Highway 139 at the eastern border of the Basin. **Figure 3-1** shows the extent of the GSP area (the BVGB) as well as the significant water bodies, communities, and highways.

Lassen and Modoc Counties were established as the exclusive Groundwater Sustainability Agencies (GSAs) for their respective portions of the Basin in 2017. **Figure 3-1** shows the two GSAs within the Basin. Round Valley basin (5-036) is a very low-priority basin to the northeast; DWR does not consider it to be connected to Big Valley basin. The Ash Creek State Wildlife Area occupies 14,583 acres in the center of Big Valley.

No other GSAs are associated with the Basin, nor are there any areas of the Basin that are adjudicated or covered by an alternative to a GSP. Landowners have the right to extract and use groundwater beneath their property.

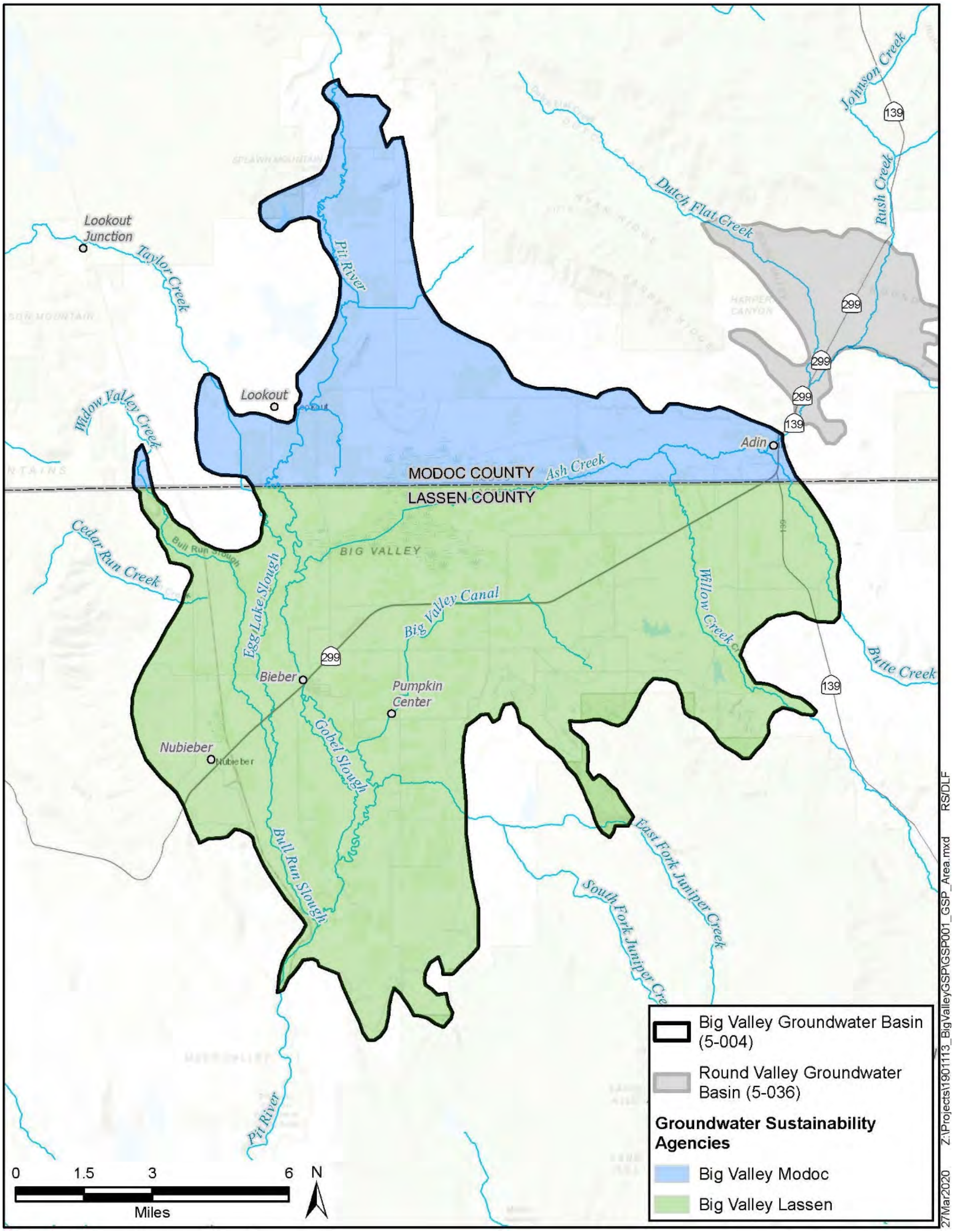

Figure 3-1 Area Covered by the GSP

3.2 Jurisdictional Areas

In addition to the GSAs, several other agencies have water management authority or planning responsibilities in the Basin, as discussed below. A map of the jurisdictional areas within the Basin is shown on **Figure 3-2**.

3.2.1 *Federal Jurisdictions*

The United States Bureau of Land Management (BLM) as well as the United States Forest Service (USFS or Forest Service) owns/manages land within the Basin, including Modoc National Forest, shown on **Figure 3-2**. Information on their Land and Resource Management Plan is described in Section 3.8. The Forest Service Ranger Station in Adin is a non-community public water supplier with a groundwater well (Water System No. CA2500547, SWRBC Public Water Supply Listing).

3.2.2 *Tribal Jurisdictions*

The Bureau of Indian Affairs (BIA) Land Area Representations database identifies one tribal property in the BVGB (BIA 2020a). Lookout Rancheria, shown on **Figure 3-2,** is associated with the Pit River Tribe. There are other "public domain allotments," or lands held in trust for the exclusive use of individual tribal members within the Basin not shown. (BIA 2020b)

3.2.3 *State Jurisdictions*

The California Department of Fish and Wildlife (CDFW) owns and operates the Ash Creek Wildlife Area, shown on **Figure 3-2**.

3.2.4 *County Jurisdictions*

The County of Modoc and the County of Lassen have jurisdiction over the land within the Basin in their respective counties as shown on **Figures 3-1** and **3-2**. Information on their respective General Plans is provided in Section 3.8. Within the Basin, Modoc County includes the census-designated community of Adin and part of the community of Lookout. Within the Basin, Lassen County contains the census-designated communities of Bieber and Nubieber.

3.2.5 *Agencies with Water Management Responsibilities*

Upper Pit Integrated Regional Water Management Plan

Big Valley lies within the area of the Upper Pit Integrated Regional Water Management Plan (IRWMP), which was developed by the Regional Water Management Group (RWMG). The IRWMP is managed by the North Cal-Neva Resource Conservation and Development Council (NCNRCD) who is a member of the RWMG along with 27 other stakeholders, including community organizations; environmental stewards; water purveyors; numerous local, county, state, and federal agencies; industry; the University of California; and the Pit River Tribe. The

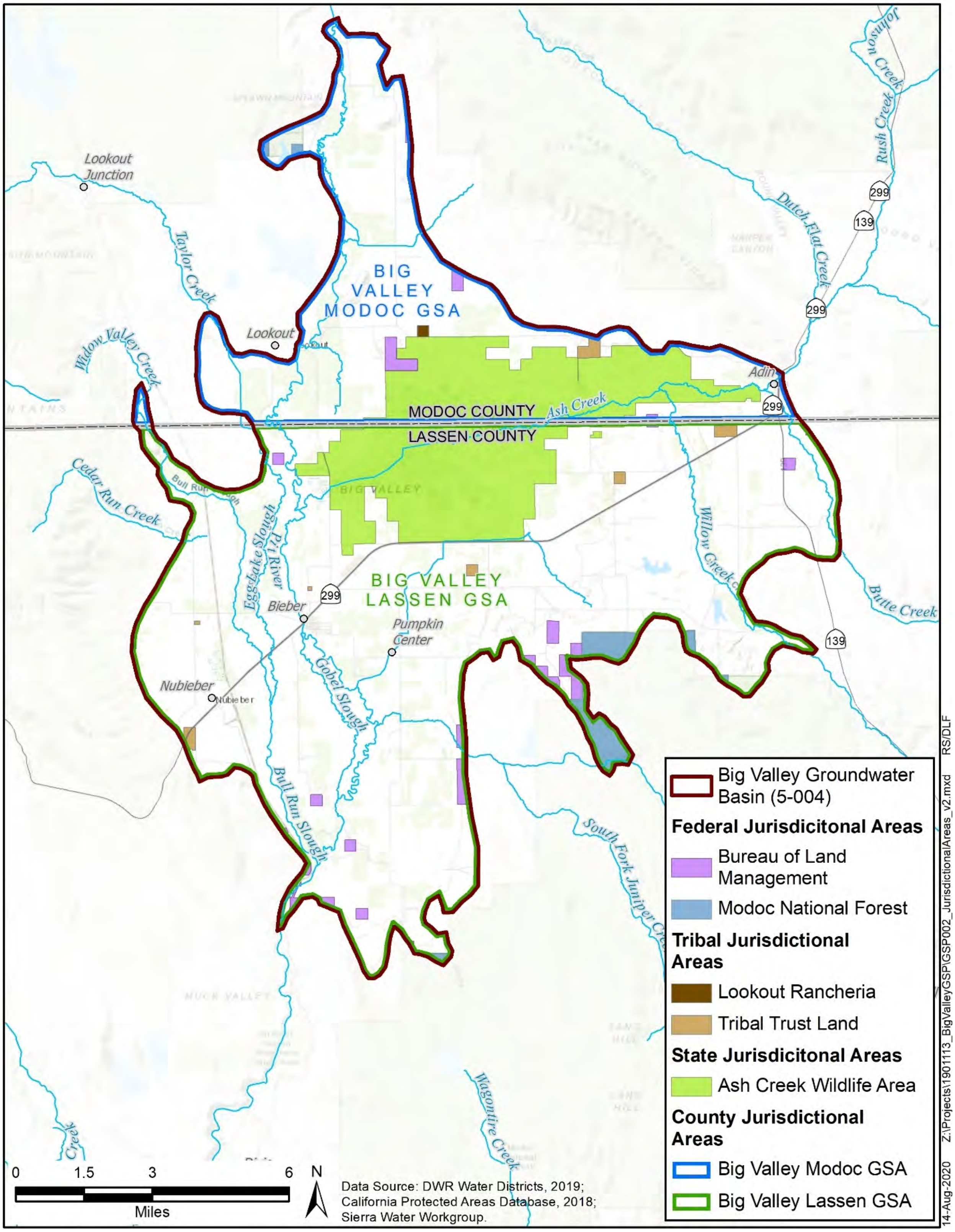

Figure 3-2 Jurisdictional Areas

IRWMP addresses a three-million-acre watershed across four counties in northeastern Califonia. The BVGB is located near the center of this area and comprises about three percent (92,000 acres) of the IRWMP watershed.

The IRWMP was established under the Integrated Regional Water Management Act (Senate Bill 1672) which was passed in 2002 to foster local management of water supplies to improve reliability, quantity and quality, and to enhance environmental stewardship. Several propositions were subsequently passed by voters to provide funding grants for planning and implementation. Beginning in early 2011, a plan was developed for the Upper Pit River area and was adopted in late 2013. During 2017 and 2018, the plan was revised according to 2016 guidelines.

Lassen-Modoc County Flood Control and Water Conservation District

The Lassen-Modoc County Flood Control and Water Conservation District (LMFCWCD or District) was established in 1959 by the California Legislature and was activated in 1960 by the Lassen County Board of Supervisors (LAFCo, 2018). The District covers all of the Lassen County portion of the Basin and a significant portion of the Modoc County portion, extending from the common boundary northward beyond Canby and Alturas. In 1965, the District established Zone 2 in a nearly 1000-square mile area encompassing and surrounding Big Valley and, in 1994, the District designated the same boundaries for Zone 2 as management Zone 2A for "groundwater management including the exploration of the feasibility of replenishing, augmenting, and preventing interference with or depletion of the subterranean supply of waters used or useful or of common benefit to the lands within the zone."

Lassen County Waterworks District #1

Lassen County Waterworks District #1 provides water and sewer services to Bieber.

Adin Community Services District

Adin Community Services District provides wastewater services to Adin.

3.3 Land and Water Use

This section describes land use in the BVGB, water use sectors, and water source types using the best readily-available information. The most recent, best available data for distinguishing surface water and groundwater uses comes from DWR land use datasets. This data is developed by DWR "to serve as a basis for calculating current and projected water uses. Surveys performed prior to 2014 were developed by DWR using some aerial imagery with significant field verification. These surveys also included DWR's estimate of water source.

Since 2014, DWR has developed more sophisticated methods of performing the surveys with a higher reliance on remote sensing information. These more recent surveys do not make available the water source. **Table 3-1** is a listing of the years for which surveys are available.

Table 3-1 Available DWR Land Use Surveys

Year	Modoc County	Lassen County	Water Source Included
1997	Yes	Yes	Yes
2011	Yes	No	Yes
2013	No	Yes	Yes
2014	Yes	Yes	No
2016	Yes	Yes	No[a]

[a] DWR provided the GSAs a hybrid dataset with the 2011 and 2013 water sources superimposed onto the 2016 land use.

3.3.2 *Land Use by Water Use Sectors*

Land use in the BVGB is organized into the same water use sectors identified in Article 2 of the GSP emergency regulations (DWR 2016a). These DWR-identified water use sectors are detailed below with the addition of Domestic as an additional sector. Domestic is added because of of the wide-spread reliance on groundwater for domestic purposes in Big Valley. **Figure 3-3** shows the 2016 distribution of land uses and **Table 3-2** summarizes the acreages of each. Several data sources were used to designate land uses as described below, including information provided by DWR through a remote sensing process developed by Land IQ. (DWR 2016b) Other data sources are described below.

Table 3-2 2016 Land Use Summary by Water Use Sector

Water Use Sector	Acres	Percent of Total
Urban	250	< 1%
Industrial	196	< 1%
Agricultural	22,246	24%
Managed Wetlands	14,583	16%
Managed Recharge	-	0%
Native Vegetation and Domestic	54,792	60%
Total	**92,067**	**100%**

- **Urban** Urban water use is non-agricultural, non-industrial water use in the census-designated places of Bieber, NuBieber and Adin. Some of the areas designated as urban may also have some minor industrial uses. These urban areas were delineated using DWR (2016b). DWR's data included the areas north and northeast of Bieber (area of the former mill and medical center) as urban. For this GSP, those areas were re-categorized from urban to industrial, as that is more descriptive of the actual land use. In addition, parcels that make up the core of Nubieber were included as urban.

- **Industrial** There is limited industrial use in the Basin. The DWR well log inventory shows six industrial wells, but all are located at the mill in Bieber, which is not active. The areas north and northeast of Bieber, including the former mill and the medical center have been categorized as industrial. In addition, the parcels associated with railroad operations in Nubieber were added. There is some industrial use associated with agriculture but that is included under the agricultural water use sector.

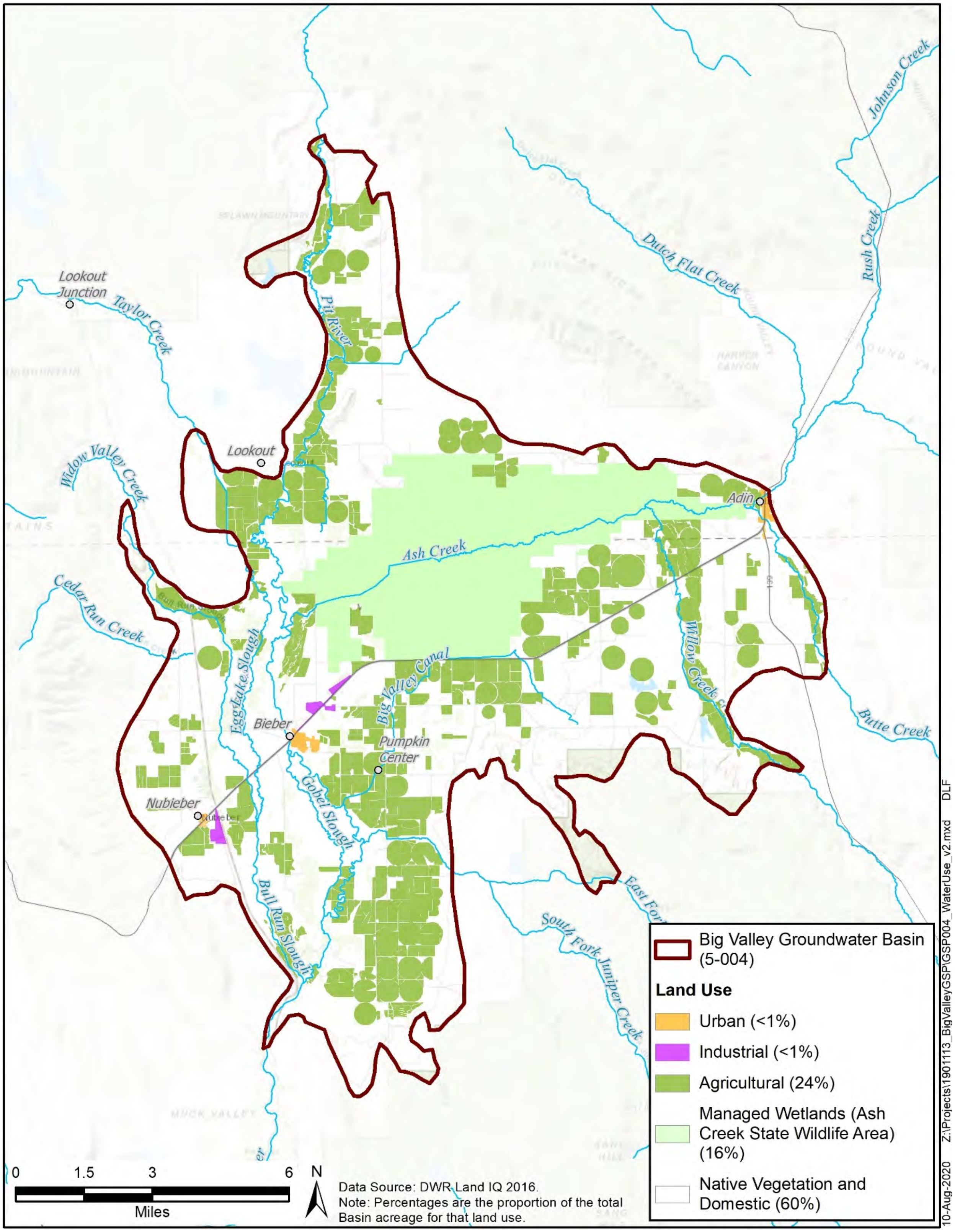

Figure 3-3 Land Use By Water Use Sector

- **Agricultural** Agricultural use is a widespread use throughout the Basin and was delineated using DWR's (2016b) land use data.
- ~~**Managed Wetlands**~~**State Wildlife Habitat** ~~The Ash Creek Wildlife Area (ACWA) is the primary area that is designated as being managed for wetland habitat.~~ The area delineated in **Figure 3-3** is the boundary of the Ash Creek Wildlife Area (ACWA), located within the center of the Basin. The area includes preserved freshwater wetlands created by the seasonal flow of six streams, including Ash Creek. (CDFW 2020)
- **Managed Recharge** There is no formal managed recharge or recycled water discharged in the Basin. However, flood irrigation of some fields and natural flooding of lowland areas does provide recharge to the Basin even though it is not of a formalized nature that would put it into this managed recharge category.
- **Native Vegetation** Native vegetation is widespread throughout the Basin. Many of the areas under this category also have domestic users. These two land uses are categorized together because it is not possible to distinguish between the two with readily available data.
- **Domestic** This sector was added for the purposes of the BVGB GSP and includes water use for domestic purposes, which aren't supplied by a community system. Domestic use generally occurs in conjunction with agricultural and native vegetation and is best represented on the map categorized with native vegetation, as most of the agricultural area is delineated by field and does not include residences.

3.3.1 Water Source Types

The Basin has two water source types: groundwater and surface water. Recycled water[1] and desalinated water are not formally utilized in the Basin, nor is stormwater used as a supplemental water supply at the time of the development of this GSP. Informal resuse of irrigation water occurs with capture and reuse of tail water by farmers and ranchers.

As detailed in **Table 3-1**, the most recent data for which water source is available are from 2011 and 2013 for Modoc and Lassen Counties, respectively. At the request of the GSAs, DWR staff provided a hybrid dataset, where the water source estimated from 2011 and 2013 was superimposed onto the 2016 land uses. **Figure 3-4** and shows DWR's estimate of water source for agricultural lands in the Basin and indicates, in general, where suface water and groundwater are used in the Basin. This data does not distinguish lands that use a combination of surface and groundwater, which is a common practice in the Basin. Therefore, the data shown on **Figure 3-4** is assumed to provide an indication of the "primary" source of water. Chapter 6 (Water Budget) will provide a further assessment of lands that use a combination of water sources.

[1] Recyled water generally refers to treated urban wastewater that is used more than once before it passes back into the water cycle. (WateReuse Association, 2020)

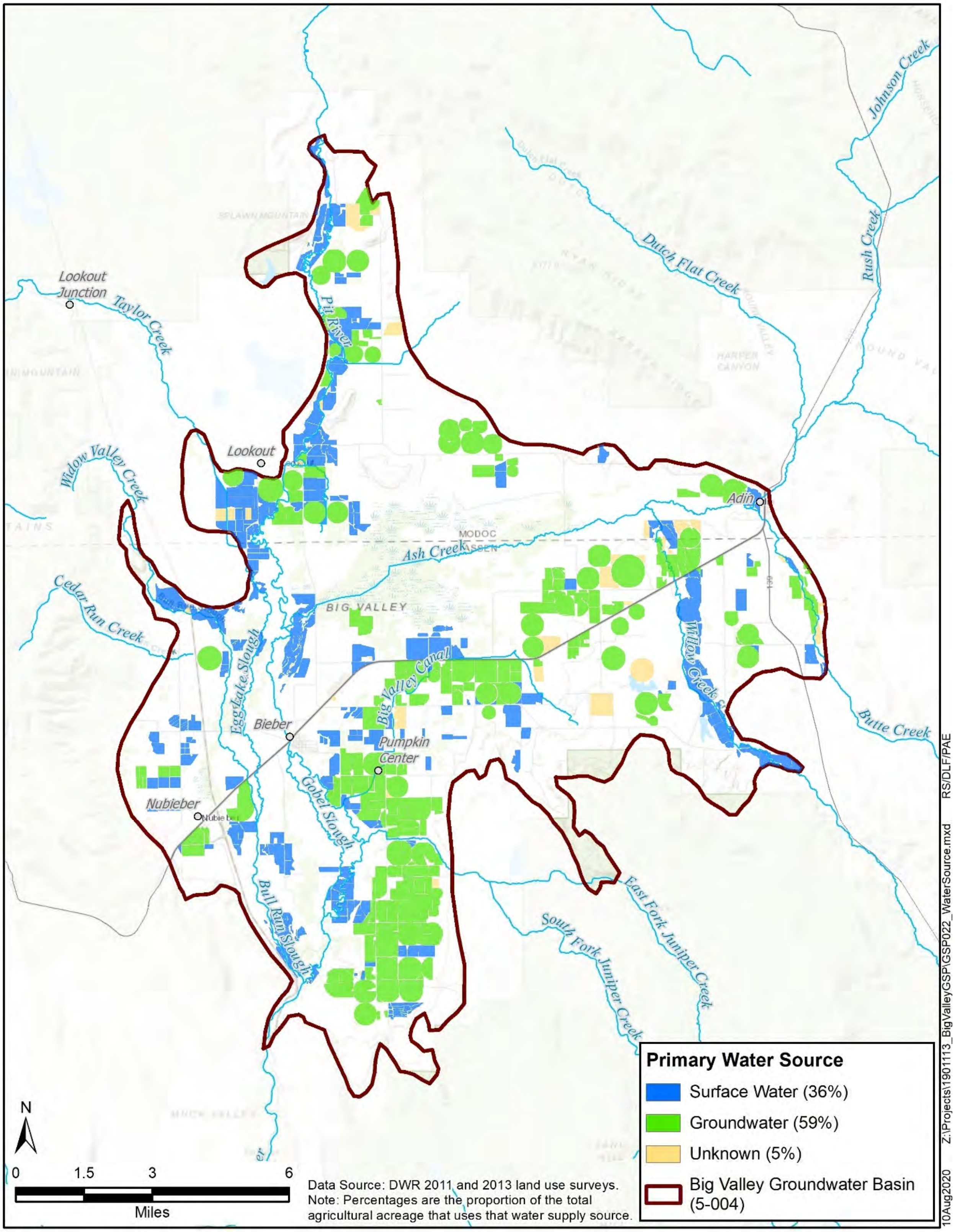

Figure 3-4 Agricultural Water Sources

As indicated previously, the two designated public water suppliers in the Basin use groundwater: Lassen County Waterworks District #1 in Bieber and the Forest Service Ranger Station in Adin. Many domestic users have groundwater wells, but there are some surface water rights from Ash Creek and the Pit River that are designated for domestic use. The Ash Creek Wildlife Area is fundamentally supported by surface water, but the CDFW does have three wells that are utilized in the fall to extend the length of time that wetland habitats are available.

3.4 Inventory and Density of Wells

3.4.1 *Well Inventory*

The best available information about the number, distribution, and types of wells in Big Valley come from well completion reports (WCRs) maintained by DWR[2]. The most recent catalog of WCRs was provided through their website (DWR, 2018) as a statewide map layer. This data includes an inventory and statistics about the number of wells in each section[3] under three categories: domestic, production, or public supply. **Table 3-3** shows the number of wells in the BVGB for each county from this data.

Table 3-3 Well Inventory in the BVGB

WCR 2018 DWR Map Layer				DWR 2015/2017 WCR Inventory		
Type of Well [a]	**Lassen County Total Wells**	**Modoc County Total Wells**		**Proposed Use of Well [b]**	**Lassen County Total Wells**	**Modoc County Total Wells**
Domestic	136	81		Domestic	142	79
Production	177	76		Irrigation	157	65
				Stock	11	5
				Industrial	6	0
Public Supply	5	1		Public	5	1
Subtotal (476)	**318**	**158**		**Subtotal (471)**	**321**	**150**
				Monitor	55	0
				Test	25	29
				Other	7	2
				Unknown	27	7
Total (476)	**318**	**158**		**Total (623)**	**435**	**188**

Source:
[a] DWR 2018 Statewide Well Completion Report Map Layer; downloaded April 2019.
[b] DWR Well Completion Report Inventories from DWR data provided to the counties in 2015 and 2017

Prior to 2018, the counties had requested and received WCRs for their respective areas from DWR during 2015 and 2017, which included an inventory of the wells. This data source had additional well categories included as shown in **Table 3-3**, which are more closely tied to the

[2] All water well drillers with a C57 drilling license in California are required to submit a well completion report to DWR whenever a well is drilled, modified, or destroyed.
[3] A section is defined through the public land survey system as a one mile by one mile square of land.

categories identified by the well drillers when each WCR is submitted, and provides additional information about the use of the wells.

The correlation between the 2018 WCR map layer categories and the categories in the 2015/2017 WCR inventory provided to the counties is indicated in **Table 3-3** by the grey shading. The table shows similar totals from the two datasets for the number of domestic, production, and public supply wells. It is unknown why these two datasets don't match exactly, but both datasets provide information that can be used in this GSP. This table shows that more than 600 wells have been drilled, of which about 475 are of a type that could involve extraction (i.e. domestic, production, or public supply). It is unknown how many wells are actively used, as some of them may be abandoned. Abandoned wells no longer in use should be formally destroyed by statewide well standards. The 2015/2017 inventory of WCRs showed 6 well destructions, all on the Lassen County side of the Basin.

3.4.2 *Well Density*

Figures 3-5, 3-6, and 3-7 show the density of wells in the Basin per square mile for domestic, production, and public supply, respectively, based on the 2018 WCR DWR map layer. These maps provide an approximation of extraction well distributions and give a general sense of where groundwater use occurs.

Figure 3-5 shows that domestic wells are located in 74 of the 180 sections (including partial sections) that comprise the BVGB. The density varies from 0 to 18 wells per square mile with a median value of 2 wells per section and an average of 3 wells per section. The highest densities of domestic wells are located near Adin, Bieber, and Lookout and in a section to the east of Lookout and a section south of Adin. In addition, moderate densities are present in the four sections around Nubieber.

Figure 3-6 shows that production wells (primarily for irrigation) are located in 93 of the 180 sections with a maximum density of 9 wells per section (median: 2 wells per section, average: nearly 3 wells per section). The highest densities of production wells are located between Bieber and Adin, to the southeast of Bieber, and one section northeast of Lookout.

Figure 3-7 shows that public supply wells have been drilled in four sections. It should be noted that the designation as a public supply well that is depicted on the map is from the designation provided in the WCR by the driller when it was drilled. The State Water Resources Control Board (SWRCB) identifies two public water suppliers in the BVGB: Lassen County Waterworks District #1 which is a community system with two wells serve Bieber and Forest Service station in Adin which maintains a well for non-community supply to its employees and visitors. These public suppliers account for 3 of the six public wells drilled. The other three are either inactive or aren't designated as SWRCB public supply.

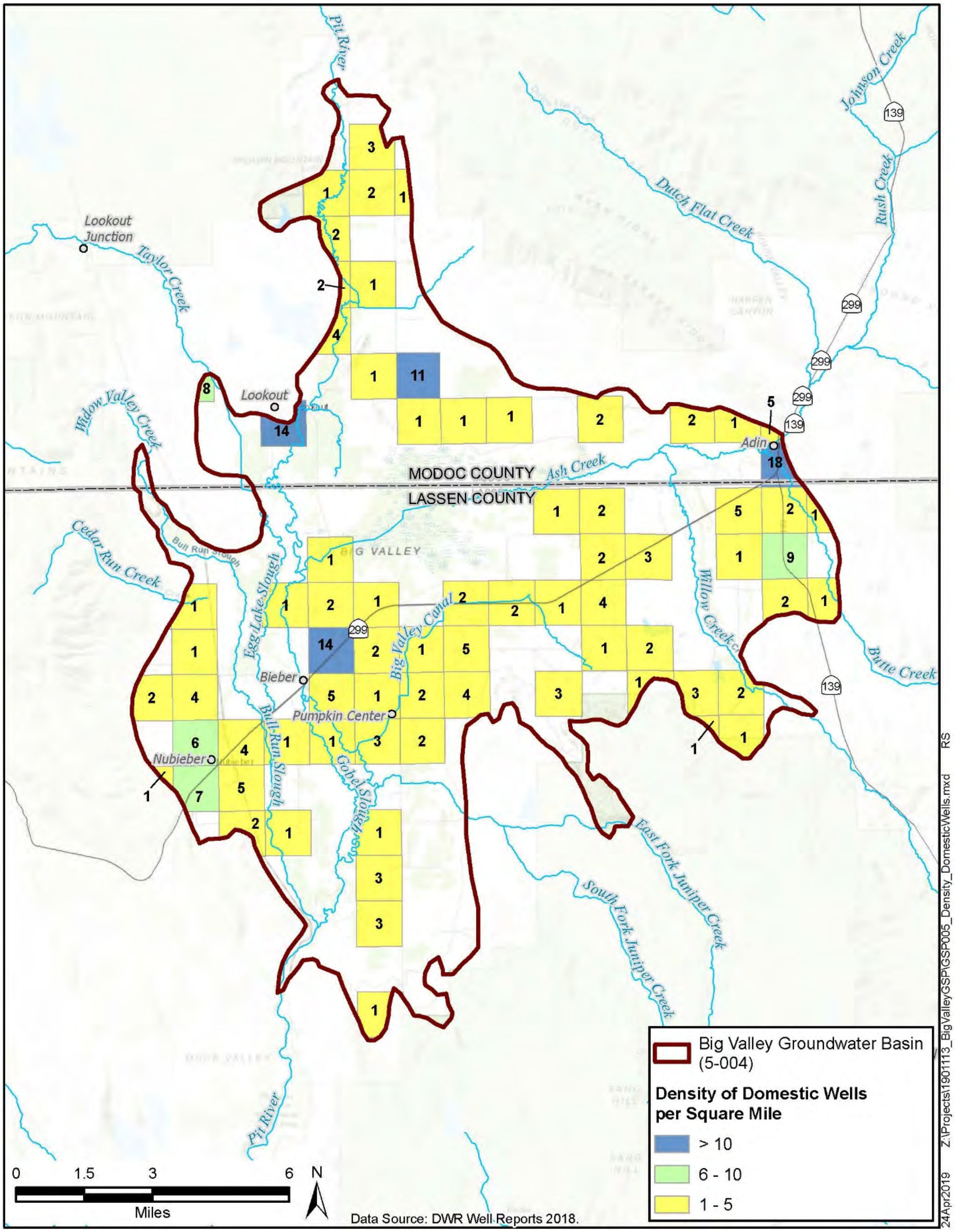

Figure 3-5 Density of Domestic Wells

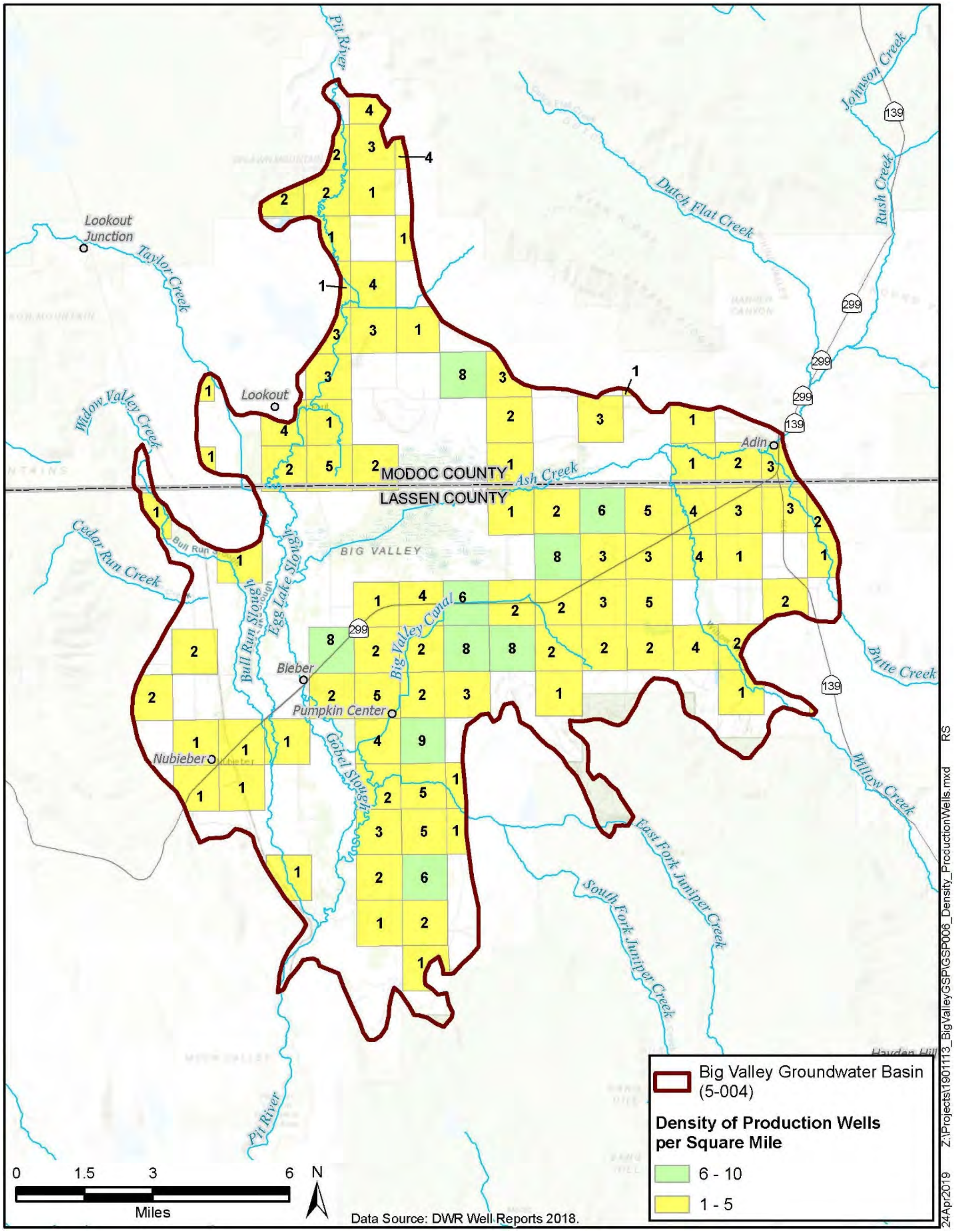

Figure 3-6 Density of Production Wells

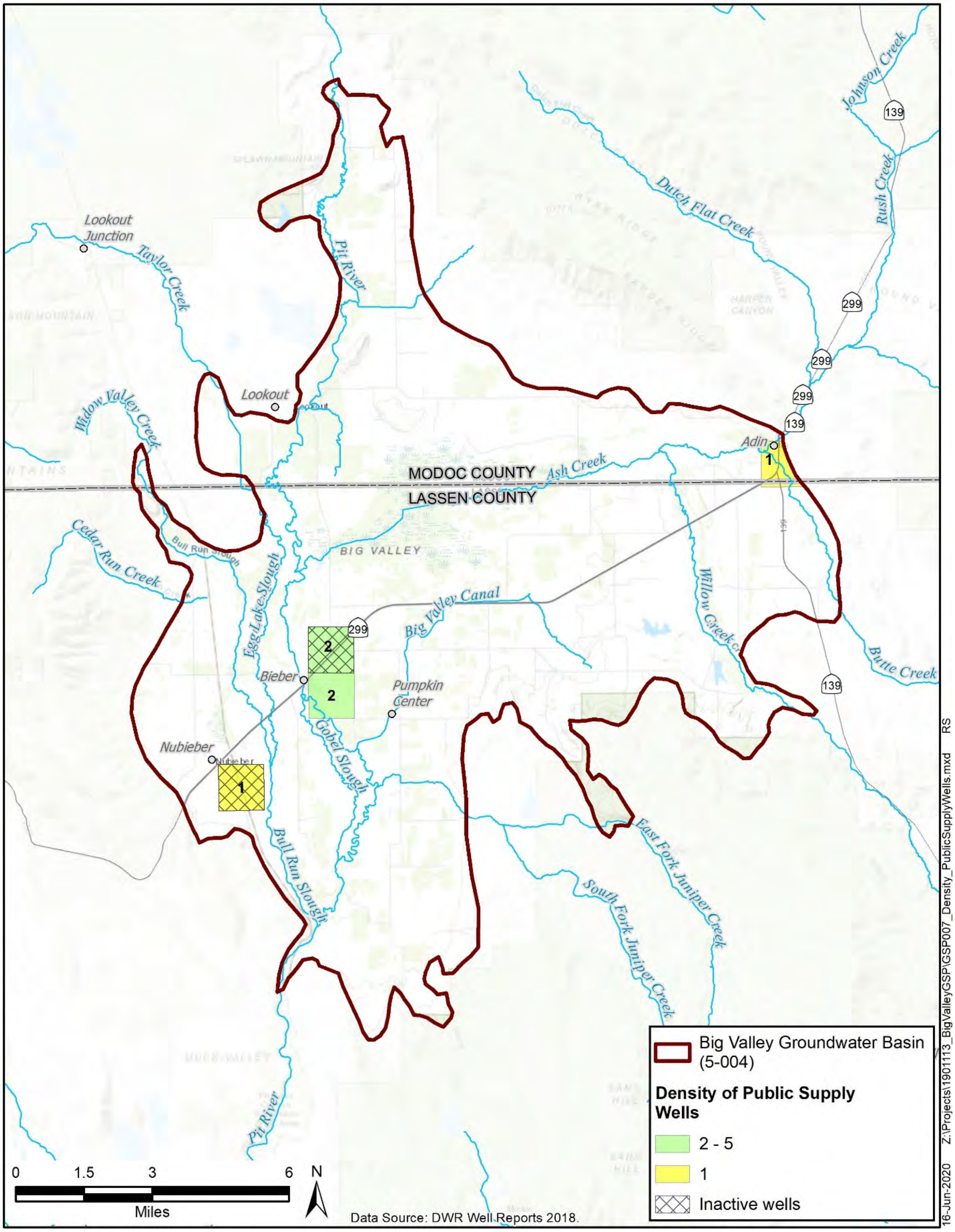

Figure 3-7 Density of Public Supply Wells

3.5 Existing Monitoring, Management, and Regulatory Programs

3.5.1 *Monitoring Programs*

This section describes the existing monitoring programs for data used in this GSP, and describes sources that can be used for the GSP monitoring networks.

3.5.1.1 Groundwater Monitoring

Levels

Lassen and Modoc Counties are the monitoring entities for the California Statewide Groundwater Elevation Monitoring (CASGEM) program. Each county has an approved CASGEM monitoring plan which provides for monitoring twice a year (spring and fall) at 21 wells. The monitoring is performed by staff from DWR on behalf of the Counties. All but one of the wells have depth information ranging from 73 to 800 feet bgs (median: 270 ft bgs, mean: 335 ft bgs)[4]. **Figure 3-8** shows the locations of the 21 CASGEM wells and one additional well which has historic data, but measurements were discontinued in the 1990's.

Lassen and Modoc Counties drilled five monitoring well clusters in 2019-2020. Each cluster consists of three shallow wells and one deep well. The locations of these clusters and the depth of the deep well at each site is shown on **Figure 3-8**.

The LMFCWCD monitors biannual water levels throughout the basin.

Pumping

The LMFCWCD installs and manages flow meters throughout the basin.

Quality

Historic groundwater quality monitoring has been performed under programs with the SWRCB, DWR, and the United States Geological Survey (USGS). The SWRCB has compiled the data from these programs and made it available on their GAMA Groundwater Information System website (SWRCB 2019). The locations of wells with historic water quality data are shown on **Figure 3-9**.

The only current programs that monitor groundwater quality on an ongoing basis are the SWRCB's Division of Drinking Water (DDW) and monitoring associated with cleanup sites. The BVGB contains two active public water suppliers regulated by the DDW: Lassen County Water District #1 in Bieber, and the Forest Service station in Adin. Water quality monitoring at their wells through the DDW can be used for ongoing monitoring in the basin and their locations are shown on **Figure 3-9**. The five newly constructed monitoring well clusters were sampled for water quality after construction and are shown on the figure.

[4] Wells depth indicates depth to with the wells are cased.

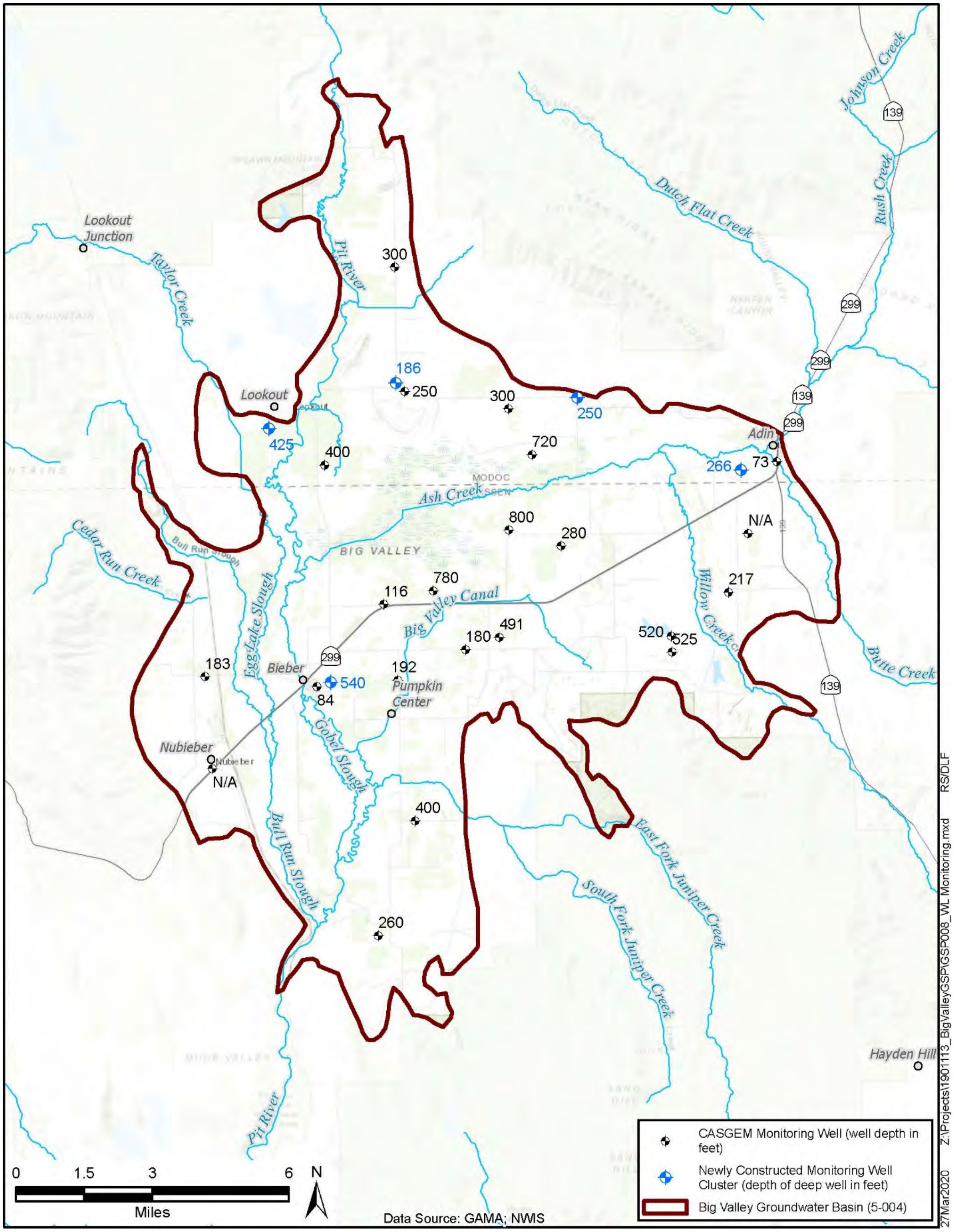

Figure 3-8 Water Level Monitoring Network

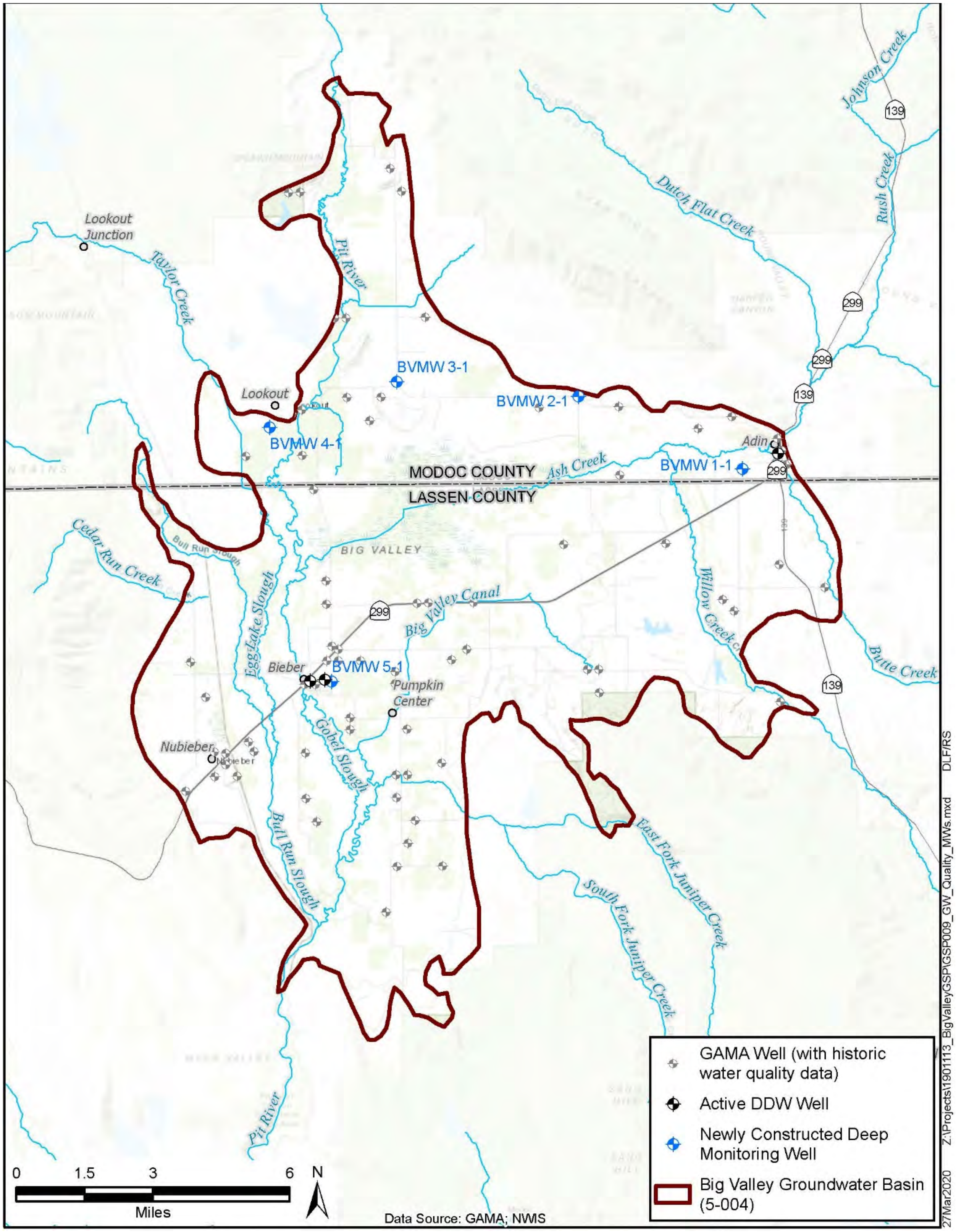

Figure 3-9 Water Quality Monitoring

The basin has five active groundwater cleanup sites in various stages of assessment and remediation, all located in Bieber. These sites are not appropriate for ongoing monitoring for groundwater resources in the basin, as they monitor only the shallow aquifer and represent a localized condition that may not be representative of the overall quality of groundwater resources in the Basin. One of the open sites is the Bieber Class II Solid Waste Municipal Landfill which has ongoing water quality monitoring. The Lookout Transfer Station also has ongoing water quality monitoing, but is located outside the boundaries of the BVGB.

Growers in Big Valley are required to participate in the Irrigated Lands Regulatory Program (ILRP), which imposes a fee per acre, through the Sacramento Valley Water Quality Coalition (SVWQC). The SVWQC Monitoring and Reporting Plan does not include any wells within the BVGB. Basin resident have expressed concerned with regulatory programs that involve costs, especially ongoing costs.

3.5.1.2 Surface Water Monitoring

Streamflow

Streamflow gages have historically been constructed and monitored within the BVGB, but active, maintained streamflow gages for streams in BVGB are limited. For the Pit River, the closest active gage that monitors stage and streamflow is located at Canby, 20 miles upstream of Big Valley. Flow on Ash Creek was measured at a gage in Adin from 1981 to 1999, and was reactivated in Fall 2019 to provide stream stage data at 15 minute intervals. Streamflow data is not currently available from the Adin gage. There is a gage where the Pit River exits the Basin in the south at the diversion for the Muck Valley Hydro Power Plant. However, the data is not readily and publicly available. Stream gauges are shown on **Figure 3-10**.

Diversions

Surface water diversions greater than 10 acre-feet per year must be reported to the SWRCB in compliance with state legislation (SB-88). The Big Valley Water Users Association (BVWUA) employs a watermaster service to measure diversions from the Pit River for submittal to the SWRCB. However, many claimants on the river do their own measurements and reporting. Ash Creek and Willow Creek diversions are monitored by the Modoc County watermaster department, for those claimants that don't do their own measurement and reporting~~for both the Lassen and Modoc portions of the streams~~.

3.5.1.3 Climate Monitoring

The Basin has limited climate monitoring. The National Oceanic and Atmospheric Administration (NOAA) has two stations located in the Basin: Bieber 4 NW and Adin RS. Both of these stations are no longer active, thus only contain historic data. Annual precipitation at the Bieber station is shown for 1985 to 1995 in **Table 3-4**.

The closest California Irrigation Management Information System (CIMIS) station, number 43, is in McArthur, CA, and measures a number of climatic factors that allow a calculation of daily reference evapotranspiration for the area. This station is approximately 10 miles southwest of the western boundary of the Basin. **Table 3-4** provides a summary of average monthly rainfall, temperature, and reference evapotranspiration (ETo) for the Basin, and **Figure 3-11** shows annual rainfall for 1984 through 2018. The locations of all climate monitoring stations are shown on **Figure 3-10**.

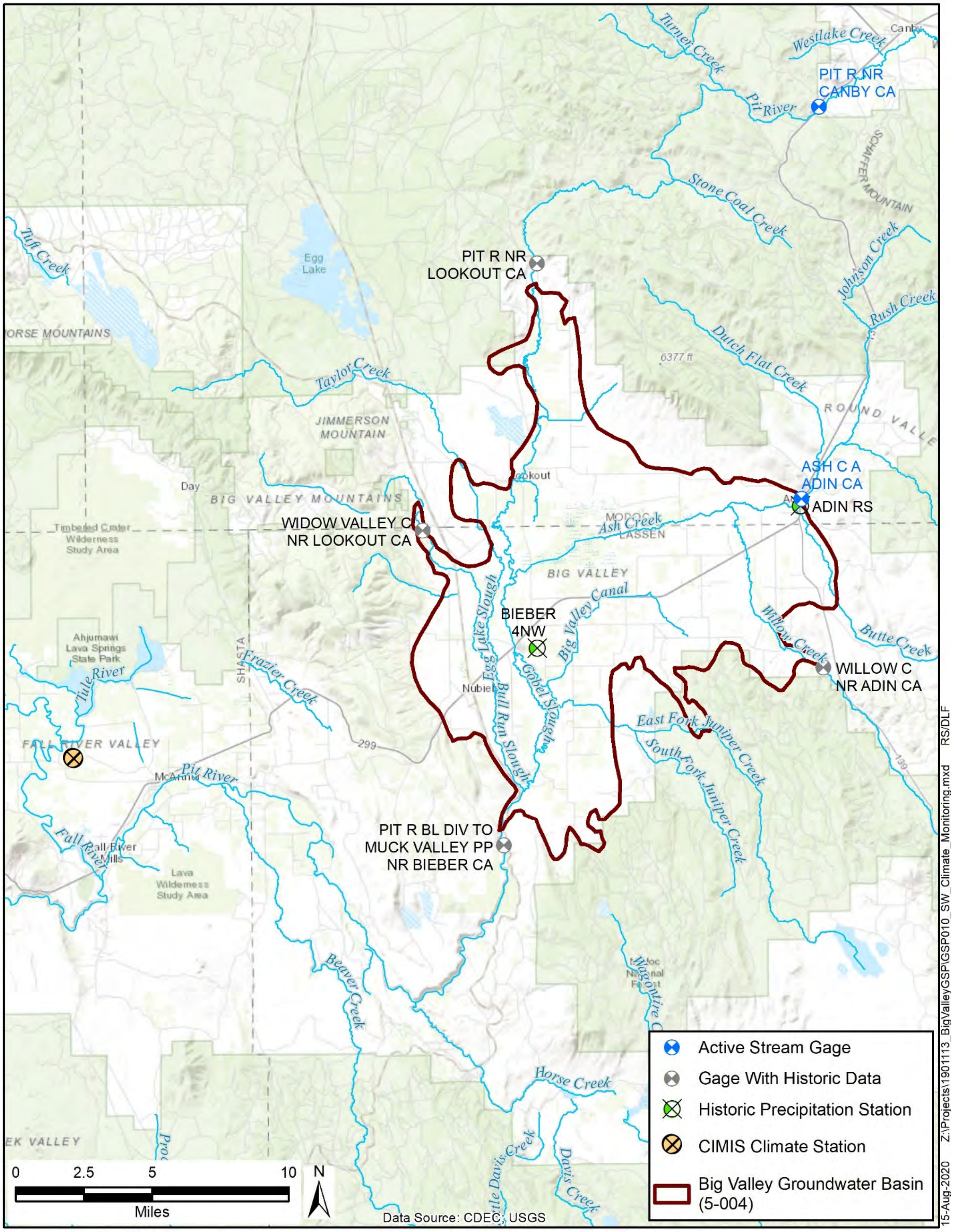

Figure 3-10 Surface Water and Climate Monitoring Network

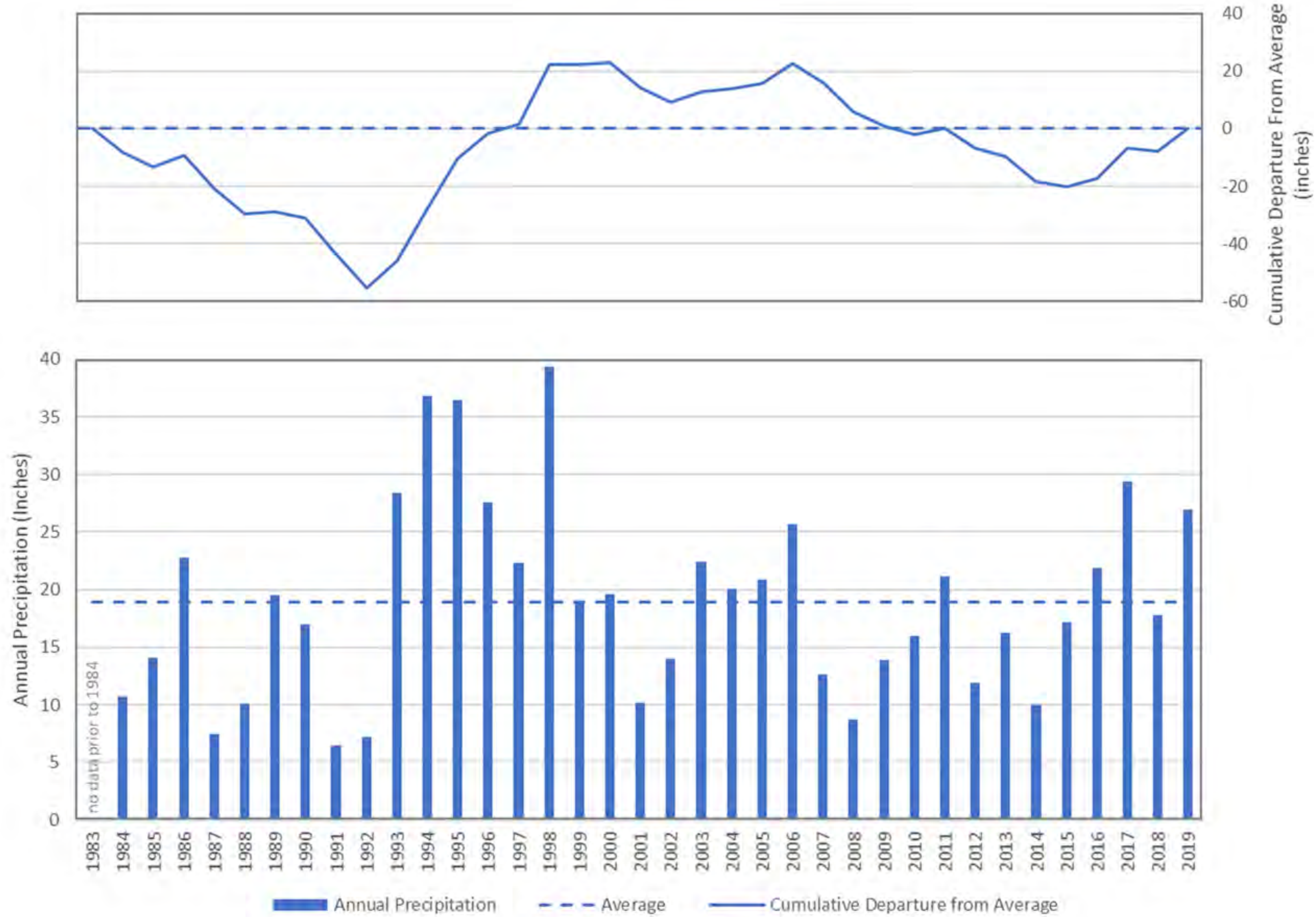

Figure 3-11 Annual Precipitation at the McArthur CIMIS Station

Table 3-4 Annual Precipitation at Bieber from 1985 to 1995

Water Year	Precipitation at Station ID: BBR (inches)
1985	14.1
1986	25.4
1987	11.6
1988	10.9
1989	20.2
1990	16.1
1991	16.5
1992	10.4
1993	28.2
1994	16.3
1995	31.8
Minimum	10.4
Maximum	31.8
Average	18.3

Table 3-5 Monthly Climate Data from CIMIS Station in McArthur (1984-2018)

Month	Average Rainfall (inches)	Average ET_o (inches)	Average Daily Temperature (°F)
October	1.4	3.02	49.5
November	2.3	1.21	38.2
December	2.9	0.75	32.1
January	2.5	0.89	32.5
February	2.6	1.57	36.8
March	2.4	3.01	42.4
April	1.8	4.39	48.2
May	1.6	5.93	55.1
June	0.7	7.24	62.8
July	0.2	8.17	69.1
August	0.2	7.18	66.1
September	0.4	5.02	59.5
Monthly Average	1.6	4.03	49.4
Average Water Year	18.8	48.3	49.4

3.5.1.4 Subsidence Monitoring

Subsidence monitoring is available in the BVGB at a single continuous global positioning satellite station (P347) on the south side of Adin. P347 began operation in September 2007 and provides daily readings. The five monitoring well clusters constructed in 2019-2020 were surveyed and a benchmark established at each site. These sites and can be reoccupied in the future to determine subsidence at those points if needed.

In addition, DWR has provided data processed from inferometric synthetic aperture radar (InSAR) collected by the European Space Agency. The InSAR data currently available provides vertical displacement information between January 2015 and September 2019. InSAR is a promising, cost-effective technique, and DWR will likely provide additional data and information going forward.

3.5.2 *Water Management Plans*

Two water management plans exist that cover the BVGB: the Lassen County Groundwater Management Plan (LCGMP) and the Upper Pit River Integrated Regional Water Management Plan (IRWMP).

Lassen County Groundwater Management Plan

The LCGMP was completed in 2007 and covers all groundwater basins in Lassen County, including the Lassen County portion of the BVGB. The goal of the LCGMP is to "…maintain or enhance groundwater quantity and quality, thereby providing a sustainable, high-quality supply for agricultural, environmental, and urban use…" (Brown and Caldwell 2007). The LCGMP achieves this through the implementation of Basin Management Objectives[5] (BMOs), which establish key wells for monitoring groundwater levels and define "action levels," which, when exceeded, activate stakeholder engagement to determine actions to remedy the exceedance. Action levels are similar to minimum thresholds in the Sustainable Groundwater Management Act (SGMA). A BMO ordinance was passed by Lassen County in 2011.

Upper Pit River Watershed IRWMP

The Upper Pit IRWMP was adopted by the Regional Water Management Group in 2013. Twenty five regional entities were involved in the plan development, which included water user groups, federal, state and county agencies, tribal groups, and conservation groups. The management of the IRWMP has now transferred to the North Cal-Neva Resource Conservation and Development Council (NCNRCDC) who has been working to update the Plan. The goal of the IRWMP is to:

> *"…maintain or improve water quality within the watershed; maintain availability of water for irrigation demands and ecological needs (both ground and surface water);*

[5] Codified as Chapter 17.02 of Lassen County Code.

sustain/improve aquatic, riparian, and wetland communities; sustain and improve upland vegetation and wildlife communities; control & prevent the spread of invasive noxious weeds; strengthen community watershed stewardship; reduce river and stream channel erosion and restore channel morphology; support community sustainability by strengthening natural-resource-based economies; support and encourage better coordination of data, collection, sharing, and reporting in the watershed; improve domestic drinking water supply efficiency/reliability; address the water-related needs of disadvantaged communities; conserve energy, address the effects of climate variability, and reduce greenhouse gas emissions."

The Upper Pit IRWMP contains the entire Watershed above Burney and extends past Alturas to the northeast. The area includes the entire BVGB.

3.5.3 *Groundwater Regulatory Programs*

Water Quality Control Plan for the Sacramento River and San Joaquin River Basins

The Basin is located within the jurisdiction of the Regional Water Quality Control Board (RWQCB) Region 5 (R5) and subject to a Water Quality Control Plan (Basin Plan), which is required by the California Water Code (Section 13240) and supported by the Federal Clean Water Act. The Basin Plan for the Sacramento River Basin and the San Joaquin River Basinwas first adopted by the RWQCB-R5 in 1975.The current version of the Basin Plan was adopted in 2018. The Porter-Cologne Water Quality Control Act requires that basin plans address beneficial uses, water quality objectives, and a program of implementation for achieving water quality objectives. Water Quality Objectives for both groundwater (drinking water and irrigation) and surface water are provided in Chapter 3 of the Basin Plan. (SWRCB, 2020)

Lassen County Water Well Ordinance

Lassen County adopted a water well ordinance in 1988 to provide for the construction, repair, modification and destruction of wells in such a manner that the groundwater of Lassen County will not be contaminated or polluted, and that water obtained from wells will be suitable for beneficial use and will not jeopardize the health, safety or welfare of the people of Lassen County. The ordinance includes requirements for permits, fees, appeals, standards and specifications, inspection, log of the well (lithology and casing), abandonment, stop work, enforcement and violations and well disinfection. Lassen County Environmental Health Department is responsible for the code enforcement related to wells.

In 1999, Lassen County adopted an ordinance requiring a permit for export of groundwater outside the County (Lassen County Code 17.01).

Modoc County Water Well Requirements

Modoc County Environmental Health Department established its requirements for the permitting of work on water wells in 1990, based on the requirements of the California Water Code (Section

13750.5). The fee structure was last revised in 2018. Modoc County also has an ordinance prohibiting the extraction of groundwater for use outside of the groundwater basin from which it was extracted. (Title 20 Chapter 20.04)

California DWR Well Standards

DWR is responsible for setting the minimum standards for the construction, alteration, and destruction of wells in California in order to protect groundwater quality, as allowed by California Water Code Sections 13700 to 13806. DWR began this effort in 1949 and has published several versions of standards in Bulletin 74, beginning in 1962, and is working on a significant update for 2021. Current requirments are provided in Bulletin 74-81, Water Well Standards: State of California, and in Bulletin 74-90 (Supplement), California Well Standards. Cities, counties, and water agencies have regulatory authority over wells and can adopt local well ordinances that meet or exceed the state standards.

Title 22 Drinking Water Program

The SWRCB Division of Drinking Water (DDW) was established in 2014 when the regulatory responsibilities were transferred from the California Department of Public Health. DDW regulates public water systems that provide “water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year,” as defined by the Health and Safety Code (Section 116275 (h). DDW further defines public water systems as:

- Community (C): Serves at least 15 service connections used by year-round residents or regularly serves 25 year-round residents. Lassen County Water District #1 serves groundwater in Bieber.
- Non-Transient Non-Community (NTNC): Serves at least the same 25 non-residential individuals during 6 months of the year. The Adin Ranger Station utilizes a well for its water supply.
- Transient Non-Community (NC): Regularly serves at least 25 non-residential individuals (transient) during 60 or more days per year.

Private domestic wells, industrial wells, and irrigation wells are not regulated by the DDW.

The SWRCB-DDW enforces the monitoring requirements established in Title 22 of the California Code of Regulations (CCR) for public water system wells, and all the data collected must be reported to the DDW. Title 22 designates the regulatory limits (e.g., maximum contaminant levels [MCLs]) for various constituents, including naturally-occuring inorganic chemicals and metals, and general characteristics; and also for man-made contaminants, including volatile and non-volatile organic compounds, pesticides, herbicides, disinfection byproducts, and other parameters.)

3.5.4 *Incorporation Into GSP*

Information in these and other various and numerous programs may be incorporated into this GSP and used during the preparation of Sustainability Management Criteria (minimum thresholds, measurable objectives, interim milestones) and will be considered during development of Projects and Management Actions.

3.5.5 *Limits to Operational Flexibility*

While some of the existing management programs and ordinances may have the potential to affect operational flexibility, they are not likely to be a factor in the Basin. For example, runoff and stormwater quality is of high quality and would not constrain recharge options. Similarly, groundwater export requirements by Lassen County and Modoc County would be taken into account for any sustainable groundwater management decisions in the Basin.

3.6 Conjunctive Use Programs

Formally established conjunctive use programs are not currently operating within the Basin.

3.7 Land Use Plans

The following sections provide a general description of the land use plans and how implementation may affect groundwater. Section 3.2 describes the jurisdictional areas within the BVGB and many of these entities have developed land use plans for their respective jurisdictions. This includes the Modoc and Lassen County general plans and the Modoc National Forest Land and Resource Management Plan.

3.7.1 *Modoc County General Plan*

The 1988 Modoc County General Plan was developed in order to meet a state requirement and to serve as the “constitution” for the community development and use of land. The plan discusses the mandatory elements of a general plan, including land use, housing, circulation (transportation), conservation and open space, noise, and safety, as well as economic development and an action program in the County. The plan was intended to serve as a guide for growth and change in Modoc County for the 15 years following its publication. Under the Conservation Element, Modoc County recognizes the importance of “use-capacity” for groundwater, among other issues, and the minimization of “adverse resource-use,” such as “groundwater mining.” The Water Resources section advocates the “wise and prudent” management of groundwater resources to support a sustainable economy as well as maintaining adequate supplies for domestic wells for rural subdivisions. Groundwater quality was recognized as generally good to excellent within the numerous basins, although some basins contain groundwater with high natural concentrations of boron and/or arsenic (Big Valley).

Policy items from the Modoc General Plan related to groundwater include:

- Cooperate with responsible agencies and organizations to solve water quality problems..
- Work with the agricultural community to resolve any groundwater overdraft problems.
- Require adequate domestic water supply for all rural subdivisions.

The action progam included several general statements for water, including:

- Initiate a cooperative effort among state and local agencies and special districts to explore appropriate actions necessary to resolve long-term water supply and quality problems in the county.
- Require as a part of the review of any subdivision approval a demonstration to the satisfaction of the County that the following conditions exist for every lot in the proposed development:
    - An adequate domestic water supply.
    - Suitable soil depth, slope and surface acreage capable of supporting an approved sewage disposal system.

In 2018, a general plan amendment was adopted to update the housing element section.

3.7.2 *Lassen County General Plan*

The Lassen County General Plan 2000 was adopted in 1999 by the Lassen County Board of Supervisors (Resolution 99-060) to address the requirements of California Government Code Section 65300 et seq, and related provisions of California law pertaining to general plans. The General Plan (GP) reflects the concerns and efforts of the County to efficiently and equitably address a wide range of development issues which confront residents, property owners, and business operators. Many of these issues also challenge organizations and agencies concerned with the management of land and resources and the provisions of community services within Lassen County.

The goals of the plan are to:

- Protect the rural character and culture of Lassen County life.
- Maintain economic viability for existing industries such as agriculture, timber and mining.
- Promote new compatible industries to provide a broader economic base.
- Create livable communities through carefully planned development which efficiently utilize natural resources and provide amenities for residents.
- Maintain and enhance natural wildlife communities and recreational opportunities.
- Sustain the beauty and open space around use in this effort.

The GP addresses the mandatory elements (land use, circulation, housing, conservation, open space, noise, and safety) via several plan documents and alternate element titles. The 1999 GP elements include land use, natural resources (conservation), agriculture, wildlife, open space, circulation, and safety. Separate documents were produced for housing, noise, and energy. The land use element designates the proposed general distribution and intensity of uses of the land, serves as the central framework for the entire general plan, and correlates all land use issues into a set of coherent development policies. The Lassen County GP land use map from 1999 is shown in **Figure 3-12**, and shows intensive agriculture as the dominant land use within the Big Valley area, along with scattered population (small) centers. Otherwise Extensive Agriculture is the dominant land use.

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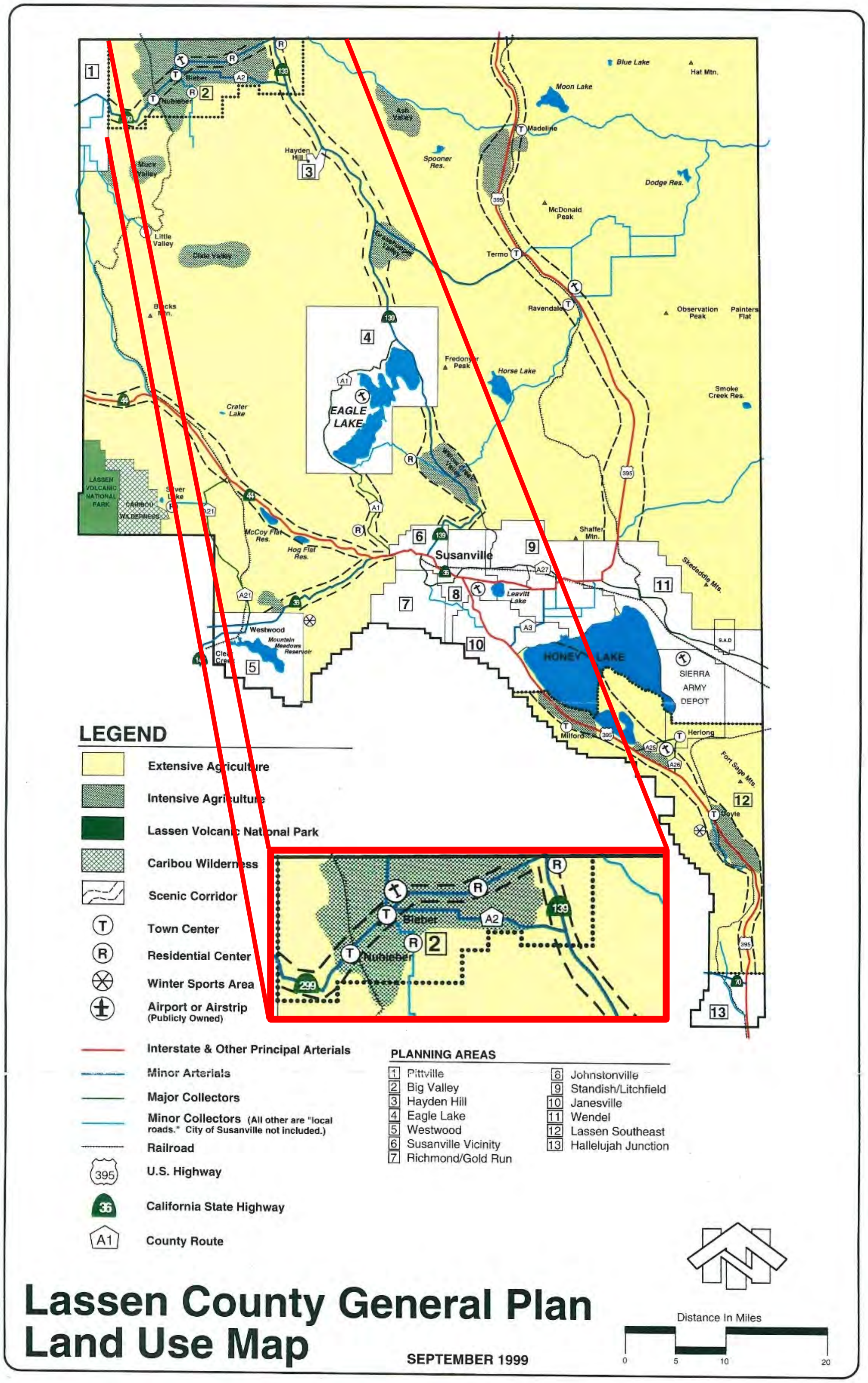

609
610 **Figure 3-12** Lassen County General Plan Land Use Map

Groundwater is addressed in several elements, including agriculture, land use, and natural resources. The GP identified the BVGB as a ‘major ground water basin’ due to the operation of wells at over 100 gallons per minute. Moreover, the GP expressed concern about water transfers and their impact on local water needs and environmental impacts due to water marketeers pumping groundwater from the BVGB into the Pit River and selling it to downstream water districts or municipalities or using groundwater to augment summer flow through the Delta. The GP recognized that safe yield is dependent on recharge and that overdraft pumping would increase operating costs due to a greater pumping lift and could result in subsidence and water quality degradation. In addition, the GP referred to 1980s legislation that authorized the formation of water districts in Lassen County to manage and regulate the use of groundwater resources and to the 1959 Lassen-Modoc County Flood Control and Water Conservation District, as discussed above. The SGMA process established the requirements for a GSP in the BVGB and creation of the two GSAs.

The land use element identified several issues related to groundwater, including public services where 62 percent of rural, unicorporated housing units relied on individual (domestic) wells for their water. Another issue included open space and the managed production of resources, which includes areas for recharge of groundwater among others. The GP referred to the 1972 Open Space Plan, which required that residental sewage disposal systems would not contaminate groudwater supplies. The agriculture element identified an issue with incompatible land uses where agricultural pumping lowers the groundwater level and impacts the use of domestic wells. The wildlife element recognized that changes in groundwater storage could impact wet meadow habitat and threaten fish and wildlife species.

Groundwater is included in polices under the water resources section of the Natural Resources (NR) and Open Space (OS) Elements, as listed below.

- NR15 POLICY: The County advocates the cooperation of state and Federal agencies, including the State Water Resources Control Board and its regional boards, in considering programs and actions to protect the quality of ground water and surface water resources.
- NR17 POLICY: The County supports measures to protect and insure the integrity of water supplies and is opposed to proposals for the exportation of ground water and surface waters from ground water basins and aquifers located in Lassen County (in whole or part) to areas outside those basins.
    - Implementation Measure:

      NR-H: The County will maintain ground water ordinances and other forms of regulatory authority to protect the integrity of water supplies in Lassen County and regulate the exportation of water from ground water basins and aquifers in the county to areas outside those basins.
- NR19 POLICY: The County supports control of water resources at the local level, including the formation of local ground water management districts to appropriately manage and protect the long-term viability of ground water resources in the interest of County residents and the County's resources.

- OS27 POLICY: The County recognizes that its surface and ground water resources are especially valuable resources which deserve and are in need of appropriate measures to protect their quality and quantity.
- OS28 POLICY: The County shall, in conjunction with the Water Quality Control Board, adopt specific resource policies and development restrictions to protect specified water resources (e.g., Eagle Lake, Honey Lake, special recharge areas, etc.) to support the protection of those resources from development or other damage which may diminish or destroy their resource value.
    - Implementaion Measure:

      OS-N: When warranted, the County shall consider special restrictions to development in and around recharge areas of domestic water sources and other special water resource areas to prevent or reduce possible adverse impacts to the quality or quantity of water resources.

3.7.3 *Modoc National Forest Land and Resource Management Plan*

Modoc National Forest lies in the mountain areas surrounding Big Valley to the south and northeast. A small portion of the National Forest extends into the Basin boundary in the south as shown in **Figure 3-2**. The U.S. Forest Service developed their Land and Resource Management Plan in 1991 to "guide natural resource management activities and establish management standards and guidelines". With regard to water resources, the plan seeks to "maintain and improve the quality of surface water" through the implementation of Best Management Practices (BMPs) among other goals. Little mention is made of groundwater in the plan. The plan is available on the Modoc National Forest website (USFS 1991).

3.7.4 *GSP Implementation Effects on Existing Land Use*

The implementation of this GSP is not expected to have an effect on existing designation of land use.

3.7.5 *GSP Implementation Effects on Water Supply*

The implementation of this GSP is not expected to have an effect on Water Supply. Prior to the development of this plan, the Counties had established several policies and ordinances for the management of water and land use in the BVGB. This GSP will incorporate the previous work and will establish sustainable management criteria to continue the successful use of the groundwater resources during the SGMA implementation period and beyond.

3.7.6 *Well Permitting*

Lassen and Modoc Counties both require a permit to install a well as discussed above. The Lassen County Municipal Code (Section 7.28.030) states that "no person, firm, corporation, governmental agency or any other legal entity shall, within the unincorporated area of Lassen County, construct, repair, modify or destroy any well unless a written permit has first been obtained from the health officer of the county." Modoc County states that "a valid permit to drill, destory, deepen, or recondition a water well is required in Modoc County. Permits are obatined from the Environmental Health Department after acceptance of a completed application, plot plan and fees."

3.7.7 *Land Use Plans Outside of the Basin*

The stakeholders submitting this GSP have not included information regarding the implementation of land use plans outside of the BVGB, as any nearby areas are also subject to the land use plan the Lassen and Modoc County General Plans or the Modoc National Forest Land Resource and Management Plan.

3.8 Management Areas

Because the GSP is still under development, the GSAs have not defined management areas within the BVGB. SGMA allows for the basin to be delineated into management areas which:

> *"…may be defined by natural or jurisdictional boundaries, and may be based on differences in water use sector, water source type, geology, or aquifer characteristics. Management areas may have different minimum thresholds and measurable objectives than the basin at large and may be monitored to a different level. However, GSAs in the basin must provide descriptions of why those differences are appropriate for the management area, relative to the rest of the basin." (DWR 2017)*

It should be noted that minimum thresholds and measurable objectives can vary throughout the basin even without established management areas. In deciding whether to implement management areas, the GSAs will need to weigh the added degree of complexity management areas bring to the GSP. For the final GSP, this section will be rewritten to reflect the GSAs decisions related to management areas.

3.9 Additional GSP Elements, if Applicable

The plan elements from California Water Code Section 10727.4 require GSPs to address numerous components listed in **Table 3-5**. The table lists the agency or department with whom the GSA will coordinate or where it will be addressed in the GSP.

Table 3-6 Plan Elements from CWC Section 10727.4

Element of Section 10727.4	Approach
(a) Control of saline water intrusion	Not applicable
(b) Wellhead protection areas and recharge areas	To be coordinated with county environmental health departments
(c) Migration of contaminated groundwater	Coordinated with RWQCB
(d) A well abandonment and well destruction program	To be coordinated with county environmental health departments
(e) Replenishment of groundwater extractions	Chapter 9, Projects and Management Actions
(f) Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage	Chapter 9, Projects and Management Actions
(g) Well construction policies	To be coordinated with county environmental health departments
(h) Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects	Coordinated with RWQCB and in Chapter 9, Projects and Management Actions
(i) Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use	To be coordinated with county farm advisors
(j) Efforts to develop relationships with state and federal regulatory agencies	Chapter 8, Plan Implementation
(k) Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity	To be coordinated with appropriate county departments.
(l) Impacts on groundwater dependent ecosystems	Chapter 5, Groundwater Conditions

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Abbreviations and Acronyms

Basin	Big Valley Groundwater Basin
b	variable typically assigned to the aquifer thickness (in feet)
bgs	Below Ground Surface
BVGB	Big Valley Groundwater Basin
Ca	calcium
CGS	California Geological Survey
DDW	Division of Drinking Water (SWRCB)
DWR	California Department of Water Resources
GEI	GEI Consultants, Inc.
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
K	potassium
K	variable typically assigned to hydraulic conductivity
msl	elevation above mean sea level
Mg	magnesium
Na	sodium
NRCS	National Resources Conservation Service
S	variable typically assigned to storativity
SAGBI	Soil Agricultural Groundwater Banking Index
SGMA	Sustainable Groundwater Management Act of 2014
SSURGO	Soil Survey Geographic Database
SWRCB	California State Water Resources Control Board
SY	specific yield
T	variable typically assigned to transmissivity
UCD	University of California at Davis
USBR	United States Bureau of Reclamation

4. Hydrogeologic Conceptual Model §354.14

A hydrogeologic conceptual model (HCM) is a description of the physical characteristics of a groundwater basin related to the hydrology, geology, and defines the principal aquifer(s). The HCM provides the context for the development of a water budget (Chapter 6), sustainable management criteria (Chapter 7), and monitoring network (Chapter 8).

This chapter presents the HCM for the Big Valley Groundwater Basin (BVGB or Basin, 5-004) and was developed by GEI Consultants for the Lassen County and Modoc County groundwater sustainability agencies (GSAs). This HCM supports the development of the monitoring network, water budget, and the sustainable management criteria of this Groundwater Sustainability Plan (GSP). The content of this HCM is defined by the regulations of the Sustainable Groundwater Management Act (SGMA) – Chapter 1.5, Article 5, Subarticle 2: 354.14.

Groundwater characteristics and dynamics in the Basin are variable. Located in a sparsely populated area, the amount of existing literature to support this HCM is sparse, with the most thorough studies being prior to the 1980's. This HCM presents the available information, data, and analyses and provides some limited new data and analyses that further the understanding. With that said, data gaps in the HCM are many and have been identified in this chapter. The HCM presents best available information and expert opinion to form the basis for descriptions of elements of this GSP: basin boundary; confining conditions; definable bottom, nature of flows near or across faults, soil permeability, and recharge potential. Significant uncertainty exists in this HCM and stakeholders have expressed concern about the possible regulatory repercussions associated with making decisions using incomplete and/or uncertain information. This includes not only hydrogeologic conditions, but also an evolving regulatory framework. The concern is that time, effort and funding could be invested in addressing data gaps and developing management strategies for regulatory priorities and requirements that become less relevant in the future.

Recommendations and options for prioritizing and addressing the data gaps are part of this document. The stakeholders in the disadvantaged communities of the Big Valley Groundwater Basin (BVGB) have limited financial means to fill data gaps, so the filling of the data gaps presented at the end of this chapter are contingent on outside funding.

4.1 Basin Setting §354.14(d)(1)

BVGB is located in Lassen and Modoc Counties in northeastern California, 50 miles north-northwest of Susanville and 70 miles east-northeast of Redding (road distances are greater). Most of BVGB is in Lassen County (60%) with the remainder in Modoc County. At it's widest points, the BVGB is approximately 21 miles long (north-south) in the vicinity of the Pit River and 15 miles wide (east-west) south of Ash Creek Wildlife area. The Basin has an irregular shape totaling 144 square miles or 92,000 acres. (DWR 2004) The topography of BVGB is relatively flat within the central area with increasing elevations along the perimeter, particularly in the eastern portions where Willow and Ash Creeks enter the Basin. Ground surface elevations range from about 4,090 feet above mean sea level (msl) near the south end of BVGB to over 4,500 feet msl at the eastern edge of the Basin. In the north central portion of the basin, two buttes protrude from the valley (Pilot and Roberts Buttes). The Pit River enters the BVGB at an elevation of 4,150 feet msl and leaves the Basin at 4,090 feet msl over the course of about 30 river miles, giving the Pit River a gradient of 2 feet per mile. By contrast, the Pit River above and below Big Valley has a gradient over 50 feet per mile. This low gradient in the Basin results in a meandering river morphology and widespread flooding during large storm events. Ash Creek enters the Basin at Adin at an elevation of 4,100 feet msl, eventually joining the Pit River when flows are sufficient to make it past Big Swamp. **Figure 4-1** shows the ground topography for the BVGB.

Topographic maps (7.5-minute) for the BVGB area include (north-south, west-east):

Donica Mountain	Halls Canyon	-
Lookout	Big Swamp	Adin
Bieber	Hog Valley	Letterbox Hill

4.2 Regional Geology and Structure §354.14(b)(1)

The regional geology is depicted on the Alturas Sheet, a 1:250,000 scale map with an excerpt shown on **Figure 4-2**. (CGS 1958) The Big Valley Groundwater Basin is in the central area of the Modoc Plateau geomorphic province. According to the California Geological Survey (2002), the Modoc Plateau is “a volcanic table land” broken into blocks by north-south faults. The Basin is underlain by a thick sequence of lava flows and tuffs. The volcanic material is variable in composition as described below, and is Miocene to Holocene age[1], which erupted into sediment-filled basins between the block-faulted mountain ranges (Norris and Webb, 1990).

According to MacDonald (1966), the Modoc Plateau is transitional between two provinces: block faulting of the Basin and Range and volcanism of the Cascade Range. This can be observed on **Figure 4-2** with the faults trending north-northwest surrounding Big Valley and the most recent center of volcanism (indicated by the numerous cinders centered around Medicine Lake, with several eruptions about 1000 years before present) about 30 miles northwest of Big Valley. Moreover, the historic volcanism and tectonics occurred concurrently, which disrupted the drainage from the province and resulted in the formation of numerous lakes, including an ancestral lake in Big Valley. Volcanic material was deposited as lava flows, ignimbrites (hot ash flows), subaerial and water-laid layers of ash (cooler), and mudflows combined with sedimentary

[1] Miocene is 23 milltion to 5.3 million years ago, Holocene is 12,000 years ago to present.

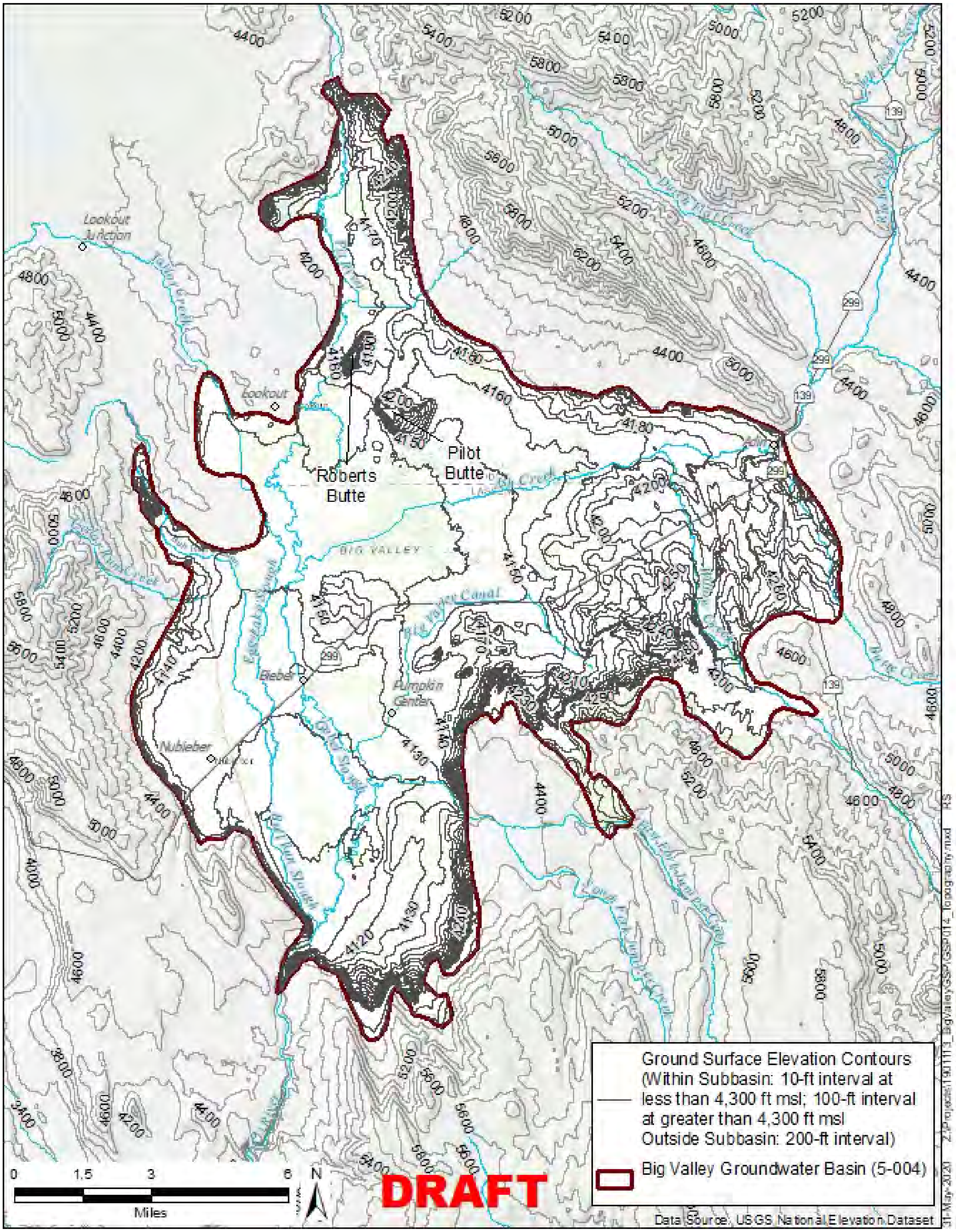

Figure 4-1 Topography

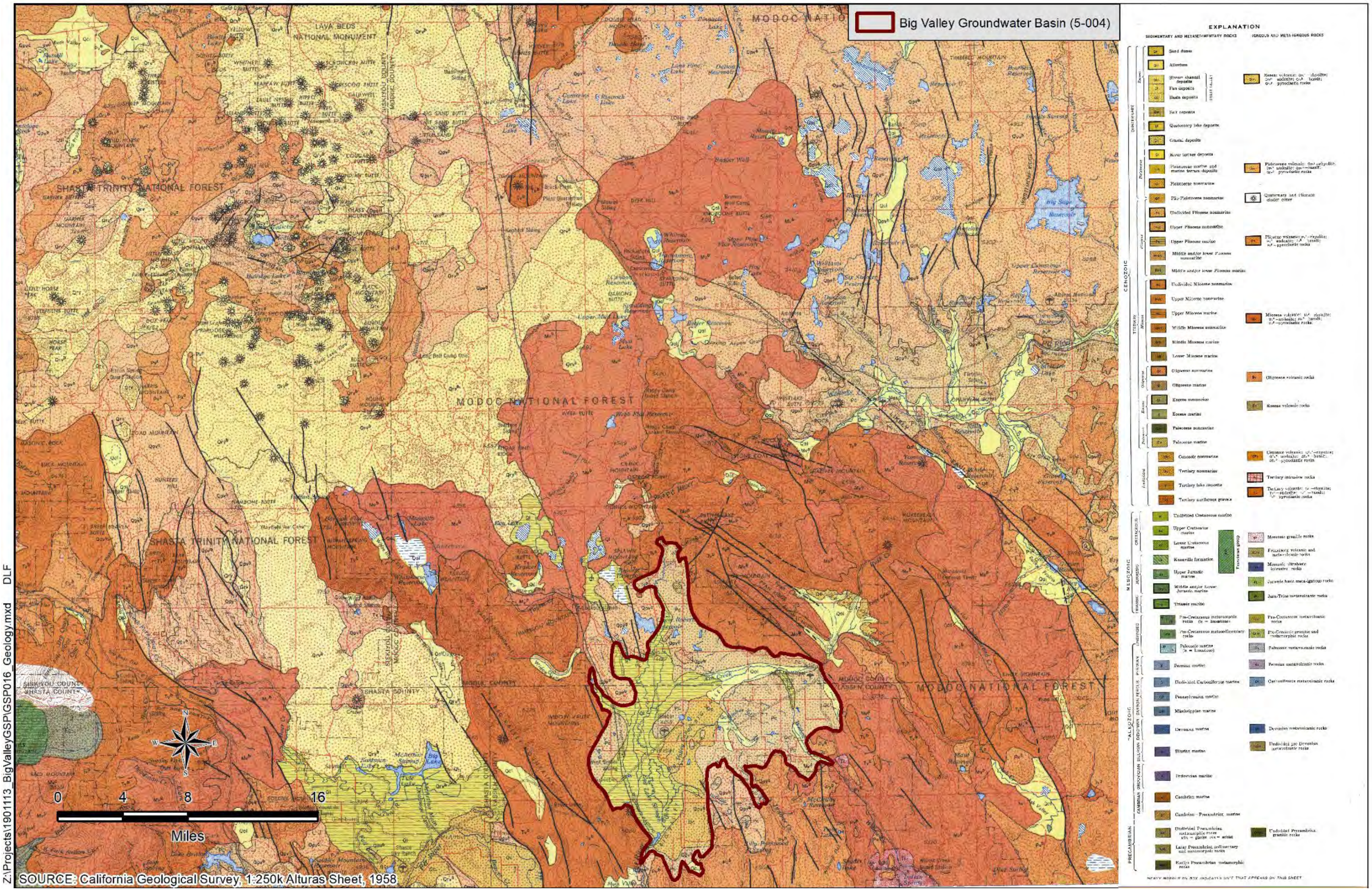

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Figure 4-2 Regional Geologic Map

material, although thick sections of rock can be either entirely sedimentary or volcanic. The composition of the lava flows are primarily basalt[2] and basaltic andesite[3], while pyroclastic[4] ash deposits are rhyolitic[5] composition.

4.2.1 *Lateral Basin Boundaries §354.14(b)(2)*

The CGS (1958) map (**Figure 4-2**) was used by DWR to draw the BVGB boundary. The lateral boundaries of BVGB are described by DWR (2004) as "bounded to the north and south by Pleistocene and Pliocene basalt and Tertiary pyroclastic rocks of the Turner Creek Formation, to the west by Tertiary rocks of the Big Valley Mountain volcanic series, and to the east by the Turner Creek Formation." In general, the boundary drawn by DWR can be described as the contact between the valley alluvial deposits and the surrounding volcanic rocks. Because this boundary was drawn using a regional-scale map drawn with the surface expression of geologic units, it may be necessary to modify the boundary at a future date with more precision in order to include the extent of aquifer materials which may extend outside of the current boundary within the subsurface.

4.3 Local Geology §354.14(d)(2)

Several geologic maps were available at a more detailed scale than the CGS (1958) map. Two of them had accompanying studies that more thoroughly described the geology. Although relatively old studies, they both provide useful information. However, they differ slightly on some details, particularly the surficial geology. The two maps are shown in **Figures 4-3** and **4-4**.

The two different reports were written for different purposes, with DWR (1963) being developed as a general investigation of the potential of groundwater resources, and GeothermEx (1975) as an investigation specifically performed to evaluate hydrothermal groundwater resources. All reviewed sources agree that the BVGB is surrounded by mountain blocks of volcanic rocks of somewhat variable composition, but primarily basalt. Although these mountains are outside of the groundwater basin, they capture and accumulate precipitation, which produces runoff that flows into BVGB. Moreover, DWR (1963) suggested that these mountains serve as "upland recharge areas" and provide subsurface recharge to BVGB. These recharge areas suggested by DWR are shown in red shading on **Figure 4-5** and correlate with Pliocene to Pleistocene[6] basalts (Tpbv and Qpbv). These units are mapped by DWR (1963) outside the Basin to the northwest and southeast as well as along the crests of Barber and Ryan Ridges to the northeast of Big Valley.[7] GeothermEx (1975) generally concurs with this mapping, except for the areas along Barber and Ryan Ridges, which they map as a much older unit (Miocene) which is corroborated

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[2] Basalt is an extrusive (volcanic) rock with relatively low silica content and high iron and magnesium content.
[3] Andesite is an extrusive rock with intermediate silica content and intermediate iron and magnesium content.
[4] Pyroclastic means formed from a volcanic eruptions, typically not from lava flows, but from material (clasts) ejected from the eruption such as ash, blocks, or "bombs".
[5] Rhyolitic rocks are extrusive with relatively high silica content and low iron and magnesium. Rhyolites are the volcanic equivalent of granite.
[6] 5.3 million years to 11,700 years ago.
[7] The GSAs specifically requested a basin boundary modification to include these upland recharge areas within the Basin boundary. The request was denied by DWR as not being sufficiently substantiated. (See **Appendix 1A**)

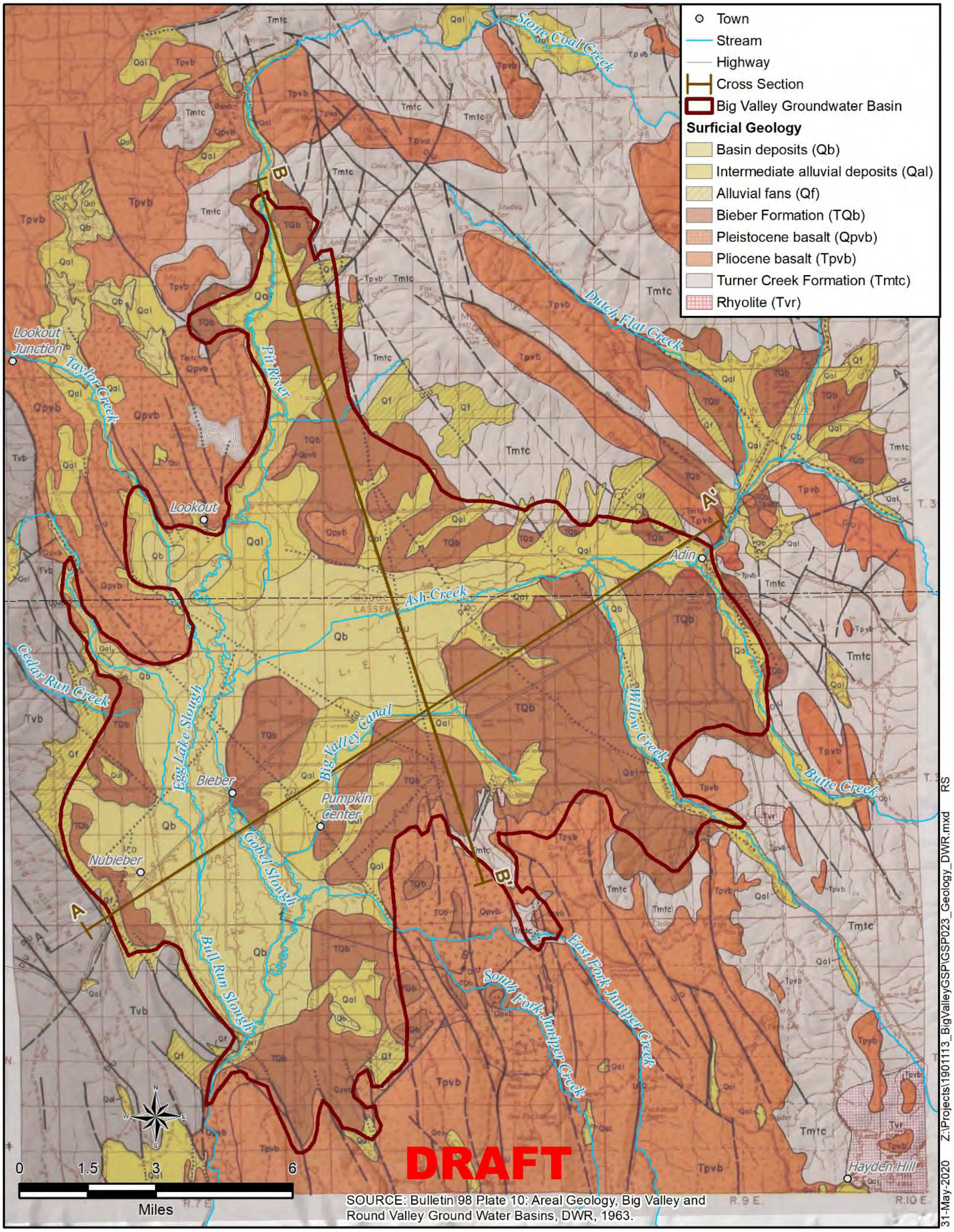

Figure 4-3 DWR 1963 Local Geologic Map

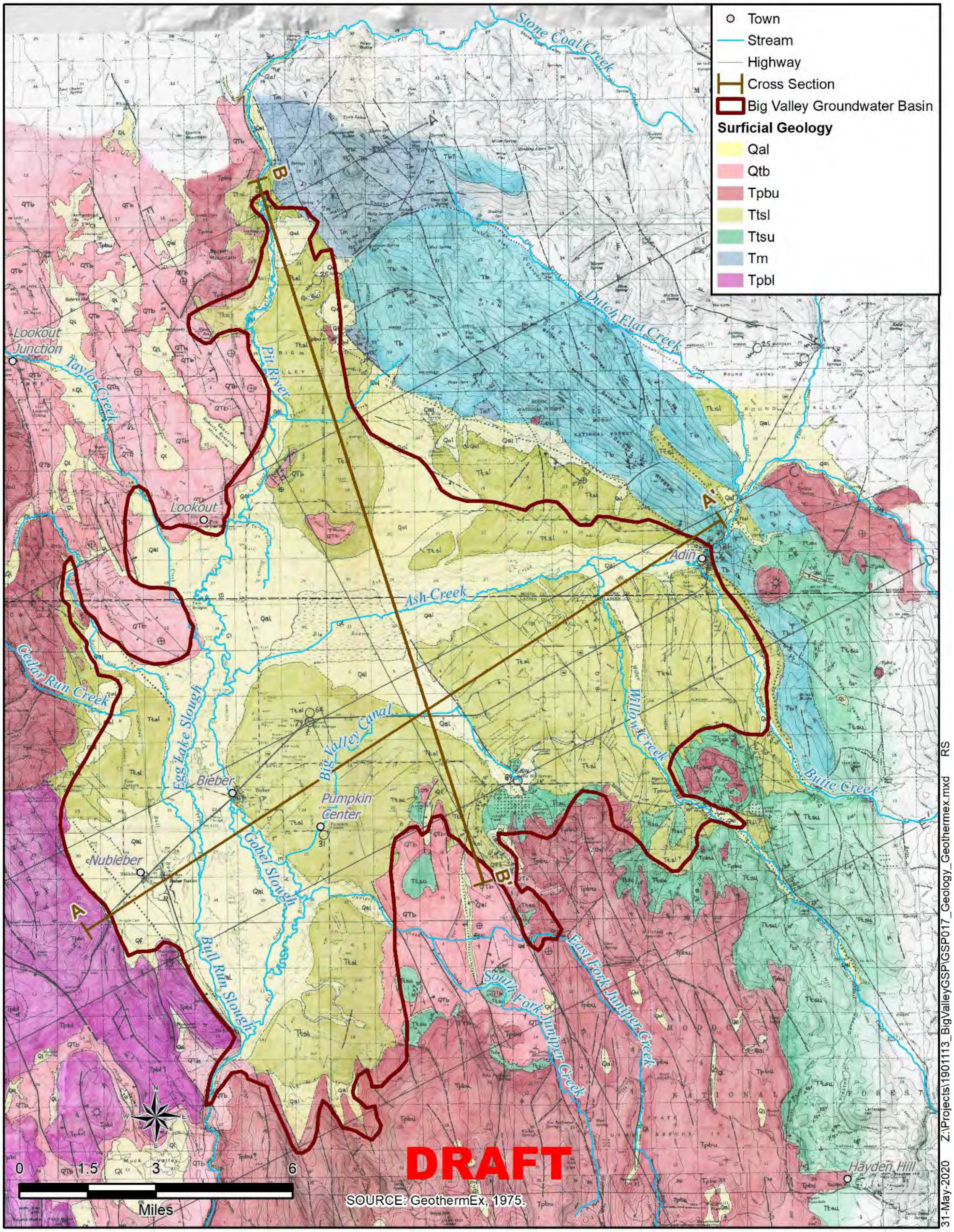

Figure 4-4 GeothermEx 1975 Local Geologic Map

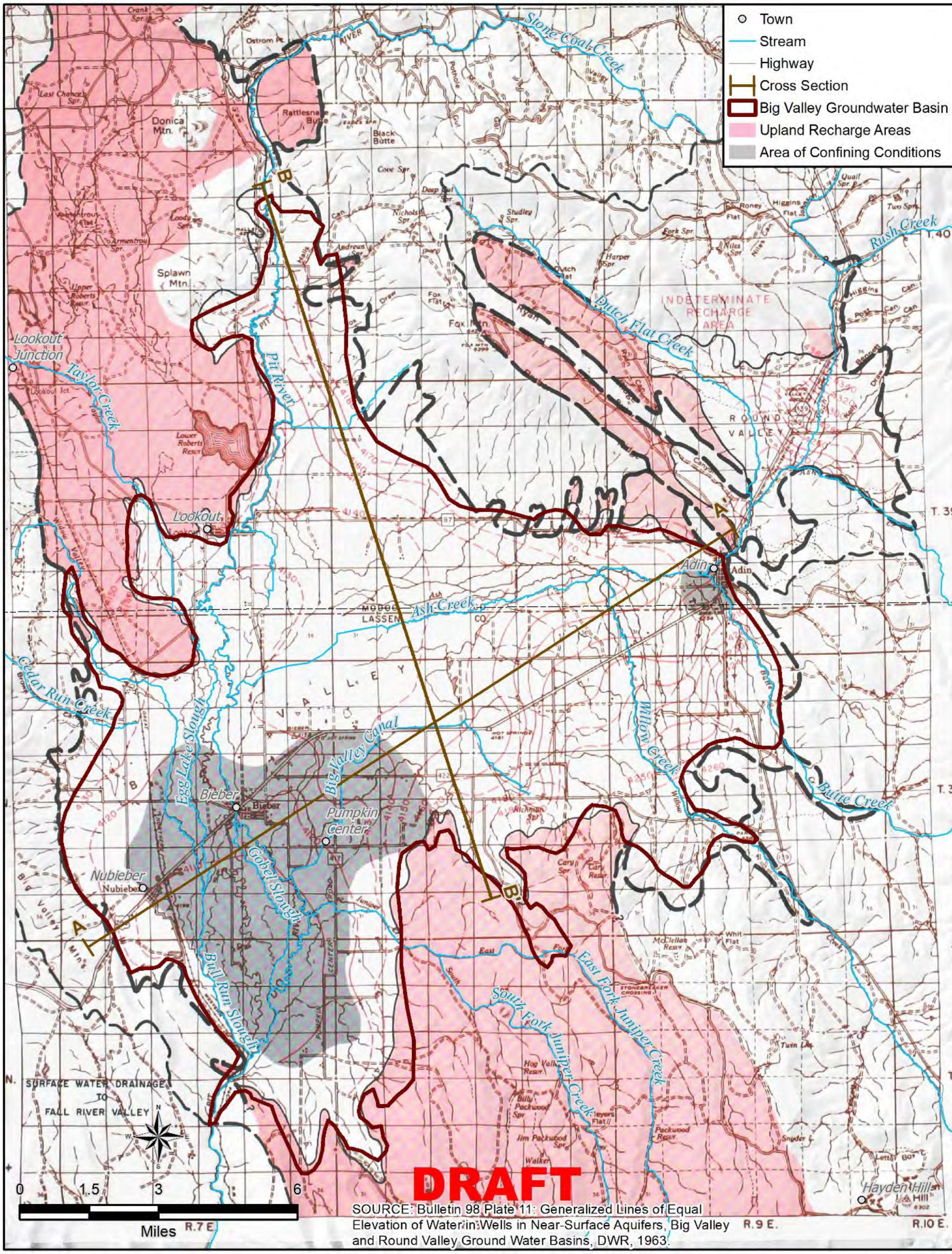

Figure 4-5 DWR 1963 Upland Recharge Areas and Areas of Confining Conditions

by a radiometric age date measured at 13.8 million years. This distinction is important because an older unit is more likely to underlie the basin sediments and less likely to be hydraulically connected to the BVGB. At the northwestern end of Barber Ridge, GeothermEx maps the oldest unit in the BVGB area (Tm) of Andesitic composition. This unit contains the site of the Shaw Pit quarry.

4.4 Principal Aquifer §354.14(b)(4)

4.4.1 *Formation Names §354.14(b)(4)(A)*

The Pliocene-Pleistocene[8] age Bieber Formation (TQb) is the main formation of aquifer material defined within BVGB, extending to depths of 1,000 feet or more. It meets the surface around the perimeter of the basin, especially on the southeast side (DWR, 1963). The formation was deposited in a lacustrine (lake) environment and is comprised of unconsolidated to semi-consolidated layers of interbedded clay, silt, sand, gravel, and diatomite[9]. Layers of black sand and white sand (pumiceous) were identified as highly permeable but discontinuous and mostly thin. GeothermEx (1975) did not embrace the DWR name and identified this formation as an assemblage of tuffaceous, diatomaceous lacustrine and fluvial sediments (Ttsu, Ttsl). Both investigations identified the formation in the same overall location, based on a comparison of the two geologic maps, but the GeothermEx map provides more detail and resolution than the DWR map. For the purposes of the GSP, the name Bieber Formation will be used.

Recent Holocene[10] deposits (labeled with Q) were mapped within the center of the basin and along drainage courses from the upland areas and are identified by DWR (1963) as alluvial fans (Qf), intermediate alluvium (Qal), and basin deposits (Qb). The composition of these unconsolidated deposits varies from irregular layers of gravel, sand, and silt with clay to poorly sorted silt and sand with minor clay and gravel (Qal) to interbedded silt, clay, and "organic muck" (Qb). The latter two deposits occur in poorly drained, low-lying areas where alkali[11] could accumulate. The thickness of these sediments is estimated to be less than 150 feet. GeothermEx (1975) identified these deposits as older valley fill (Qol), lake and swamp deposits (Ql), fan deposits (Qf) as well as undifferentiated alluvium (Qal). All of these recent deposits are aquifer material[12] and are part of the Big Valley principal aquifer.

The principal aquifer consists of the Bieber Formation (TQb and recent deposits (Qal, Qg, Qb). While DWR (1963) delineates an "area of confining conditions" in the southwest area of the

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[8] 5.3 million to 12 thousand years old.
[9] Diatomite is a fine-grained sedimentary rock made primarily of silica. It is formed from the deposition of diatoms who make their microscopic shells from silica.
[10] Recent geologic period from 11,700 years old to present.
[11] Alkali means relatively high in alkali and alkali earth metals (primarily sodium, potassium, calcium, and magnesium) and generally results in a high pH (greater than 7 or 8).
[12] Meaning they contain porous material with recoverable water.

basin on **Figure 4-5**, the data to support the confinement and the definition of a broad-scale, well-defined aquitard[13] is not currently available.

As described above and below, aquifer conditions vary greatly throughout the Basin. However, a clearly defined, widespread distinct aquifer units have not been identified, and with the data currently available a single principal aquifer will be used for this GSP. Future data collection and development of the groundwater resources could lead to the definition of additional aquifers.

4.4.2 *Geologic Profiles §354.14(c)*

Figures 4-6 and **4-7** show cross-sections across Big Valley. The locations of the cross-sections are shown on **Figures 4-3, 4-4,** and **4-5**. The locations of these sections were drawn to be similar to those drawn by DWR (1963) and GeothermEx (1975) and characterize the aquifers in two directions (southwest-northeast, and northwest-southeast). The sections show the lithology of numerous wells across the valley. Very little geological correlation could be made across each section which is likely to be related to the concurrent block faulting and volcanic and alluvial depositional input from various highland areas flowing radially into Big Valley. These complex structural and depositional variables result in great stratigraphic variation over short distances. The pertinent information from cross-sections presented by DWR (1963) and GeothermEx (1975) are shown on the sections.

4.4.3 *Definable Bottom §354.14(b)(3)*

The SGMA and DWR's GSP regulations do not provide clear guidance for what constitutes a "definable bottom" of a basin. However, DWR's (2016) Bulletin 118 Interim Update describe the "physical bottom" as where the porous sediments contact the underlying bedrock and the "effective bottom" as the depth below which water is unusable because it is brackish or saline.

The "physical bottom" of BVGB is difficult to define because few borings have been drilled deeper than 1200 ft and the compositions of the alluvial and bedrock formations are similar (derived from active volcanism), with contacts that are gradational. Also, some of the lavas probably flowed into Big Valley forming lava lenses that are now interlayered below, above and laterally with permeable aquifer sediments. Moreover, the base of the aquifer system is likely variable across BVGB due to the concurrent volcanism and horst/graben faulting of the bedrock.

The deepest wells drilled in the Basin include two test borings by DWR to depths of 1843 and 1231 feet and two geothermal test wells near Bieber to depths of 2125 and 7000 feet. The lithologic descriptions of the deepest (7000 foot) well east of Bieber only extend 4100 feet and indicate aquifer-type materials (sands) throughout. The other three deep well lithologies give similar indication of aquifer material to their total depth.

The two geothermal wells also had temperature logs, and some water quality. Water temperatures increased to over 100°F beyond depths of about 2000 to 3000 feet. The Bieber

[13] Layer of low permeability that prevents significant flow, except at very slow rates.

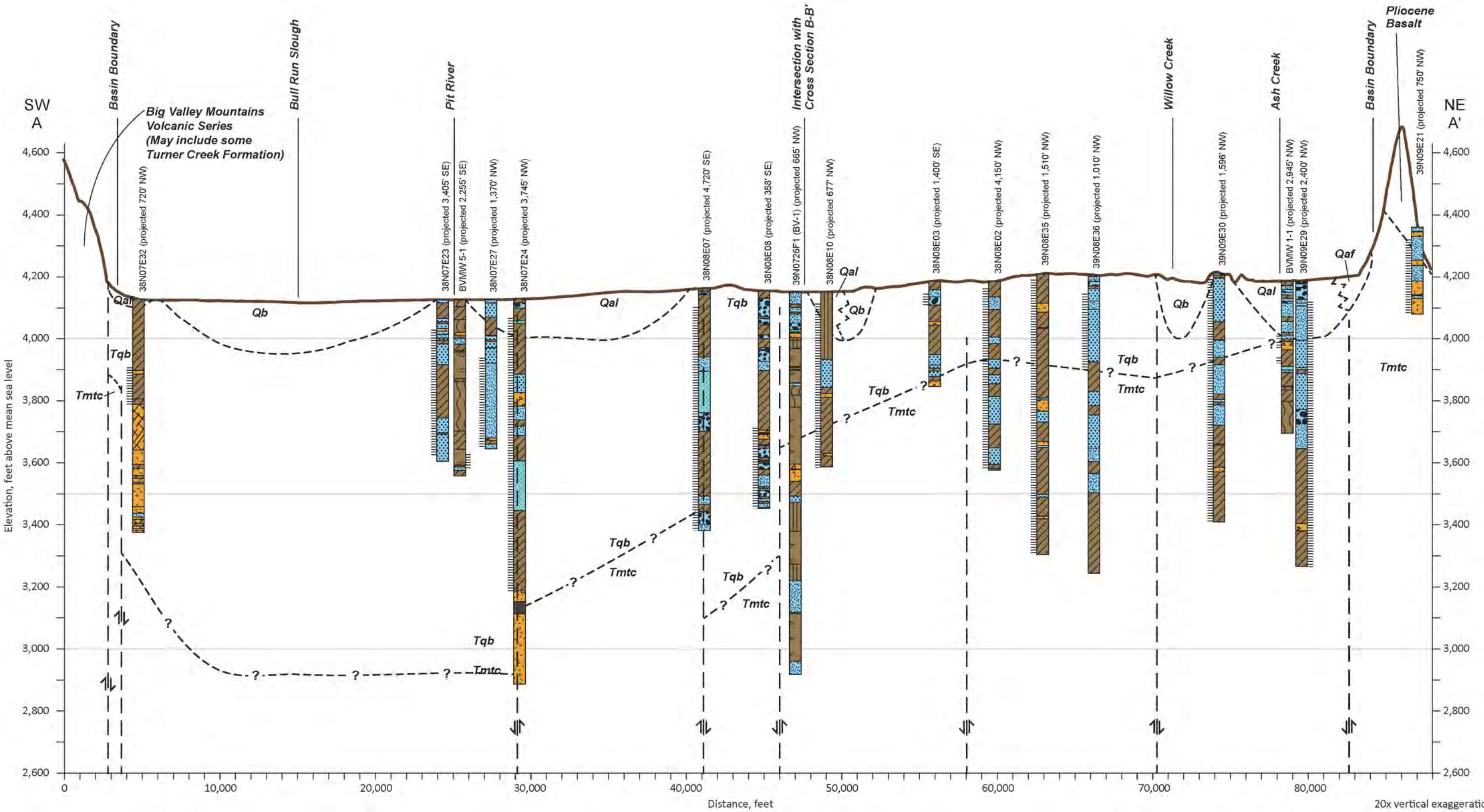

Figure 4-6 Geologic Cross Section A-A'

Note: Key to lithologic symbologies is in development and will be included in future draft(s).

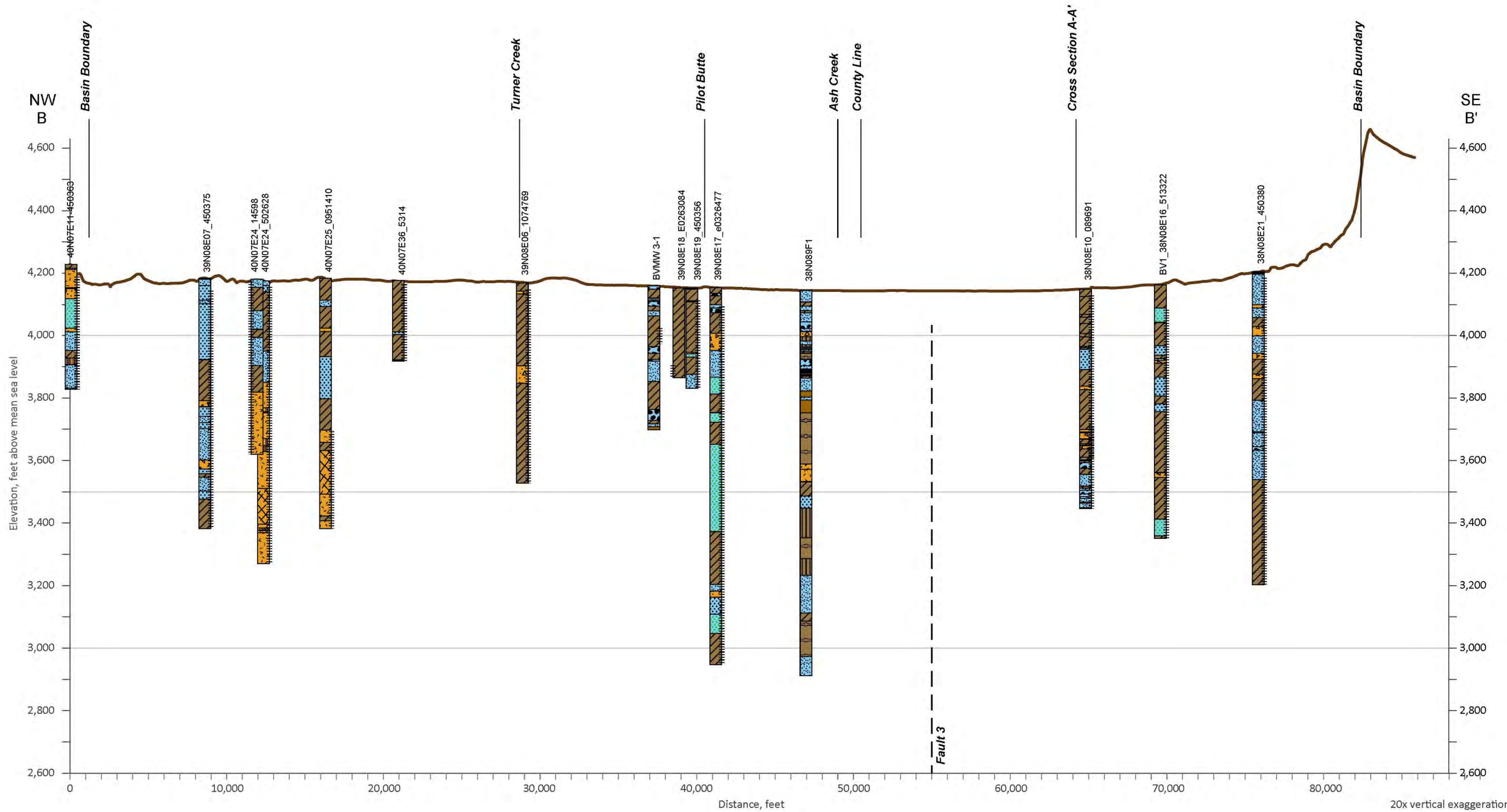

Figure 4-7 Geologic Cross Section B-B'

Note: Key to lithologic symbologies is in development and will be included in future draft(s).

School Well had water quality samples collected from 1665 to 2000 foot interval and indicated water quality higher in total dissolved solids (632 mg/l) than is present in shallower portions of the Basin.

The information from these two wells indicated that temperature and water quality concerns increase with depth, but a clear delineation of where water becomes unusable cannot be determined with the data available. With no scientific evidence to clearly define a physical or effective bottom of the aquifer, an approach to define a practical bottom is being used to satisfy the GSP Regulations which require a aquifer bottom to be defined (§ 354.14(a)(1)).

The approach for defining the practical bottom is to ensure that all known water wells are included within the aquifer. DWR's well log inventory shows that over 600 wells have been installed in the BVGB. Although DWR's well log inventory may not completely and precisely capture all the wells in the basin, it is the only readily available inventory. Wells in this inventory with known depths are summarized in **Table 4-1**. The only wells drilled deeper than 1,200 feet are the two DWR test borings and geothermal wells discussed above.

Table 4-1 Well Depths

<table>
<tr><th>Depth Interval (feet bgs)</th><th colspan="2">Deepest Well per Section [a]</th><th>Count of All Wells</th></tr>
<tr><td>< 200</td><td colspan="2">10%</td><td>41%</td></tr>
<tr><td>200 – 400</td><td>16%</td><td rowspan="2">43%</td><td>25%</td></tr>
<tr><td>400 – 600</td><td>27%</td><td>17%</td></tr>
<tr><td>600 – 800</td><td>28%</td><td rowspan="2">42%</td><td>12%</td></tr>
<tr><td>800 – 1000</td><td>14%</td><td>4%</td></tr>
<tr><td>1000 – 1200</td><td colspan="2">4%</td><td>1%</td></tr>
<tr><td>> 1200 [b]</td><td colspan="2">1%</td><td>< 1%</td></tr>
</table>

[a] A section is a 1 mile by 1 mile square. There are 134 sections in the BVGB

[b] Test borings: BV-1 and BV-2 are only water wells drilled deeper than 1200 ft

For this GSP, the "practical bottom" of the aquifer is set at 1200 feet, but may extend to 4,100 or deeper. This delineation of 1200 feet is consistent with DWR's approach, established over 50 years ago which declared a practical bottom of 1000 feet. 1200 feet encompasses the levels where groundwater can be accessed and monitored for beneficial use.

4.4.4 *Structural Properties with Potential to Restrict Groundwater Flow §354.14(b)(4)(C)*

Faults can sometimes affect flow, but sufficient evidence has not been gathered and analyzed to determine whether any of the faults in Big Valley restrict or facilitate flow. The mountains around BVGB are heavily faulted, with older basalt units more faulted than younger basalt units.

Most of the faults trend to the north/northwest with some faulting oriented northeasterly. **Figure 4-8** is an excerpt of the regional fault map by the California Geological Survey (2010). Faults on the western side of BVGB are shown to be Quaternary in age while faults on the eastern side are pre-Quaternary (older than 2.6 million years [my]). Note that numerous faults to the west of BVGB were identified as later Quaternary to Holocene-age faults (displacement during the last 700,000 or within the last 11,700 years, respectively).

Some of the faults extend across the Basin, concealed beneath the alluvial materials. Two hot springs are located in the valley near these faults. DWR (1963) acknowledged the potential restriction of groundwater flow by faults but did not provide specific information. However, such fault impacts on groundwater flow cannot be determined with certainty at this time given the limited number of widely spaced wells with groundwater level data. and the absence of a pumping test to verify restricting conditions.

4.4.5 *Physical Properties and Hydraulic Characteristics §354.14(b)(4)(B)*

The physical properties of a groundwater system are typically defined by the hydraulic conductivity[14], transmissivity[15], and storativity[16] of the aquifer. The preferred method of defining hydraulic characteristics is a pumping test with pumping rates and water levels monitored (either in the pumping well or a nearby monitoring well) throughout the test. Such pumping tests were performed after the construction of five sets of monitoring wells in late 2019 and early 2020.

The tests were performed by pumping each 2.5-inch diameter well for one hour at a rate of 8 gallons per minute (gpm) while measuring water level drawdown in the pumping well. A well efficiency[17] of 70% was assumed and the length of the well screen was used as a proxy for the aquifer thickness (b). **Table 4-2** shows the results of the Theis[18] solution that best matched the drawdown curve at each well. Storativity (S) ranged from highly confined ($3.0x10^{-6}$ at BVMW 3-1) to unconfined ($1.5x10^{-1}$ at BVMW 4-1). Hydraulic conductivity (K) ranged from 2 feet per day (ft/d) to 19 ft/d, although these K values likely range higher since pumping tests with larger pumps in larger wells for longer periods of time tend to give higher T and K. The results of these five pumping tests are documented further in **Appendix 4A**.

[14] Hydraulic conductivity (K) is defined as the volume of water that will move in a unit of time under a unit hydraulic gradient through a unit area. It is a measure of how easily water moves through a material and is usually given in gallons per day per square foot (gpd/ft^2) or feet per day (ft/day).
[15] Transmissivity (T) is the product of K and aquifer thickness (b) and is a measure of how easily water moves through a thickness of aquifer. It is usually expressed in units of gallons per day per foot of aquifer (gpd/ft) or square feet per day (ft^2/day).
[16] Storativity (S, also called storage coefficient) is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area per unit change in groundwater elevation. High values of S are indicative of unconfined aquifers, while low values indicate confined (pressurized) aquifers. S does not have units.
[17] Pumping tests with water levels measured in the pumping well will experience more drawdown than elsewhere in the aquifer. The predicted drawdown divided by the actual drawdown is well efficiency.
[18] Theis is a mathematical solution for predicting drawdown in a well and is commonly used to estimate K, T, and S.

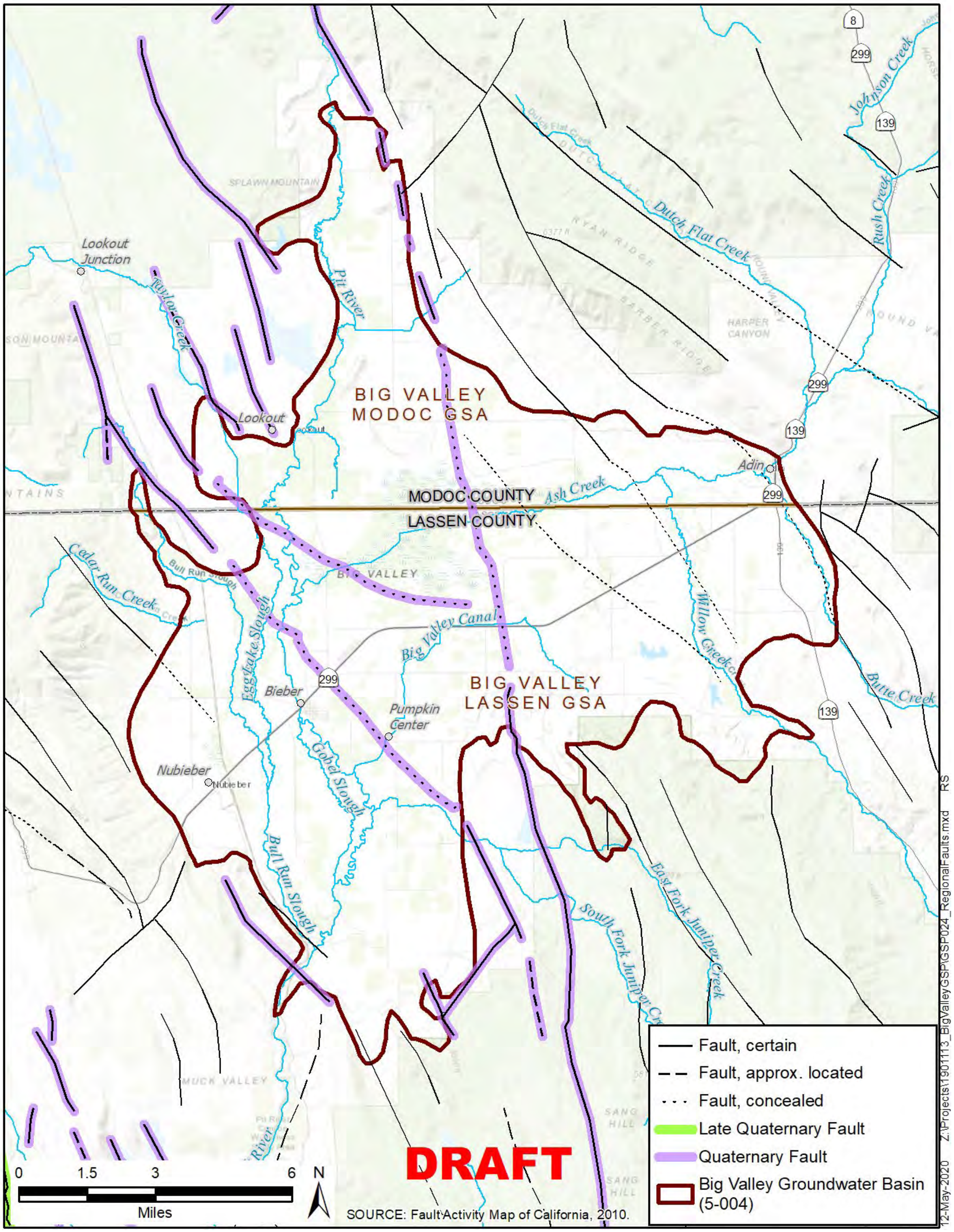

Figure 4-8 Local Faults

Table 4-2 Aquifer Test Results

Parameter	Units	BVMW 1-1	BVMW 2-1	BVMW 3-1	BVMW 4-1	BVMW 5-1
Thickness (b)	ft	50	40	50	30	50
Flow (Q)	gpm	8	8	8	8	8
Drawdown after 1 hr	ft	4.3	16.0	27.5	2.0	3.0
Transmissivity (T)	gpd/ft	3000	750	700	4200	4500
Storativity (S)	unitless	1.5E-03	1.0E-03	3.0E-06	1.0E-01	2.0E-03
Hydraulic Conductivity (K)	ft/d	8	3	2	19	12

The specific yield (SY) is another important aquifer characteristic, as it defines the fraction of the aquifer that contains recoverable water, and therefore governs the volume of groundwater stored in the Basin. USBR (1979) discussed the SY in Big Valley and postulated that it varies with depth, at 7% for the first 100 feet below ground surface (bgs), 6% for the 100 to 200 feet bgs, and 5% from 200 to 1000 feet bgs. However, they don't give any supporting evidence for these percentages. SY in the Sacramento Valley has been estimated to vary between 5 to 10% (DWR 1978). Since Big Valley aquifer materials were primarily deposited in a lacustrine environment (as opposed to Sacramento Valley which has a higher percentage of riverine deposits), Big Valley's SY is likely on the lower end at 5%. This conservative percentage will be used for all depth intervals in this GSP.

4.5 Soils §354.14(d)(3)

Information on soils within the BVGB were obtained from the Soil Survey Geographic Database (SSURGO) of the Natural Resources Conservation Service (NRCS). The SSURGO data included two categories of information relevant to the GSP: taxonomic soil orders and hydrologic soil groups. Taxonomic data include general characteristics of a soil and the processes of formation while hydrologic data relate to the soil's ability to transmit water under saturated conditions and is an important consideration for hydrology and groundwater recharge. The following section describes the soils of BVGB.

4.5.1 *Taxonomic Soil Orders*

Of the 12 established taxonomic soil orders, three were found within the BVGB, as listed below, and their distributions are presented in **Figure 4-9**. Descriptions below were taken from the *Illustrated Guide to Soil Taxonomy* (NRCS, 2015):

- Alfisol – Naturally fertile soils with high base saturation and a clay-enriched subsoil horizon. Alfisols develop from a wide range of parent materials and occur under broad environmental conditions, ranging from tropical to boreal. The movement of clay and other weathering products from the upper layers of the soil and their subsequent accumulation in the subsoil are important processes. The soil-forming processes are in relative balance. As a result, nutrient bases (such as calcium, magnesium, and potassium) are supplied to the soil through weathering and the leaching process is not sufficiently intense to remove them from the soil before plants can use and recycle them.

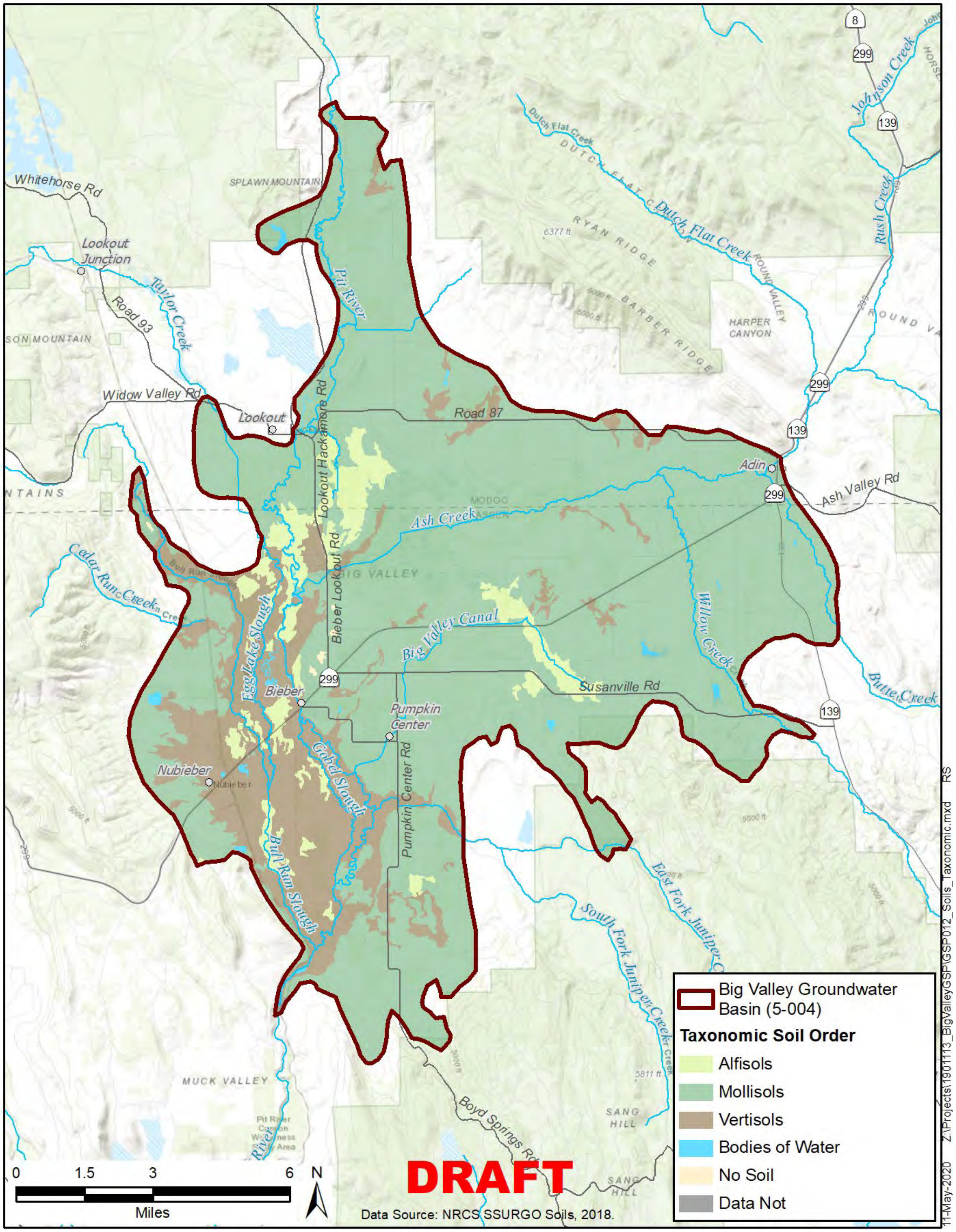

Figure 4-9 Taxonomic Soils Classifications

- Mollisol – Very dark-colored, naturally very fertile soils of grasslands. Mollisols develop from predominantly grasslands in temperate regions at midlatitudes and result from deep inputs of organic matter and nutrients from decaying roots, especially the short, mid, and tall grasses common to prairie and steppe areas. Mollisols have high contents of base nutrients throughout their profile due to mostly non-acid parent materials in environments (subhumid to semiarid) where the soil was not subject to intense leaching of nutrients.

- Vertisol – Very clayey soils that shrink and crack when dry and expand when wet. They are dominated by clay minerals (smectites) and tend to be very sticky and plastic when wet and very firm and hard when dry. Vertisols are commonly very dark in color and distinct soil horizons are often difficult to discern due to the deep mixing (churning) that results from the shrink-swell cycles. Vertisols form over a variety of parent materials, most of which are neutral or calcareous, over a wide range of climatic environments, but all Vertisols require seasonal drying.

Mollisols are the most prominent soil order within the BVGB occupying nearly 78% of the total area. Vertisols occupy over 16% and are found mostly on the southwestern side of BVGB within the floodplain of the Pit River. Small patches of Vertisols are scattered in the remainder of the basin. Alfisols occupy over 5% of the basin and are found mostly on the west side of the basin and along Hot Spring Slough in the south-central portion of the basin.

4.5.2 *Hydrologic Soil Groups*

The NRCS Hydrologic Soils Group (HSG) classifications provide an indication of soil infiltration potential and ability to transmit water under saturated conditions, based on hydraulic conductivities of shallow, surficial soils. **Figure 4-10** shows the distribution of the hydrologic soil groups, where higher conductivities (greater infiltration) are labeled as Group A and lowest conductivities (lower infiltration) as Group D. As defined by the NRCS (2012), the four HSGs are:

- Hydrologic Group A – "Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures." Group A soils have the highest conductivity values (greater than 5.67 inches per hour [in/hr]) and therefore a high infiltration rate[19], and the greatest recharge potential.

- Hydrologic Group B – "Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Group B soils have a wide range of conductivity values (1.42 in/hr to 5.67 in/hr), a moderate infiltration rate[2], and a moderate potential for recharge.

[19] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey

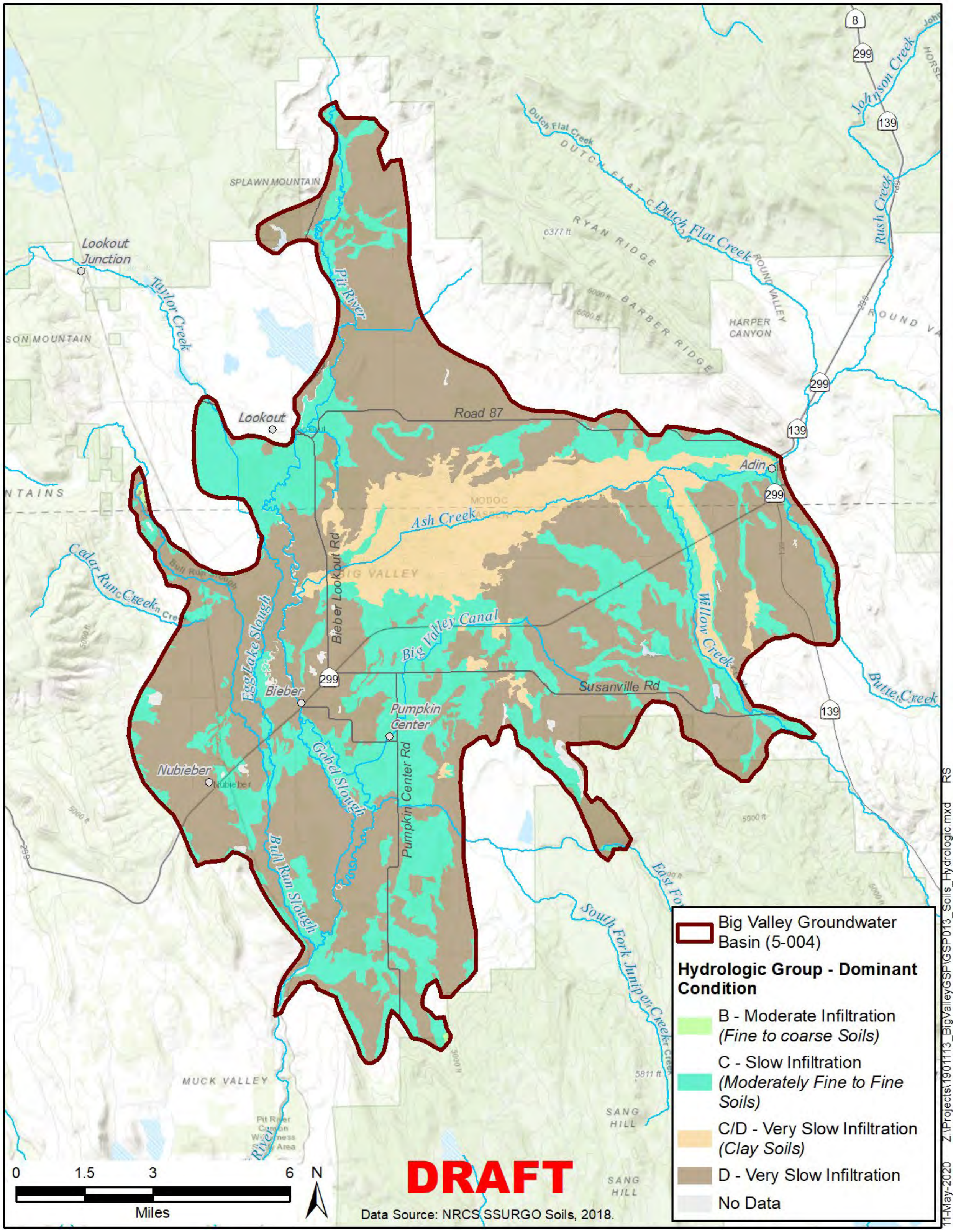

Figure 4-10 Hydrologic Soils Group Classifications

- Hydrologic Group C – "Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures." Group C soils have a relatively low range of conductivity values (0.14 to 1.42 in/hr), a slow infiltration rate[2], and limited potential for groundwater recharge due to their fine textures.

- Hydrologic Group D – "Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential." Group D soils have conductivity values less than 0.14 in/hr, a very slow infiltration rate2, and a very limited capacity to contribute to groundwater recharge.

A dual hydrologic group (C/D) is assigned to an area to characterize runoff potential under drained and undrained conditions, where the first letter represents drained conditions and the second letter applies to undrained conditions. For the purposes of this GSP, these dual soils are considered to have a very slow infiltration rate.

According to this HSG dataset, no areas BVGB show high infiltration rates (Group A), and only a tiny area (<0.1%) of Group B soil (moderate infiltration) is located on the western edge of the basin at the top of Bull Run Slough near Kramer Reservoir. The remainder of the Basin is shown with hydrologic soils Groups C and D, slow to very slow infiltration rates (Group C at 30% and Group D at 58% of Basin area). Most of the Ash Creek Wildlife Area is underlain by the dual hydrologic group C/D (11% of Basin area).

It should be noted that the NRCS develops these maps using a variety of information including remote sensing and some limited field data collection and does not always capture variations that may occur on a small scale. Historical experience from landowners and additional field data could identify areas of better infiltration. Additionally, Group C and D soils may have slow infiltration rates due to shallow hardpan, and groundwater recharge could potentially be enhanced if this hardpan can be disrupted.

4.5.3 *Soil Agricultural Groundwater Banking Index*

The University of California at Davis (UCD) has established the Soil Agricultural Groundwater Banking Index (SAGBI) using data within the SSURGO database, which gives a rating of suitability of the soils for groundwater recharge. This index expands on the HSG to include topography, chemical limitations, and soil surface condition. This effort has resulted in a mapping tool that illustrates six SAGBI classes (excellent to very poor) and has been completed for much of the state. This mapping tool is only available for the Modoc County portion of BVGB as shown on **Figure 4-11**, and the indices vary mostly between moderately poor to very

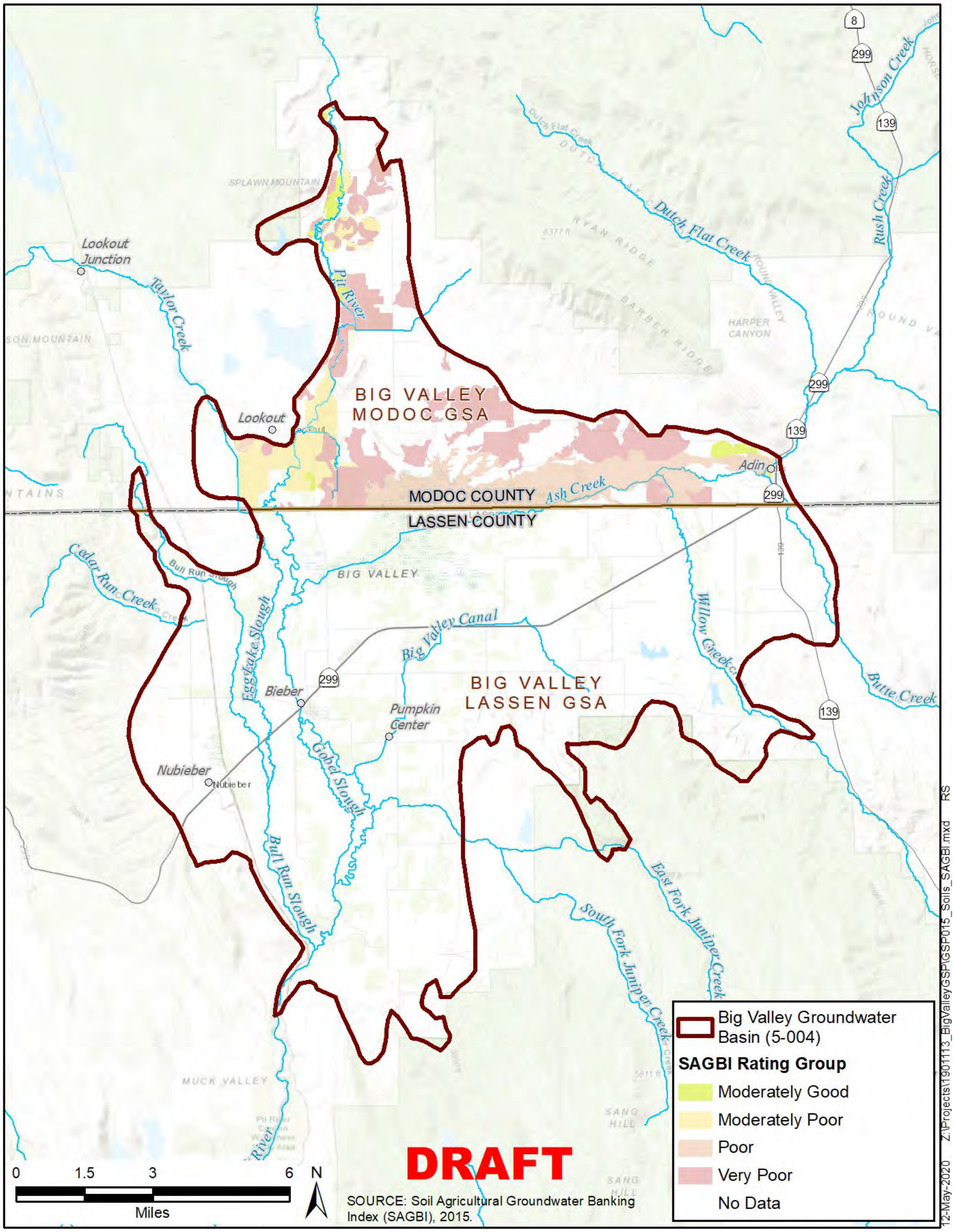

Figure 4-11 SAGBI Classifications

poor. Small areas of moderately good are present along the Pit River as it enters BVGB and to the west of Adin. It should be noted that the SAGBI is a large-scale, planning level tool and does not preclude local site conditions that are good for groundwater recharge.

4.6 Beneficial Uses of Principal Aquifers §354.14(b)(4)(E)

Beneficial uses of groundwater include agricultural, environmental, municipal, and domestic uses. A description of each is provided below.

Agricultural

Agricultural users get their supply from surface water diversions, groundwater, or a combination of the two. **Figure 3-4** from the previous chapter illustrates the primary source being used around the Basin. The primary crops are grain and hay crops (primarily alfalfa) with some wild rice.

Industrial

There is little to no industrial groundwater use in the BVGB. According to DWR well logs, six industrial wells have been drilled, all of them near Bieber at Big Valley Lumber, which is not currently in operation.

Environmental

Environmental uses for wetland and riparian botanical and wildlife habitat occur primarily within the Ash Creek Wildlife Area (ACWA) in the center of the Basin, near the overflow channels adjacent to the Pit River in the southern portion of the Basin, and along the riparian corridors of some of the minor streams that flow into Big Valley. **Figure 4-12** shows the wetlands delineated in the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. (DWR 2018) This dataset is a compilation of 48 publicly available State and Federal agency data sources, which have been screened to include the data most likely to be associated with groundwater. This dataset is a starting point in identifying groundwater dependent ecosystems (GDEs). Groundwater dependent ecosystems will be discussed further in Chapter 5.

Municipal

The State Water Resources Control Board (SWRCB) recognizes two public water systems that use groundwater under the purview of the Division of Drinking Water (DDW): Lassen County Waterworks District #1 (LCWWD#1) which serves the community of Bieber and the Forest Service Station in Adin which provides groundwater to a non-community, non-transient population.

Domestic

Domestic users include residents that use their own well for household purposes. The BVGB has a population of about 1,046. With the 312 Bieber residents receiving water from municipal supply, the majority of the remaining 734 residents are domestic users.

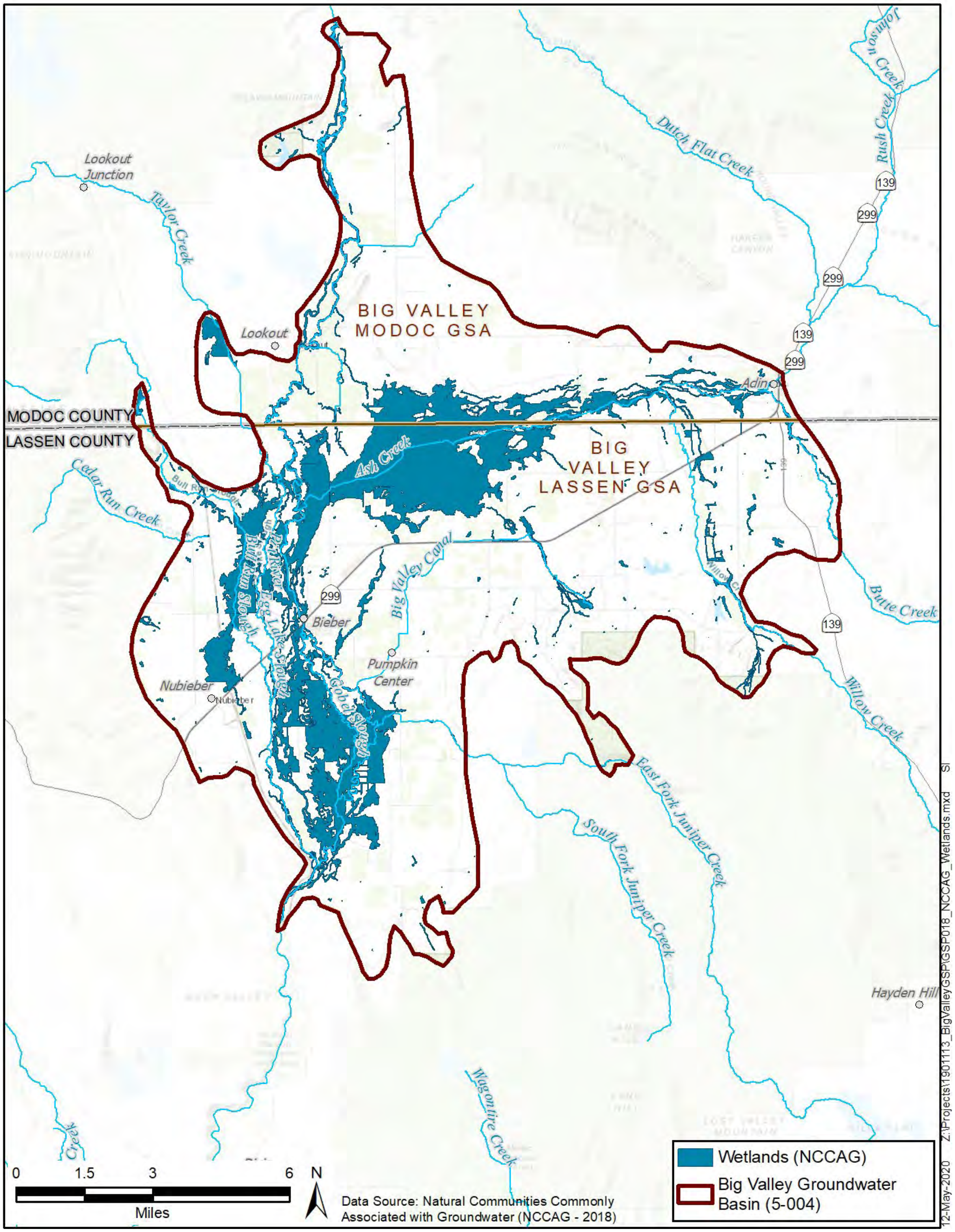

Figure 4-12 NCCAG Wetlands

4.7 General Water Quality §354.14(b)(4)(D)

Previous reports have characterized the water quality as excellent. (DWR 1963, USBR 1979) The central area of the basin, where naturally occurring hot springs influence the chemistry, has elevated levels of sulfate, fluoride, boron, and arsenic. (USBR 1979) These localized areas with higher mineral content occur near the major faults that traverse the valley.

Figure 4-13 shows a Piper Diagram for water samples that were collected in late 2019 and early 2020 and characterizes the relative concentrations of the major cations (Ca, Mg, Na, K) and anions (SO_4, Cl, HCO_3). The dominant cations range from sodium rich to mixed with higher

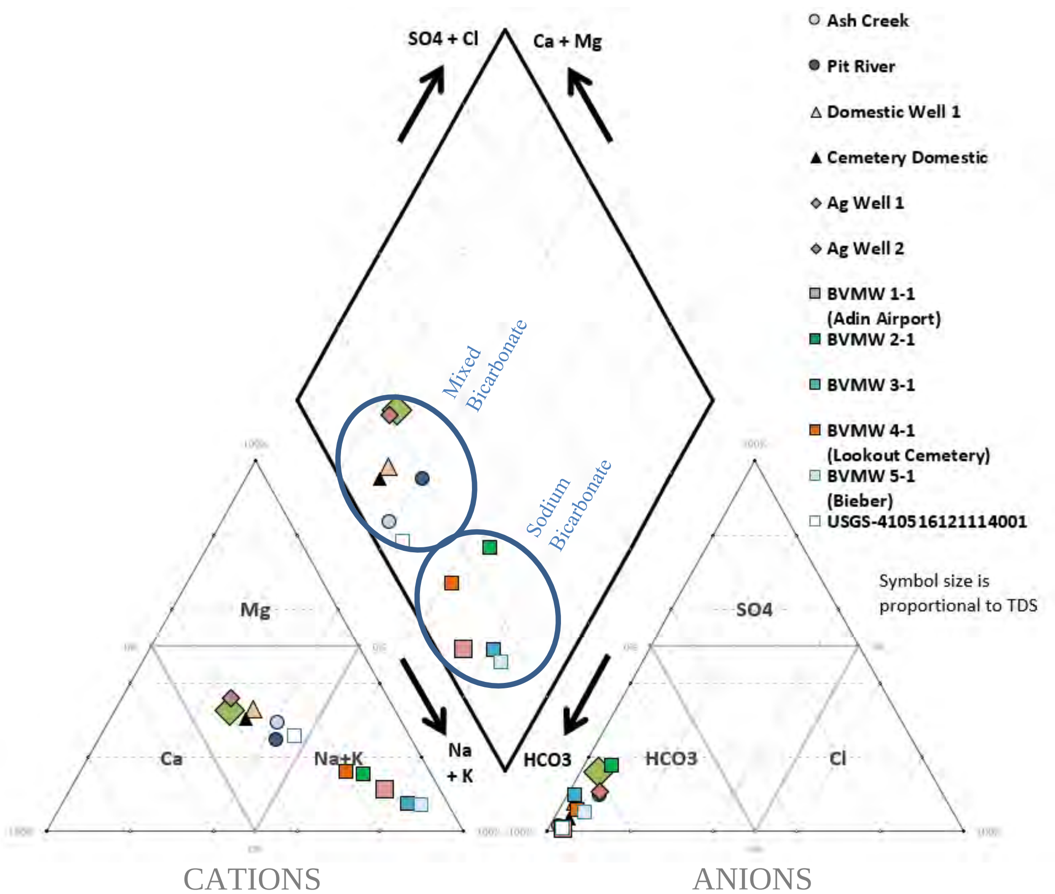

Figure 4-13 Piper Diagram showing major cations and anions

amounts of calcium and magnesium which increases the water hardness. The major anion is strongly bicarbonate which indicates that the water is generally young in geologic terms.

Some areas in the Basin have elevated levels of iron, manganese, and/or arsenic, all of which are naturally occurring in volcanic terrains such as Big Valley. The nature and distribution of these constituents will be discussed further in Chapter 5.

4.8 Groundwater Recharge and Discharge Areas §354.14(d)(4)

4.8.1 *Recharge*

Groundwater recharge in BVGB likely occurs via several mechanisms discussed below.

Underflow from adjacent upland areas and other areas outside the basin

The upland areas consist of fractured basalt flows where the precipitation infiltrates vertically through joints and fractures until it hits underlying aquifer material and then travels horizontally into the Basin. DWR has postulated that the areas shown in pink on **Figure 4-14** provide recharge in such a way. However, other areas adjacent to the Basin could provide some recharge in a similar fashion. In addition, underflow could enter the Basin where the Pit River and Ash Creek enter the Basin.

Infiltration of precipitation on the valley floor

Some direct infiltration of rain and snow on the valley floor likely occurs. However, because the aquifer materials in the basin are largely lacustrine and much of the soils have slow infiltration rates, most of the precipitation likely runs off or is consumed through evapotranspiration. **Figure 4-14** shows the areas from the NRCS datasets that may have a slightly higher infiltration rate (HSG B and HSG C) than the other areas and therefore potentially more recharge.

Rivers and streams that flow through the Basin

Streams that flow through the basin lose water to the aquifer, particularly where they enter the Basin. Aquifer materials are typically coarser on the fringes of the Basin where the stream gradient begins to flatten. In general recharge likely occurs in the eastern portions of the Basin along Ash Creek, Butte Creek, and Willow Creek and then flows westerly through the subsurface. As Ash Creek flows to the center of the Basin and Big Swamp, the water slows and spreads out into a large marsh. The California Department of Fish and Wildlife, who owns and manages that land has recently enhanced this slowing and spreading of water through “pond and plug” projects which bring the water up out of the previously incised channel. Even though the soils and aquifer materials in this portion of the Basin have slow infiltration rates, recharge still is likely to occur from Big Swamp because of the long period of time that the shallow soils remain wet and saturated.

Deep percolation of irrigation water

Depending on the irrigation method, particularly flood irrigation, deep percolation of irrigation water into the aquifer likely occurs. Flood irrigation tends to be practiced adjacent to the southern portions of the Pit River. But irrigation throughout the Basin may provide recharge, depending on the amount of water applied.

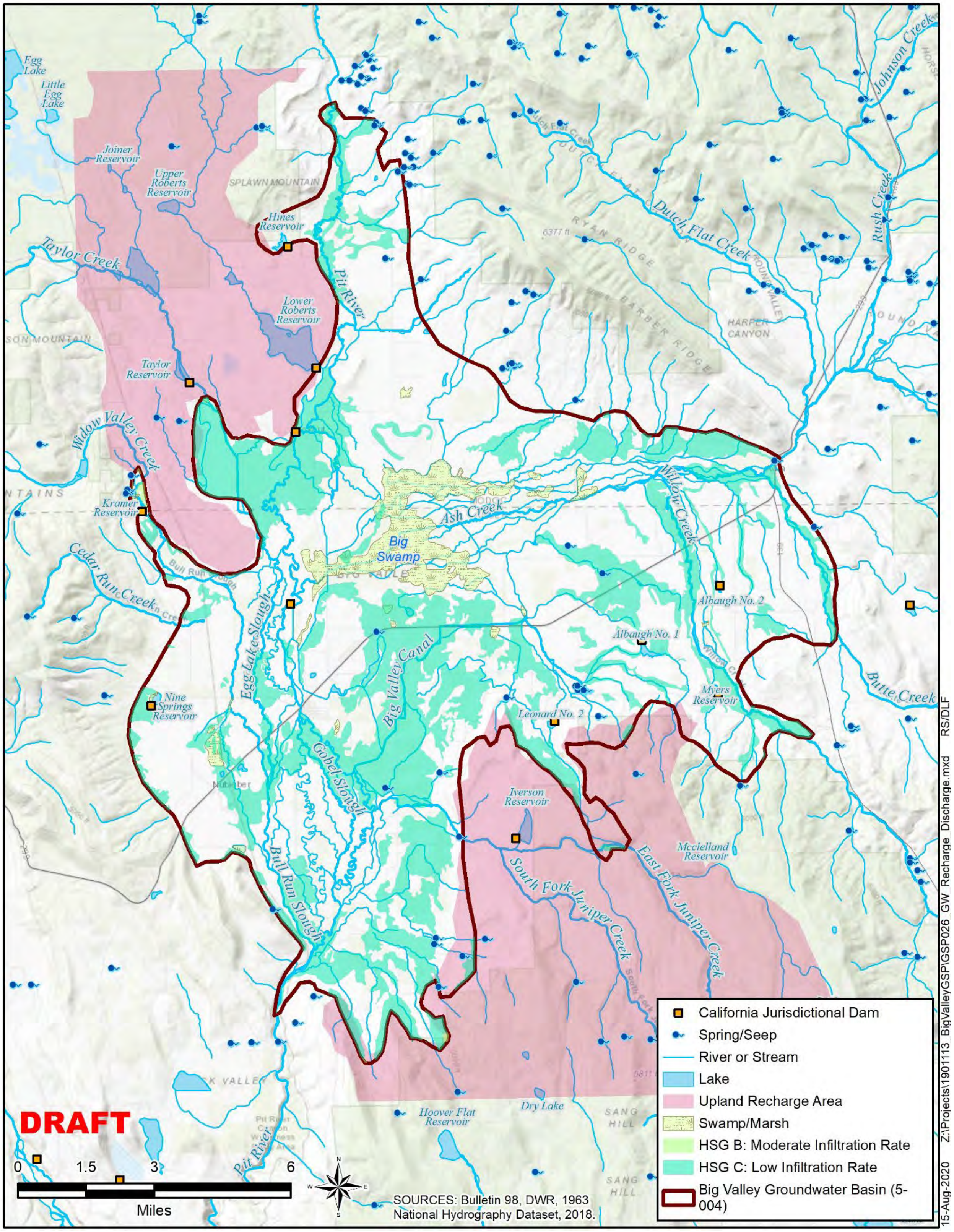

Figure 4-14 Recharge, Discharge, and Major Surface Water Bodies

4.8.2 *Discharge*

Flow out of the groundwater aquifer (and out of the Basin) most likely occurs at the southern portion of the Basin where groundwater flow is towards the Pit River. The gaining river[20] then transports the water out of the Basin. DWR (1963) indicates that artesian[21] conditions occurred in this southwestern area and therefore historically discharged some small portion to the surface. Based on currently documented water levels, this area is no longer artesian. There are numerous springs throughout the basin shown on **Figure 4-14** where groundwater is discharged, including several hot springs in the center of the Basin. Evapotranspiration may also be a significant discharge mechanism.

4.9 Surface Water Bodies §354.14(d)(5)

Figure 4-14 shows the numerous small streams that enter the Basin and flow towards the center where they connect with the two major streams: the Pit River and Ash Creek. The figure also shows the many small ponds and several reservoirs that are in and around the Basin. The dams that are within the jurisdiction of DWR's Division of Safety of Dams are shown. While many of these impoundments are located outside of Basin boundaries, they represent supplies that hydrologically flow to/through the Basin. The reservoirs provide options for the timing of release of those waters, rather than importing supplies from sources external to the Basin.

4.10 Imported Water Supplies §354.14(d)(6)

BVGB users do not import surface water into the basin, where the water originates in a watershed other than the one in which BVGB is located

4.11 Data Gaps in the Hydrogeologic Conceptual Model §354.14(b)(5)

As discussed in the introduction, hydrogeology has inherent uncertainties due to sparse data, and in the case of Big Valley, a limited number of detailed studies on the groundwater resources in the Basin. Identified below are some of the uncertainties associated with the hydrogeology in the Basin. In some instances, this uncertainty can be reduced while other uncertainties will remain. The filling of the data gaps below is contingent on the needs that arise as the GSP is developed and implemented and the level of available funding.

Basin Boundary

The Basin boundary was drawn with a regional scale map (CGS 1958) and was not drawn with as much precision as subsequent geologic maps. Additionally, the "uplands" areas outside the

[20] Gaining rivers are where groundwater flows toward the river and contributes to surface water flow.
[21] Artesian aquifers are under pressure and wells screened in them flow from the surface.

Basin boundary are postulated to be recharge areas interconnected to the basin, which is contrary to DWR's definition of a lateral basin boundary as being "features that significantly impede groundwater flow". (DWR 2016) Further refinement of the Basin boundaries may be desired and necessary.

Confining conditions

Confining conditions exist throughout the Basin. Often the confinement is simply a result of depth and the fact that horizontal hydraulic conductivities are about 10 times greater than vertical. However, in the southwest portion of the Basin, DWR (1963) has documented an area of confining conditions. It is unknown whether the confinement is due to a single, coherent aquitard or is just a result of depth. It is also unknown whether the confinement is significant enough to warrant separate principal aquifers, which could have implications for the GSP.

Definable bottom

This HCM has used the "practical" depth of 1,200 feet as the definable bottom. If stakeholders seek to develop groundwater deeper than this depth, newly constructed wells will demonstrate that the "physical bottom" and/or the base of fresh water ("effective bottom") extend deeper.

Faults as barriers to flow

It is unknown if the faults which traverse the Basin are barriers to flow. On the Lassen County side of the Basin, this has bearing on understanding whether the eastern portions of the basin near Willow Creek are interconnected with the southwestern portions of the Basin near Pumpkin Center. This uncertainty could be reduced by conducting a pumping test with observation well(s) on the other side of the fault.

Soil permeability

The NRCS mapping of soils indicates primarily low to very low permeability soils throughout the Basin. However, there is some variation of permeabilities indicated by the maps, which are drawn at a large scale with limited field verification. Further field investigation of soils and permeability tests could help identify more permeable areas where groundwater recharge could be enhanced.

Recharge

The recharge sources below have been identified, but the rate and amount of recharge is unknown. In development of the water budget, estimates of the amount of recharge will be estimated using changes in water levels over a hydrologic base period.

- Effect of Ash Creek on recharge (incl. Big Swamp)
- Effect of Pit River on recharge (incl. overflow channels)
- Effect of smaller streams on recharge (incl.Willow Creek)

- Amount of recharge from direct precipitation
- Amount of recharge from deep percolation of applied water
- Amount of recharge from upland recharge areas

4.12 References

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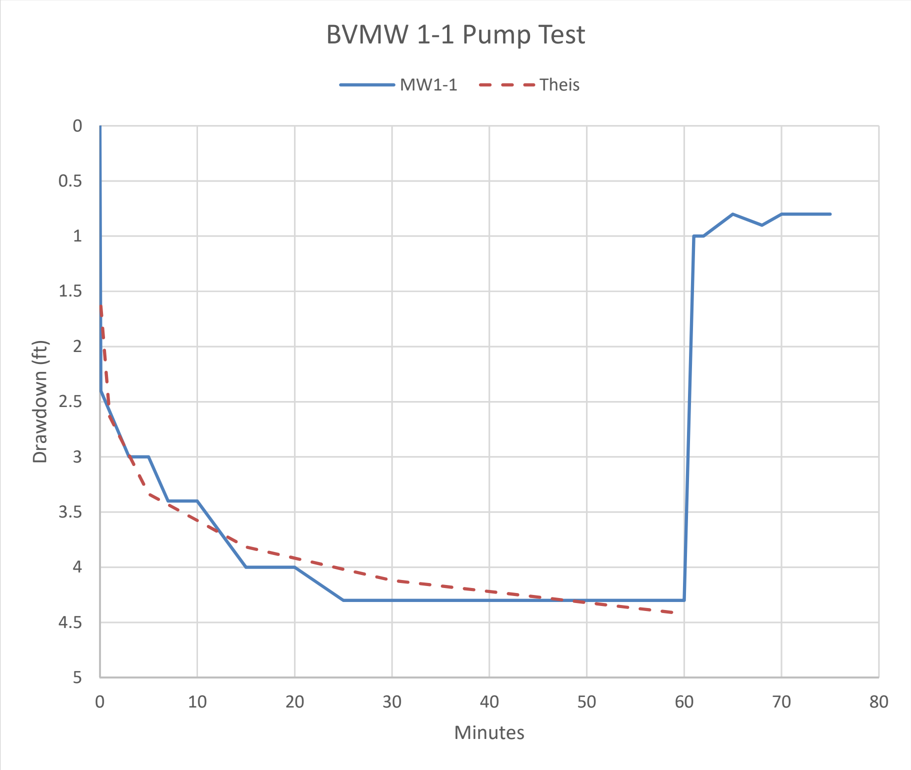
Appendix 4A

Aquifer Test Results

Pumping Test

MW1-1		**Adin Airport**	
Time	**Minutes**	**Depth to Water (ft)**	**Drawdown**
10:59	0.0	31.6	0
11:00	0.1	34	2.4
11:03	3	34.6	3
11:05	5	34.6	3
11:07	7	35	3.4
11:10	10	35	3.4
11:15	15	35.6	4
11:20	20	35.6	4
11:25	25	35.9	4.3
11:30	30	35.9	4.3
11:35	35	35.9	4.3
11:40	40	35.9	4.3
11:45	45	35.9	4.3
11:50	50	35.9	4.3
11:55	55	35.9	4.3
12:00	60	35.9	4.3
12:01	61	32.6	1
12:02	62	32.6	1
12:05	65	32.4	0.8
12:08	68	32.5	0.9
12:10	70	32.4	0.8
12:15	75	32.4	0.8



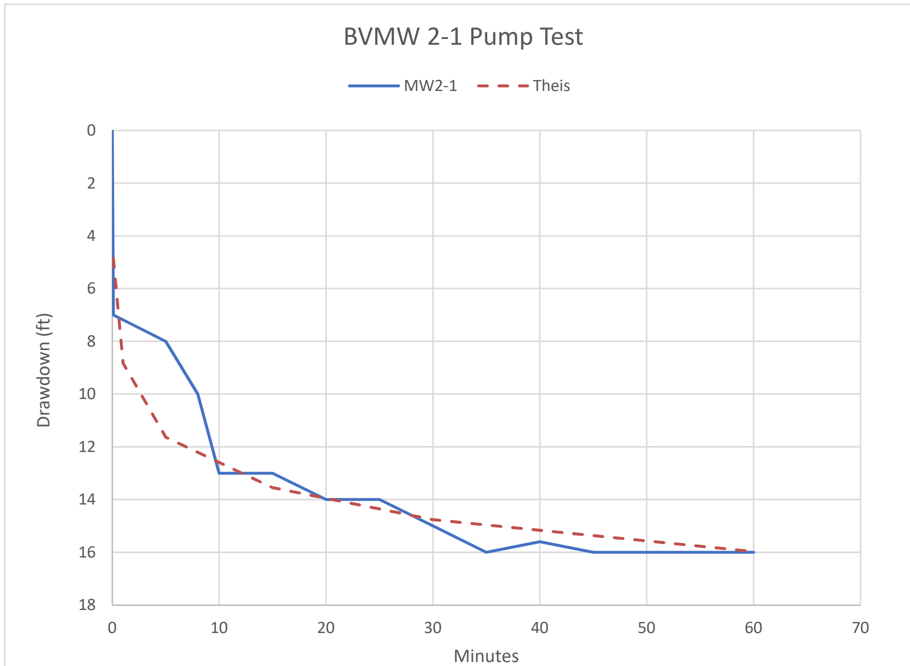
Theis Solution

Thickness (b)	50	ft
Flow (Q)	8	gpm
Well Efficiency	0.7	unitless
Transmissivity (T)	3000	gpd/ft
Radius (r)	1	ft
Storativity (S)1	1.5E-03	unitless
Hydraulic Conductivity (K)	8	ft/d

Pumping Test

MW2-1

Time	Minutes	Depth to Water (ft)	Drawdown
7:40	0	26	0
7:41	0.1	33	7
7:45	5	34	8
7:48	8	36	10
7:50	10	39	13
7:55	15	39	13
8:00	20	40	14
8:05	25	40	14
8:10	30	41	15
8:15	35	42	16
8:20	40	41.6	15.6
8:25	45	42	16
8:30	50	42	16
8:35	55	42	16
8:40	60	42	16

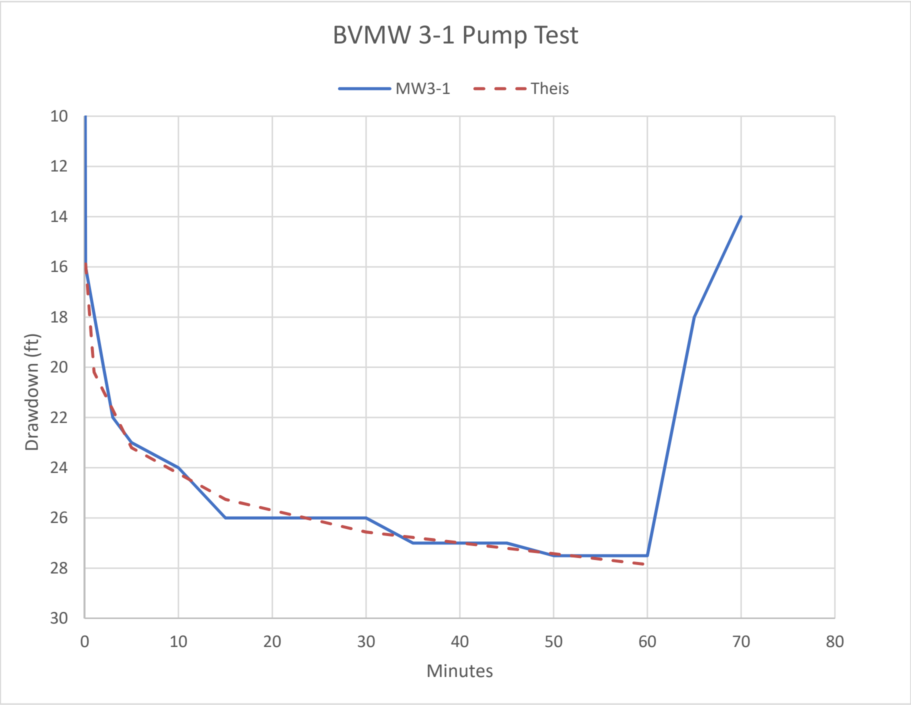


Theis Solution

Thickness (b)	40	ft
Flow (Q)	8	gpm
Well Efficiency	13	unitless
Transmissivity (T)	750	gpd/ft
Radius (r)	1	ft
Storativity (S)1	0	unitless
Hydraulic Conductivity (K)	3	ft/d

Pumpng Test

MW3-1		Lookout	
Time	**Minutes**	**Depth to Water (ft)**	**Drawdown**
9:20	0	18	0
9:21	0.1	34	16
9:22	2	38	20
9:23	3	40	22
9:25	5	41	23
9:30	10	42	24
9:35	15	44	26
9:40	20	44	26
9:45	25	44	26
9:50	30	44	26
9:55	35	45	27
10:00	40	45	27
10:05	45	45	27
10:10	50	45.5	27.5
10:15	55	45.5	27.5
10:20	60	45.5	27.5
10:25	65	36	18
10:30	70	32	14



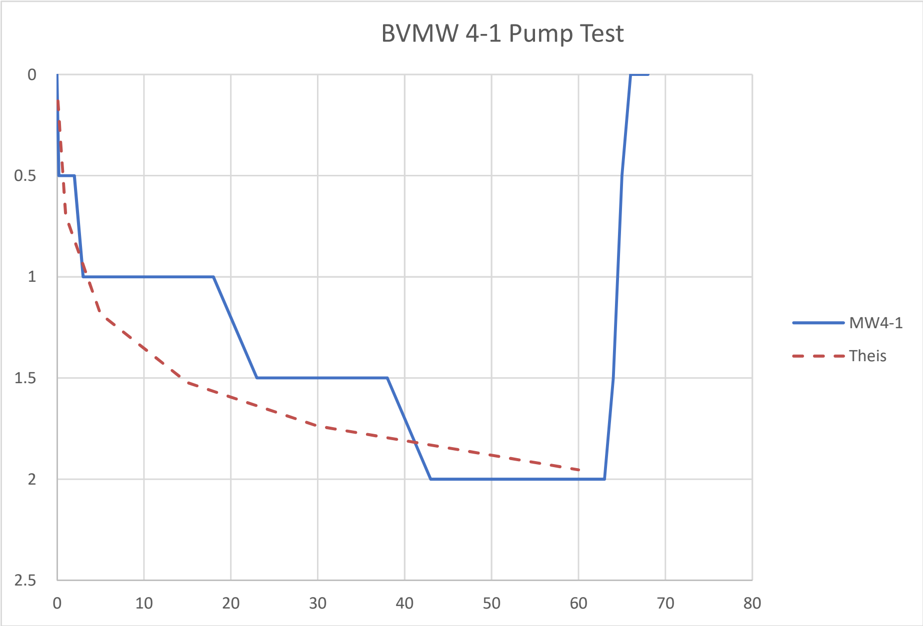
Theis Solution

Thickness (b)	50	ft
Flow (Q)	8	gpm
Well Efficiency	13	unitless
Transmissivity (T)	700	gpd/ft
Radius (r)	1	ft
Storativity (S)1	0.000003	unitless
Hydraulic Conductivity (	1.87	ft/d

Pumping Test

MW4-1

Time	**Minutes**	**Depth to Water (ft)**	**Drawdown**
1:55	0	33.5	0
1:57	0.2	34	0.5
1:58	1	34	0.5
1:59	2	34	0.5
2:00	3	34.5	1
2:05	8	34.5	1
2:10	13	34.5	1
2:15	18	34.5	1
2:20	23	35	1.5
2:25	28	35	1.5
2:30	33	35	1.5
2:35	38	35	1.5
2:40	43	35.5	2
2:45	48	35.5	2
2:50	53	35.5	2
2:55	58	35.5	2
3:00	63	35.5	2
3:01	64	35	1.5
3:02	65	34	0.5
3:03	66	33.5	0
3:04	67	33.5	0
3:05	68	33.5	0



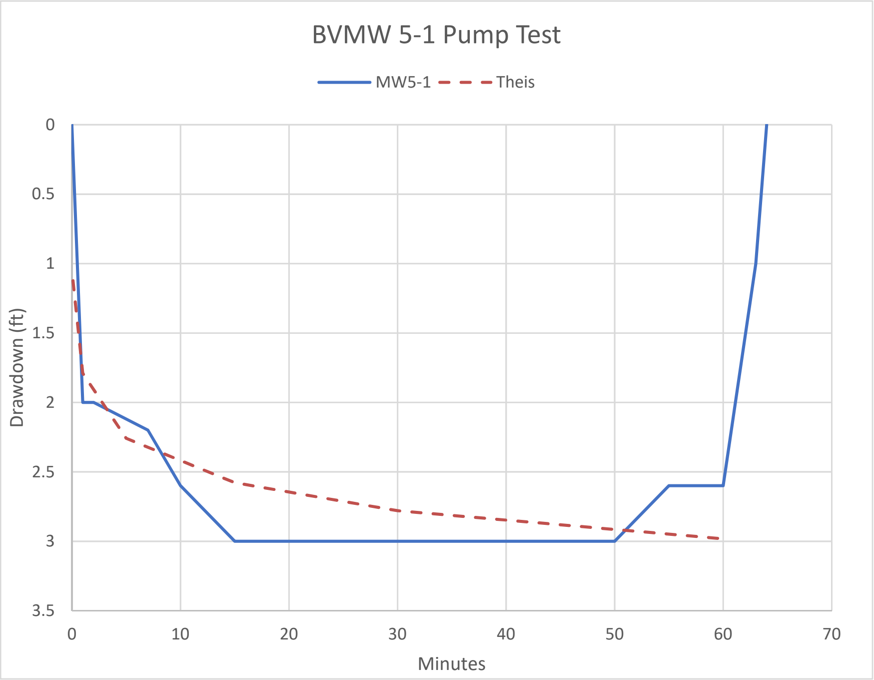
Theis Solution

Thickness (b)	30	ft
Flow (Q)	8	gpm
Well Efficiency	13	unitless
Transmissivity (T)	4200	gpd/ft
Radius (r)	1	ft
Storativity (S)1	0.1	unitless
Hydraulic Conductivity (K)	19	ft/d

Pumping Test

MW5-1

Time	Minutes	Depth to Water (ft)	Drawdown
11:50	0	42	0
11:51	1	44	2
11:52	2	44	2
11:57	7	44.2	2.2
12:00	10	44.6	2.6
12:05	15	45	3
12:10	20	45	3
12:15	25	45	3
12:20	30	45	3
12:30	40	45	3
12:35	45	45	3
12:40	50	45	3
12:45	55	44.6	2.6
12:50	60	44.6	2.6
12:57	63	43	1
12:58	64	42	0



Theis Solution

Thickness (b)	50	ft
Flow (Q)	8	gpm
Well Efficiency	13	unitless
Transmissivity (T)	4500	gpd/ft
Radius (r)	1	ft
Storativity (S)1	0.002	unitless
Hydraulic Conductivity (K)	12	ft/d

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Tables

Figures

Appendices

Abbreviations and Acronyms

ACWA	Ash Creek Wildlife Area
AF	Acre-Feet
As	arsenic
Basin	Big Valley Groundwater Basin
BVGB	Big Valley Groundwater Basin
CASGEM	California Statewide Groundwater Elevation Monitoring
CGPS	Continuous Global Positioning System
DTW	Depth to Water
DWR	Department of Water Resources
Fe	iron
ft	feet
GAMA	Groundwater Ambient Monitoring and Assessment (program of the SWRCB and USGS)
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System (software)
GMP	Groundwater Management Plan
GPS	Global Positioning System
GSP	Groundwater Sustainability Plan
InSAR	Interferometric Synthetic-Aperture RADAR
LNAPL	Light non-aqueous phase liquid
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level

Mn	manganese
MTBE	Methyl tert-butyl ether
NWIS	National Water Information System (USGS)
NCCAG	Natural Communities Commonly Associated with Groundwater
PBO	Plate Boundary Observatory
PFAS	per/polyfluoroalkyl substances
RWQCB	Regional Water Quality Control Board
SC	specific conductance
SGMA	Sustainable Groundwater Management Act of 2014
SRI	Sacramento River Index of water year types
SWRCB	State Water Resources Control Board
TBA	tert-Butyl alcohol
TDS	total dissolved solids
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WY	Water Year (October 1 – September 30)
yr	year

5. Groundwater Conditions §354.16

This chapter presents available information on the Groundwater Conditions for the Big Valley Groundwater Basin (BVGB or Basin, 5-004) developed by GEI Consultants for the Lassen County and Modoc County groundwater sustainability agencies (GSAs). This chapter provides some of the information needed for the development of the monitoring network and the sustainable management criteria of this Groundwater Sustainability Plan (GSP). The content of this chapter is defined by the regulations of the Sustainable Groundwater Management Act of 2014 (SGMA) – Chapter 1.5, Article 5, Subarticle 2: 354.16. GEI Certified Hydrogeologists provided the content of this chapter and will affix their professional stamps (as required by the regulations) once the chapter is finalized into the GSP.

5.1 Groundwater Elevations

Historic groundwater elevations are available from a total of 22 wells in Big Valley, six located in Modoc County and sixteen in Lassen County as shown on **Figure 5-1** and listed in **Table 5-1**. Twenty of the wells are part of Lassen and Modoc Counties' monitoring network which was approved by the counties in 2011, in compliance with the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The Department of Water Resources (DWR) staff measure water levels in these wells twice annually (spring and fall) on behalf of the counties. Some measurements from wells are missing, which is typically a result of access issues to the wells sites or occasionally a well owner who has removed their well from the monitoring program. These wells may or may not be used as part of the GSP monitoring network, which will be addressed in Chapter 8.

The first water level measurements in the BVGB began in the late 1950s at two wells near Bieber (17K1) and Nubieber (32A2). Regular monitoring of these two wells began in the mid-1960s and monitoring began in most of the other wells during the late 1970s or early 1980s. Three wells located on the Ash Creek Wildlife Area (ACWA) were added to the CASGEM networks in 2016. Of the 22 historically monitored wells one well (12G1) has not been monitored since 1992, and one well (06C1) has no measurements since 2015. Construction details are not available for one well (32R1). Well 32R1 could benefit from 'downhole' video inspection of the well casing to determine the depth interval associated with the water levels.

In addition to these 22 wells, five well clusters were constructed in late 2019 and early 2020 to support the GSP. Their locations are shown on **Figure 5-1**. Each cluster consists of a deep well (200-500 feet) and three shallow wells (60-100 feet). These wells were drilled to explore the geology, with the deep well giving water level information for main portion of the aquifer used at that location. The three shallow wells are screened shallow to determine the direction and magnitude of flow in the shallow subsurface and potentially to give an indication of how groundwater interacts with surface water and possibly the location of groundwater recharge. Water level information is not yet available from these five clusters.

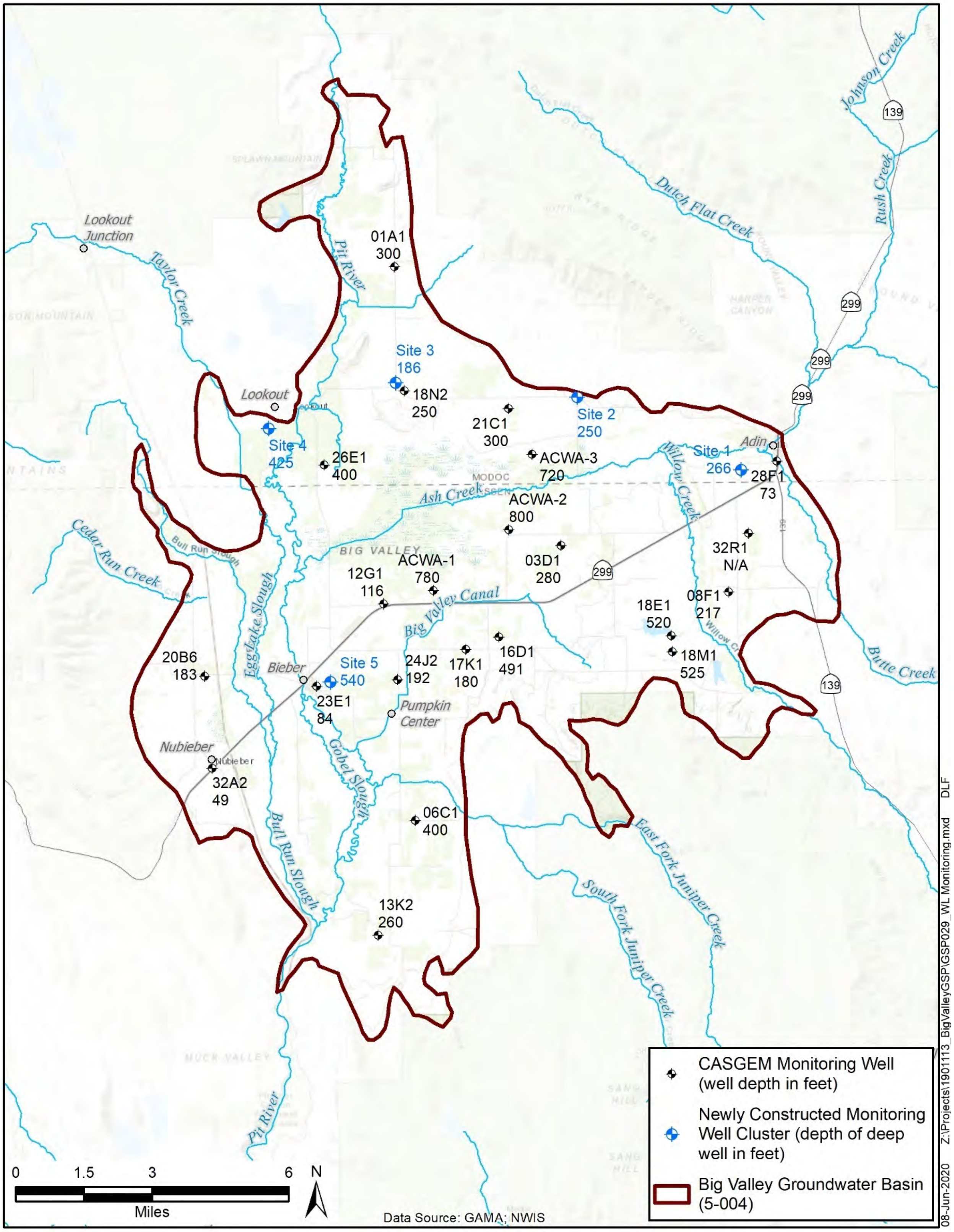

Figure 5-1 Water Level Monitoring

Table 5-1 Historic Water Level Monitoring Wells

Well Name	State Well Number	CASGEM ID	County	Well Use	Well Depth (feet bgs)	Ground Elevation (feet msl)	Reference Point Elevation (feet msl)	Period of Record Start Year	Period of Record End Year	Number of Measurements	Minimum Groundwater Elevation (feet msl)	Maximum Groundwater Elevation (feet msl)
18E1	38N09E18E001M	411356N1209900W001	Lassen	Irrigation	520	4248.40	4249.50	1981	2019	73	4198.20	4234.10
23E1	38N07E23E001M	411207N1211395W001	Lassen	Residential	84	4123.40	4123.40	1979	2020	81	4070.40	4109.10
260	39N07E26E001M	411911N1211354W001	Modoc	Irrigation	400	4133.40	4135.00	1979	2020	79	4088.90	4131.30
01A1	39N07E01A001M	412539N1211050W001	Modoc	Stockwatering	300	4183.40	4184.40	1979	2020	81	4035.40	4163.90
03D1	38N08E03D001M	411647N1210358W001	Lassen	Irrigation	280	4163.40	4163.40	1982	2020	71	4076.60	4148.60
06C1	37N08E06C001M	410777N1210986W001	Lassen	Irrigation	400	4133.40	4133.90	1982	2016	69	4066.20	4126.80
08F1	38N09E08F001M	411493N1209656W001	Lassen	Other	217	4253.40	4255.40	1979	2020	83	4167.90	4229.50
12G1	38N07E12G001M	411467N1211110W001	Lassen	Residential	116	4143.38	4144.38	1979	1993	28	4130.98	4138.68
13K2	37N07E13K002M	410413N1211147W001	Lassen	Irrigation	260	4127.40	4127.90	1982	2018	70	4061.90	4109.70
16D1	38N08E16D001M	411359N1210625W001	Lassen	Irrigation	491	4171.40	4171.60	1982	2020	74	4078.73	4162.40
17K1	38N08E17K001M	411320N1210766W001	Lassen	Residential	180	4153.30	4154.30	1957	2020	146	4115.08	4150.00
18M1	38N09E18M001M	411305N1209896W001	Lassen	Irrigation	525	4288.40	4288.90	1981	2020	74	4192.30	4232.70
18N2	39N08E18N002M	412144N1211013W001	Modoc	Residential	250	4163.40	4164.40	1979	2020	80	4136.60	4160.20
20B6	38N07E20B006M	411242N1211866W001	Lassen	Residential	183	4126.30	4127.30	1979	2019	80	4076.94	4116.60
21C1	39N08E21C001M	412086N1210574W001	Modoc	Irrigation	300	4161.40	4161.70	1979	2020	79	4082.10	4148.50
24J2	38N07E24J002M	411228N1211054W001	Lassen	Irrigation	192	4138.40	4139.40	1979	2019	77	4056.70	4137.70
28F1	39N09E28F001M	411907N1209447W001	Modoc	Residential	73	4206.60	4207.10	1982	2020	76	4194.57	4202.10
32A2	38N07E32A002M	410950N1211839W001	Lassen	Other	49	4118.80	4119.50	1959	2020	133	4106.70	4118.80
32R1	39N09E32R001M	411649N1209569W001	Lassen	Irrigation	unknown	4243.40	4243.60	1981	2020	64	4161.20	4205.50
ACWA-1	38N08E07A001M	411508N1210900W001	Lassen	Irrigation	780	4142.00	4142.75	2016	2020	8	4039.15	4126.35
ACWA-2	39N08E33P002M	411699N1210579W001	Lassen	Irrigation	800	4153.00	4153.20	2016	2020	8	4126.40	4139.35
ACWA-3	39N08E28A001M	411938N1210478W001	Modoc	Irrigation	720	4159.00	4159.83	2016	2020	7	4136.23	4150.58

source: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer

bgs = below ground surface

msl = above mean sea level

5.1.1 *Groundwater Level Trends §354.16(a)(2)*

Figures 5-2 and **5-3** show hydrographs for the two wells with the longest monitoring records along with background colors representing the Water Year (WY) type: wet, normal, dry, and critical dry. These WY types are developed from the Sacramento River Index (SRI), which is calculated from annual runoff of the Sacramento River Watershed, of which the Pit River is a tributary. The SRI (no units) varies between 3.1 and 15.3 (average: 8.1) and are divided into the four WY categories.

Figure 5-2 Hydrograph of Well 17K1

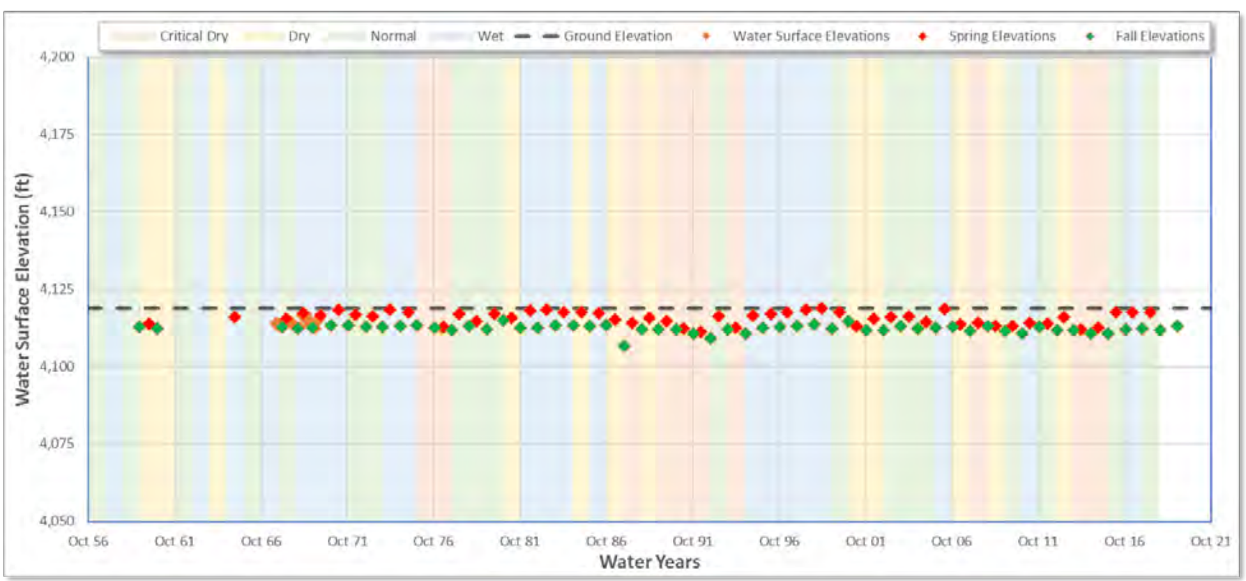

Figure 5-3 Hydrograph of Well 32A2

The water level record for these two wells illustrates that some areas of the Basin have experienced little to no change in water levels, while other areas have fluctuated more and have shown a measurable decline since about 2000. Hydrographs for all 22 wells are presented in **Appendix 5A**. On each hydrograph in the appendix a red trend line is shown, which is determined from a linear regression[1] of the spring water level measurements between 2000 and 2019. The average water level change during that period, in feet per year, is also shown. Twelve wells show stable (less than -1 ft/yr of decline) or rising water levels and nine wells show declining water from -1 to -3.1 ft/yr. These water level changes are shown graphically on **Figure 5-4** with the stable or rising water levels shown in green and areas with declines in excess of -1 ft/yr in orange and red.

5.1.2 *Vertical Groundwater Gradients §354.16(a)(2)*

Vertical hydraulic gradients are apparent when groundwater levels in wells screened deep in the aquifer differ from water levels measured shallow in the aquifer at the same general location. Vertical gradients indicate that the deep portion of the aquifer is separate from the shallow (e.g. by a very low permeability clay layer) and/or that pumping in one of the aquifers has occurred and the vertical flow between the aquifers is in progress of stabilizing. Chapter 4 contained the Hydrogeologic Conceptual Model which defined a single principal aquifer in the BVGB; therefore, there is no vertical gradient that needs to be described between principal aquifers. However, vertical gradients likely exist, and the five recently constructed well clusters will have data to describe these gradients once water level data is available from those wells. The locations of the clusters are shown on **Figure 5-1**.

5.1.3 *Groundwater Contours §354.16(a)(1)*

Spring and fall 2018 water level measurements from the 21 active CASGEM wells were used to illustrate current groundwater conditions. 2018 was used to illustrate current conditions because there were several wells without data for 2019 or 2020. **Figures 5-5** and **5-6** show the 2018 seasonal high and seasonal low groundwater elevation contours, respectively. Each contour line shows equal groundwater elevation. Groundwater flows from higher elevations to lower elevations, perpendicular to the contour lines. The direction of flow is emphasized on the figures in certain areas with arrows. In general, groundwater is highest in the east, where Willow and Butte Creeks enter the Basin. The general flow of water is to the west and south. The contours do indicate, however, northerly flow from the lower reaches of Ash Creek. In the southern portions of the BVGB, groundwater flows toward the east.

[1] Also known as a line of best fit, which is developed from a mathematical interpretation of the data.

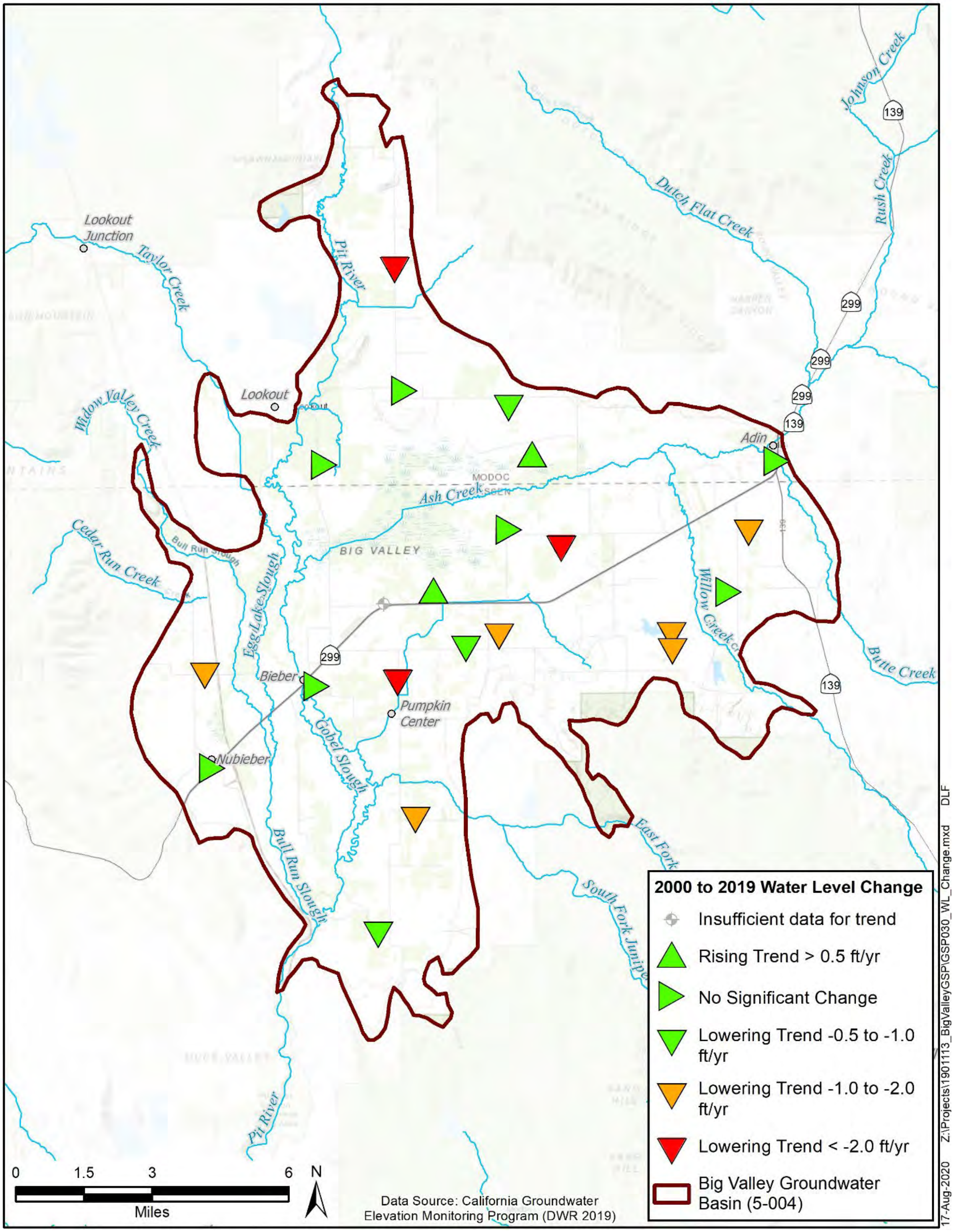

Figure 5-4 Average Water Level Change Since 2000 Using Spring Measurements

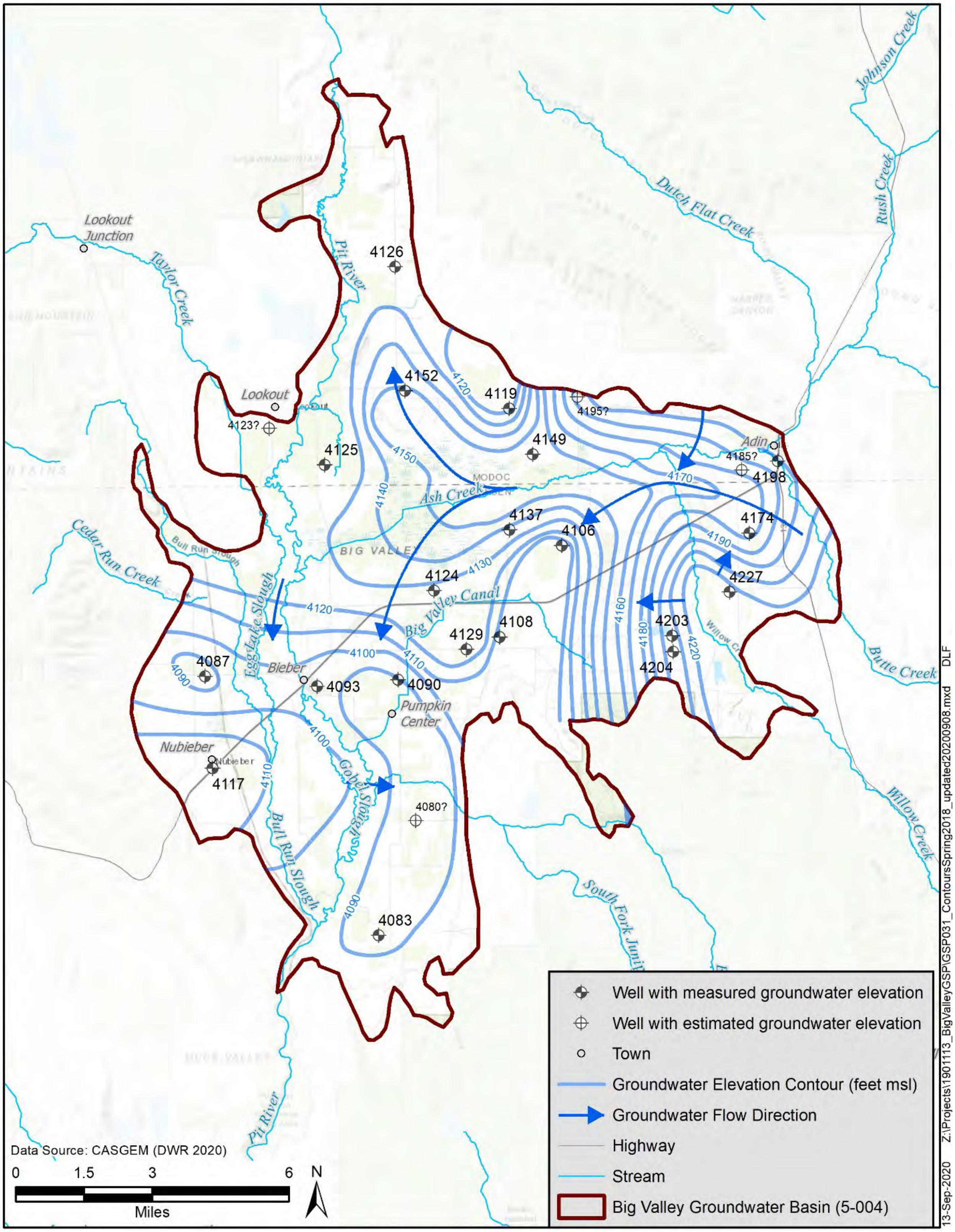

Figure 5-5 Groundwater Elevation Contours and Flow Direction Spring 2018

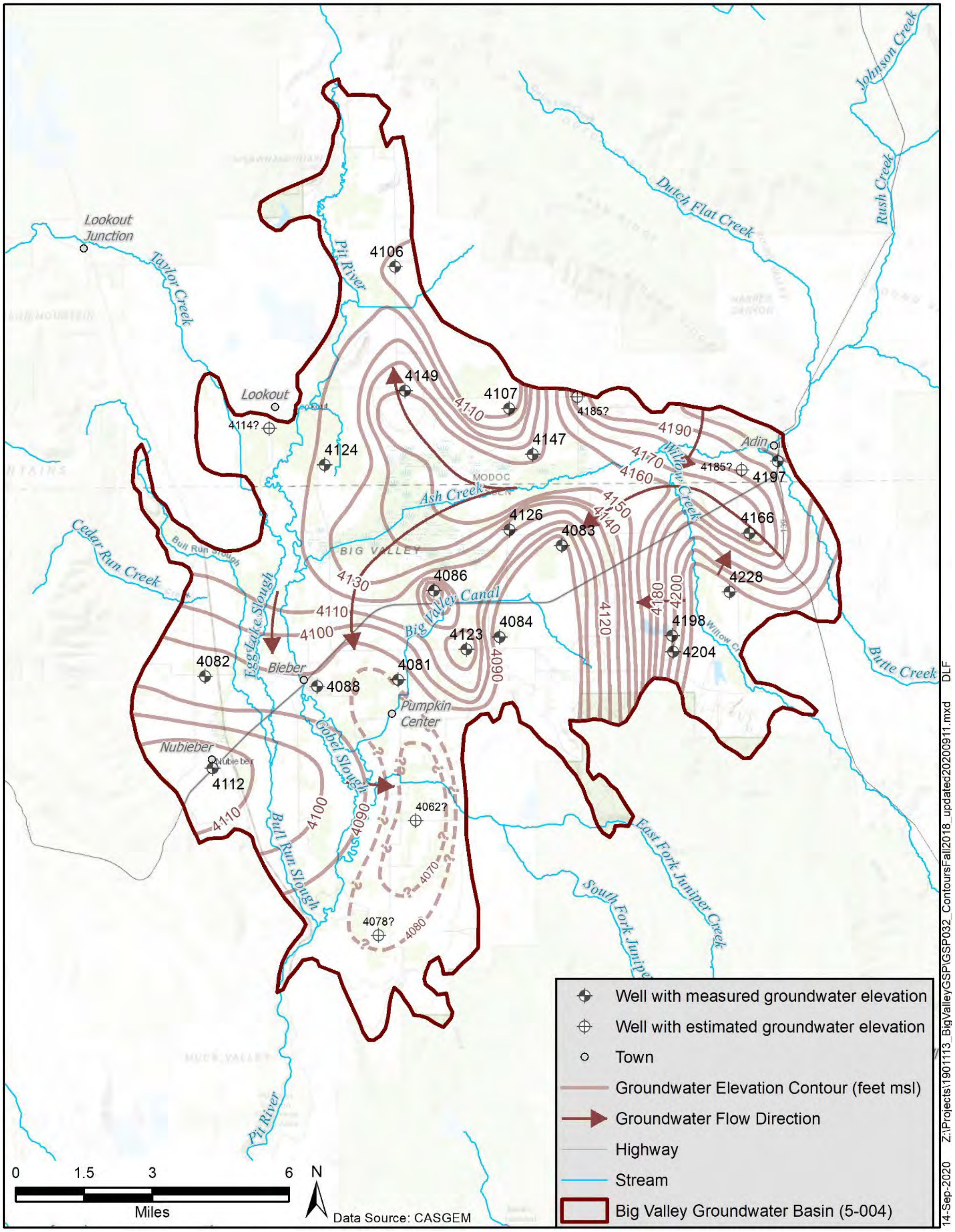

Figure 5-6 Groundwater Elevation Contours and Flow Direction Fall 2018

5.2 Change in Storage §354.16(b)

In order to determine the annual and seasonal change in groundwater storage, groundwater elevation surfaces[2] were developed for spring and fall for each year between 1983 and 2018. These surfaces are included in **Appendix 5B**. The amount of groundwater in storage for each set of contours was calculated. This calculation was performed using Geographic Information System (GIS) software which can subtract the groundwater elevation surface from the ground elevation surface (using a digital elevation model) at each raster cell (pixel) and calculate the average depth to water (DTW) throughout the Basin. This average DTW was then subtracted from the definable bottom of the Basin (1,200 feet), multiplied by the area of the basin, and multiplied by 5%, which is used as the specific yield (the fraction of the aquifer material that contains recoverable water from Chapter 4).
Table 5-2 shows, from 1983 to 2018, the total water in storage, the change in storage from the previous year, and the cumulative change in storage. **Figure 5-7** shows this information graphically, along with the annual precipitation from the McArthur station. This graph shows that groundwater storage generally declines during dry years and stays stable or increases slightly during normal or wet years. During the period from 1983 to 2000, groundwater levels dipped, then returned to the same levels. After 2000, groundwater storage has generally declined by about 96,000 acre-feet (AF) (using spring measurements) which is a slight increase from the historic low of about 116,000 AF in spring 2015. During this same period (2000 to 2015), precipitation has gone through an average cycle of wet and dry years.

Annual groundwater use is not shown on **Figure 5-7** as required by SGMA regulations. Groundwater use will be addressed in Chapter 6 (Water Budget).

5.3 Seawater Intrusion §354.16(c)

The BVGB is not located near the ocean, and therefore seawater intrusion is not applicable to this GSP.

5.4 Groundwater Quality Conditions §354.16(d)

As noted in Chapter 4, previous, historic reports have characterized the water quality in the BVGB as excellent (DWR 1963, USBR 1979). Groundwater is generally suitable for all beneficial uses and only localized contamination plumes have been identified in the BVGB. This section presents an analysis of recent groundwater quality conditions and the distribution of known groundwater contamination sites in compliance with GSP Regulation §354.16(d).

[2] Groundwater elevation surfaces are developed using the known groundwater elevations at wells throughout the Basin and using kriging. Kriging is a mathematical method that predicts (interpolates) what groundwater levels are between known points. The kriging surface consists of a grid (pixels) covering the entire basin that has interpolated groundwater elevation values for each grid cell.

Table 5-2 Change in Storage 1998-2018

Year	Average Spring Depth to Water[1] (feet)	Spring Storage[2] (Acre-feet)	Spring Cumulative Change in Storage (Acre-feet)	Average Fall Depth to Water[1] (feet)	Fall Storage[2] (Acre-feet)	Fall Cumulative Change in Storage (Acre-feet)
1983	29.3	5,390,192	-	37.1	5,354,430	(35,762)
1984	29.4	5,389,508	(684)	36.4	5,357,352	(32,841)
1985	31.4	5,380,526	(9,666)	38.9	5,346,150	(44,042)
1986	31.0	5,382,539	(7,653)	40.1	5,340,481	(49,711)
1987	32.6	5,375,135	(15,057)	42.1	5,331,386	(58,806)
1988	34.9	5,364,459	(25,733)	43.9	5,323,094	(67,099)
1989	35.2	5,363,150	(27,042)	42.5	5,329,302	(60,890)
1990	35.6	5,360,976	(29,216)	46.2	5,312,610	(77,582)
1991	36.8	5,355,677	(34,515)	43.2	5,326,124	(64,068)
1992	38.0	5,350,297	(39,895)	48.5	5,301,609	(88,583)
1993	36.9	5,355,293	(34,899)	42.1	5,331,046	(59,146)
1994	37.5	5,352,221	(37,971)	43.1	5,326,613	(63,579)
1995	35.3	5,362,737	(27,456)	41.0	5,336,197	(53,996)
1996	32.4	5,375,861	(14,332)	39.6	5,342,700	(47,493)
1997	31.8	5,378,600	(11,592)	39.7	5,342,405	(47,787)
1998	31.1	5,382,014	(8,179)	36.9	5,355,217	(34,975)
1999	29.5	5,389,070	(1,122)	38.7	5,346,921	(43,271)
2000	32.3	5,376,287	(13,905)	46.5	5,310,947	(79,245)
2001	38.0	5,350,015	(40,177)	51.1	5,289,979	(100,213)
2002	39.3	5,344,357	(45,835)	46.6	5,310,695	(79,497)
2003	39.4	5,343,881	(46,311)	48.9	5,299,889	(90,303)
2004	39.2	5,344,515	(45,677)	47.7	5,305,401	(84,791)
2005	41.5	5,334,164	(56,028)	47.8	5,305,141	(85,052)
2006	36.7	5,356,175	(34,017)	46.2	5,312,218	(77,975)
2007	38.8	5,346,641	(43,551)	49.4	5,297,661	(92,531)
2008	41.6	5,333,712	(56,480)	51.7	5,287,070	(103,122)
2009	42.5	5,329,337	(60,856)	53.7	5,277,825	(112,368)
2010	46.4	5,311,440	(78,752)	54.4	5,274,613	(115,580)
2011	45.9	5,313,710	(76,482)	52.5	5,283,348	(106,844)
2012	44.9	5,318,299	(71,893)	56.3	5,265,670	(124,523)
2013	49.3	5,298,013	(92,179)	58.0	5,257,951	(132,242)
2014	51.7	5,287,059	(103,133)	61.6	5,241,427	(148,765)
2015	54.4	5,274,644	(115,548)	67.5	5,214,239	(175,953)
2016	51.3	5,288,702	(101,490)	62.6	5,237,000	(153,193)
2017	49.7	5,296,127	(94,066)	61.1	5,243,879	(146,313)
2018	50.1	5,294,464	(95,728)	59.0	5,253,677	(136,515)

Note: Parentheses indicate negative numbers

[1] From water surface elevation contours - Appendix 5A

[2] Calculated from average depth to water, area of basin, 1,200 foot aquifer bottom, and specific yield of 5%

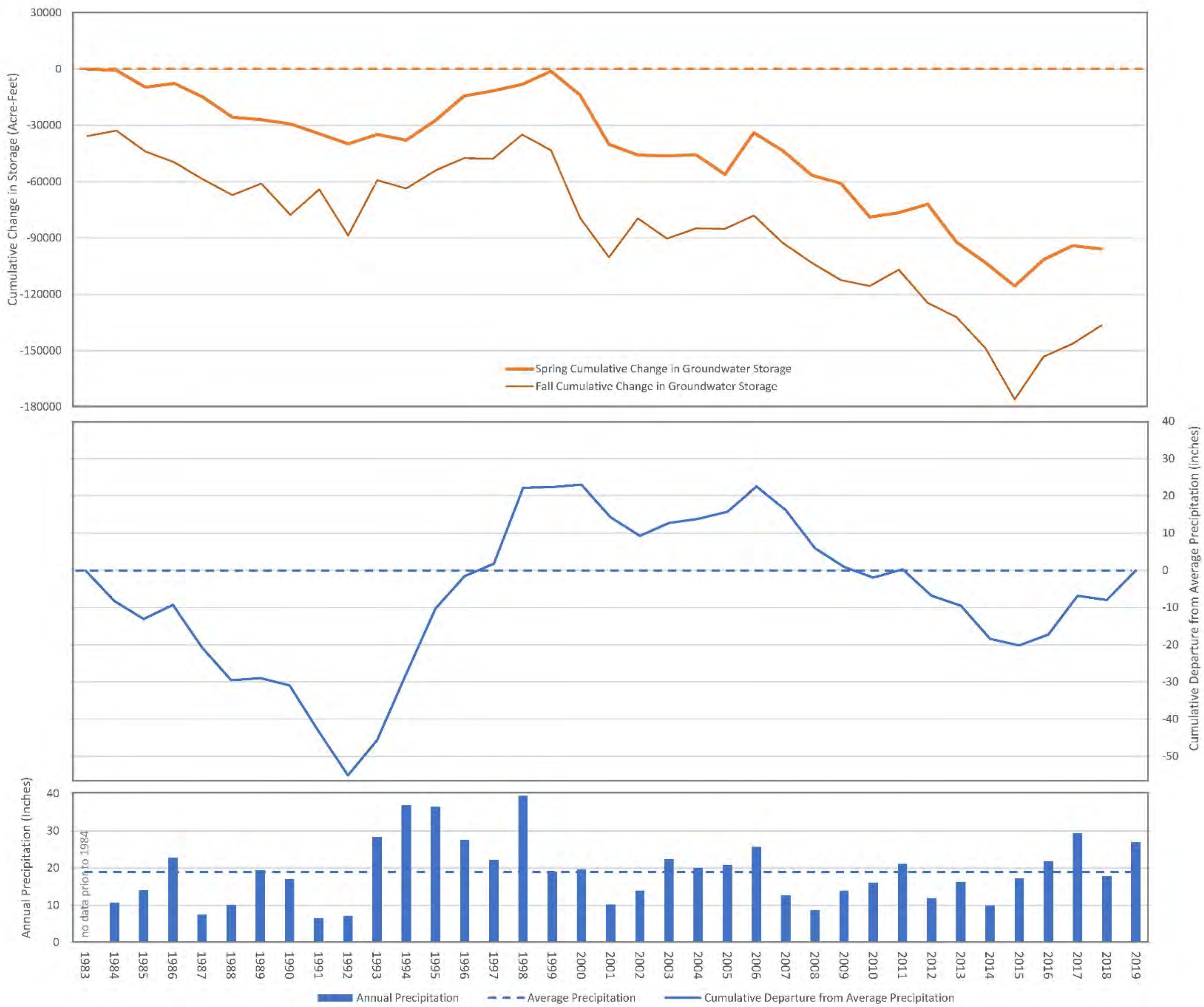

Figure 5-7 Cumulative Change in Storage and Precipitation

5.4.1 *Naturally Occurring Constituents*

The concentration of naturally occurring constituents varies throughout the BVGB. Previous reports have noted the potential elevated concentrations of arsenic, boron, fluoride, iron, manganese, and sulfate. (DWR 1963, USBR 1979) All of these constituents are naturally occurring and in these historic reports, they indicate that most of these constituents are associated with localized thermal waters found in the area of hot springs in the center of the Basin.

More recent conditions were analyzed using a statistical approach using data available from the state's Groundwater Ambient Monitoring and Assessment (GAMA) Groundwater Information System (SWRCB 2020a). The GAMA data provides the most comprehensive, readily available water quality dataset and contains results from numerous programs including:

- Division of Drinking Water (public supply systems)
- Department of Pesticide Regulation
- Department of Water Resources (historic ambient monitoring)
- Environmental Monitoring Wells (regulated facilities and cleanup sites)
- United States Geological Survey (USGS) Groundwater Ambient Monitoring and Assessment (GAMA) program
- USGS National Water Information System (NWIS) data

Water quality results in these datasets go back to the 1950s. Because conditions can change as groundwater is used over time, data prior to the 1983 water year (WY) were eliminated from the statistical analysis of the data. WY 1983 was chosen because the bulk of the historic water level wells (**Figure 5-1**) came online by 1983. In addition, data from the Environmental Monitoring Wells programs were eliminated since water quality issues associated with these regulated sites are typically highly localized, often are associated with isolated, perched groundwater, and are already regulated. The nature and location of groundwater contamination sites are discussed in Section 5.4.2.

Table 5-3 shows the statistical evaluation of the filtered GAMA water quality data along with the water quality results obtained from the five well clusters constructed to support the GSP. The constituents selected to assess the suitability in the Basin based on thresholds for different beneficial uses. For domestic and municipal uses, the inorganic constituents that are regulated under state drinking water standards are shown. Boron and sodium are also shown, since elevated concentrations can affect the suitability of the water for agricultural uses. The suitability threshold concentration for each constituent is shown, using either the maximum contaminant level (MCL) or agricultural threshold, whichever was lower. Because of their elevated concentrations, iron and manganese were evaluated for both drinking water and agricultural thresholds. It is assumed that water suitable for domestic, municipal, and agricultural purposes would also be suitable for environmental and industrial beneficial uses.

Table 5-3 Water Quality Statistics

Constituent Name	Suitability Threshold Concentration	Suitability Threshold Type	Total # of Meas	min	max	# Meas Above Threshold	% of Meas Above Threshold	# Wells With Meas	# Wells with Average Above Threshold	% of Wells with Average Above Threshold	# Wells with Most Recent Meas Above Threshold	% of Wells with Most Recent Meas Above Threshold	Comment
Aluminum	200	DW1	41	0	552	2	5%	18	1	6%	0	0%	Low concern due to only two threshold exceedances and zero recent measurements above MCL
Antimony	6	DW1	45	0	36	1	2%	20	1	5%	0	0%	Low concern due to only one threshold exceedance and zero recent measurements above MCL
Arsenic	10	DW1	53	0	12	4	8%	23	3	13%	3	13%	
Barium	1000	DW1	49	0	600	0	0%	23	0	0%	0	0%	
Beryllium	4	DW1	48	0	1	0	0%	23	0	0%	0	0%	
Cadmium	5	DW1	49	0	1	0	0%	23	0	0%	0	0%	
Chromium (Total)	50	DW1	36	0	20	0	0%	13	0	0%	0	0%	
Chromium (Hexavalent)	10	DW1*	13	0.05	3.29	0	0%	13	0	0%	0	0%	
Copper	1300	DW1	34	0	190	0	0%	21	0	0%	0	0%	
Fluoride	2000	DW1	42	0	500	0	0%	16	0	0%	0	0%	
Lead	15	DW1	28	0	6.2	0	0%	16	0	0%	0	0%	
Mercury	2	DW1	44	0	1	0	0%	19	0	0%	0	0%	
Nickel	100	DW1	46	0	10	0	0%	20	0	0%	0	0%	
Nitrate (as N)	10000	DW1	151	0	4610	0	0%	24	0	0%	0	0%	
Nitrite	1000	DW1	62	0	930	0	0%	20	0	0%	0	0%	
Nitrate + Nitrite (as N)	10000	DW1	2	40	2250	0	0%	2	0	0%	0	0%	
Selenium	50	DW1	49	0	5	0	0%	23	0	0%	0	0%	
Thallium	2	DW1	46	0	1	0	0%	20	0	0%	0	0%	
Chloride	250000	DW2	66	1400	79000	0	0%	43	0	0%	0	0%	
Iron	300	DW2	50	0	11900	26	52%	21	8	38%	9	43%	Low human health concern due to being a secondary MCL for aesthetics
Iron	5000	AG	50	0	11900	2	4%	21	2	10%	2	10%	
Manganese	50	DW2	45	0	807	28	62%	21	12	57%	11	52%	Low human health concern due to being a secondary MCL for aesthetics
Manganese	200	AG	45	0	807	22	49%	21	7	33%	7	33%	
Silver	100	DW2	36	0	20	0	0%	19	0	0%	0	0%	
Specific Conductance	900	DW2	66	125	1220	3	5%	42	1	2%	1	2%	
Sulfate	250000	DW2	60	500	1143000	1	2%	40	0	0%	0	0%	Low concern due to only one threshold exceedance and zero recent measurements above MCL
Total Dissolved Solids (TDS)	500000	DW2	57	131000	492000	0	0%	39	0	0%	0	0%	
Zinc	5000	DW2	34	0	500	0	0%	20	0	0%	0	0%	
Boron	700	AG	40	0	100	0	0%	34	0	0%	0	0%	
Sodium	69000	AG	33	11600	69000	0	0%	21	0	0%	0	0%	

Sources:

GAMA Groundwater Information System, accessed June 5, 2020 (SWRCB 2020)

University of California Cooperative Extension Farm Advisor (UCCE 2020)

Notes:

GAMA data was filtered to remove all measurements before Oct 1, 1982 and all GeoTracker cleanup sites

Constituents listed are all inorganic naturally occurring elements and compounds that have a SWRCB drinking water maximum contaminant limit (MCL), plus Boron, which has a threshold for agricultural use.

All measurements in micrograms per liter, except specific conductance which is measured in microsiemens per centimeter.

Green indicates less than 1%

Yellow indicates between 1% and 10%

Red indicates greater than 10%

Threshold Types:

DW1: Primary drinking water MCL

DW2: Secondary drinking water MCL (for aesthetics such as taste, color, and odor)

AG: Agricultural threshold based on guidelines by the Food and Agricultural Organization of the United Nations (Ayers and Westcot 1985)

* Hexavalent chromium was regulated under a primary drinking water MCL until the MCL was invalidated in 2017. The SWRCB is working to re-establish the MCL.

The subset of water quality data was analyzed to determine which constituents to investigate further. **Table 5-3** shows that most constituents have not had concentrations measured above their corresponding threshold since 1983 and were not investigated further. Sulfate, aluminum, and antimony only had one or two detections above their threshold, and none of these were recent, so these constituents were not investigated further. Arsenic (As), iron (Fe), manganese (Mn), specific conductance (SC), and total dissolved solids (TDS) were investigated further. All of these constituents are naturally occurring.

Arsenic, Iron, and Manganese

As, Fe, and Mn show elevated concentrations in over 10% of the wells. Although iron and manganese are regulated under secondary drinking water standards (for aesthetics such as color taste, and odor) and are not of concern for human health as drinking water, these constituents were still chosen for further investigation because they also have multiple detections above the agricultural suitability threshold. (Ayers and Westcot 1985) **Figures 5-8** through **5-10** show the trends over time. Wells with single measurements are shown as dots, where wells that had multiple measurements shown as lines. These figures indicate that the number of wells with highly elevated concentrations of arsenic and manganese concentrations may have decreased over the last 40 years of groundwater use. Iron concentrations are generally below the agricultural suitability threshold (Ayers and Westcot, 1985), with two recent elevated measurements from the monitoring wells constructed in support of the GSP.

Specific Conductance and Total Dissolved Solids

SC is a measure of the water's ability to conduct electricity. TDS is a measure of the total amount of dissolved materials (i.e. salts) in water. SC and TDS are related to one another (higher TDS results in higher SC) and SC is often used as a proxy for TDS. Although there was only one recent measurement over the MCL for SC, both SC and TDS were investigated further because they are important indicators of general water quality conditions.

Figures 5-11 and **5-12** show the distribution of elevated levels of SC and TDS around the Basin. **Figures 5-13** and **5-14** show the trends over time. Wells with single measurements are shown as dots, where wells that had multiple measurements shown as lines. These figures indicate that the number of wells with highly elevated concentrations of SC and TDS may have decreased over the last 40 years.

5.4.2 *Groundwater Contamination Sites and Plumes*

To determine the location of potential groundwater contamination sites and plumes, the State Water Resources Control Board's (SWRCB's) GeoTracker website was consulted. GeoTracker catalogs known groundwater contamination sites and waste disposal sites. (SWRCB 2020b) A search of GeoTracker identified ten sites where groundwater could potentially be contaminated. These sites are in the vicinity of Bieber and Nubieber as listed in **Table 5-4** and shown on **Figure 5-15**. The sites include leaking underground storage tanks (LUSTs), cleanup program sites, and land disposal sites. Half of the sites are open and subject to on-going regulatory

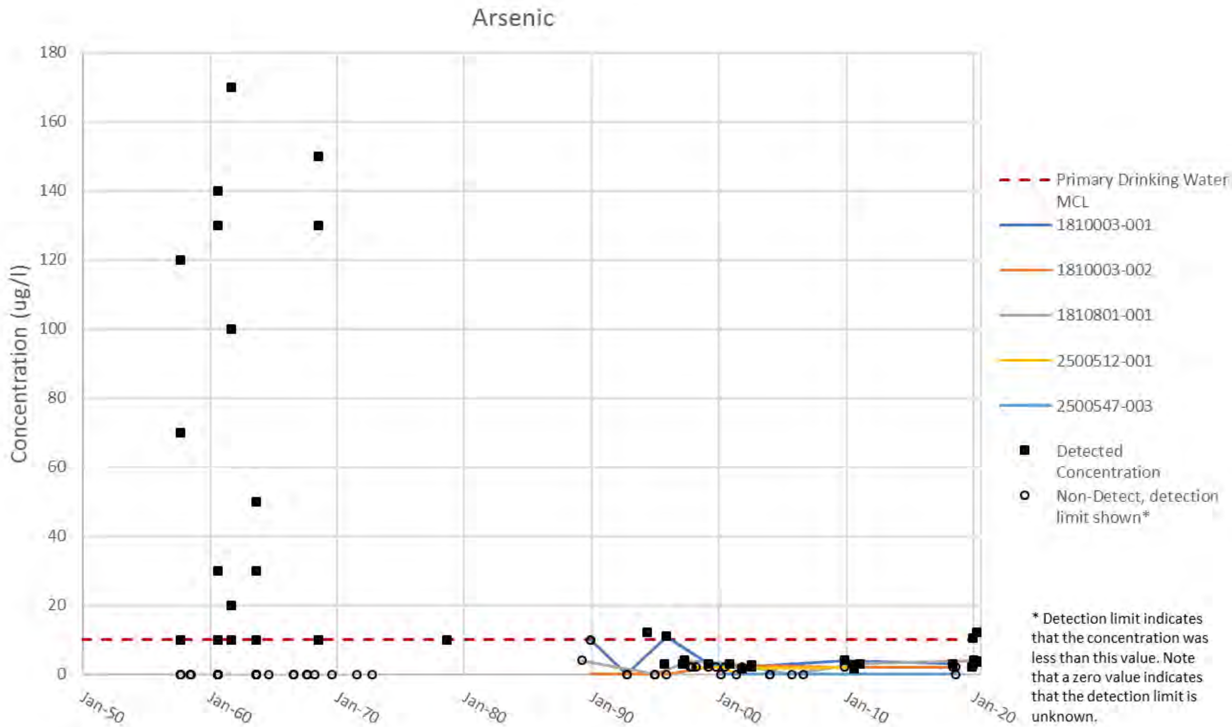

Figure 5-8 Arsenic Trends

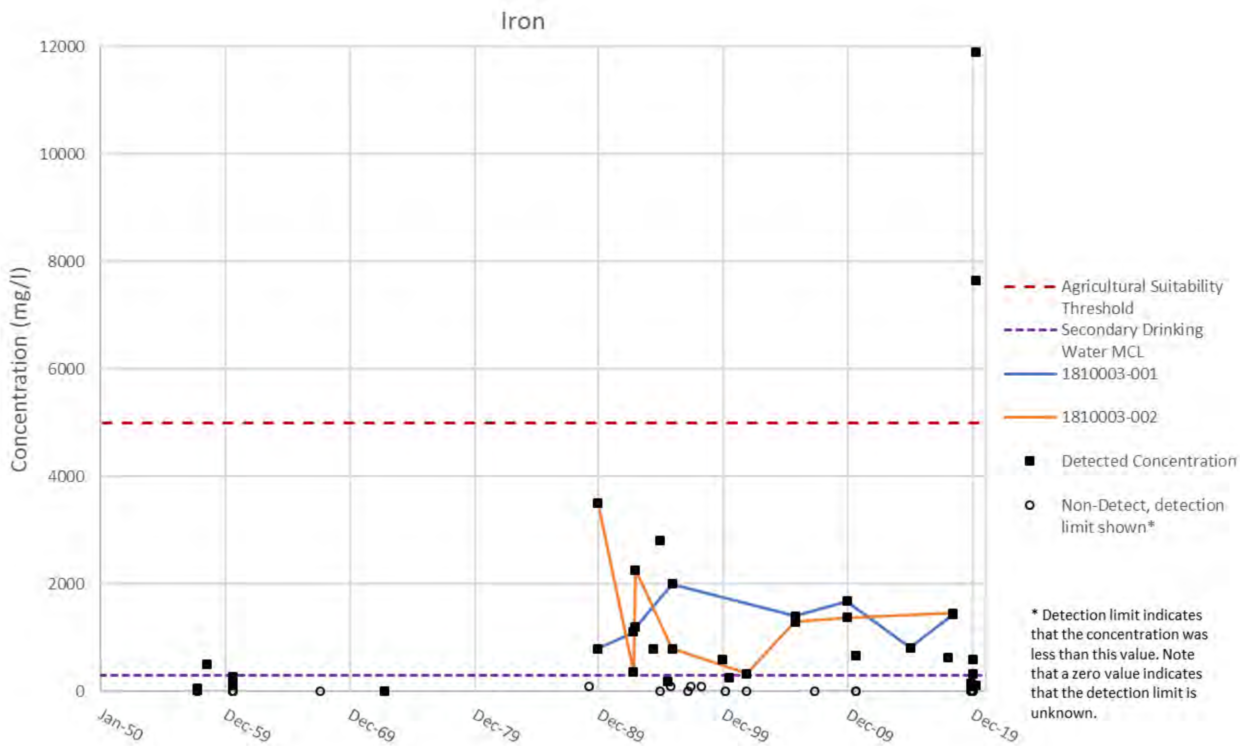

Figure 5-9 Iron Trends

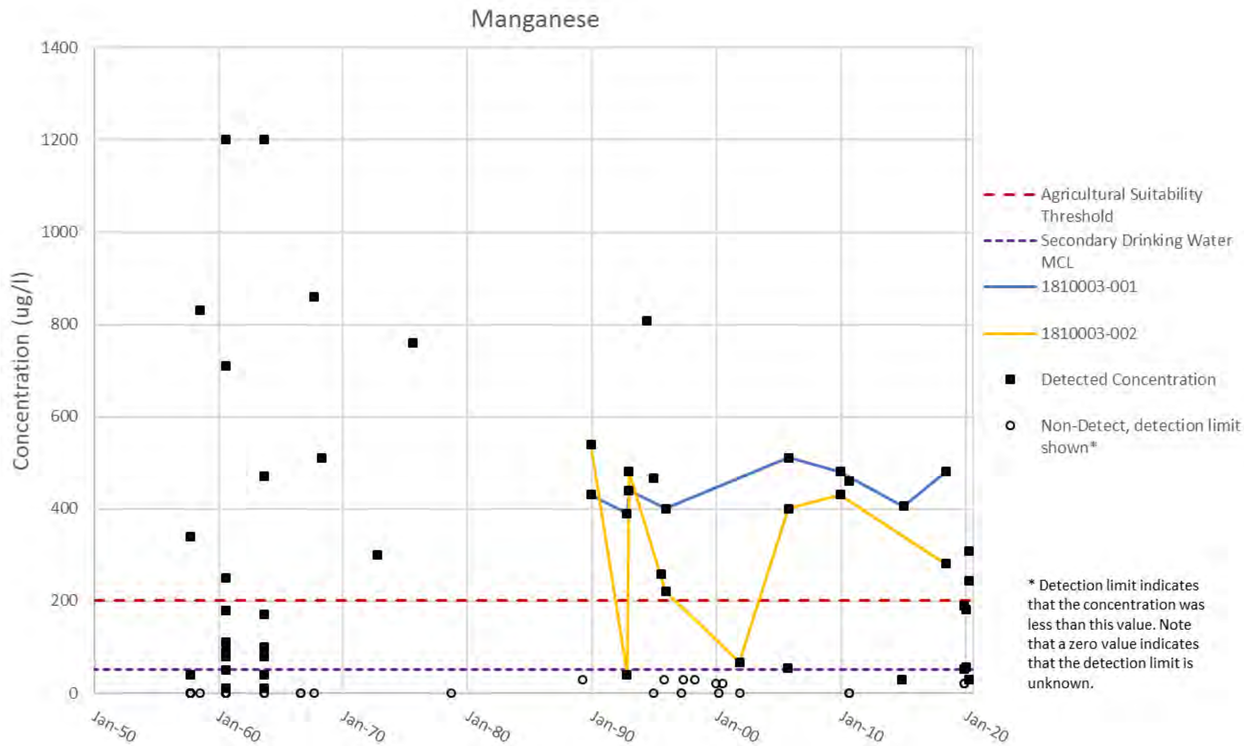

Figure 5-10 Manganese Trends

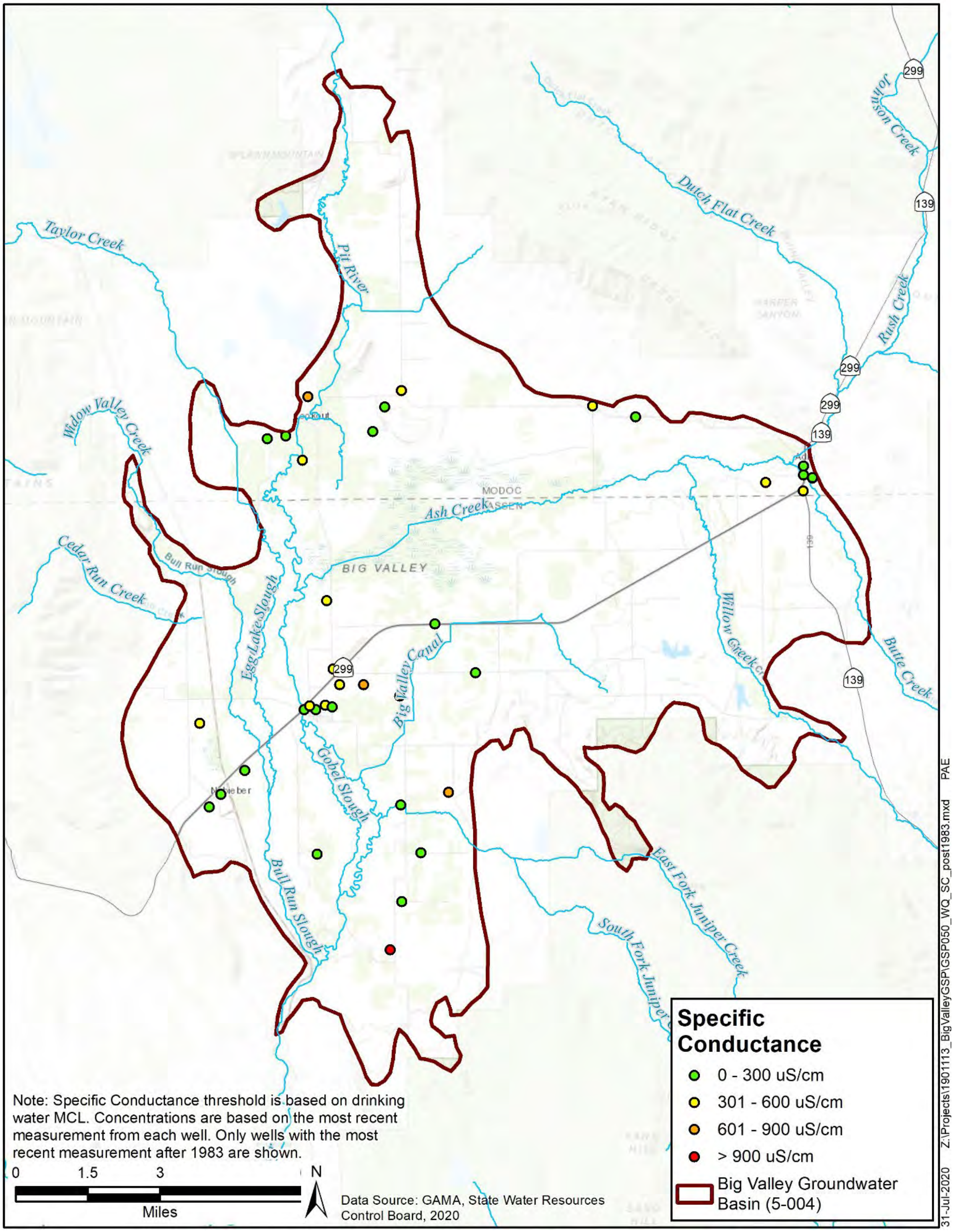

Figure 5-11 Distribution of Elevated Specific Conductance

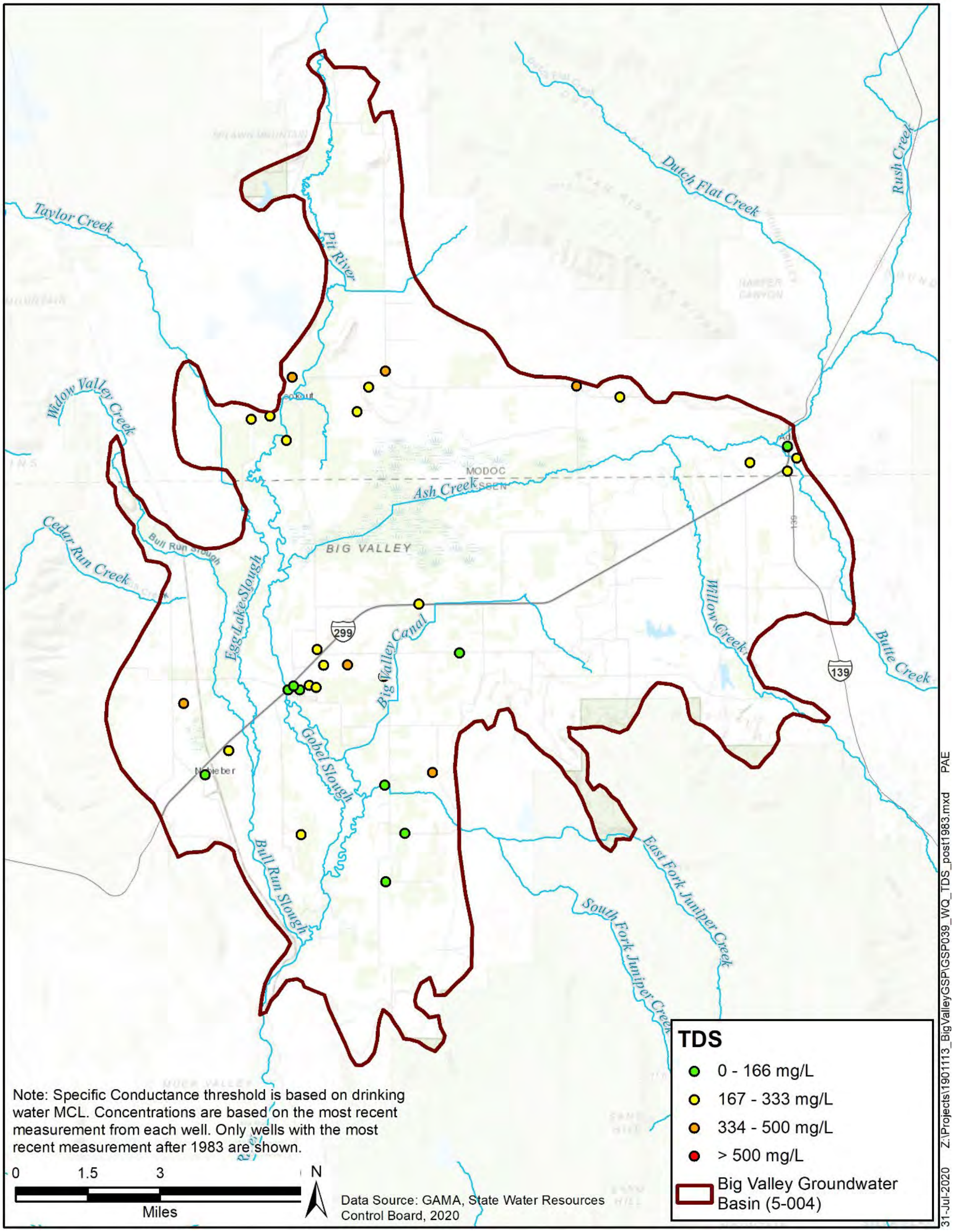

Figure 5-12 Distribution of Elevated TDS Concentrations

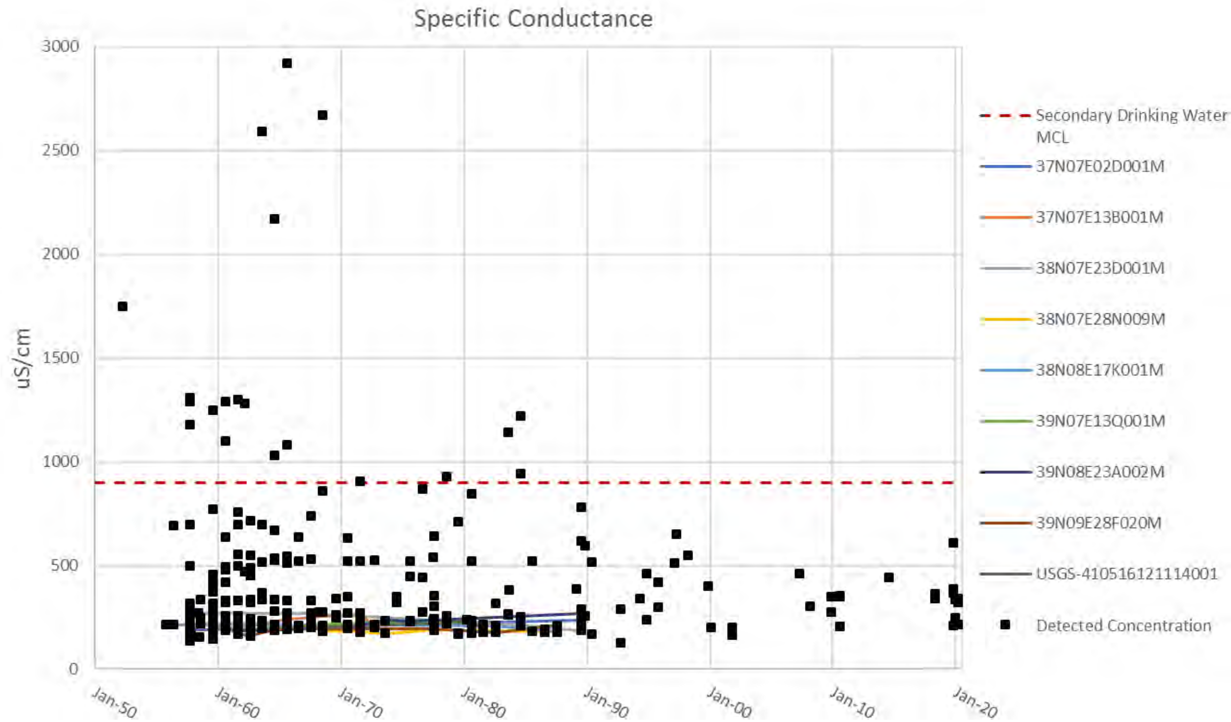

Figure 5-13 Specific Conductance Trends

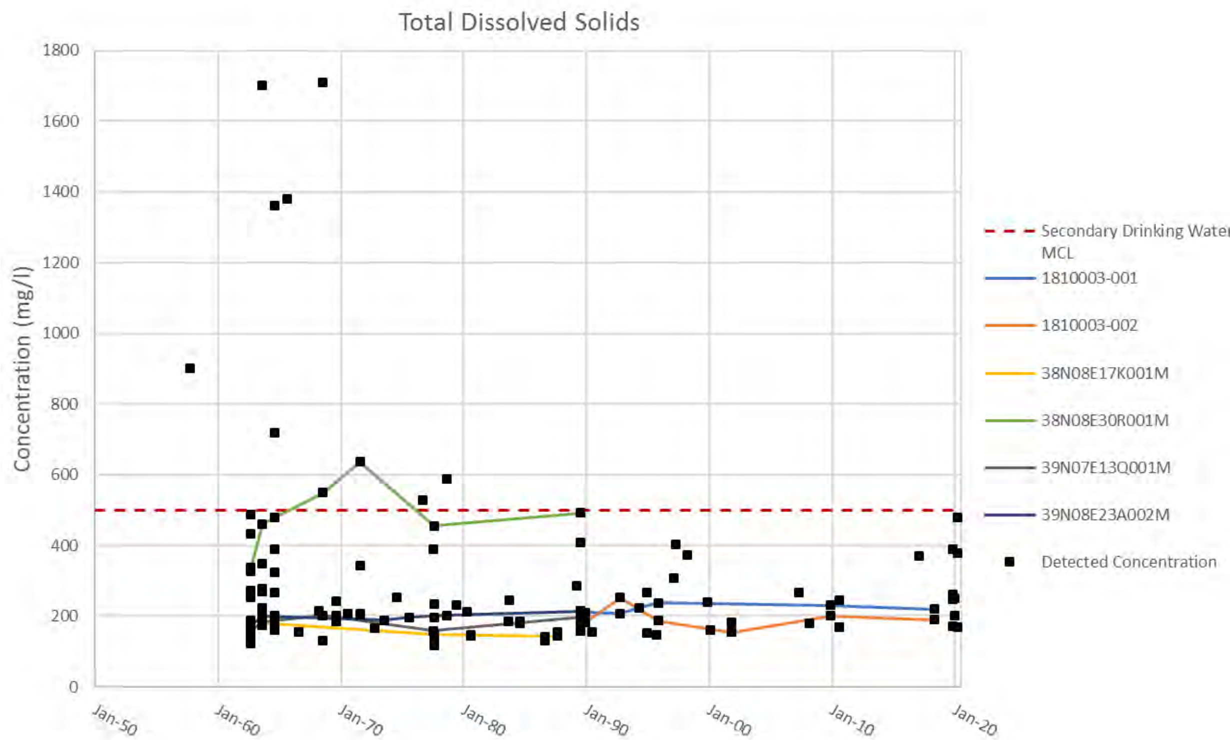

Figure 5-14 TDS Trends

Table 5-4 Known Potential Groundwater Contamination Sites in the BVGB

GeoTracker ID	Latitude	Longitude	Case Type	Status	Last Regulatory Acitivity	Case Begin Date	Potential Contaminants of Concern	Site Summary
T10000003882	41.12050	-121.14605	LUST Cleanup Site	Open - Assessment & Interim Remedial Action	04/16/20	10/17/11	Benzene, Diesel, Ethylbenzene, Total Petroleum Hydrocarbons (TPH), Xylene	The case was opened following an unauthorized release from an underground storage tank(s). Tank removal and further site assessment, including installation of eight monitoring wells, led to remedial actions. Periodic groundwater monitoring started in October 2013 and has been ongoing though March 2020.
T0603593601	41.13230	-121.13070	LUST Cleanup Site	Open - Remediation	07/29/20	03/22/00	Gasoline	Active gas station with groundwater impacts. Full-scale remediation via groundwater extraction and treatment began in September 2013 and was shut-down in April 2017 because it was determined that it was no longer an effective remedy to treat soil and groundwater. At the time of system shutdown, the influent MTBE concentration was 5,650 ug/L which exceeds the Low-Threat Closure Policy criteria. Additionally, high levels of TPHg and sheen/free product are present. A soil vapor extraction (SVE) system operated for a limited time in 2016/2017 but was not effective. In April 2018, it was determined that active remediation is not a cost-effective path to closure given low permeability of site soils. Staff suggested incorporating institutional controls (IC) and risk-based cleanup objectives instead of active remediation of soil and groundwater. The IC approach was dependent on the submittal of several documents related to soil management, deed restriction, and risk modeling plus annual groundwater sampling. This information has not been provided and the RWQCB sent an Order for this information.
T0603500006	41.12241	-121.14128	LUST Cleanup Site	Completed - Case Closed	01/04/00	06/28/99	Diesel	A 2000-gallon underground storage tank was removed and limited contaminated soil was present in the excavation. Petroleum hydrocarbons were not found in the uppermost groundwater. These findings led to the closure of the case.
L10005078943	41.12941	-121.14169	Land Disposal Site	Open - Closed facility with Monitoring*	06/26/20	06/30/08	Higher levels of Inorganic constituents, organic chemicals (synthetic), per/polyfluoroalkyl substances	Disposal activities at Bieber Landfill occurred from the early 1950s until 1994. The landfill was closed during the early 2000s. While active, the site received residential, commercial, and industrial non-hazardous solid waste. Formerly an unlined burn dump, the site was converted to cut-and-cover landfill operation in 1974. Landfill refuse is estimated to occupy less than 13 acres of the 20-acre site. Wastes are estimated to be approximately 10 to 15 feet thick. The Class III landfill was closed in accordance with Title 27 of the California Code of Regulations. A transfer station was established at the site for the transporation of waste to another landfill. Groundwater levels and quality are monitored twice per year at four wells.
T0603500003	41.12124	-121.14061	LUST Cleanup Site	Completed - Case Closed	09/13/94	07/31/91	Heating Oil / Fuel Oil	A 1000-gallon underground storage tank was removed and contaminated soil was present beneath the tank, which led to installation of nine soils borings and three monitoring wells. Contaminated soil was removed but an adjacent building limited the extent of the excavation so contaminated soil remains under the building. Hydrocarbons were initally found in one well but not in subsequent sampling. The RWQCB concurred with a request to close the investigation.
T10000003101	41.13151	-121.13658	Cleanup Program Site	Open - Assessment & Interim Remedial Action	07/22/20	04/03/07	Benzene, Toluene, Xylene, MTBE / TBA / Other Fuel Oxygenates, Gasoline, Other Petroleum	A diesel leak was found in association with an industrial chipper. Corrective action included excavation of diesel-impacted soil, removing contaminated water, and groundwater monitoring. Results of soil and groundwater sampling indicate low concentrations of TPHg and BTEX and that there is no offsite migration. Staff have determined that the case is ready for closure, pending decommissioning of the site monitoring wells.
SL0603581829	41.09251	-121.17904	Cleanup Program Site	Completed - Case Closed	09/01/05	01/08/05	Petroleum - Diesel fuels, Petroleum - Other	Contaminated soil excavated and transported to Forward Landfill for disposal. Contaminated groundwater (7,000 gallons) extracted with vacuum truck for disposal.
T0603500002	41.12188	-121.13546	LUST Cleanup Site	Completed - Case Closed	07/17/06	10/20/86	Gasoline / diesel	Three underground storage tanks were removed and contaminated soil was present beneath the tank, which led to installation of nine monitoring wells and three remediation wells. Natural attenuation of the hydrocarbon impact was acceptable to the RWQCB due to the limited, well-defined extent of the impact and the limited and declining impact to groundwater. The RWQCB concurred with a request to close the site.
T0603500004	41.12134	-121.13547	LUST Cleanup Site	Completed - Case Closed	03/12/99	06/12/97	Diesel	A 5000-gallon underground storage tank was removed and very low levels of petroluem hydrocarbons were detected in the soil, which was allowed to be spread onsite and the case was closed.
T10000002713	41.11993	-121.14271	Cleanup Program Site	Open - Site Assessment	12/30/16	03/10/10	Other Petroleum	The site is an old bulk plant which was built in the 1930's and handled gasoline and diesel. During a routine inspection in March 2010, evidence of petroleum spills were identified at the loading dock area. A follow-up inspection was conducted in April 2010. The ASTs and loading dock were removed but additional contamination was noted under the removed structures. Furthermore, a shallow excavation contained standing water with a sheen. Due to the potential impacts to shallow groundwater, the Central Valley Water Board became the lead agency in December 2010. Additional information was requested in December 2016. A response is not evident.

*This terminology indicates that the landfill is closed (no new material being disposed), but the site is open with regard to ongoing groundwater monitoring.
Source: GeoTracker (SWRCB 2020b)

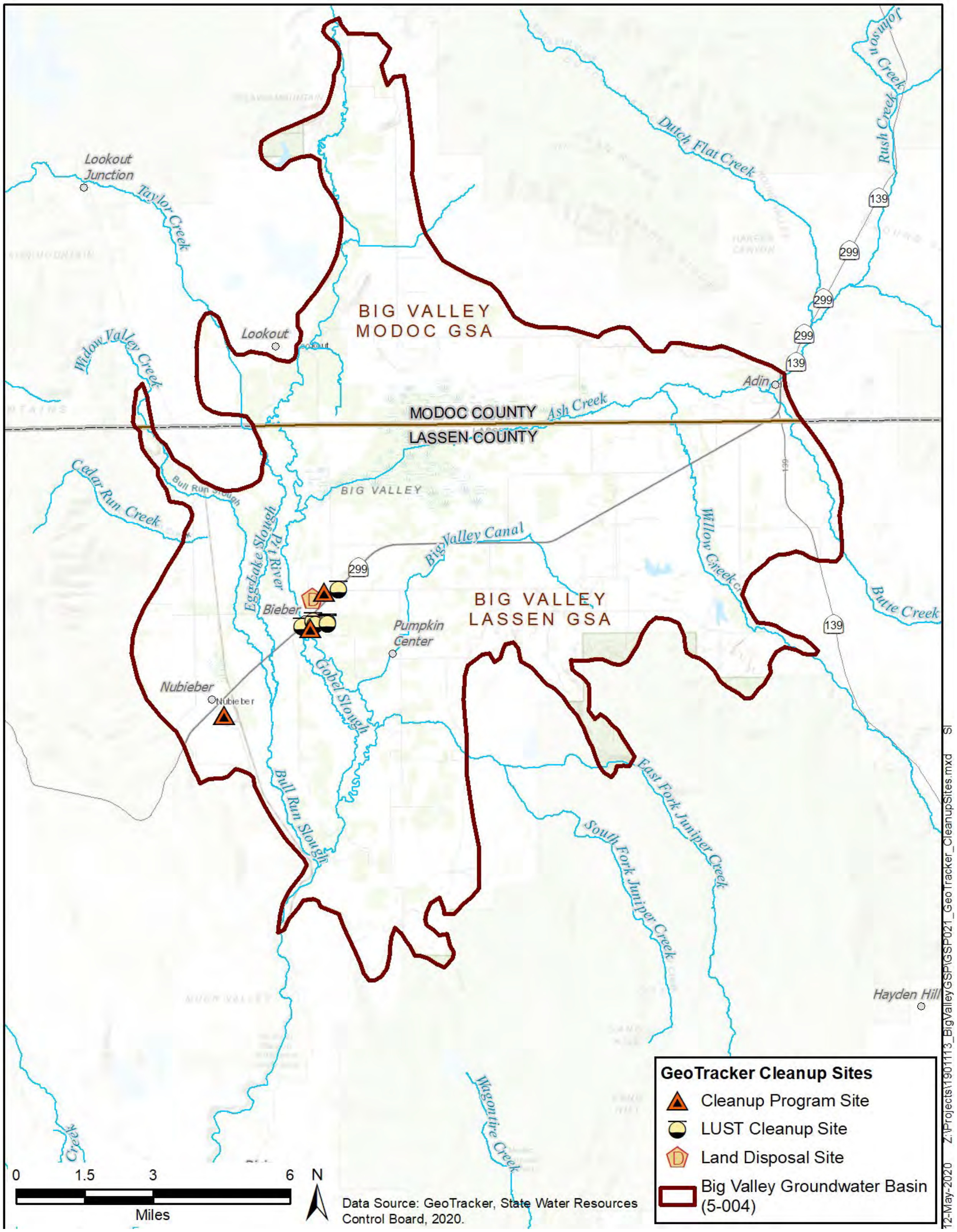

Figure 5-15 Location of Known Potential Groundwater Contamination Sites

requirements. The contaminants are listed in **Table 5-4**, which also gives a summary of the case history. Most of the contaminants originated at LUST sites leaking petroleum hydrocarbons which are light non-aqueous phase liquids (LNAPLs). LNAPLs are less dense than water and their solubility is quite low, meaning that if they reach groundwater, they float on top and generally do not migrate into the deeper portions of the aquifer. Moreover, many of the constituents can be degraded by naturally occurring bacteria in soil and groundwater so the hydrocarbons do not migrate far from the LUST sites. However, MTBE[3], TBA[4], and fuel oxygenates are more soluble in water. Two LUST sites and the landfill site are subject to long-term monitoring while a fourth site is ready for case closure.

The Bieber Landfill is subject to on-going semi-annual monitoring of groundwater levels and groundwater quality at four shallow wells. This monitoring is required by the California Regional Water Quality Control Board (RWQCB Order No. R5-2007-0175), after the formal closure of the landfill in the early 2000s. Trace concentrations of several organic constituents[5] have been detected at MW-1, the closest downgradient well to the site, but rarely at the other three wells. Higher concentrations of inorganic constituents (e.g. TDS, SC, others) are also present at MW-1. During 2019, the landfill was also required to analyze groundwater samples from MW-1, MW-2 and MW-4 for per/polyfluoroalkyl substances (PFAS), which are an emerging group of contaminants that are being studied for their effect on human health and may be subject to very low regulatory criteria (parts per trillion). Fifteen of 28 PFASs were detected at MW-1 and nine of 28 PFASs were detected at MW-4 (none at MW-2). The SWRCB/RWQCB evaluation of these data is still pending.

5.5 Subsidence §354.16(e)

Vertical displacement of the land surface (subsidence) is comprised of two components: 1) elastic displacement which fluctuates according to various cycles (daily, seasonally, and annually) due to temporary changes in hydrostatic pressure (e.g. atmospheric pressure and changes in groundwater levels) and 2) inelastic displacement or permanent subsidence which can occur from a variety of natural and human-caused phenomena, including groundwater pumping. Lowering of groundwater levels can cause prolonged and/or extreme decrease in hydrostatic pressure of the aquifer. This decrease in pressure can allow the aquifer to compress, primarily within fine-grained beds (clays). Inelastic subsidence cannot be restored after the hydrostatic pressure increases. Other causes of inelastic subsidence include natural geologic processes (e.g. faulting) and the oxidation of organic rich (peat) soils as well as human-caused processes such as mining and grading of land surfaces for agricultural use.

[3] Methyl tert-butyl ether (MTBE) is a fuel additive that was used starting in 1979 and was banned in California after 2002. MTBE is sparingly soluble in water and has a primary MCL of 13 ug/l for human health and a secondary MCL of 5 ug/l for aesthetics.
[4] tert-Butyl alcohol (TBA) is also a fuel additive and is used to produce MTBE. TBA does not have a drinking water MCL in California.
[5] 1,1-dichoroethane, 1,4-dichlorobenzene, cis-1,2-dichloroethylene, benzene, chlorobenzene, MTBE, 2,4,5-trichlorophenoxyacetic acid

Subsidence can be measured by a variety of methods, including:

- Regular measurements of any vertical space between the ground surface and the concrete pad surrounding a well. If space is present and increasing over time, subsidence may be occurring at that location. If a space is not present, subsidence may not be occurring, or the well is not deep enough to show that subsidence is occurring because the well and groundwater are subsiding together.
- Terrestrial (ground-based) surveys of paved roads and benchmarks.
- Global Positioning Survey (GPS) of benchmarks. GPS uses a constellation of satellites to measure the 3-dimensional position of a benchmark. The longer the time that the GPS is left to collect measurements, the higher the precision. Big Valley has one continuously-operating GPS (CGPS) station near Adin.
- Monitoring of specially constructed "extensometer" wells. There are no extensometers in the BVGB.
- Use of Interferometric Synthetic-Aperture Radar (InSAR), which is microwave-based satellite technology that has been used to evaluate ground surface elevation and deformation since the early 1990s. InSAR can document changes in ground elevation between successive passes of the satellite. Between 2015 and 2019, InSAR was used to evaluate subsidence throughout California, including Big Valley.

Subsidence was recognized as an important consideration in the 2007 Groundwater Management Plan (GMP) for Lassen County (Brown and Caldwell 2007) but was not identified as an issue for Big Valley specifically. The analysis in the GMP was based on indirect observations (groundwater levels) and anecdotal information. This section presents additional data that has become available since the development of the GMP.

5.5.1 *Continuous GPS Station P347*

A CGPS station (P347) was installed at the CalTrans yard near Adin in September 2007. The station is part of the Plate Boundary Observatory (PBO) which is measuring 3-dimensional changes in the Earth surface due to the movement of tectonic plates (e.g. Pacific and North American plates).

Figure 5-16 is a plot of the vertical displacement at P347 and shows a slight decline (0.6 inches) over the first 11 years of operation, based on the annual mean values (large black open circles). Daily values (blue dots) show substantial variation, as much as an inch, but more typically only 0.1 inch on average. This scattering of daily values around the annual mean provides an indication of the elastic nature of the displacement. The overall decline of 0.6 inches is an indication of inelastic displacement has occurred over an 11-year period, which equates to a rate of -0.05 inches per year at this location near Adin.

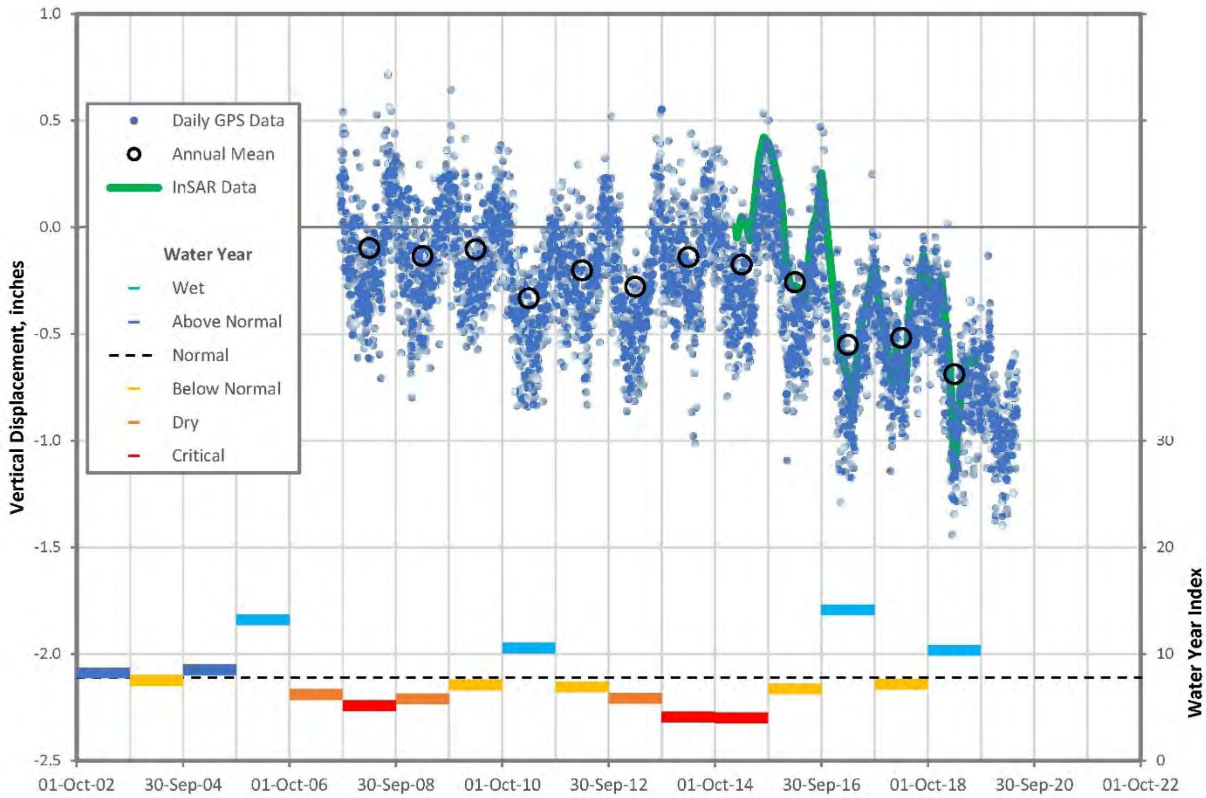

Figure 5-16 Vertical Displacement at CGPS P347

5.5.2 *InSAR Mapping 2015 to 2019*

Figure 5-17 is a map of InSAR data made available by DWR for the 4.3-year period between June 2015 and September 2019. The majority of Big Valley was addressed by this InSAR survey although the survey excludes some areas (shown in white on **Figure 5-17**) including much of the Big Swamp/Ash Creek Wildlife Area, areas along the Pit River near Lookout, and south of Bieber. Most of the survey shows downward displacement (subsidence) between 0 and -1 inches throughout Big Valley. This widespread, small displacement is likely due to natural geologic activities.

Two localized areas of subsidence exceeding -1.5 inches are apparent from this data, one in the east-central portion of the basin north of Highway 299 and one in the southern portion of the Basin between the Pit River and Bull Run Slough. Maximum downward displacement in the Basin is -3.3 inches, or -0.77 inches per year over the 4.3-year period. It is unknown if the subsidence in these areas has been induced by groundwater extraction.

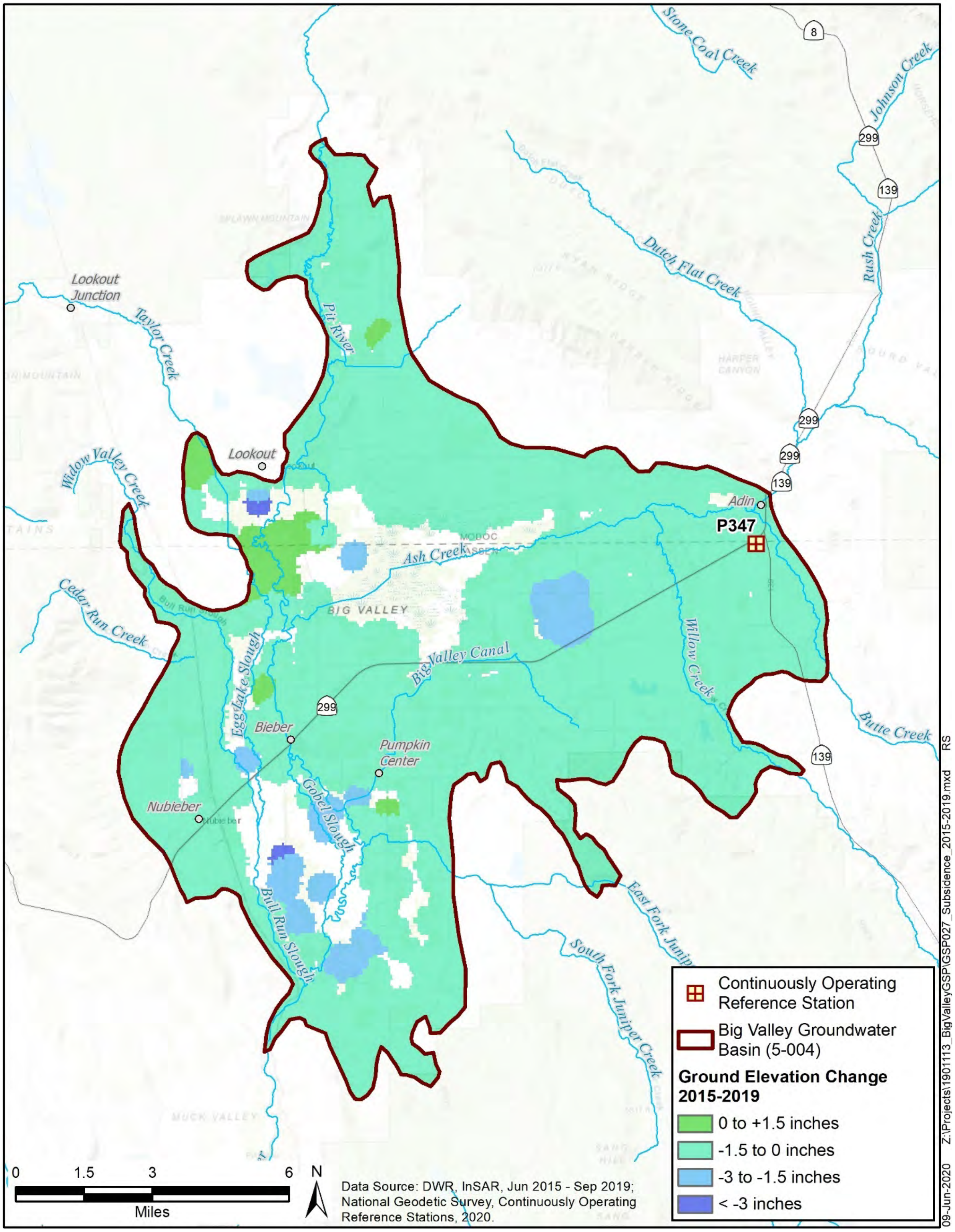

Figure 5-17 InSAR Change in Ground Elevation 2015 to 2019

5.6 Interconnected Surface Water §354.16(f)

Interconnected surface water refers to surface water that is "hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted" (DWR 2016). For the purposes of this GSP, interconnected surface water includes major streams that are known to be perennial[6]. **Figure 5-18** shows all of the major (named) streams from the National Hydrography Dataset (NHD, USGS 2020), excluding several streams that are known to go dry.

Interconnected streams can be gaining (groundwater flowing toward the stream) or losing (groundwater flowing away from the stream). The flow directions from the groundwater contours can indicate whether the stream is gaining or losing, as are shown on **Figure 5-18**. In addition, shallow monitoring well clusters[7] give the direction of shallow groundwater flow as shown by the black arrows on **Figure 5-18**.

- **Reach 1 – Butte Creek:** Butte Creek enters the BVGB on the eastern fringe of the Basin, flowing north to the confluence with Ash Creek in Adin. Groundwater flow indicates that the stream is losing. Throughout its length in the Basin.

- **Reach 2 – Upper Ash Creek:** This reach includes Ash Creek from where it enters the Basin to the confluence with Willow Creek. Based on groundwater contours, groundwater flows toward the creek on the north, but away from the creek on the south side. Shallow groundwater flow indicated by the monitoring well cluster at the Adin Airport is to the south-southwest.

- **Reach 3 – Willow Creek:** Willow Creek enters the BVGB in the southeastern portion of the Basin and flows north into Ash Creek. Groundwater contours indicate that Reach 3 is a losing stream with flow away from the stream both westerly and northeasterly directions. In the lower portions of Reach 3, Willow Creek is fully appropriated and during summer months there is virtually no flow in the channel as most of the flow has been diverted into reservoirs and onto lands adjacent to the river.

- **Reach 4 – Lower Ash Creek:** This reach includes Ash Creek from Willow Creek to the confluence with the Pit River. In this reach surface water velocities slow considerably, and the surface water spreads out to occupy a large freshwater marsh. Groundwater flows away from Reach 4, with contours indicating both northerly and southerly flow away from the marsh.

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[6] With year-round flow, indicating it is not completely depleted.
[7] The clusters are sets of three wells drilled in close proximity to each other for the purpose of determining shallow groundwater flow direction and gradient. At the time of writing this draft chapter, two clusters have enough data to determine flow direction, one cluster near Adin and one near Lookout. Appendix 5C contains data collected at the two clusters and their flow directions.

- **Reach 5 – Hot Springs Slough:** This stream is spring-fed and flows into the marsh in the center of the Basin. Groundwater levels are considerably lower than ground surface in this area, and the upper portions of the slough may be disconnected from groundwater. The slough flows into the marsh area in the center of the basin where it may contribute to groundwater recharge.

- **Reach 6 – Upper Pit River:** Reach 6 includes the Pit River from where it enters the BVGB (at an elevation of about 4160 (msl)) to its confluence with Ash Creek (at an elevation of about 4135 feet msl. The Pit River is generally losing in this portion of the Basin, with groundwater elevations less than 4130 feet msl throughout the reach, as shown in **Figures 5-5** and **5-6**. Just south of lookout, the stream may become gaining based on the well cluster at the Adin Cemetery. This location showed a thick hard-rock basalt layer, which may perch water on top and flow toward the stream. Groundwater beneath basalt may have a different flow direction.

- **Reach 7 – Taylor Creek / Egg Lake Slough:** Taylor Creek enters the BVGB west of Lookout and flows south, parallel to the Pit River and joins Bull Run Slough near the town of Nubieber. This reach may be losing near lookout, but is neither gaining nor losing as it crosses into Lassen County based on groundwater contours.

- **Reach 8 – Widow Valley Creek / Bull Run Slough:** Widow Valley Creek enters the BVGB on the western edge of the Basin and flows southerly into a broad, flat plain joining Egg Lake Slough at Nubieber and the Pit River at the southern edge of the Basin. Groundwater contours are Groundwater contours indicate that the stream is neither gaining, with losing conditions indicated south of Nubieber.

- **Reach 9 – Lower Pit River:** This reach extends from the confluence with Ash Creek to the where the Pit River exits at the southern tip of the Basin and includes Gobel Slough. Similar to Reach 8, conditions are neither gaining nor losing for much of the reach, until the Pit River passes the town of Bieber. South of Bieber groundwater flow is to the east, away from the river.

The descriptions above give a qualitative indication of interactions between surface water and groundwater. Quantitative estimates of flow between the two will be presented in Chapter 6.

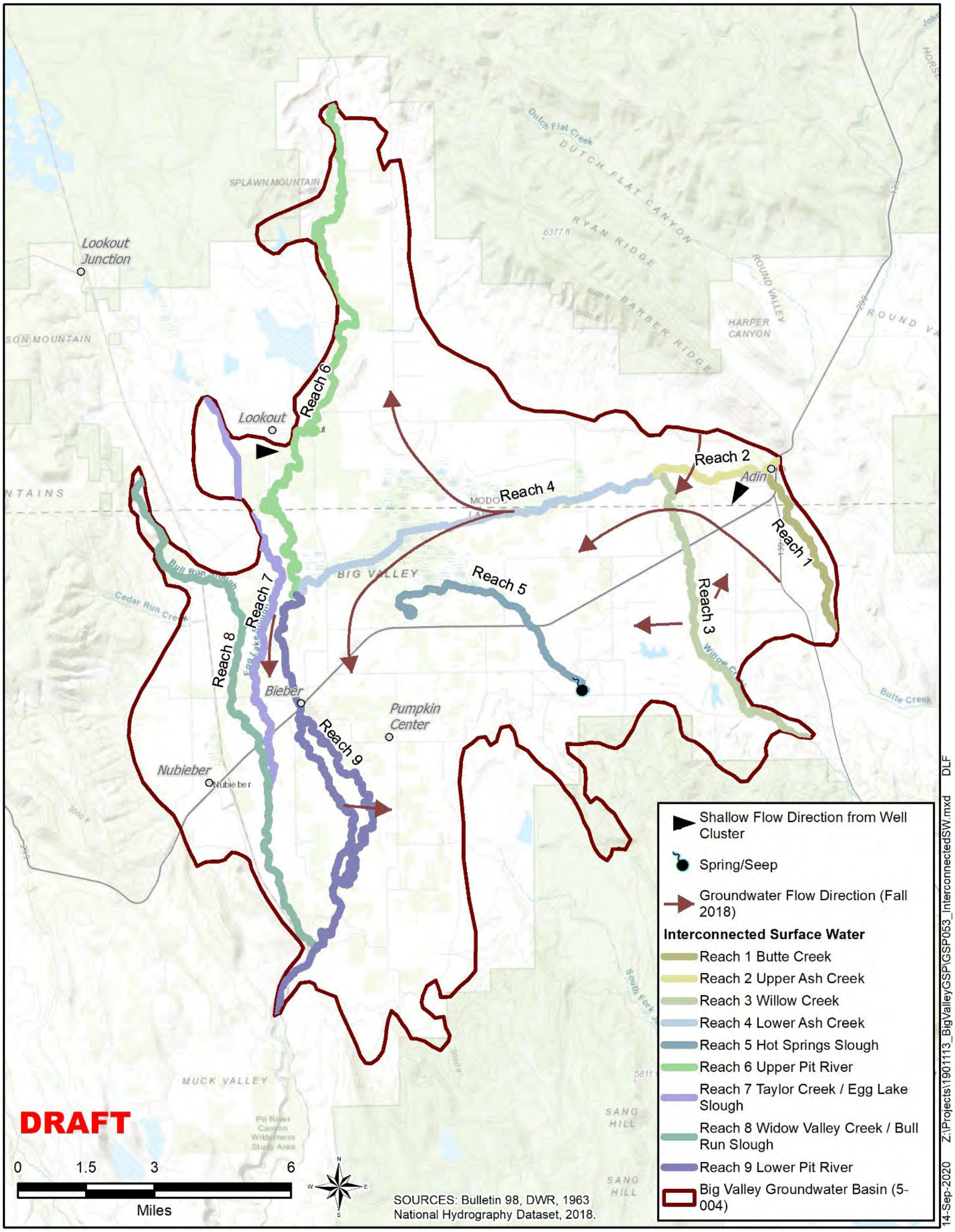

Figure 5-18 Interconnected Surface Water

5.7 Groundwater-Dependent Ecosystems §354.16(g)

SGMA requires GSPs to identify Groundwater Dependent Ecosystems but does not explicitly state the requirements that warrant a GDE designation. SGMA defines a GDE as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface”. (DWR 2016) GDEs are considered a beneficial use of groundwater.

The most comprehensive and readily accessible data to identify GDEs is referred to as the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. The abstract of the dataset documentation reads:

> *The Natural Communities dataset is a compilation of 48 publicly available State and federal agency datasets that map vegetation, wetlands, springs, and seeps in California. A working group comprised of DWR, the California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) reviewed the compiled dataset and conducted a screening process to exclude vegetation and wetland types less likely to be associated with groundwater and retain types commonly associated with groundwater, based on criteria described in Klausmeyer et al., 2018.*
>
> *Two habitat classes are included in the Natural Communities dataset: (1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions; and (2) vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes).*
>
> *The data included in the Natural Communities dataset do not represent DWRs determination of a GDE. However, the Natural Communities dataset can be used by GSAs as a starting point when approaching the task of identifying GDEs within a groundwater basin. (DWR 2018)*

Figures 5-19 and **5-20** show the NCCAG geospatial data, which is separated into two categories: wetlands and vegetation, respectively.

The Wetlands area (12,800 total acres) is subdivided into two primary habitats, palustrine (or freshwater marsh) and riverine, based on setting. Palustrine is dominant at 96% of the total wetland area while riverine is present at 4% and can be seen along river courses. Sixteen springs account for a very small areal component. Most of the springs are in Lassen County (13) although numerous springs are located outside the BVGB boundary.

The Vegetation area (11,500 total acres) is subdivided further into two primary habitats, based on the plant species. Wet Meadows was the largest primary habitat at 59% of the vegetation area but did not include a dominant species. Willow was the second largest habitat at 41% of the vegetation area.

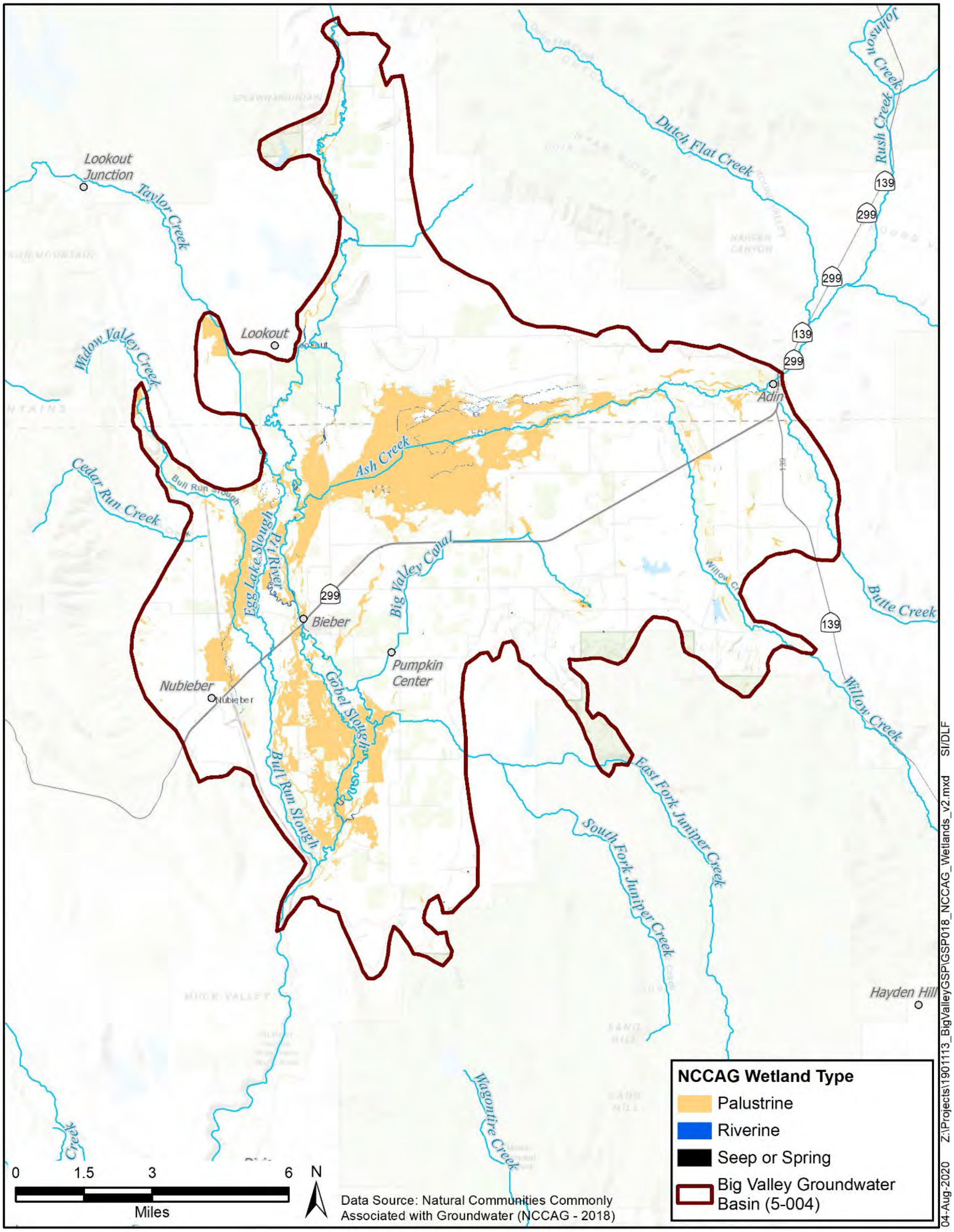

Figure 5-19 NCCAG Wetlands

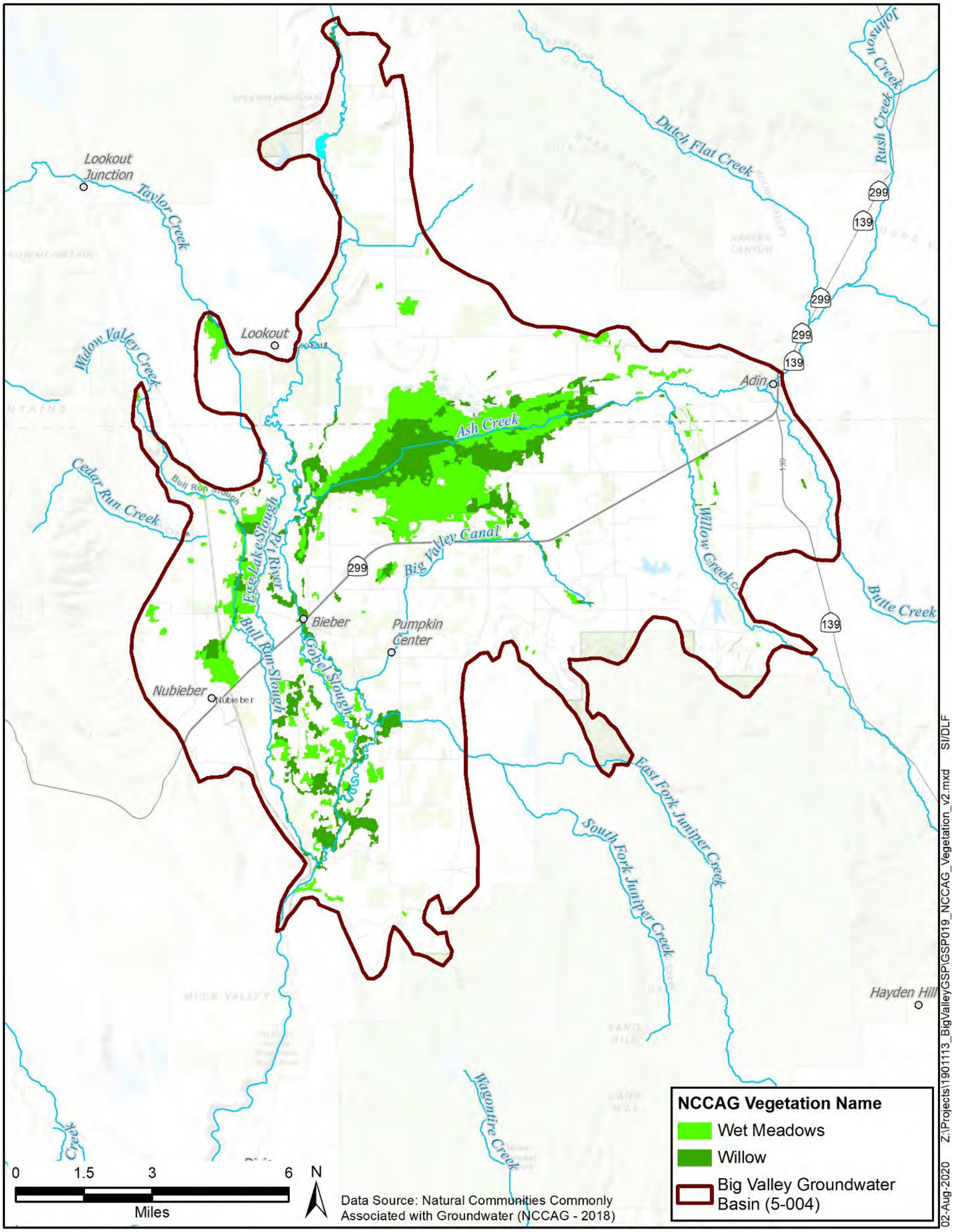

Figure 5-20 NCCAG Vegetation

These two maps identify *potential* GDEs as the NCCAG documentation acknowledges in its abstract. For these areas to be designated as *actual* GDEs, the groundwater level needs to be close enough to the ground surface that it would support the vegetation. **Figure 5-21** shows the depth to water for spring 2015. Spring 2015 is used because that is the SGMA baseline, and SGMA does not require that conditions be returned to a condition pre-2015. Spring is used, as that represents the highest water levels and thus the level that could be accessed by vegetation seasonally.

The depth to water that could potentially be accessed by GDEs depends on the rooting depth of the vegetation. Plant roots can extend up to 30 feet or more (TNC 2020), and 30 has been used by other GSPs as the threshold for GDEs. However, an assessment of native plants present in the Big Valley Groundwater Basin found that maximum rooting depths of species present is 10 feet as shown in **Table 5-5**. However, access to groundwater by plant roots extends above the water table as groundwater seeps upward to fill soil pores. This is known as the capillary fringe and can extend least a few feet or potentially much more depending on the soil type. As a conservative estimate, a capillary fringe of 10 feet is used. Therefore, for the purposes of delineating GDE's, only those areas in the NCCAG datasets that are in areas with groundwater less than 20 feet will be classified as GDEs. **Figure 5-22** shows the GDEs and was generated using the coverages from **Figures 5-19** and **5-20** that have a depth to groundwater less than 20 feet (**Figure 5-21**).

Table 5-5 Big Valley Common Plant Species Rooting Depths

Species	Rooting Depth
Carex spp.	Up to 5 ft
Alfalfa	9 feet
Aspen	10 feet and less
Willow	2-10 feet
Elderberry	10 feet and less
Saltgrass	2 feet

Sources: CNPS 2020, TNC 2020, Snell 2020

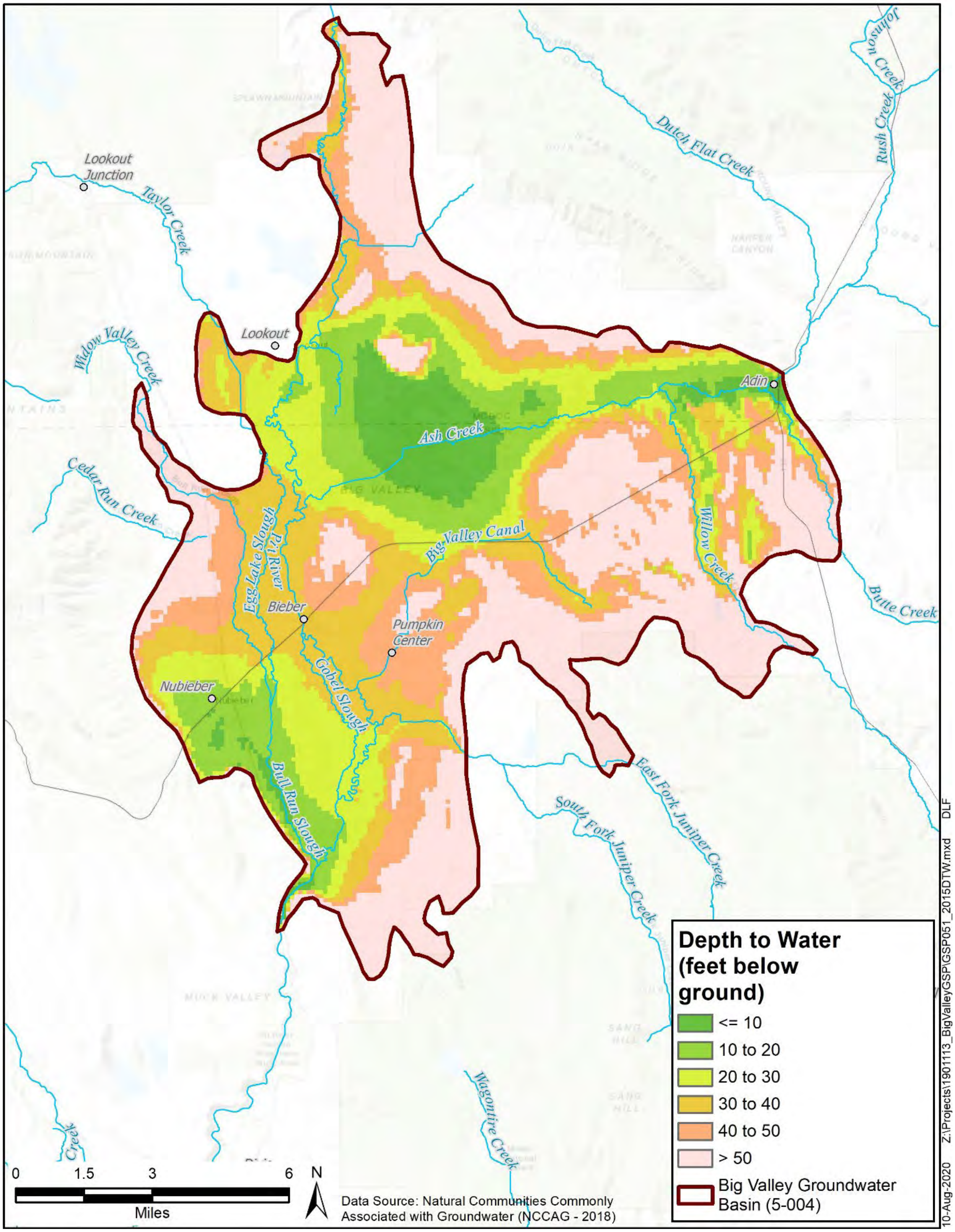

Figure 5-21 Depth to Groundwater Spring 2015

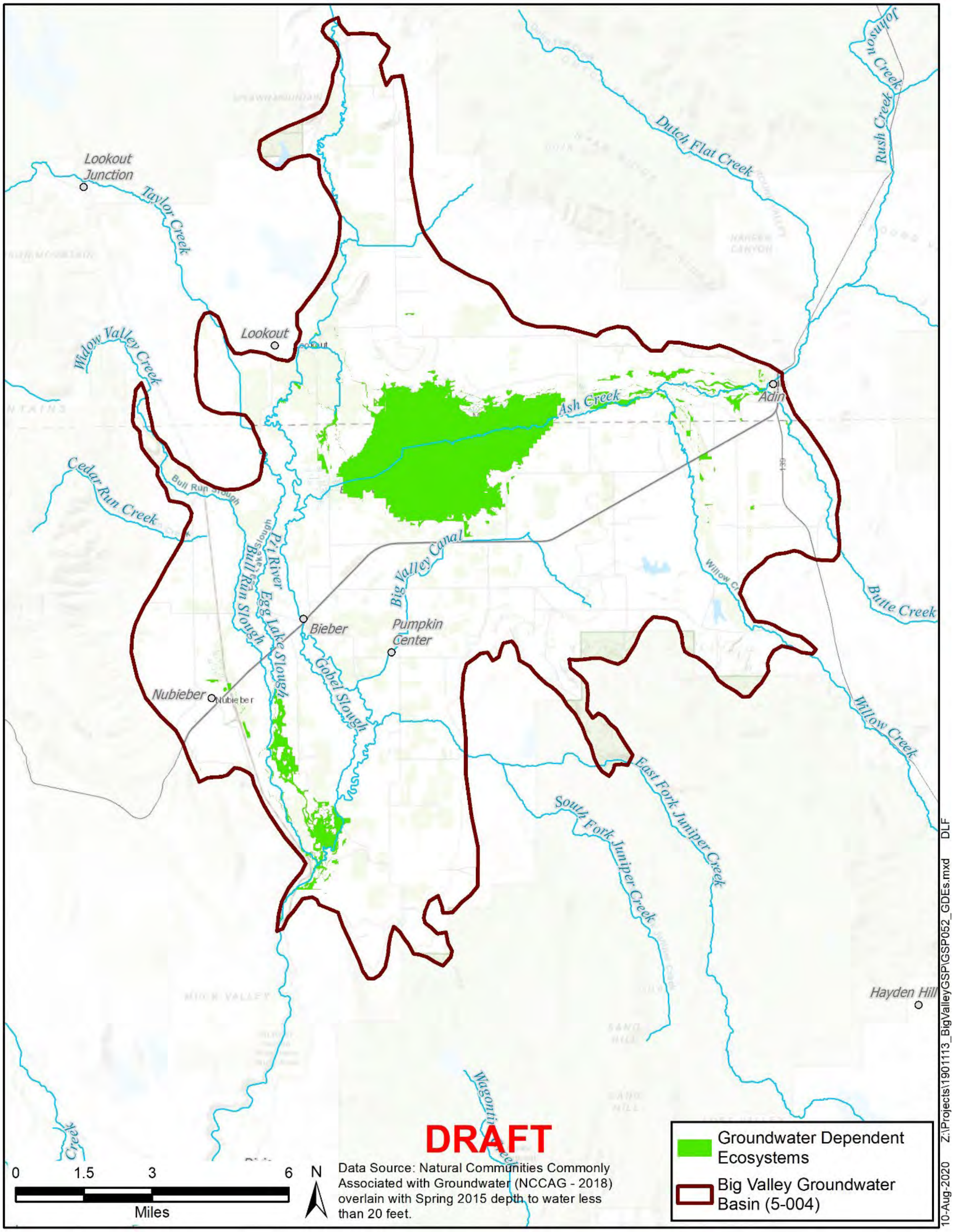

Figure 5-22 Groundwater Dependent Ecosystems

5.8 References

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Appendix 5A

Water Level Hydrographs

Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087190-38N07E32A002M
Alternate Name	38N07E32A002M
State Number	38N07E32A002M
CASGEM ID	410950N1211839W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Other
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.0950
	Long:	-121.1839
Well Delth		49.00 ft
Ground Surface Elevation		4118.80 ft
Ref. Point Elevation		4119.50 ft

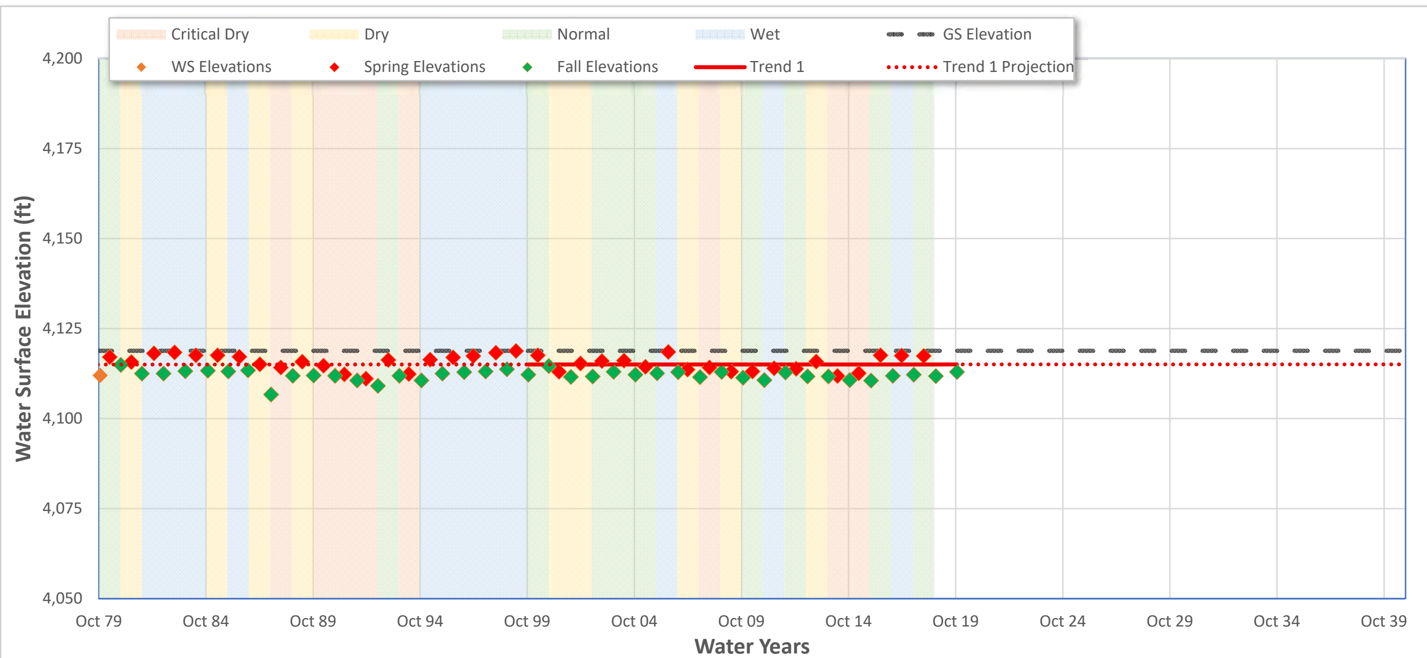
Well Period of Record

Period-of-Record		1959..2020
WS Elev-Range	Min:	4106.7 ft
	Max	4118.8 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	0.001 ft/yr
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087188-38N07E23E001M
Alternate Name	38N07E23E001M
State Number	38N07E23E001M
CASGEM ID	411207N1211395W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1207
	Long:	-121.1395
Well Delth		84.00 ft
Ground Surface Elevation		4123.40 ft
Ref. Point Elevation		4123.40 ft

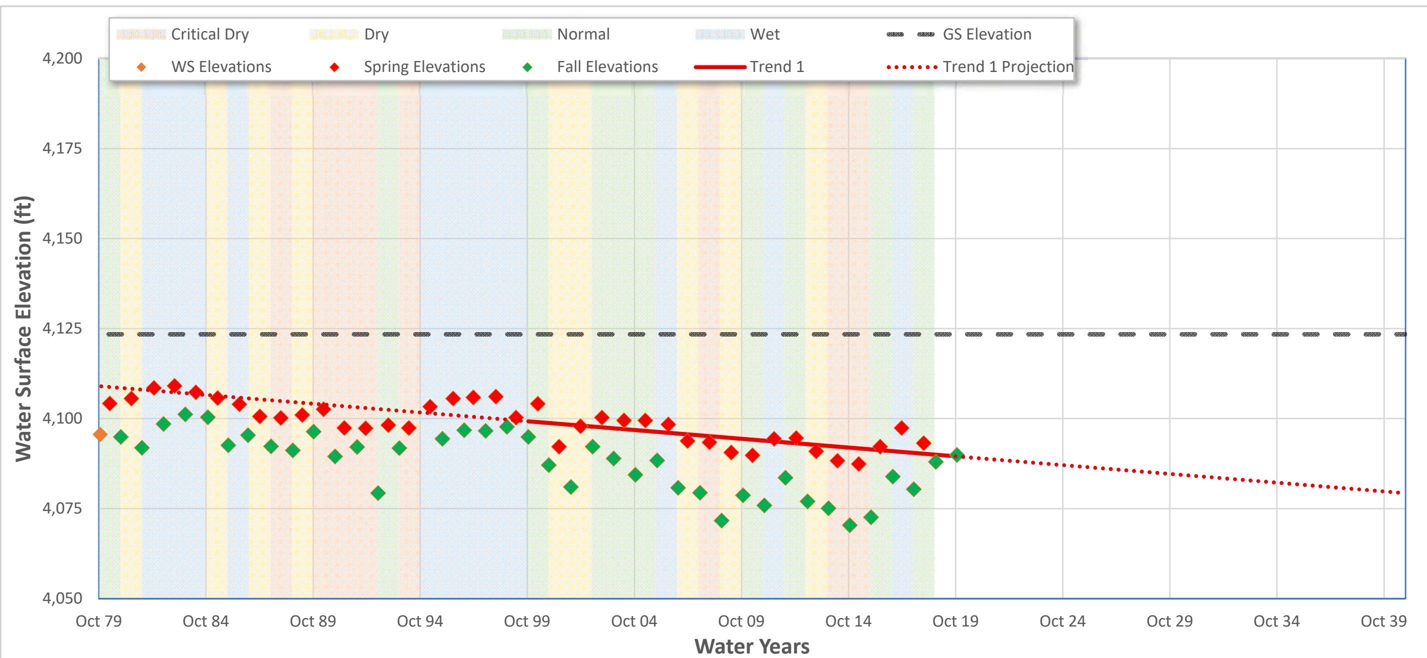
Well Period of Record

Period-of-Record		1979..2020
WS Elev-Range	Min:	4070.4 ft
	Max	4109.1 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.487 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	086510-38N07E20B006M
Alternate Name	38N07E20B006M
State Number	38N07E20B006M
CASGEM ID	411242N1211866W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1242
	Long:	-121.1866
Well Delth		183.00 ft
Ground Surface Elevation		4126.30 ft
Ref. Point Elevation		4127.30 ft

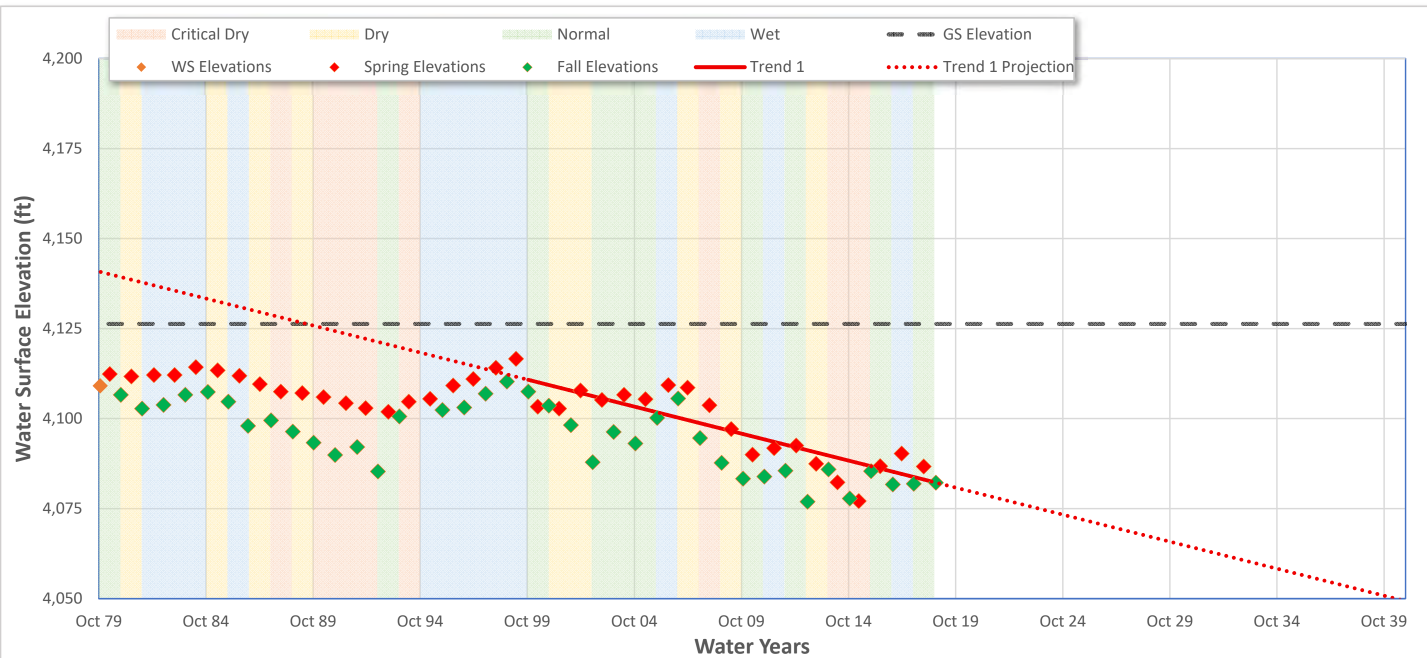
Well Period of Record

Period-of-Record		1979..2019
WS Elev-Range	Min:	4076.9 ft
	Max	4116.6 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.501 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087331-37N07E13K002M
Alternate Name	37N07E13K002M
State Number	37N07E13K002M
CASGEM ID	410413N1211147W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.0413
	Long:	-121.1147
Well Delth		260.00 ft
Ground Surface Elevation		4127.40 ft
Ref. Point Elevation		4127.90 ft

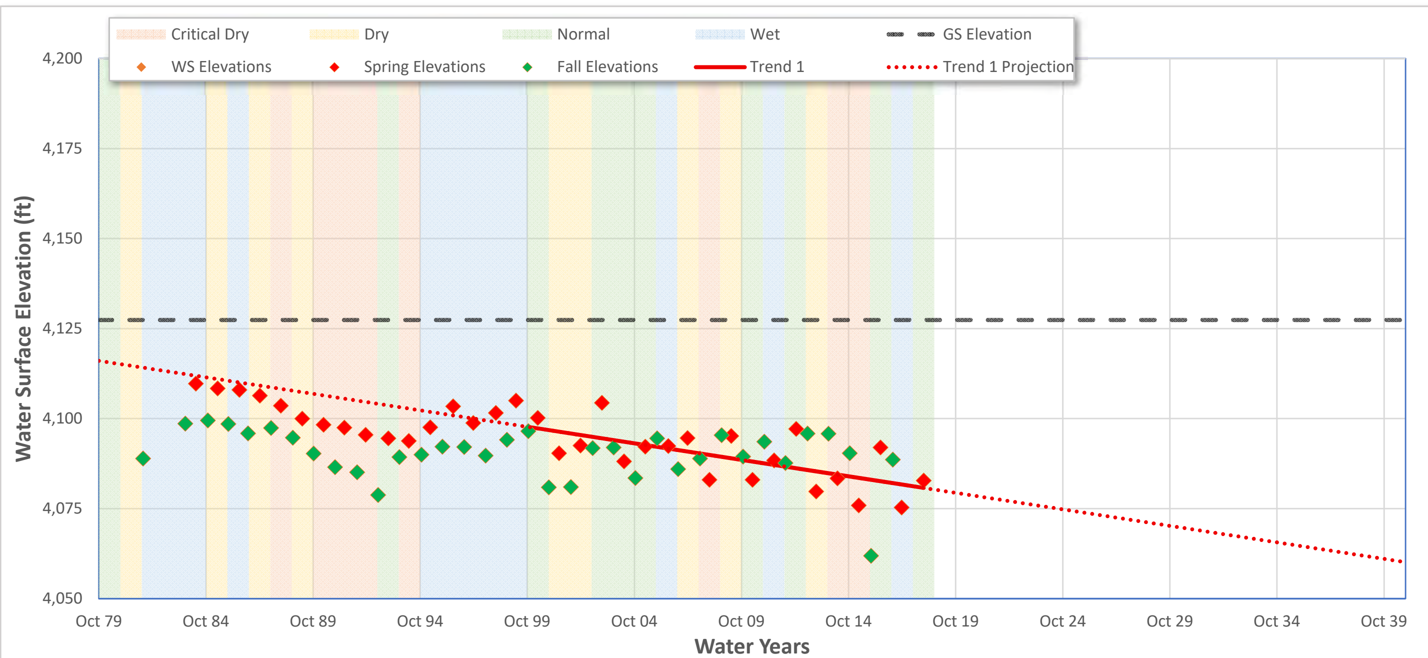
Well Period of Record

Period-of-Record		1982..2018
WS Elev-Range	Min:	4061.9 ft
	Max	4109.7 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.917 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087332-37N08E06C001M
Alternate Name	37N08E06C001M
State Number	37N08E06C001M
CASGEM ID	410777N1210986W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.0777
	Long:	-121.0986
Well Delth		400.00 ft
Ground Surface Elevation		4133.40 ft
Ref. Point Elevation		4133.90 ft

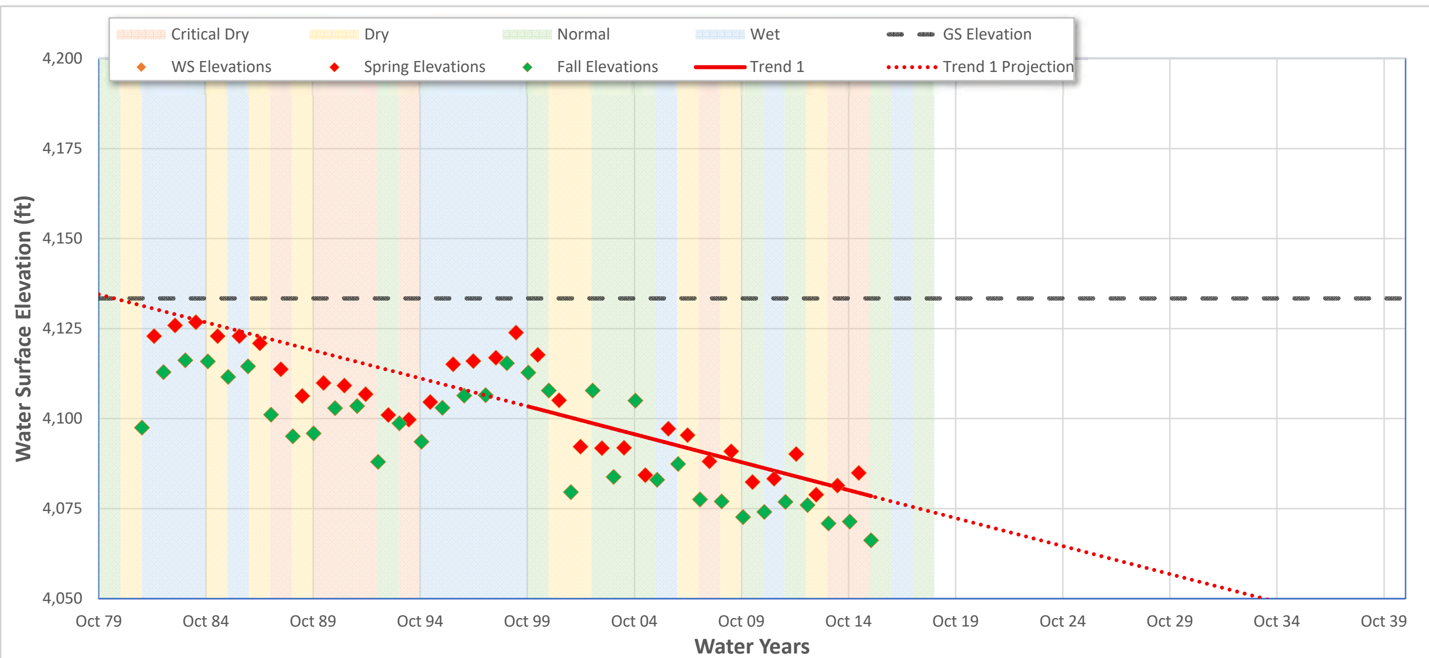
Well Period of Record

Period-of-Record		1982..2016
WS Elev-Range	Min:	4066.2 ft
	Max	4126.8 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.553 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087199-39N07E26E001M
Alternate Name	39N07E26E001M
State Number	39N07E26E001M
CASGEM ID	411911N1211354W001

Well Location

County	Modoc
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1911
	Long:	-121.1354
Well Delth		400.00 ft
Ground Surface Elevation		4133.40 ft
Ref. Point Elevation		4135.00 ft

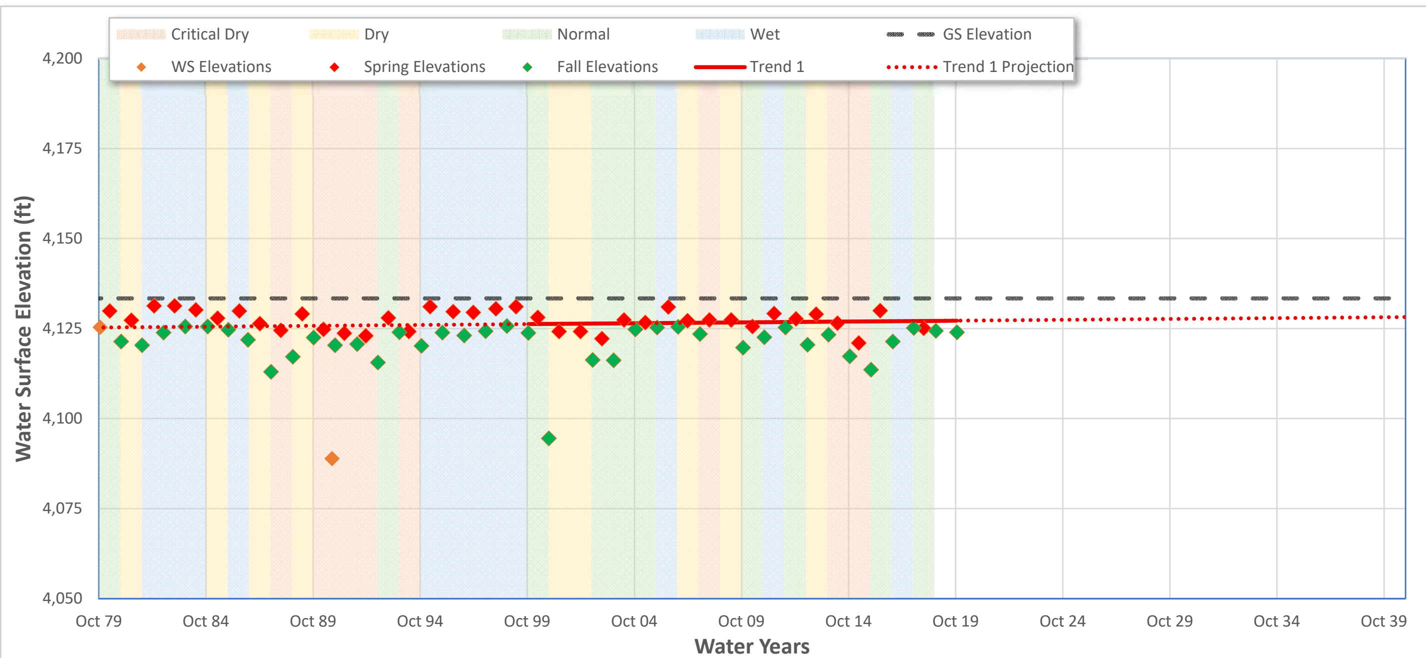
Well Period of Record

Period-of-Record		1979..2020
WS Elev-Range	Min:	4088.9 ft
	Max	4131.3 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	0.048 ft/yr
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087189-38N07E24J002M
Alternate Name	38N07E24J002M
State Number	38N07E24J002M
CASGEM ID	411228N1211054W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1226
	Long:	-121.1054
Well Delth		192.00 ft
Ground Surface Elevation		4138.40 ft
Ref. Point Elevation		4139.40 ft

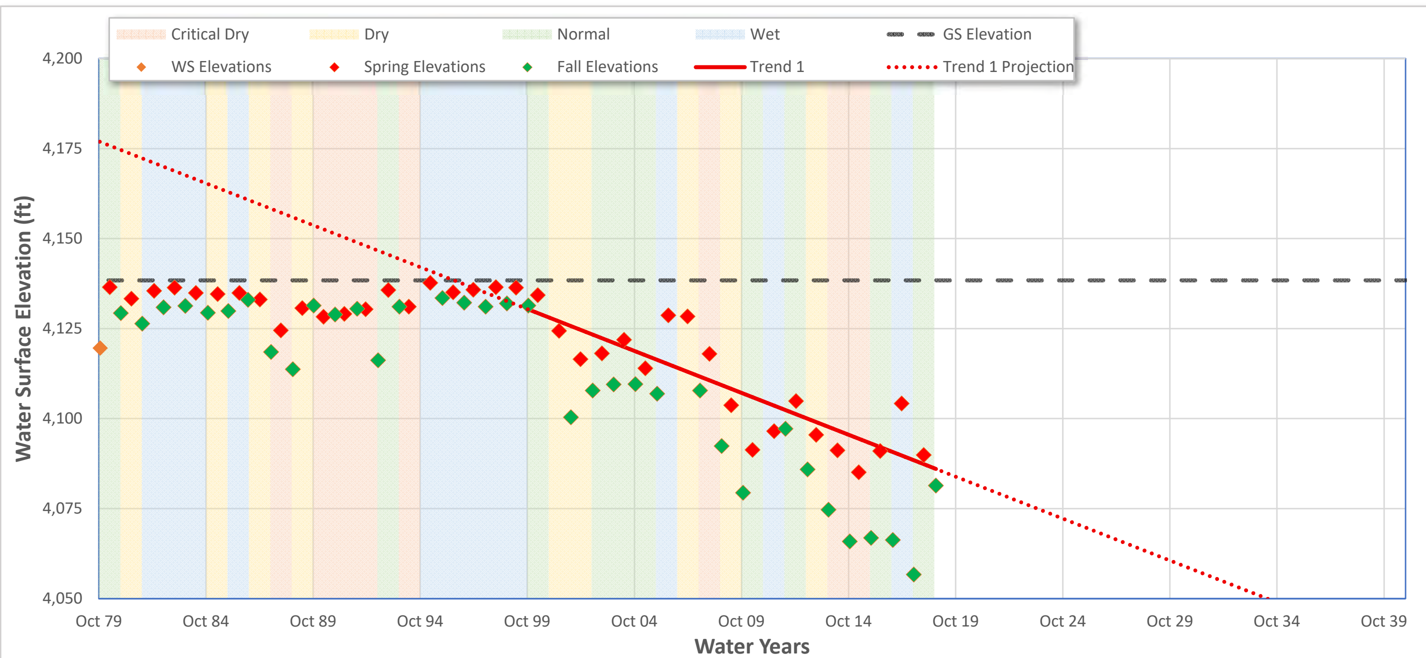
Well Period of Record

Period-of-Record		1979..2019
WS Elev-Range	Min:	4056.7 ft
	Max	4137.7 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(2.328 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

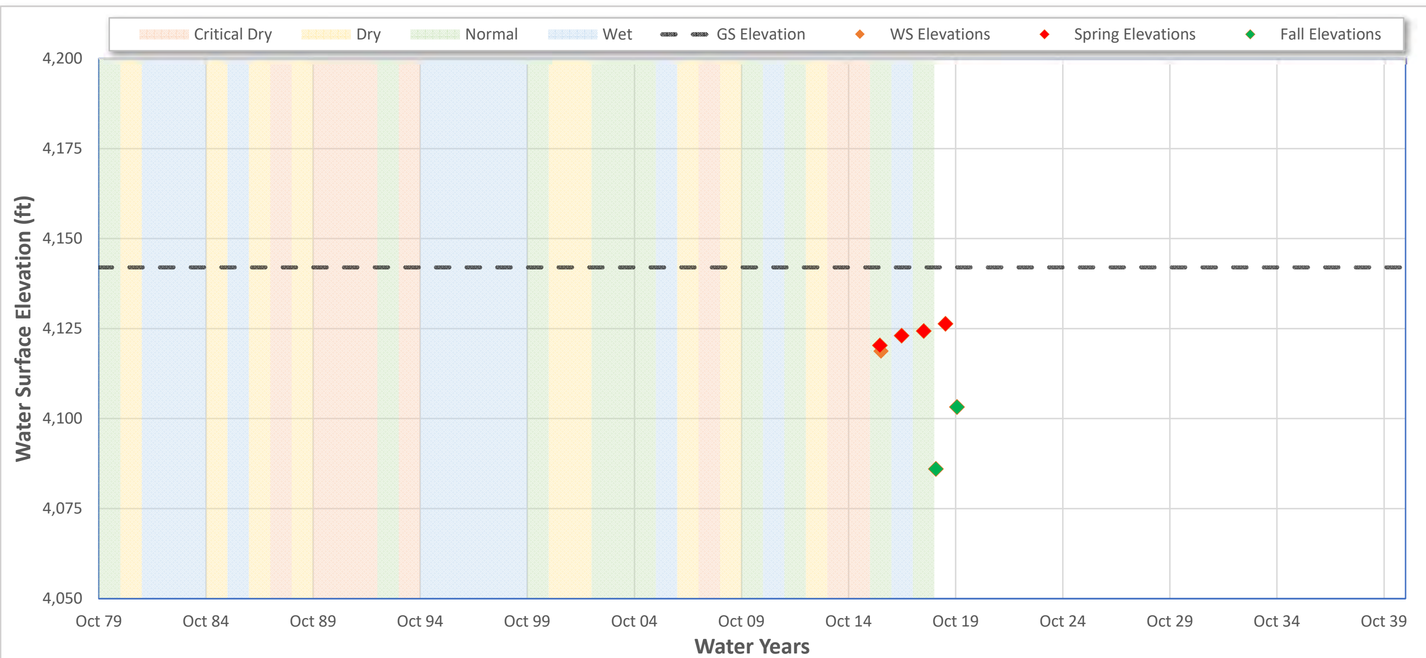
Date: 2/19/2020

Well Information	
Well ID	087403-ACWA-1
Alternate Name	ACWA-1
State Number	38N08E07A001M
CASGEM ID	411508N1210900W001
Well Location	
County	Lassen
Basin	BIG VALLEY
Sub-Basin	-
Well Type Information	
Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.1508
	Long:	-121.0900
Well Delth		780.00 ft
Ground Surface Elevation		4142.00 ft
Ref. Point Elevation		4142.75 ft
Well Period of Record		
Period-of-Record		2016..2020
WS Elev-Range	Min:	4039.2 ft
	Max	4126.4 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	1.889 ft/yr
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	086615-38N07E12G001M
Alternate Name	38N07E12G001M
State Number	38N07E12G001M
CASGEM ID	411467N1211110W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1467
	Long:	-121.1110
Well Delth		116.00 ft
Ground Surface Elevation		4143.38 ft
Ref. Point Elevation		4144.38 ft

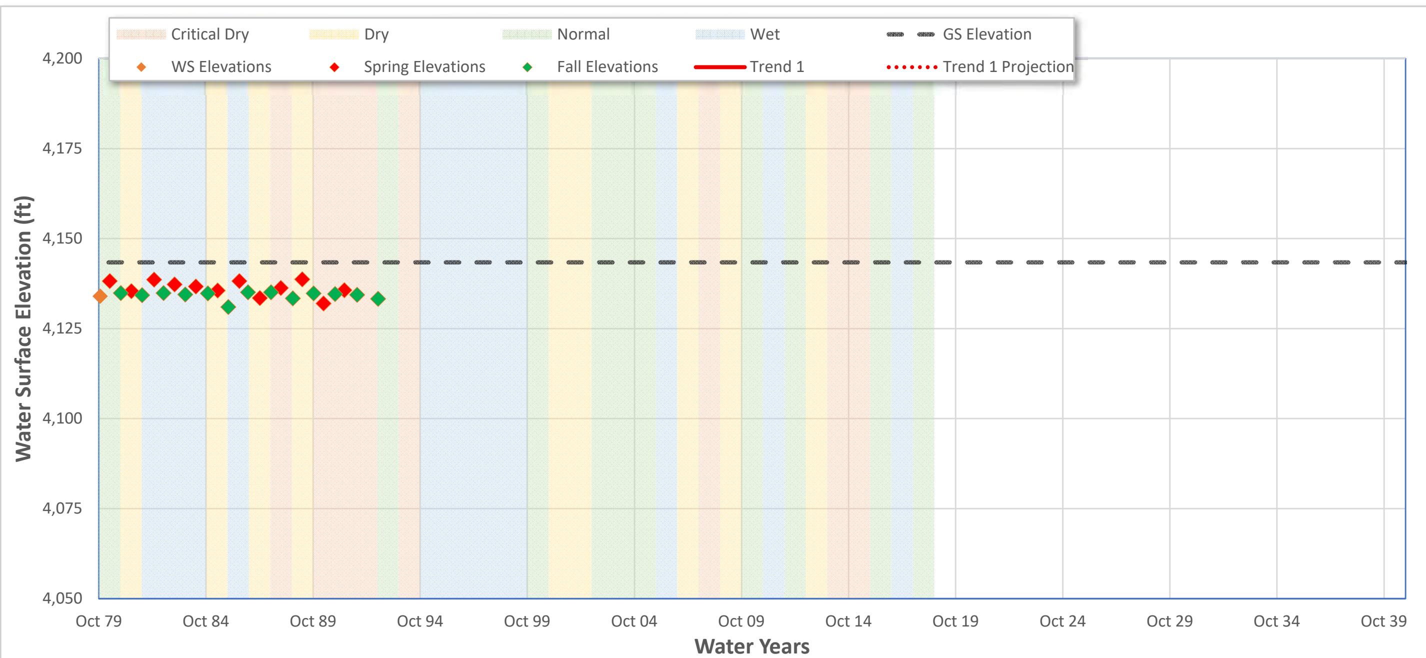
Well Period of Record

Period-of-Record		1979..1993
WS Elev-Range	Min:	4131.0 ft
	Max	4138.7 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	-
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	086206-ACWA-2
Alternate Name	ACWA-2
State Number	39N08E33P002M
CASGEM ID	411699N1210579W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1699
	Long:	-121.0579
Well Delth		800.00 ft
Ground Surface Elevation		4153.00 ft
Ref. Point Elevation		4153.20 ft

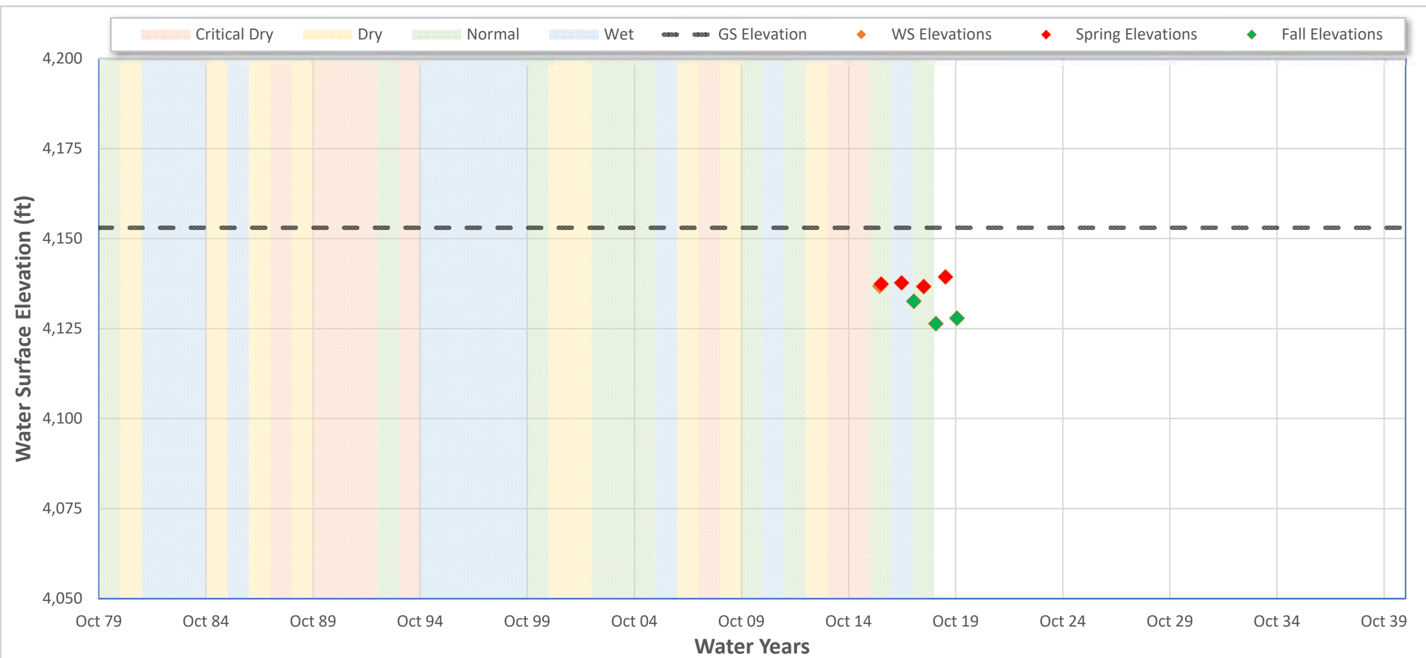
Well Period of Record

Period-of-Record		2016..2020
WS Elev-Range	Min:	4126.4 ft
	Max	4139.4 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	0.484 ft/yr
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

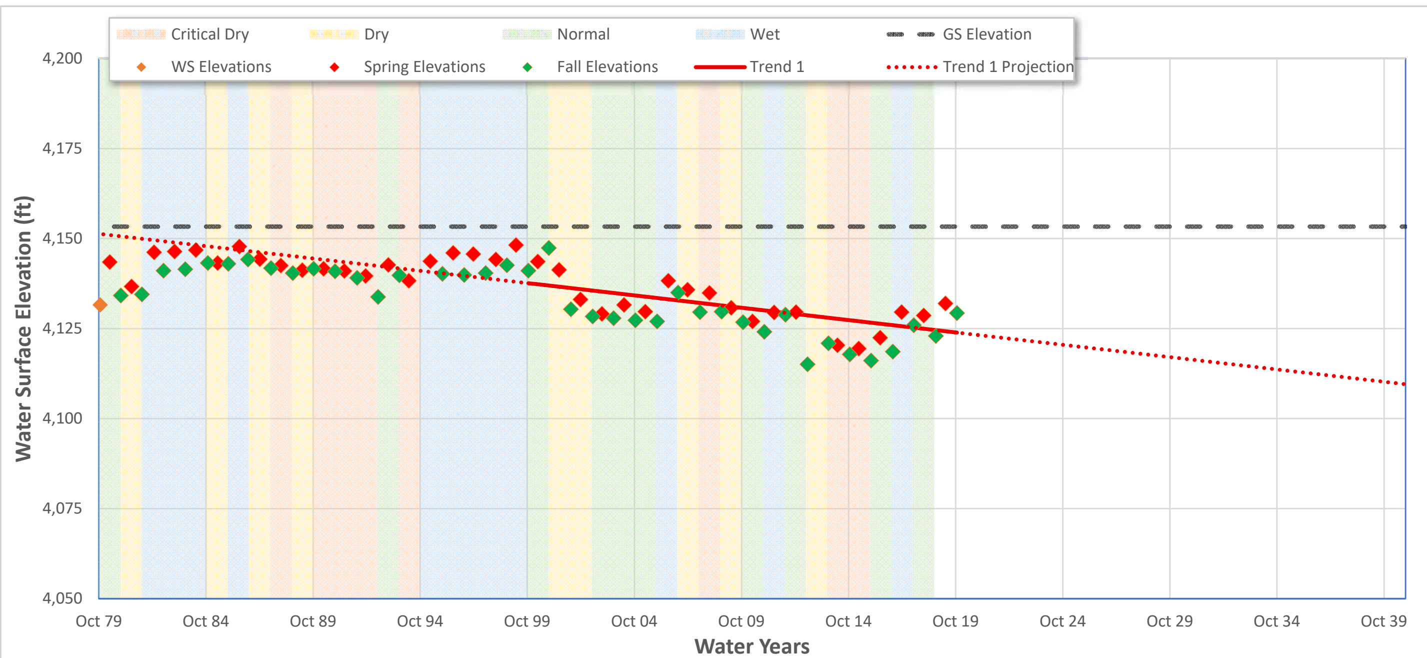
Date: 2/19/2020

Well Information	
Well ID	087193-38N08E17K001M
Alternate Name	38N08E17K001M
State Number	38N08E17K001M
CASGEM ID	411320N1210766W001
Well Location	
County	Lassen
Basin	BIG VALLEY
Sub-Basin	-
Well Type Information	
Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.1320
	Long:	-121.0766
Well Delth		180.00 ft
Ground Surface Elevation		4153.30 ft
Ref. Point Elevation		4154.30 ft
Well Period of Record		
Period-of-Record		1957..2020
WS Elev-Range	Min:	4115.1 ft
	Max	4150.0 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.685 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

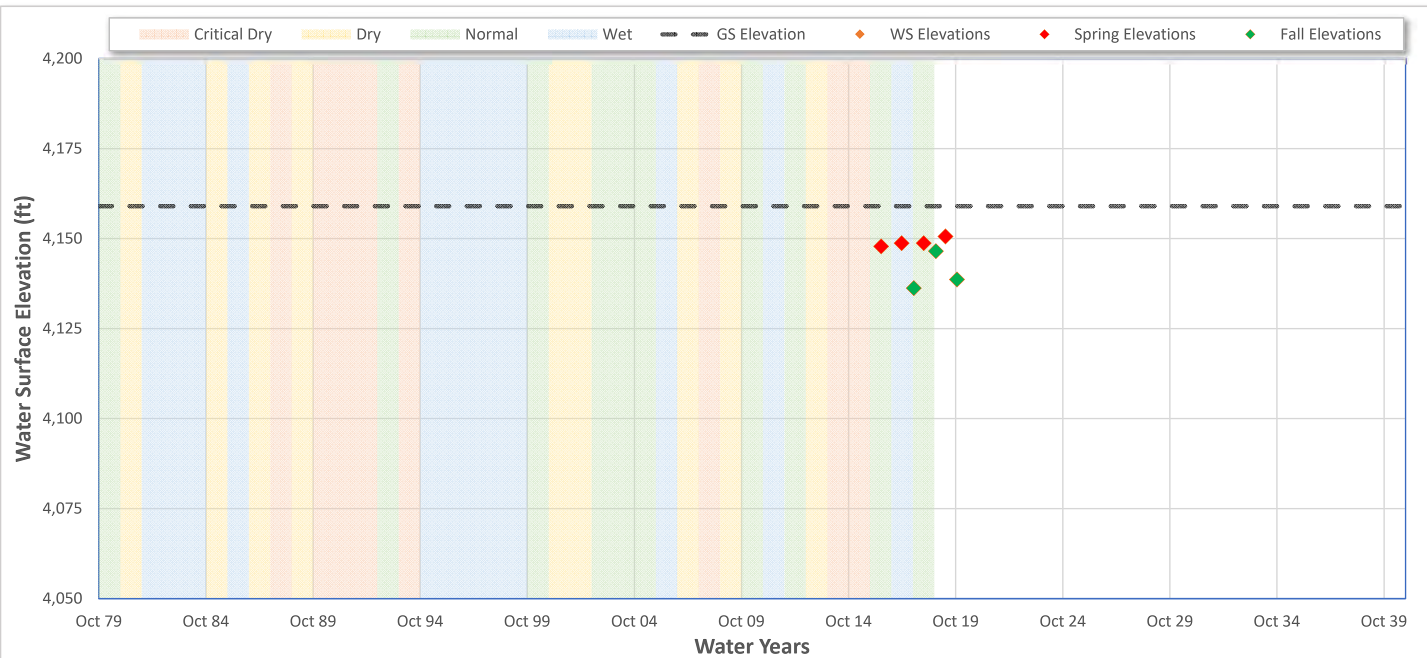
Date: 2/19/2020

Well Information	
Well ID	087526-ACWA-3
Alternate Name	ACWA-3
State Number	39N08E28A001M
CASGEM ID	411938N1210478W001
Well Location	
County	Modoc
Basin	BIG VALLEY
Sub-Basin	-
Well Type Information	
Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.1938
	Long:	-121.0478
Well Delth		720.00 ft
Ground Surface Elevation		4159.00 ft
Ref. Point Elevation		4159.83 ft
Well Period of Record		
Period-of-Record		2016..2020
WS Elev-Range	Min:	4136.2 ft
	Max	4150.6 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	0.821 ft/yr
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087201-39N08E21C001M
Alternate Name	39N08E21C001M
State Number	39N08E21C001M
CASGEM ID	412086N1210574W001

Well Location

County	Modoc
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.2084
	Long:	-121.0576
Well Delth		300.00 ft
Ground Surface Elevation		4161.40 ft
Ref. Point Elevation		4161.70 ft

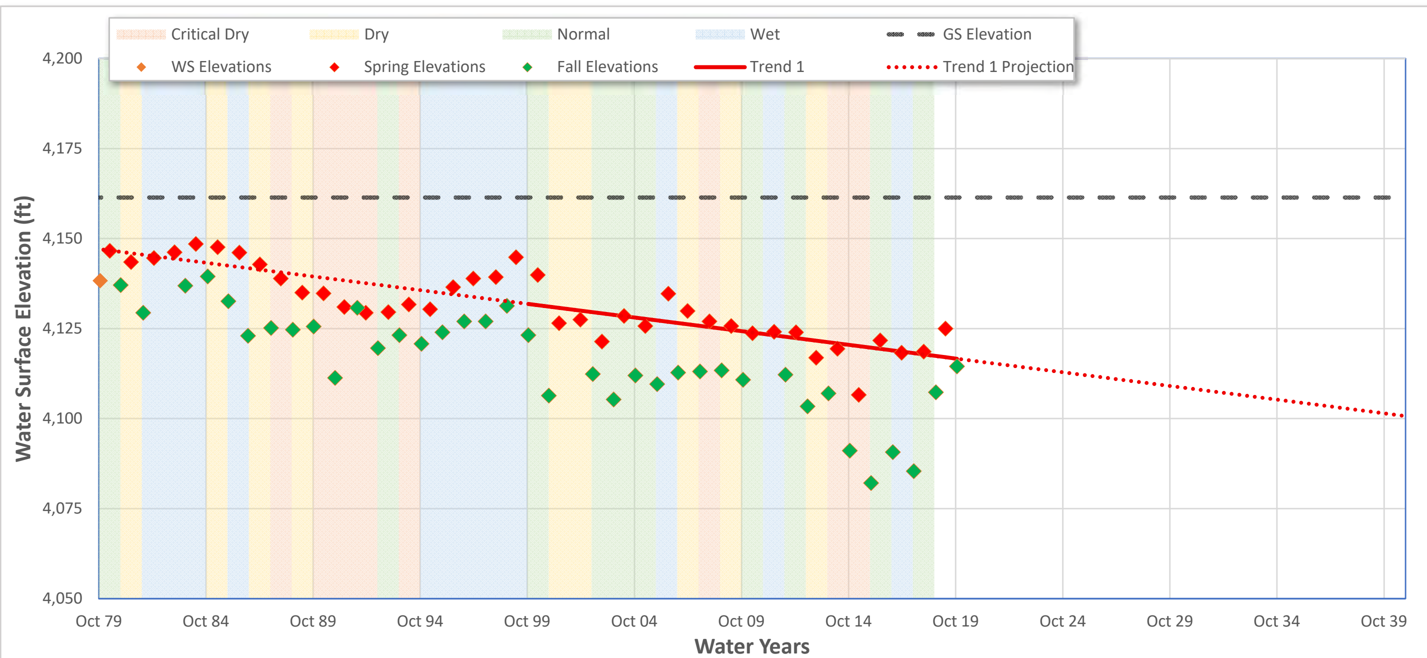
Well Period of Record

Period-of-Record		1979..2020
WS Elev-Range	Min:	4082.1 ft
	Max	4148.5 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.760 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087191-38N08E03D001M
Alternate Name	38N08E03D001M
State Number	38N08E03D001M
CASGEM ID	411647N1210358W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1646
	Long:	-121.0360
Well Delth		280.00 ft
Ground Surface Elevation		4163.40 ft
Ref. Point Elevation		4163.40 ft

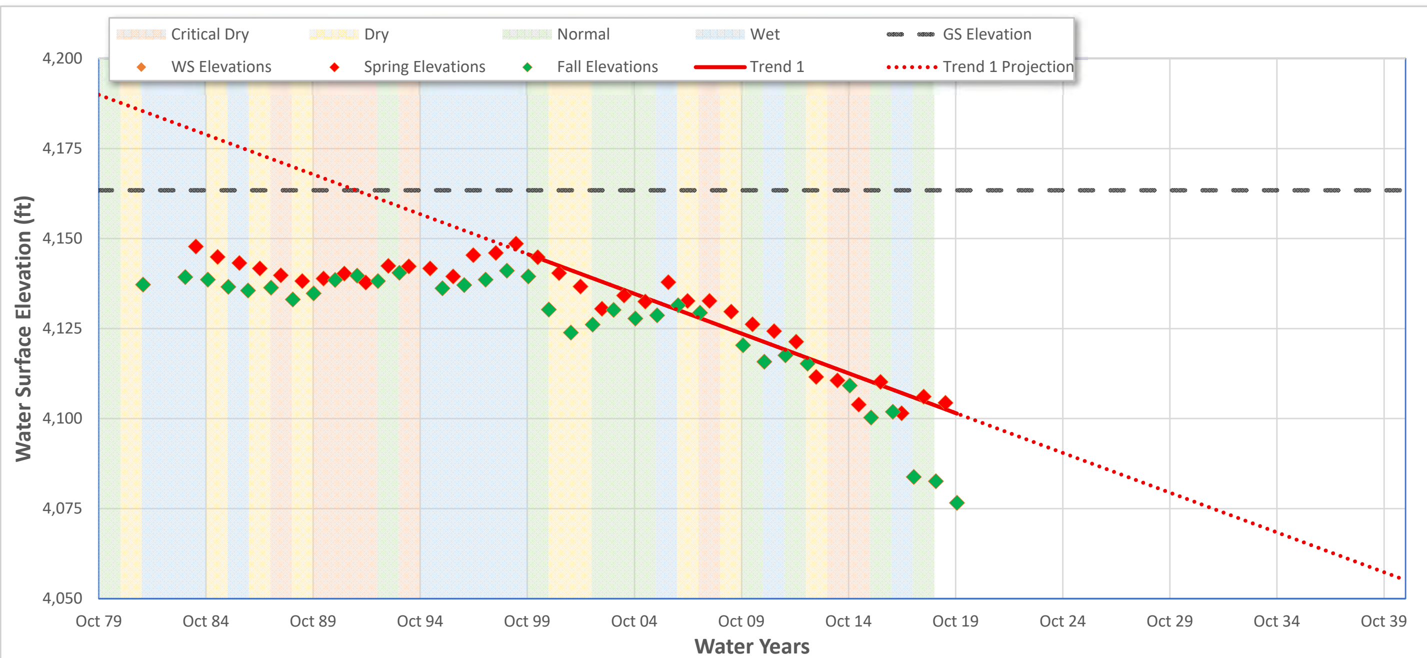
Well Period of Record

Period-of-Record		1982..2020
WS Elev-Range	Min:	4076.6 ft
	Max	4148.6 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(2.210 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information	
Well ID	087200-39N08E18N002M
Alternate Name	39N08E18N002M
State Number	39N08E18N002M
CASGEM ID	412144N1211013W001

Well Location	
County	Modoc
Basin	BIG VALLEY
Sub-Basin	-

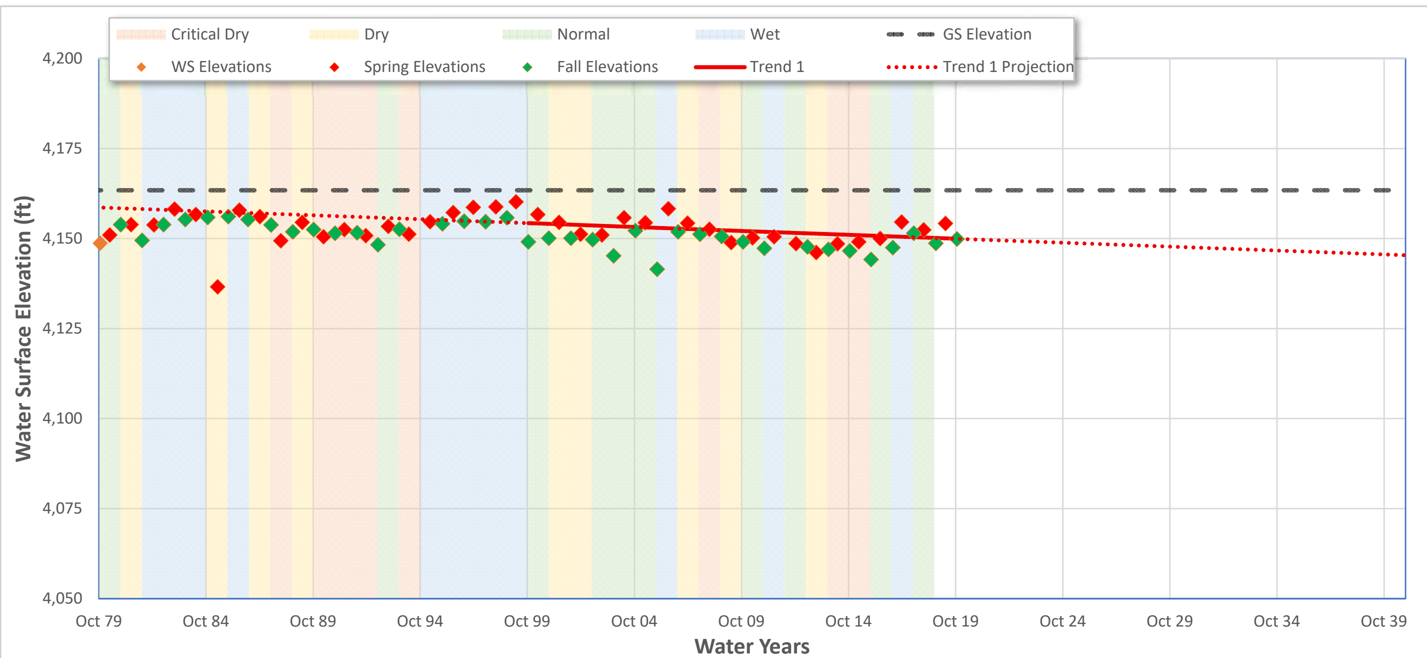
Well Type Information	
Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.2144
	Long:	-121.1013
Well Delth		250.00 ft
Ground Surface Elevation		4163.40 ft
Ref. Point Elevation		4164.40 ft

Well Period of Record		
Period-of-Record		1979..2020
WS Elev-Range	Min:	4136.6 ft
	Max	4160.2 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.217 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087192-38N08E16D001M
Alternate Name	38N08E16D001M
State Number	38N08E16D001M
CASGEM ID	411359N1210625W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1358
	Long:	-121.0625
Well Delth		491.00 ft
Ground Surface Elevation		4171.40 ft
Ref. Point Elevation		4171.60 ft

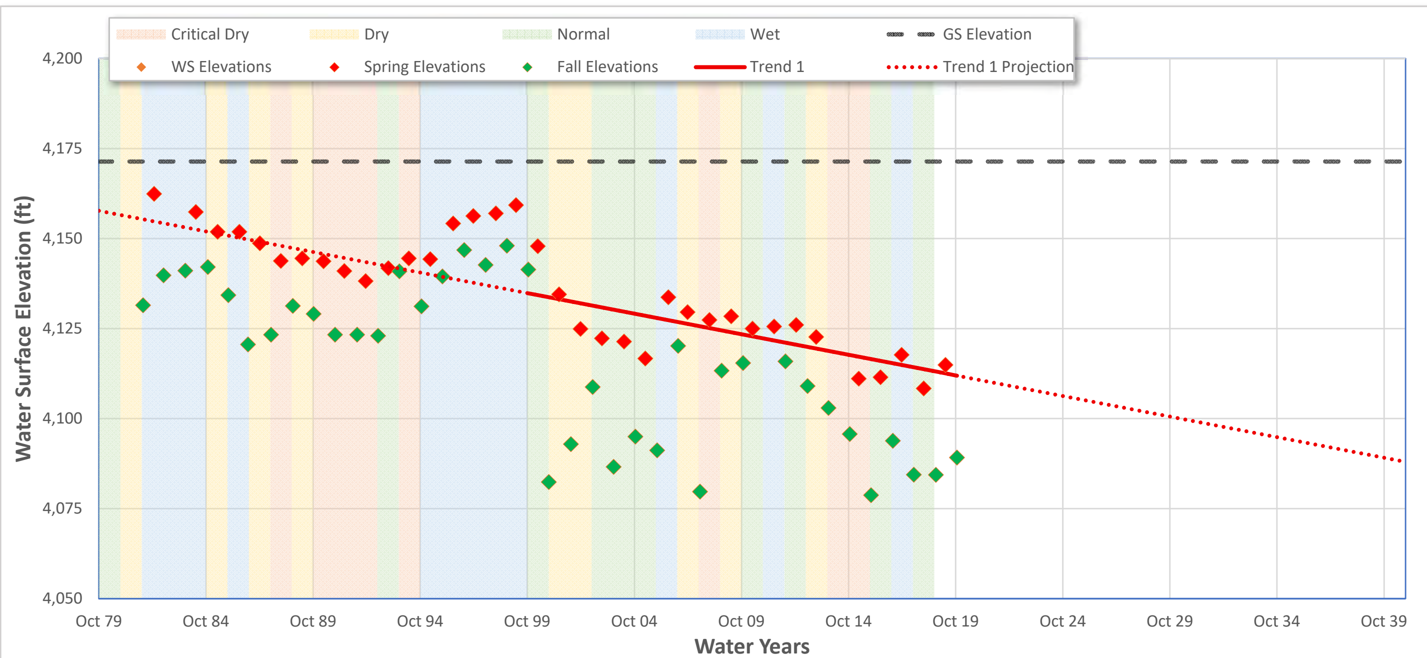
Well Period of Record

Period-of-Record		1982..2020
WS Elev-Range	Min:	4078.7 ft
	Max	4162.4 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.143 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

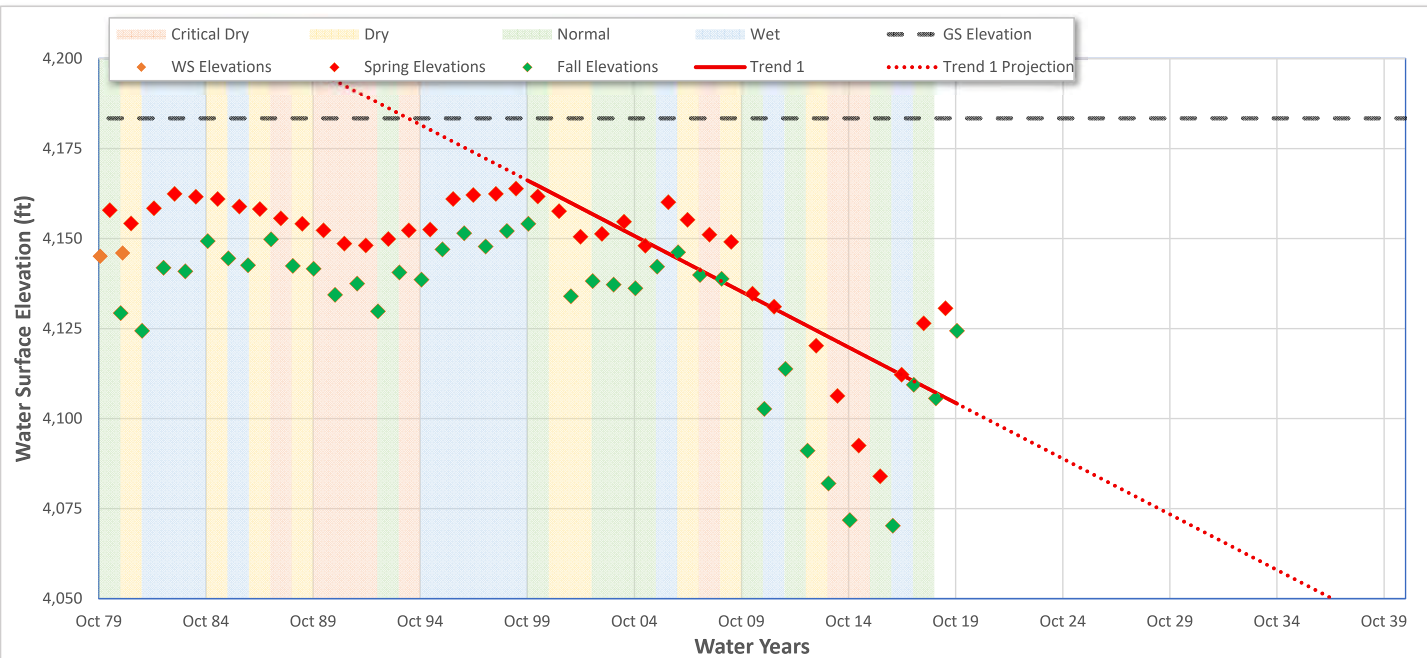
Date: 2/19/2020

Well Information	
Well ID	087197-39N07E01A001M
Alternate Name	39N07E01A001M
State Number	39N07E01A001M
CASGEM ID	412539N1211050W001
Well Location	
County	Modoc
Basin	BIG VALLEY
Sub-Basin	-
Well Type Information	
Well Type	-
Well Use	Stockwatering
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.2539
	Long:	-121.1050
Well Delth		300.00 ft
Ground Surface Elevation		4183.40 ft
Ref. Point Elevation		4184.40 ft
Well Period of Record		
Period-of-Record		1979..2020
WS Elev-Range	Min:	4035.4 ft
	Max	4163.9 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(3.092 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087204-39N09E28F001M
Alternate Name	39N09E28F001M
State Number	39N09E28F001M
CASGEM ID	411907N1209447W001

Well Location

County	Modoc
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Residential
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1907
	Long:	-120.9447
Well Delth		73.00 ft
Ground Surface Elevation		4206.60 ft
Ref. Point Elevation		4207.10 ft

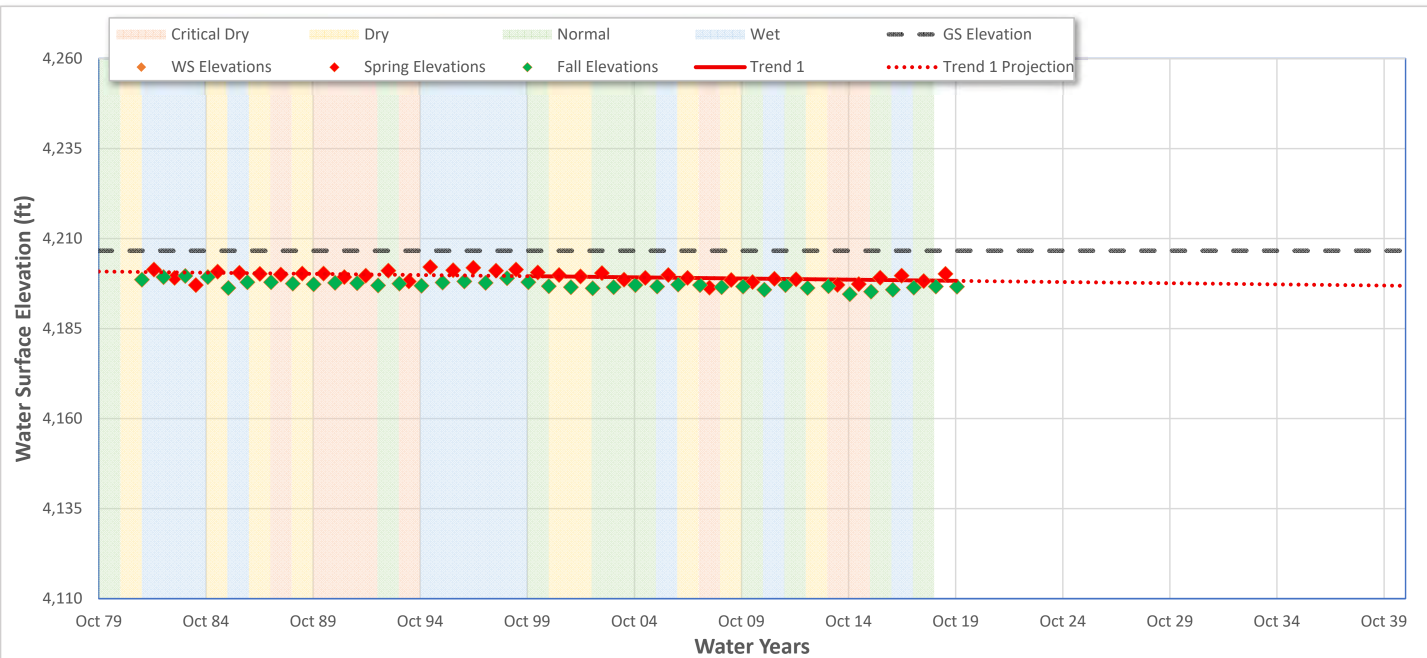
Well Period of Record

Period-of-Record		1982..2020
WS Elev-Range	Min:	4194.6 ft
	Max	4202.1 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.065 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

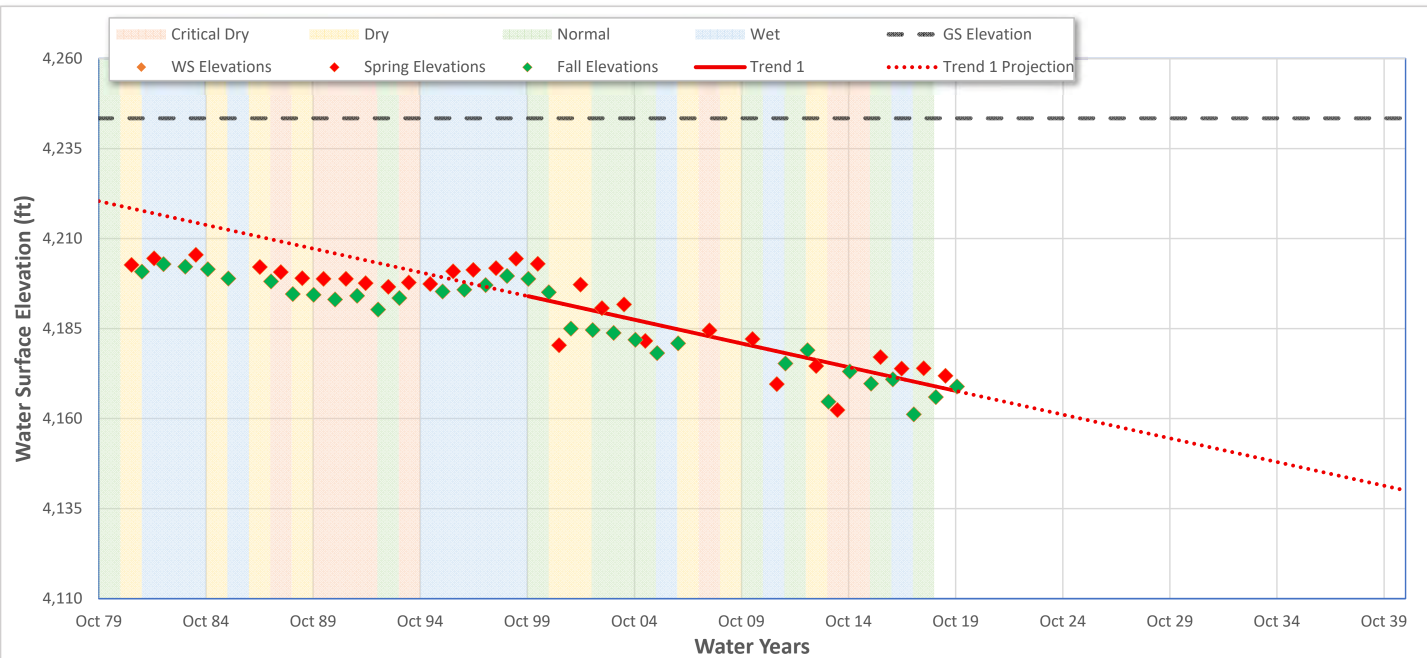
Date: 2/19/2020

Well Information	
Well ID	087205-39N09E32R001M
Alternate Name	39N09E32R001M
State Number	39N09E32R001M
CASGEM ID	411649N1209569W001
Well Location	
County	Lassen
Basin	BIG VALLEY
Sub-Basin	-
Well Type Information	
Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry		
Location	Lat:	41.1680
	Long:	-120.9570
Well Delth		-
Ground Surface Elevation		4243.40 ft
Ref. Point Elevation		4243.60 ft
Well Period of Record		
Period-of-Record		1981..2020
WS Elev-Range	Min:	4161.2 ft
	Max	4205.5 ft

Trend Analysys		
Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.317 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087195-38N09E18E001M
Alternate Name	38N09E18E001M
State Number	38N09E18E001M
CASGEM ID	411356N1209900W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1356
	Long:	-120.9900
Well Delth		520.00 ft
Ground Surface Elevation		4248.40 ft
Ref. Point Elevation		4249.50 ft

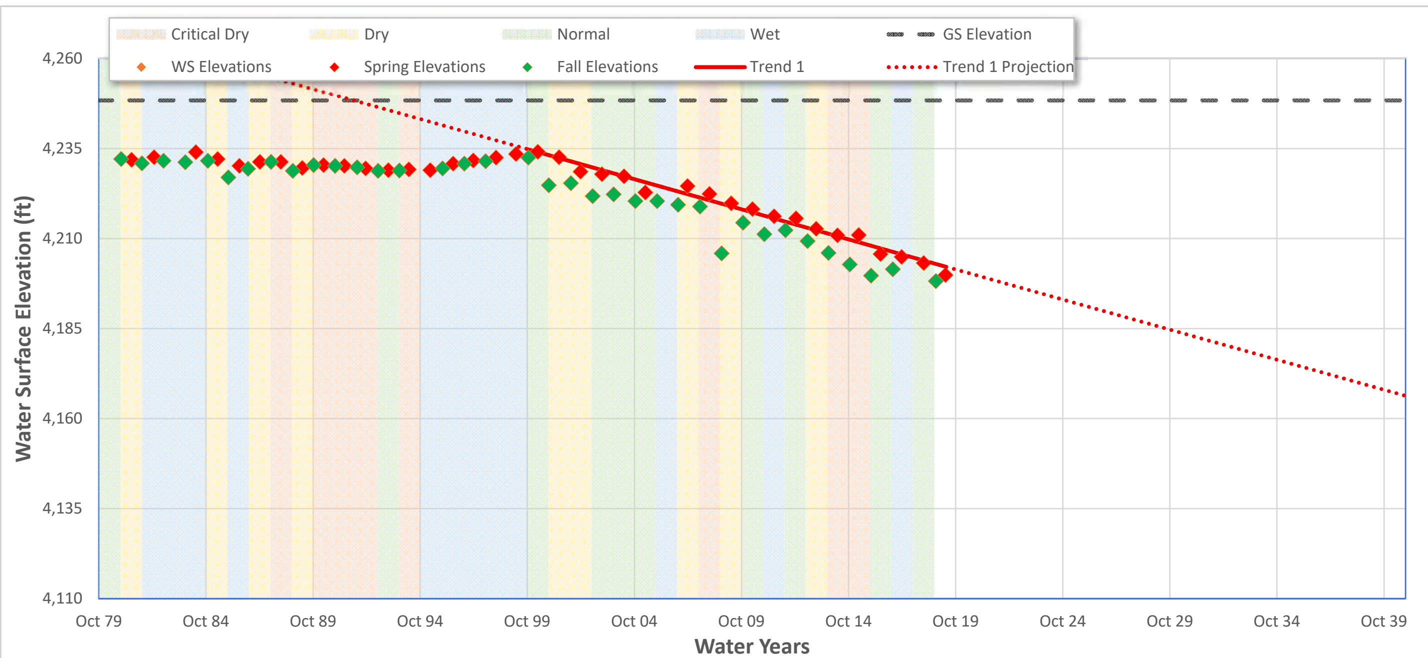
Well Period of Record

Period-of-Record		1981..2019
WS Elev-Range	Min:	4198.2 ft
	Max	4234.1 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.671 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087194-38N09E08F001M
Alternate Name	38N09E08F001M
State Number	38N09E08F001M
CASGEM ID	411493N1209656W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Other
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1493
	Long:	-120.9656
Well Delth		217.00 ft
Ground Surface Elevation		4253.40 ft
Ref. Point Elevation		4255.40 ft

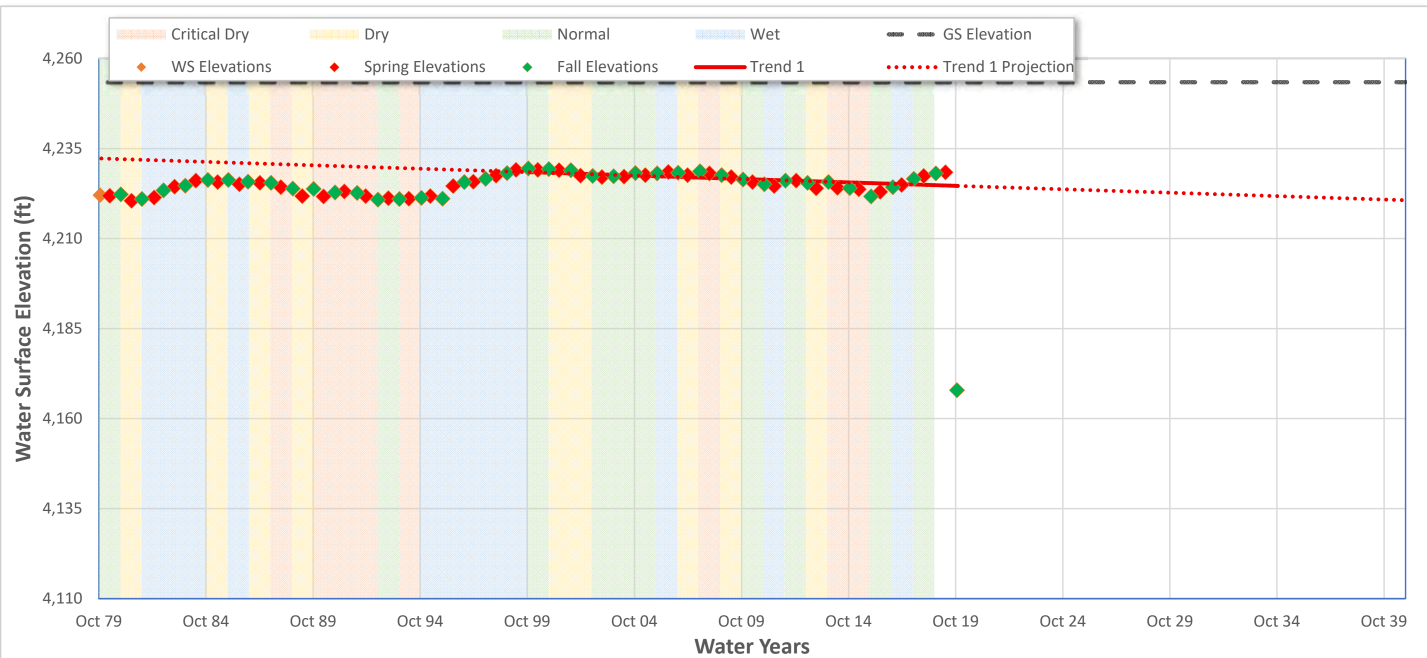
Well Period of Record

Period-of-Record		1979..2020
WS Elev-Range	Min:	4167.9 ft
	Max	4229.5 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(0.190 ft/yr)
Show Trend 2		None
Date Range	Start WY:	
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Well Water Surface Level Report

Date: 2/19/2020

Well Information

Well ID	087196-38N09E18M001M
Alternate Name	38N09E18M001M
State Number	38N09E18M001M
CASGEM ID	411305N1209896W001

Well Location

County	Lassen
Basin	BIG VALLEY
Sub-Basin	-

Well Type Information

Well Type	-
Well Use	Irrigation
Completion Type	Single

Well Coordinates/Geometry

Location	Lat:	41.1305
	Long:	-120.9897
Well Delth		525.00 ft
Ground Surface Elevation		4288.40 ft
Ref. Point Elevation		4288.90 ft

Well Period of Record

Period-of-Record		1981..2020
WS Elev-Range	Min:	4192.3 ft
	Max	4232.7 ft

Trend Analysys

Seasonal Data Method		Max/Min
Show Trend 1		Spring Data
Date Range	Start WY:	2000
	End WY:	2040
Extend Trend Line		Yes
Trend Results	Slope	(1.477 ft/yr)
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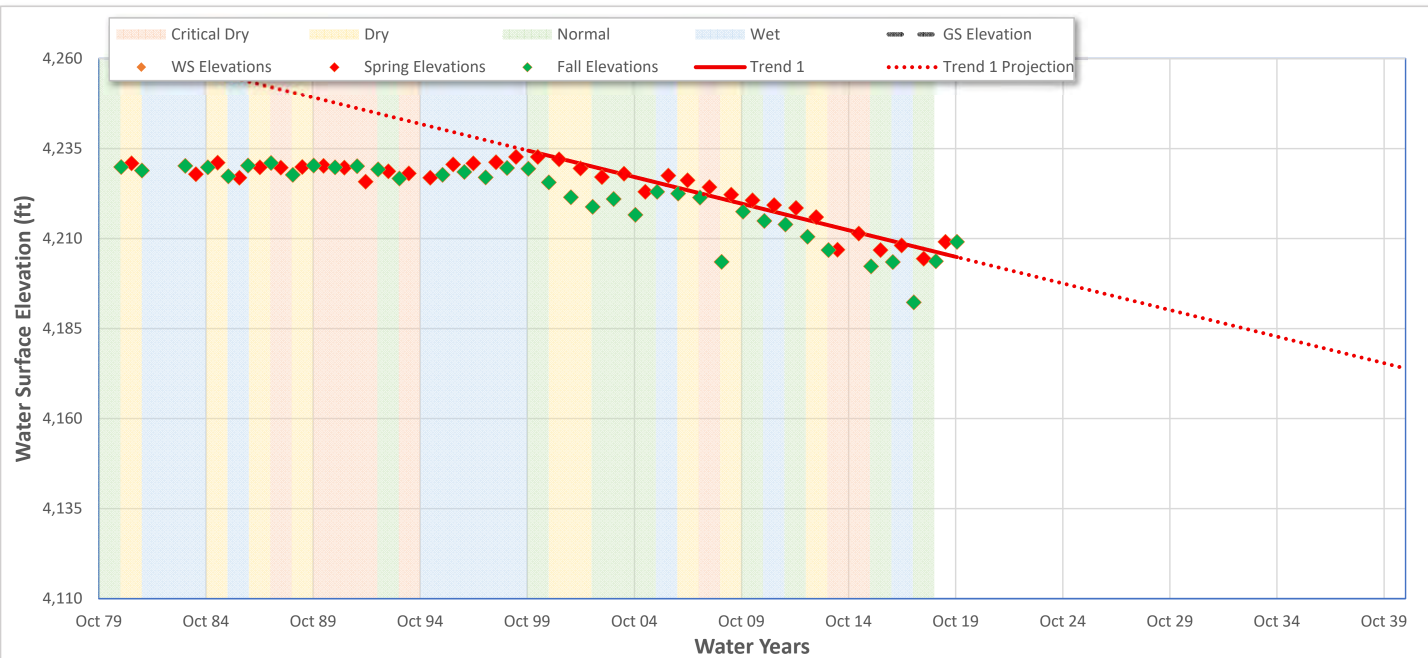
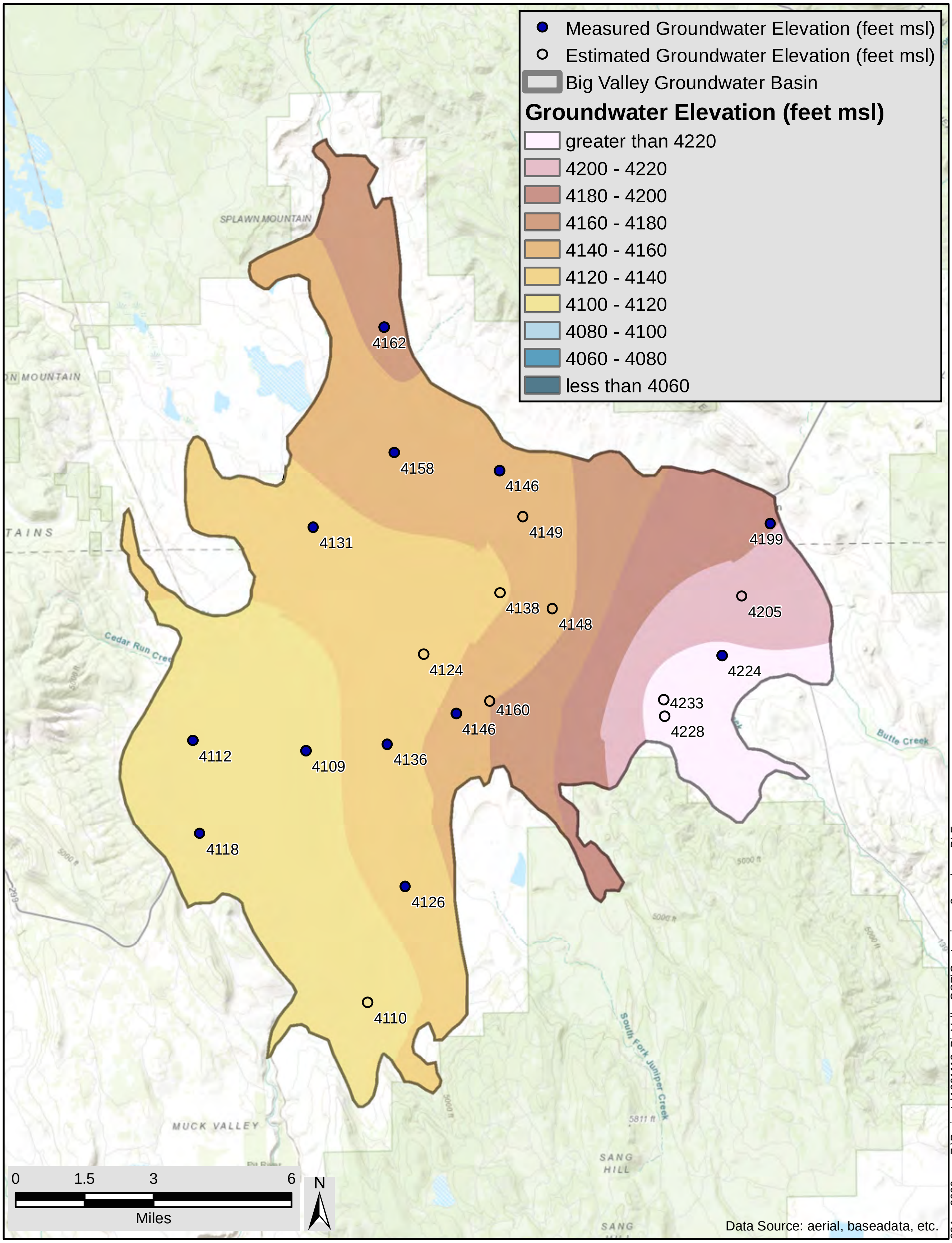
	End WY:	
Extend Trend Line		No
Trend Results	Slope	

Water Surface Elevation (WSE) Hydrograph



Appendix 5B

Groundwater Elevation Contours 1983 to 2018



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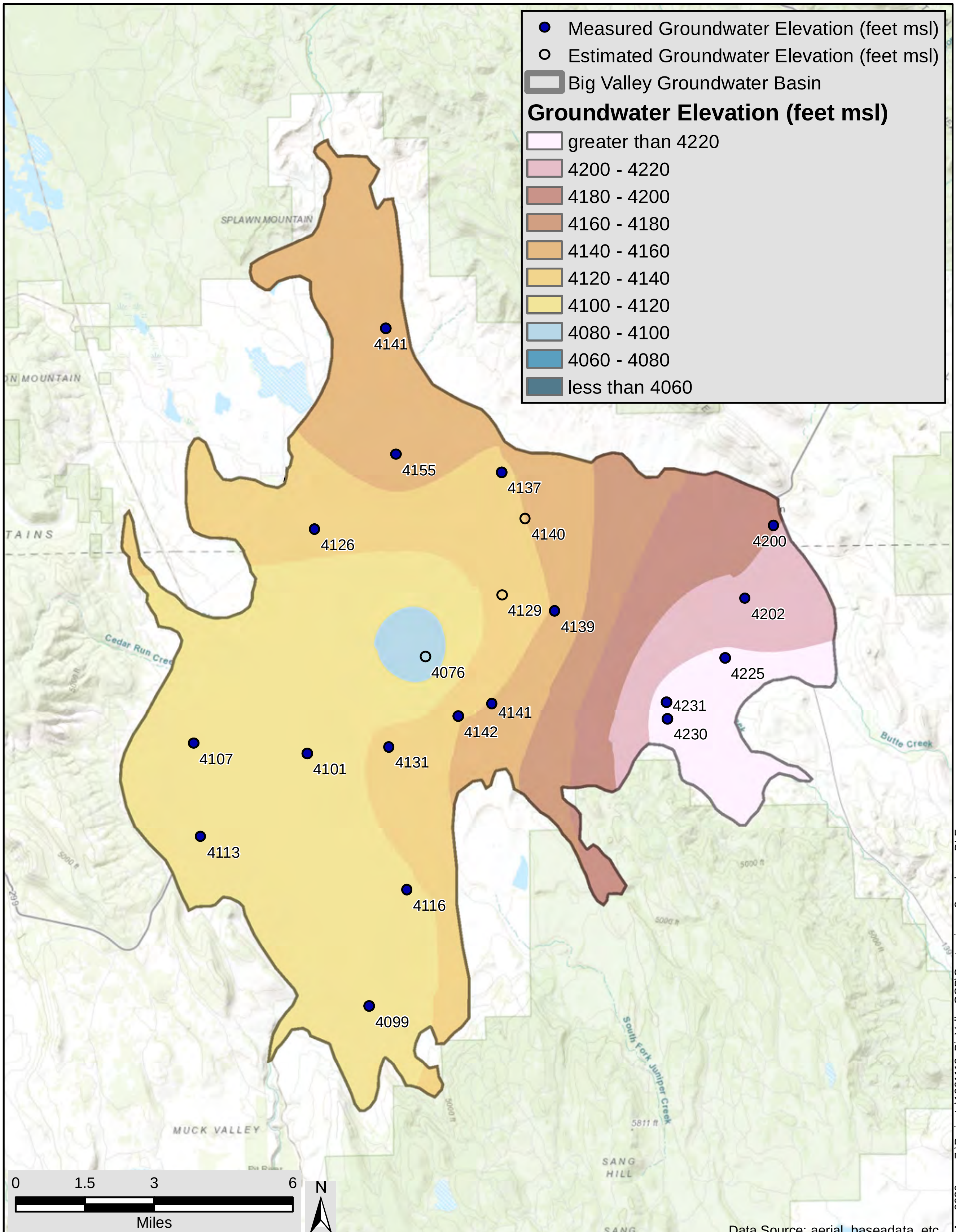
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1983
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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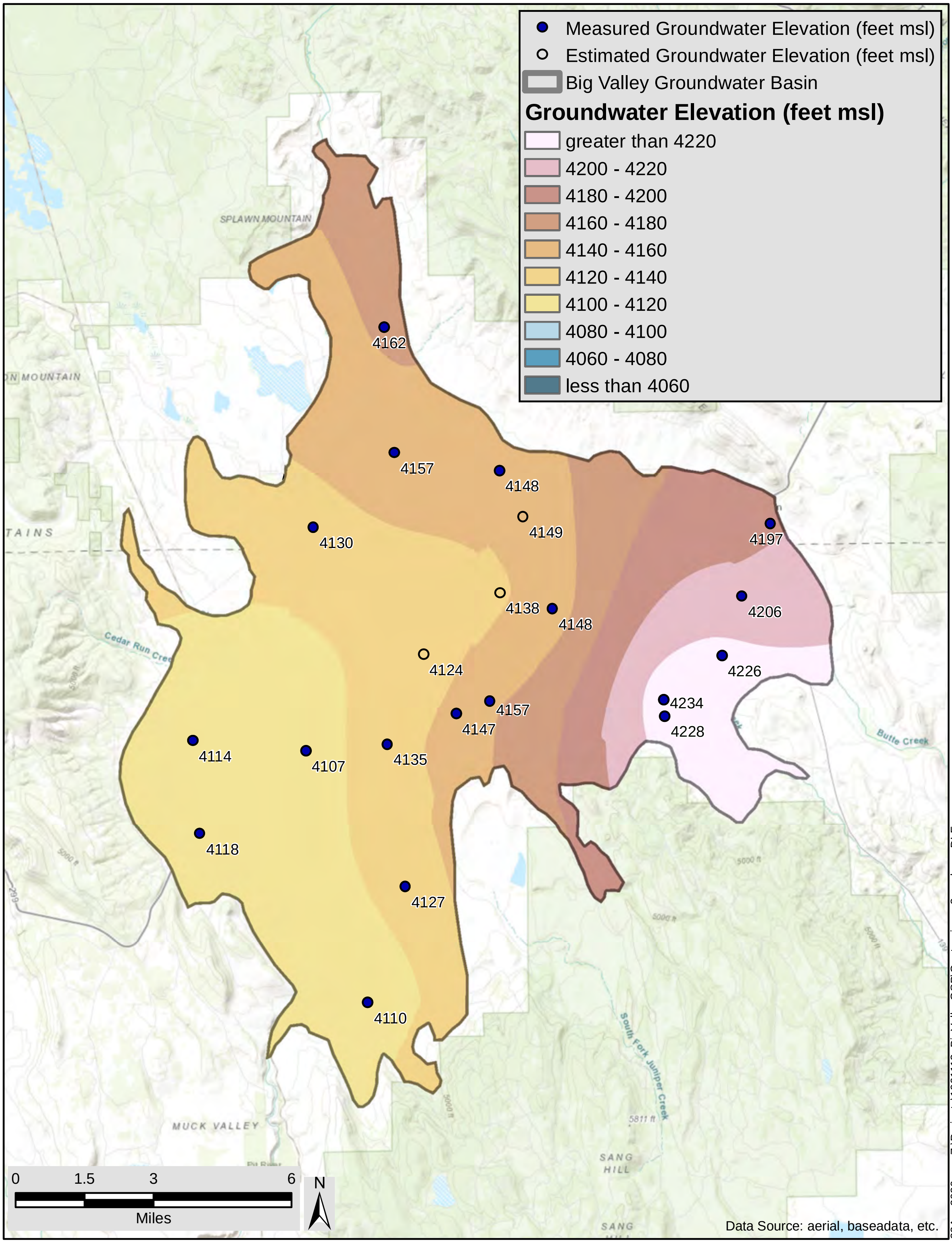
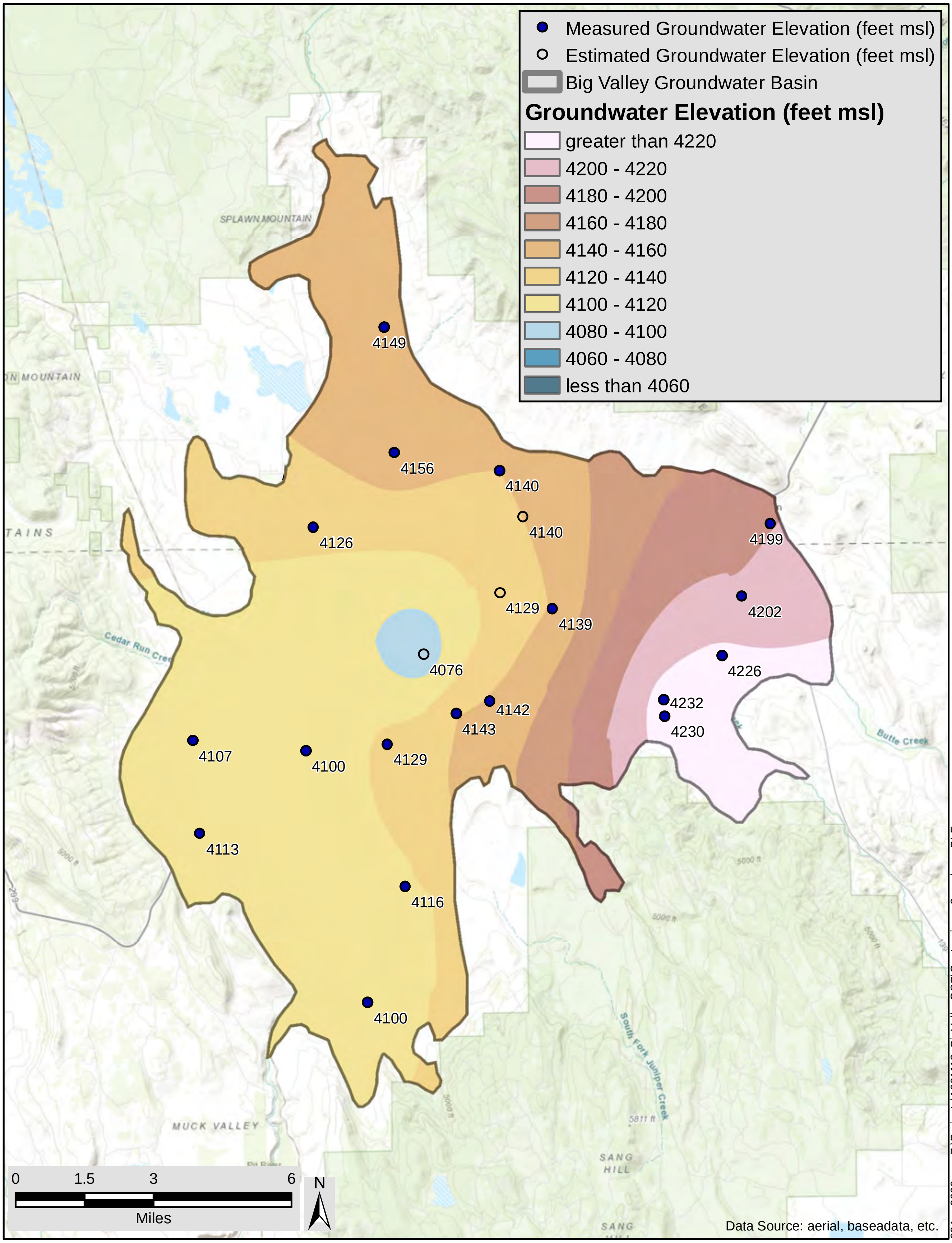
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1983
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1984
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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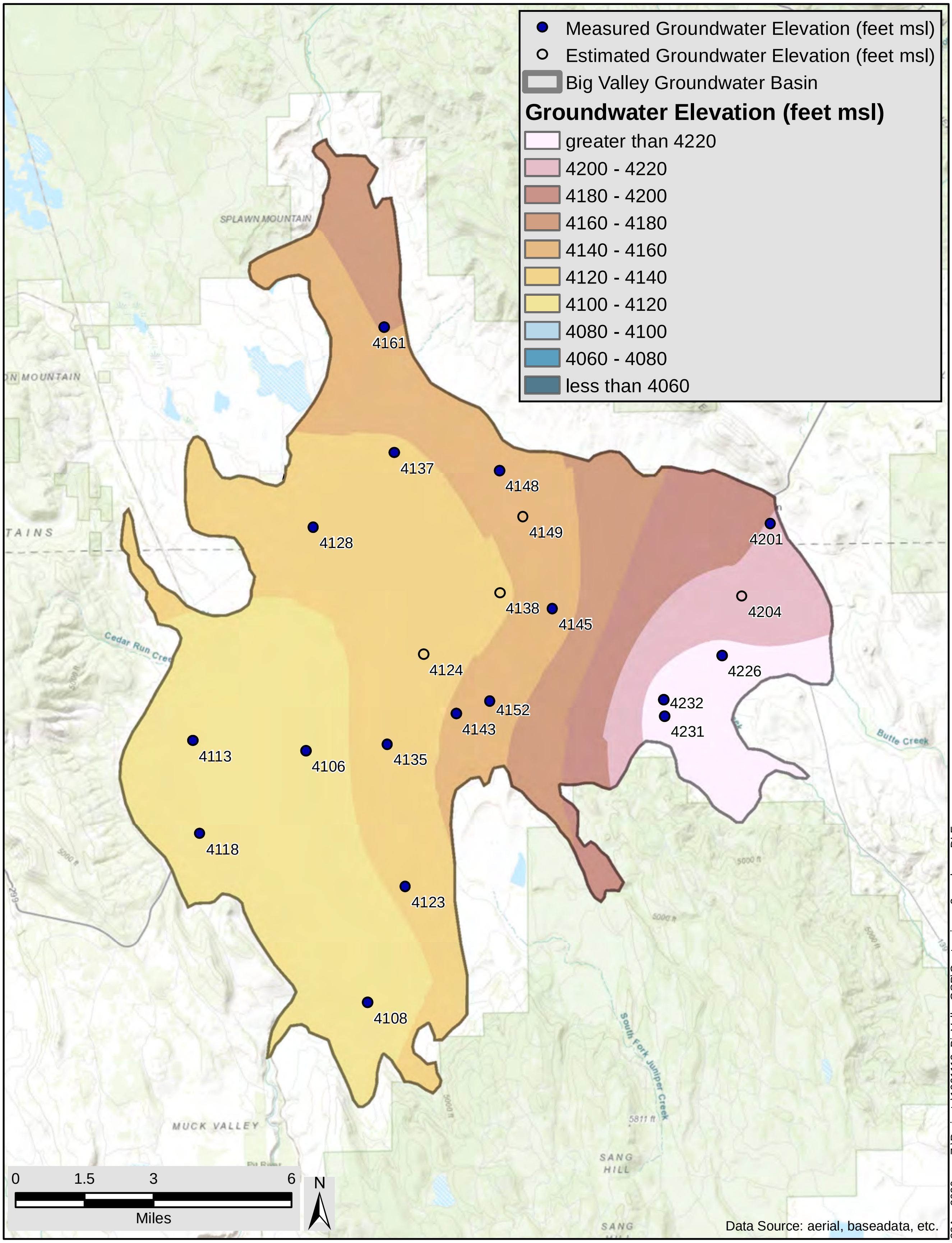
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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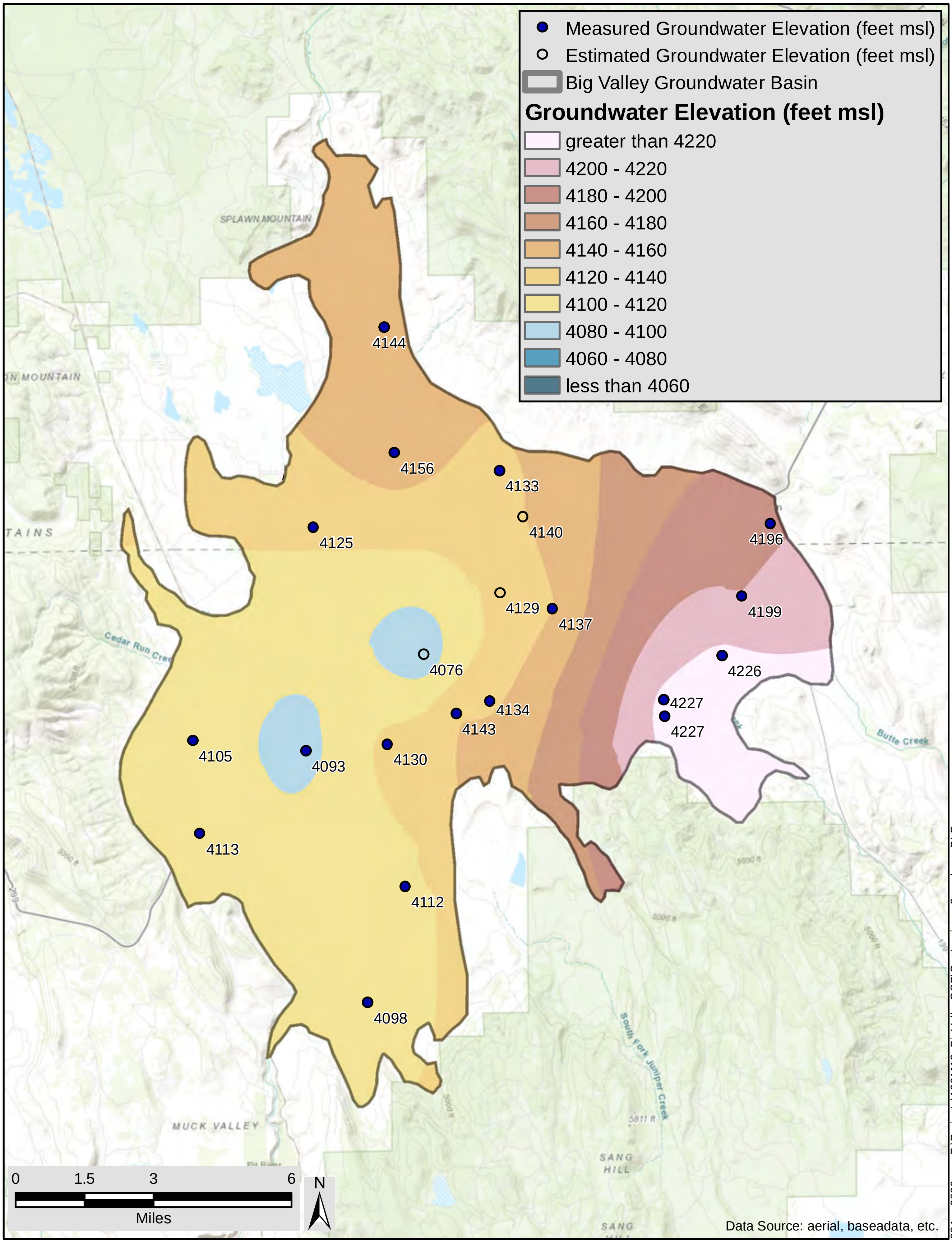
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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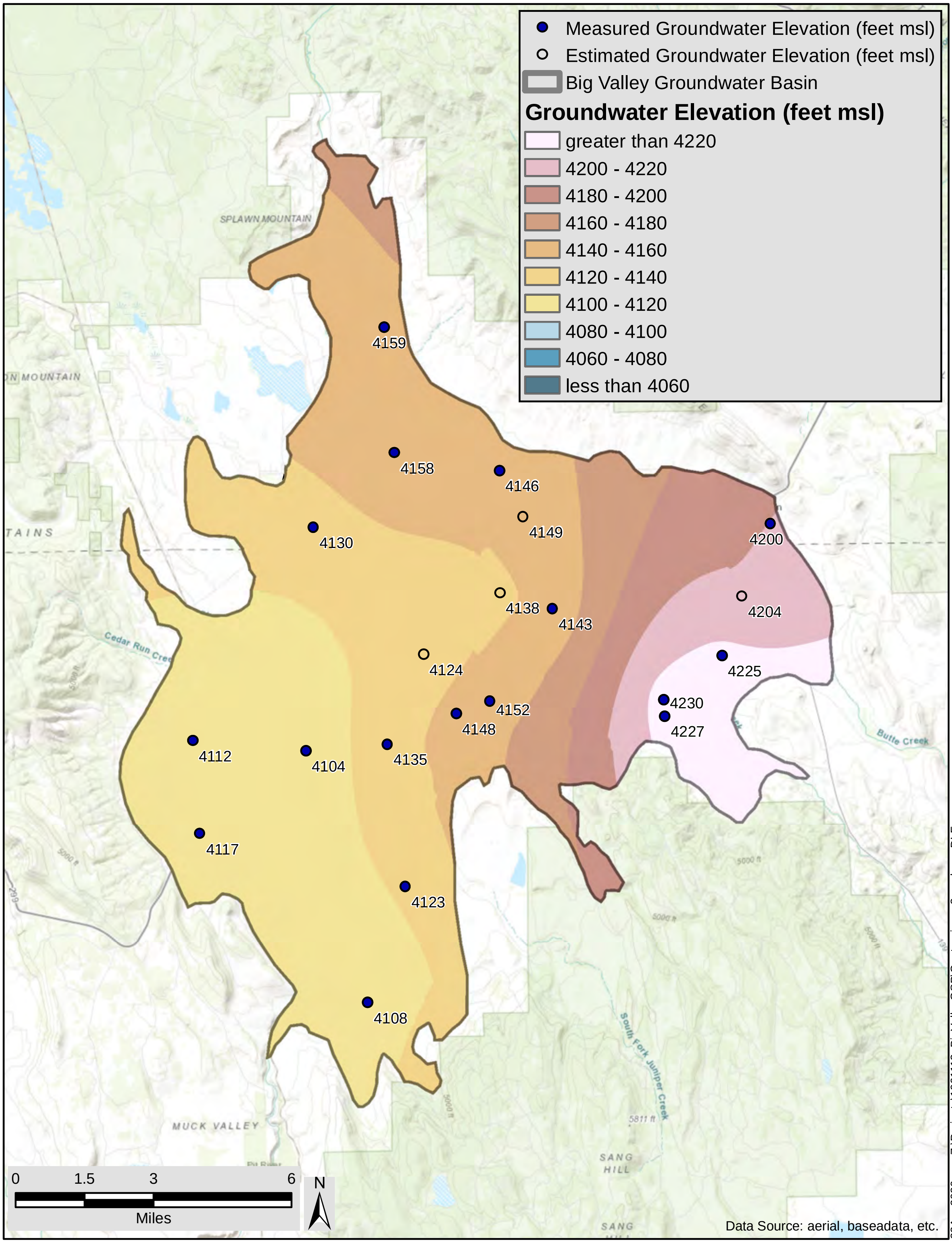
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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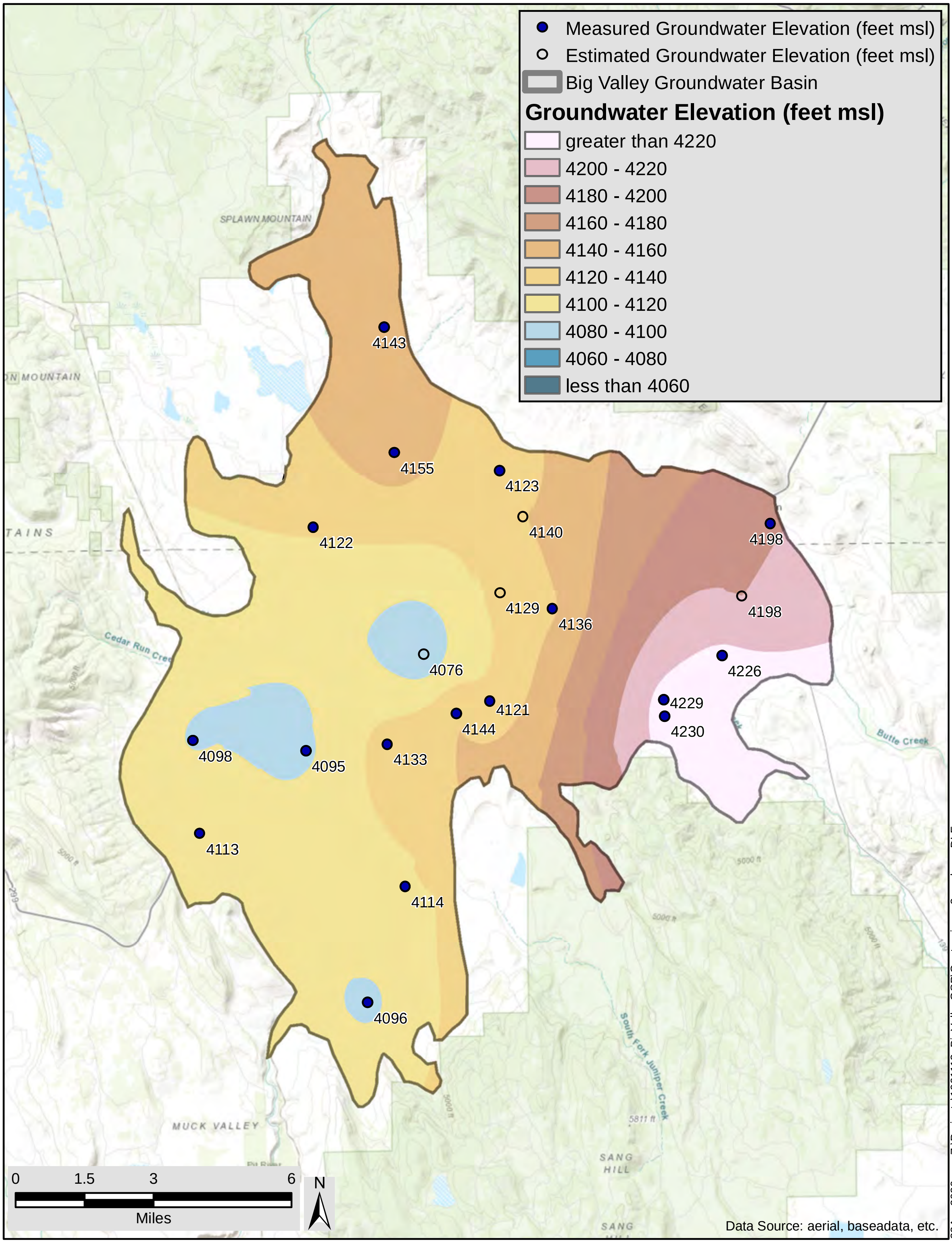
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1986
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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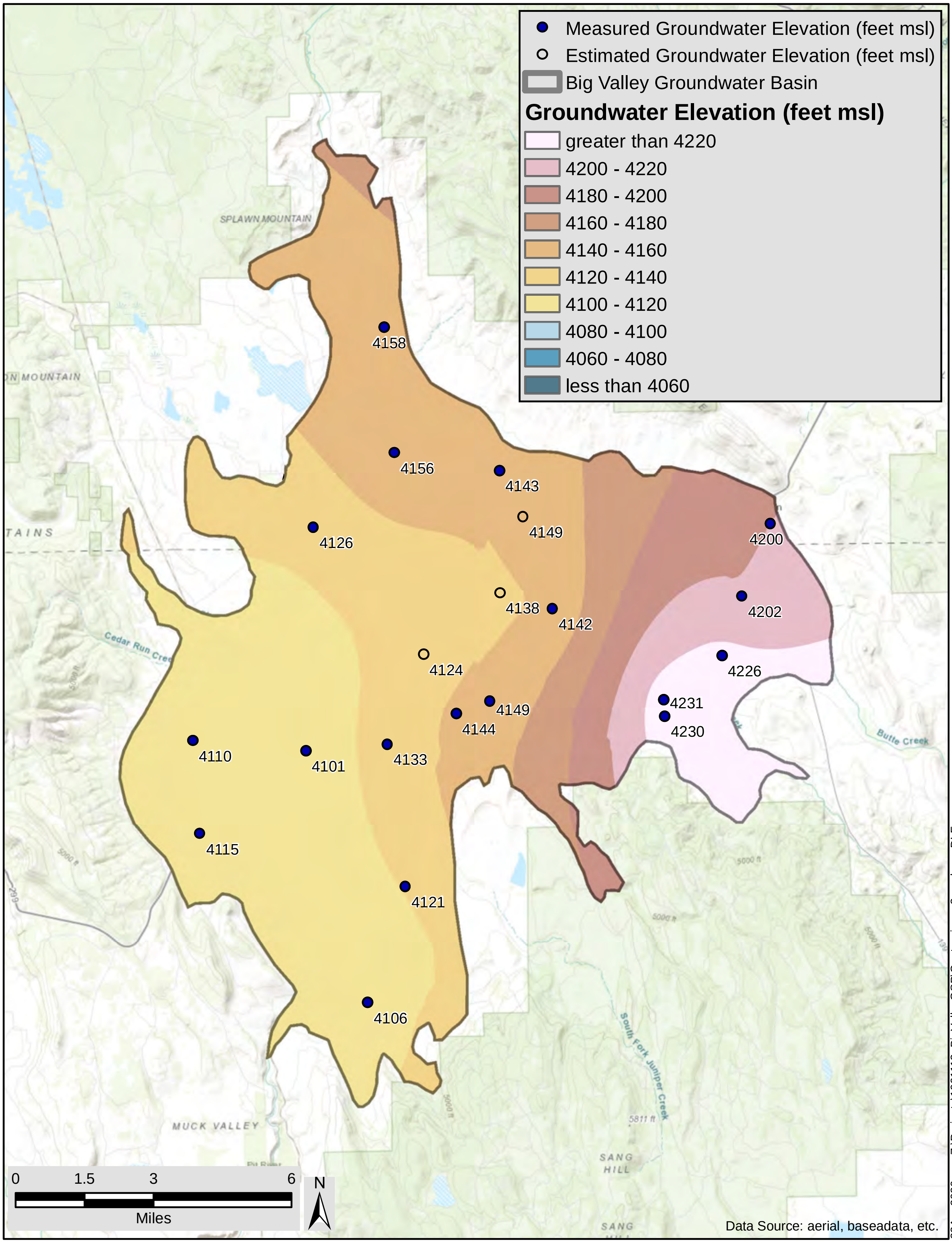
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1986
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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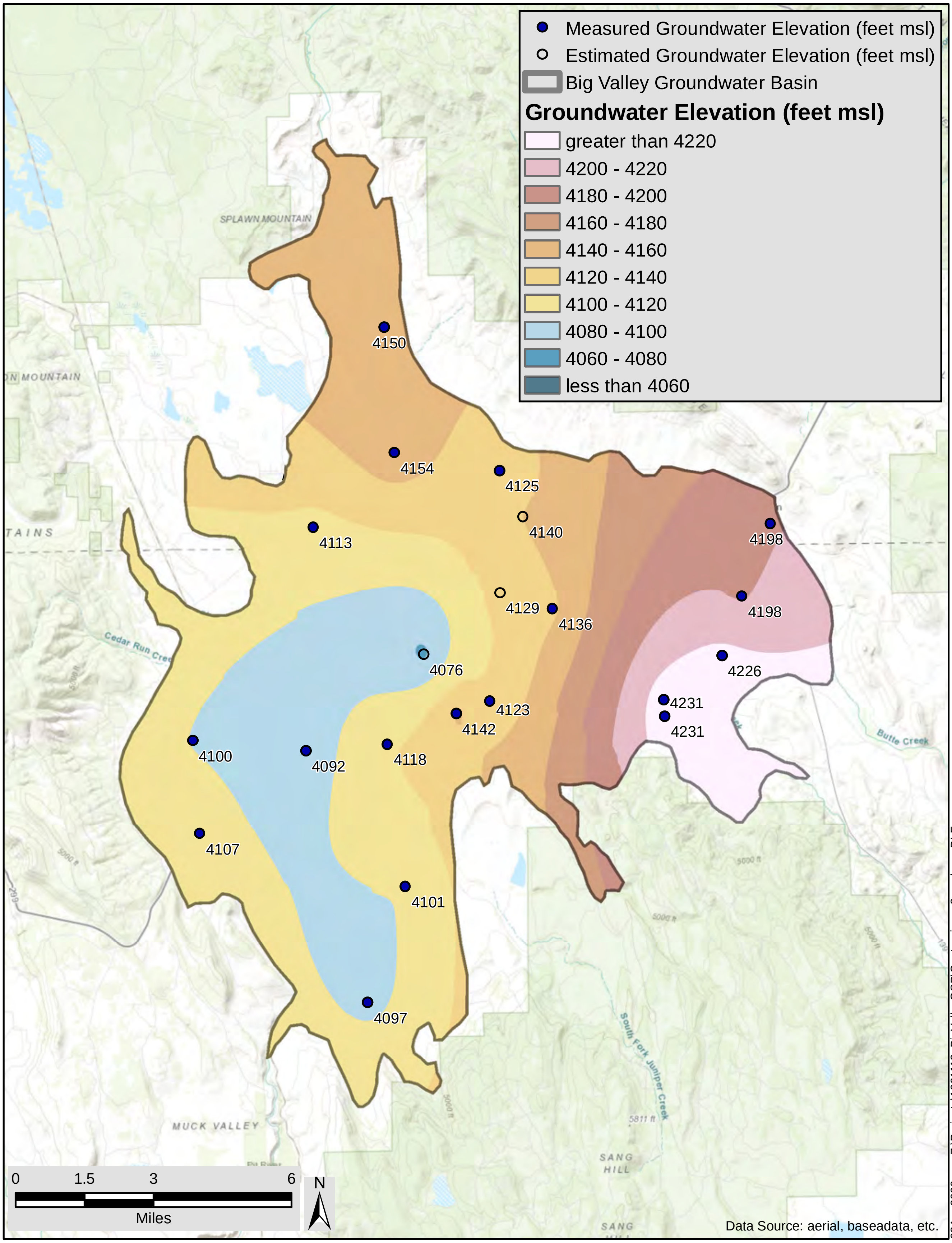
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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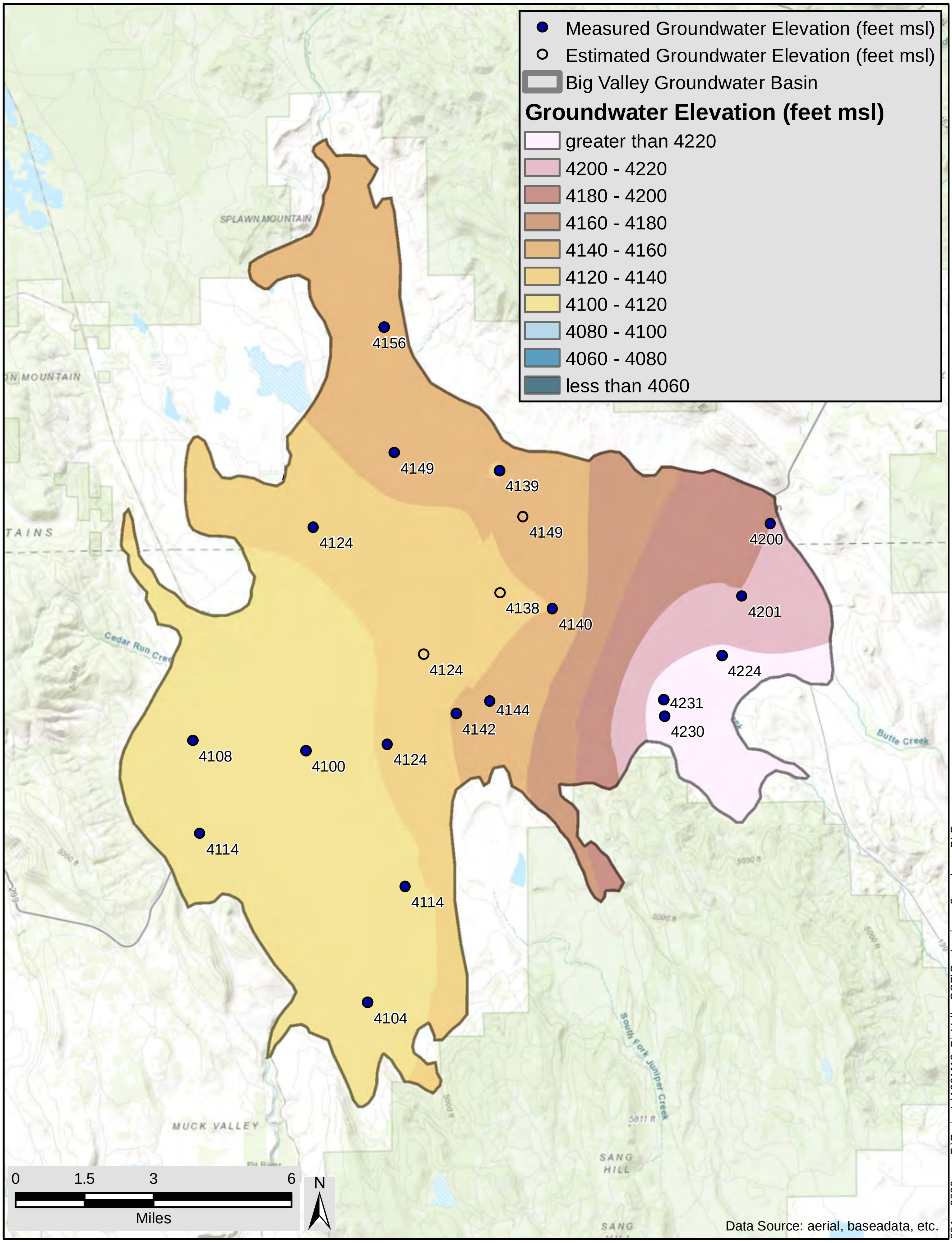
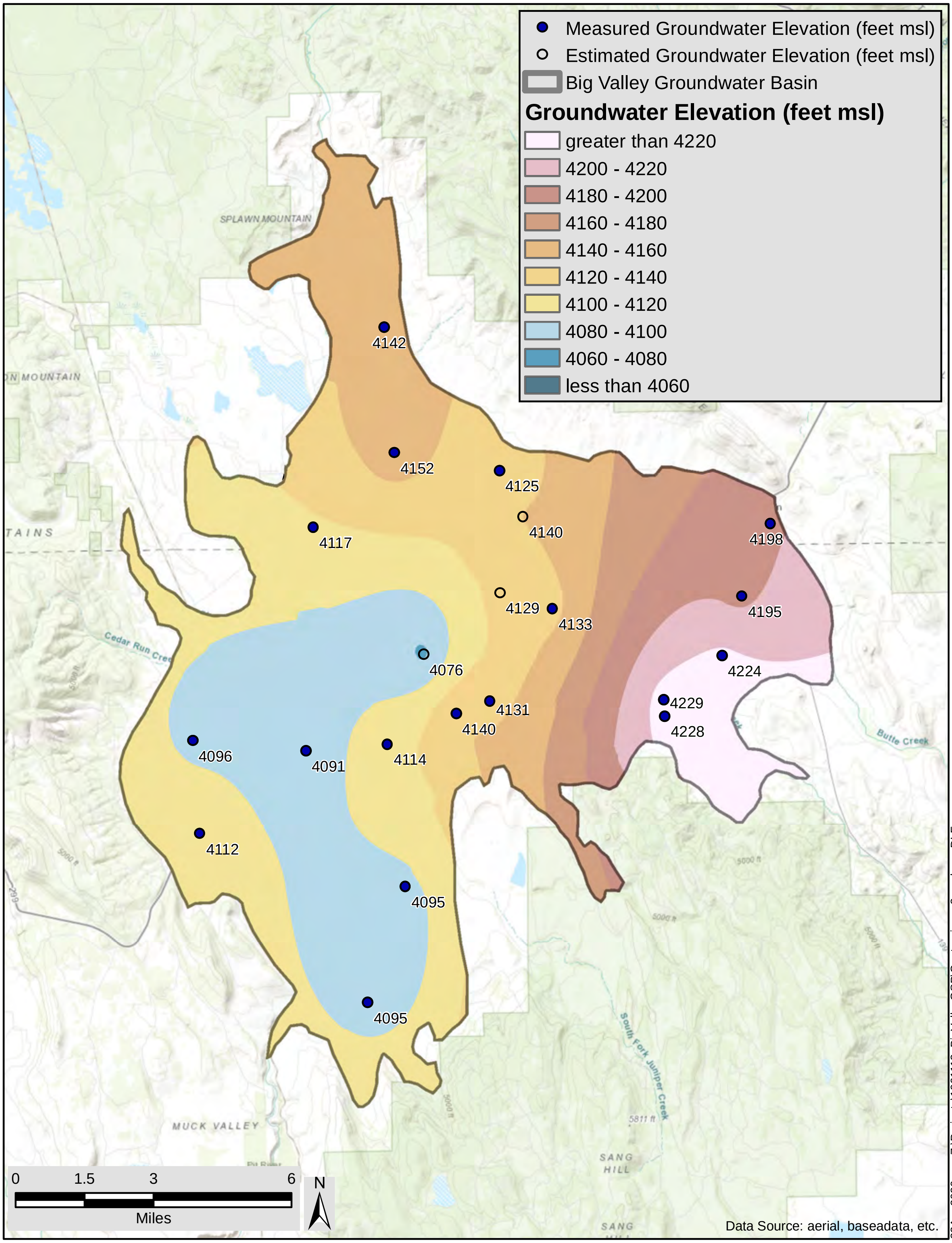
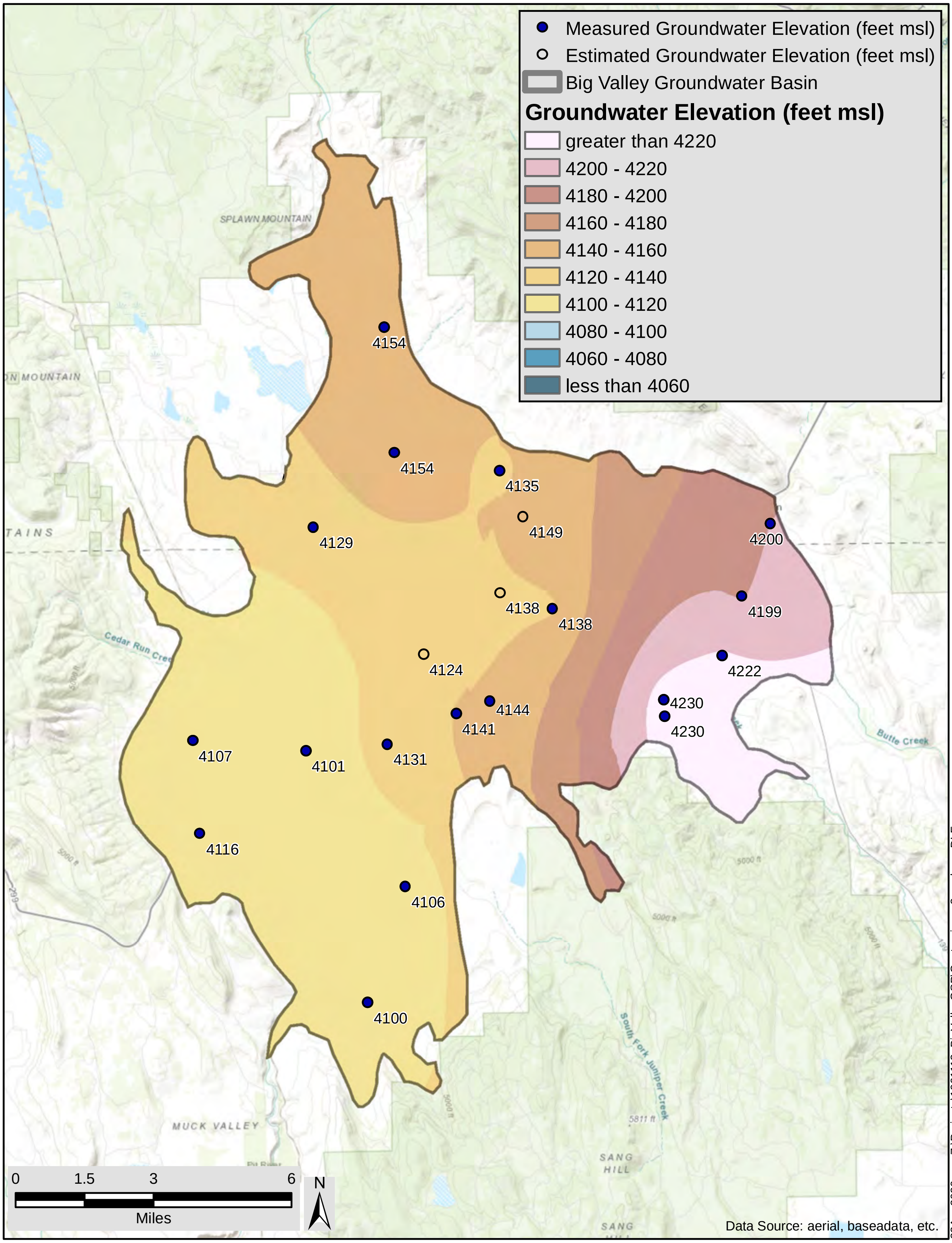
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1988
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1988
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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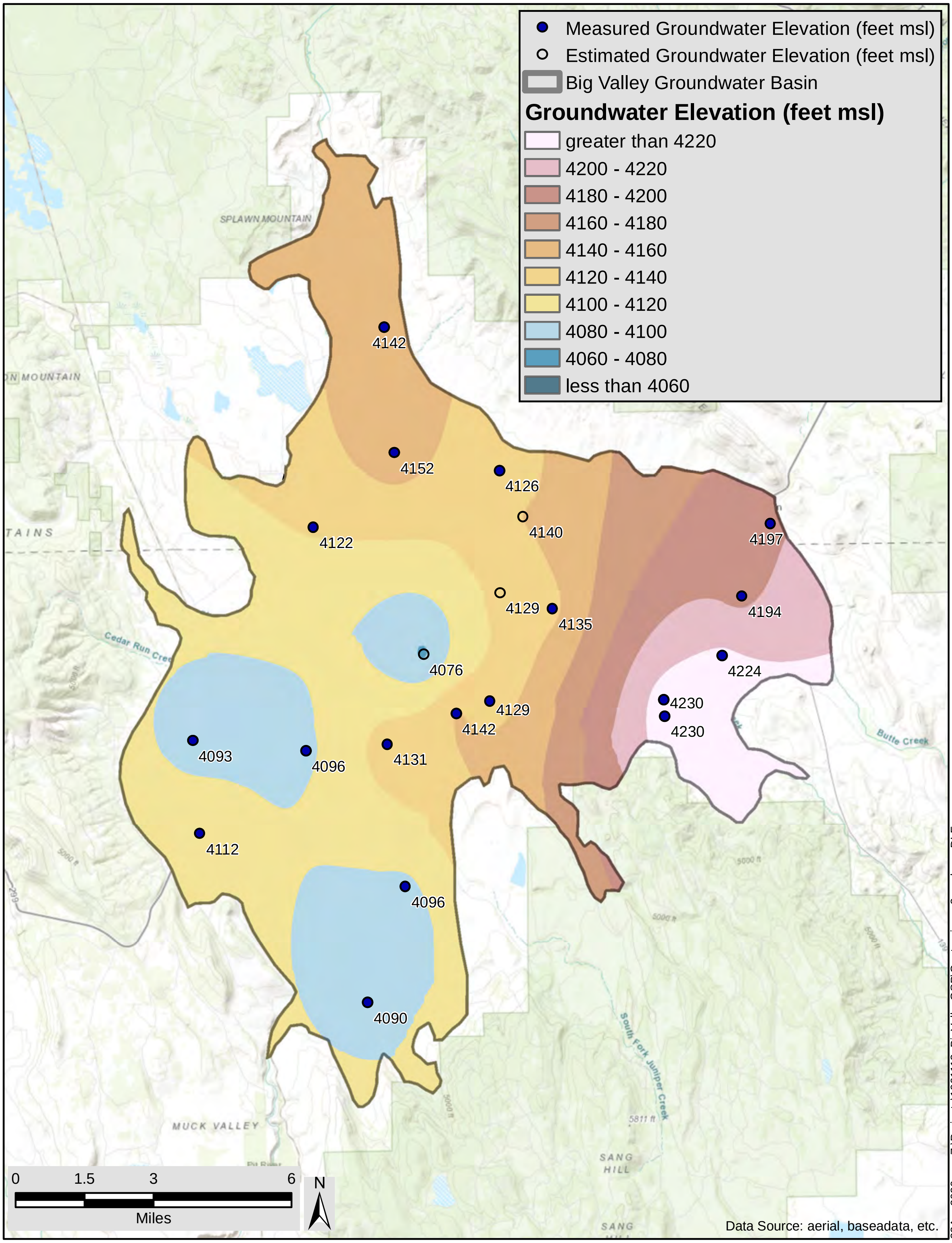
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1989
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1989
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE

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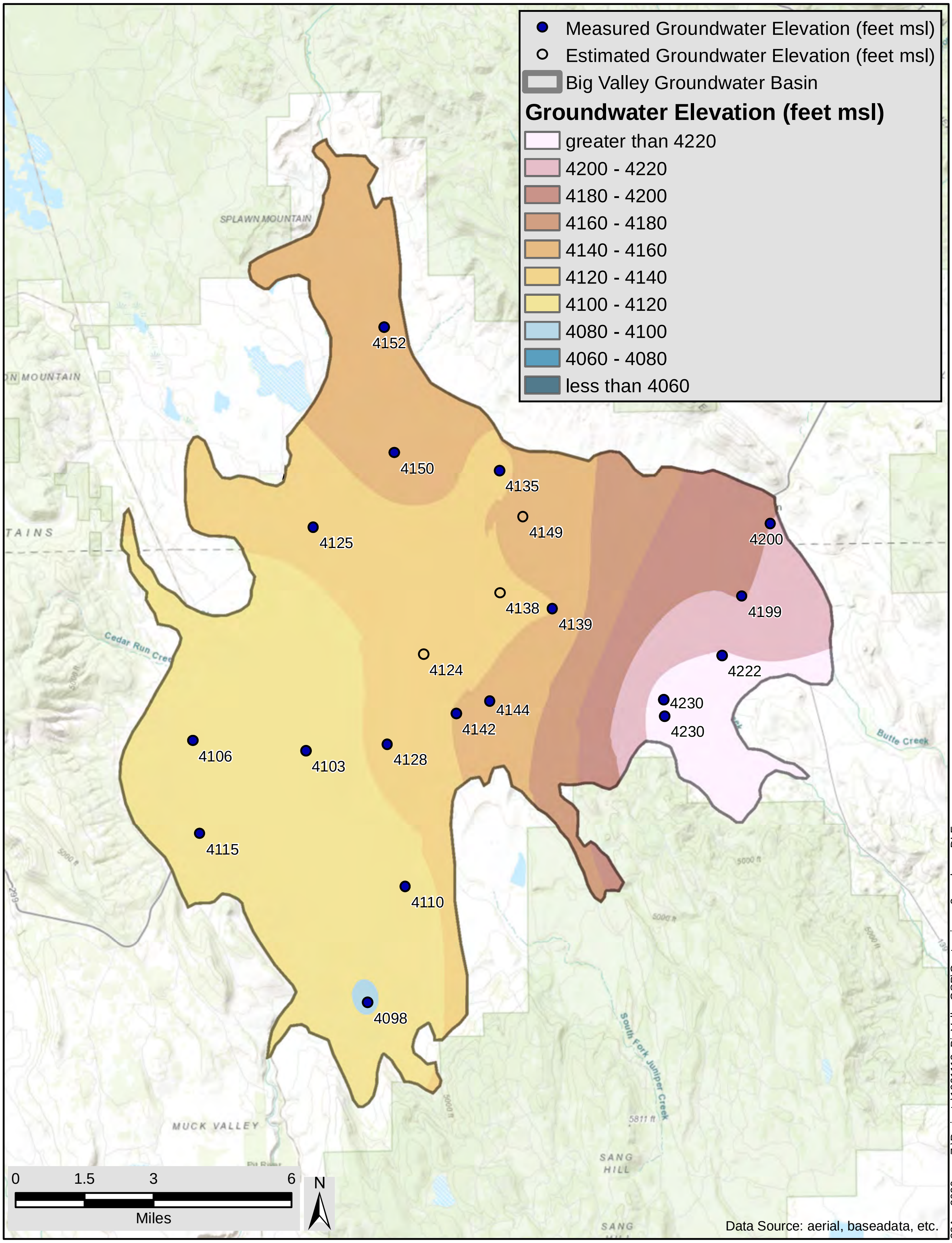

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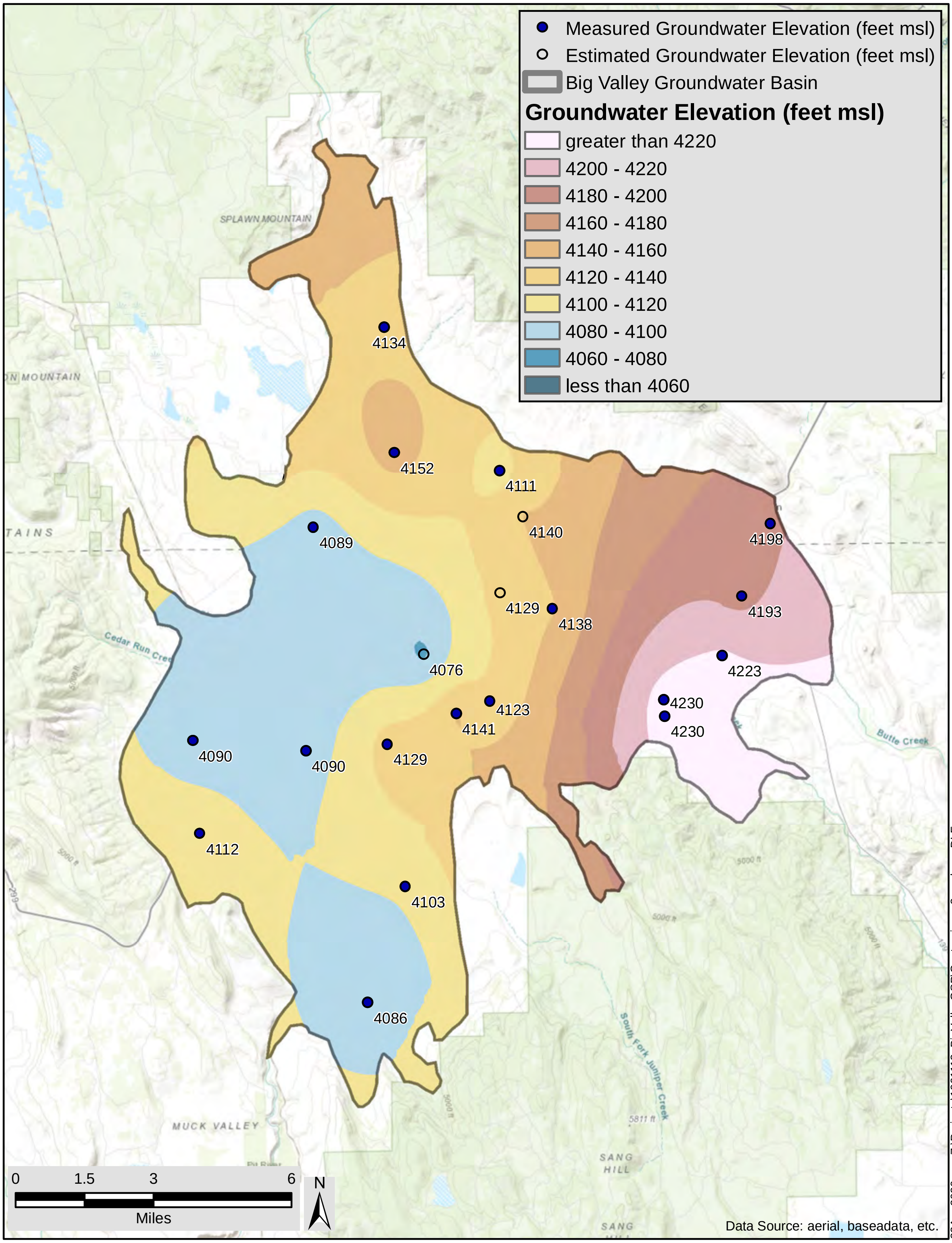
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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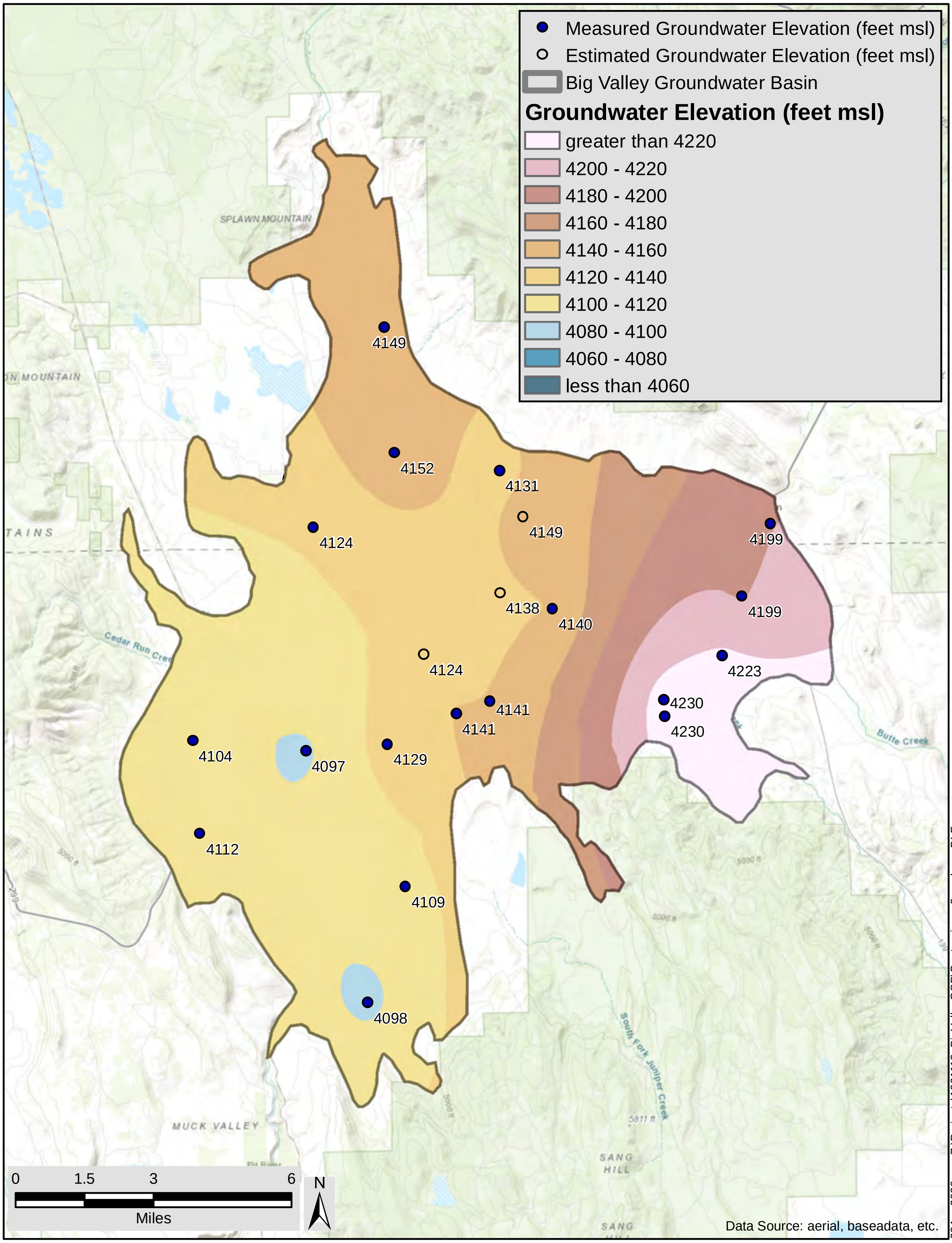
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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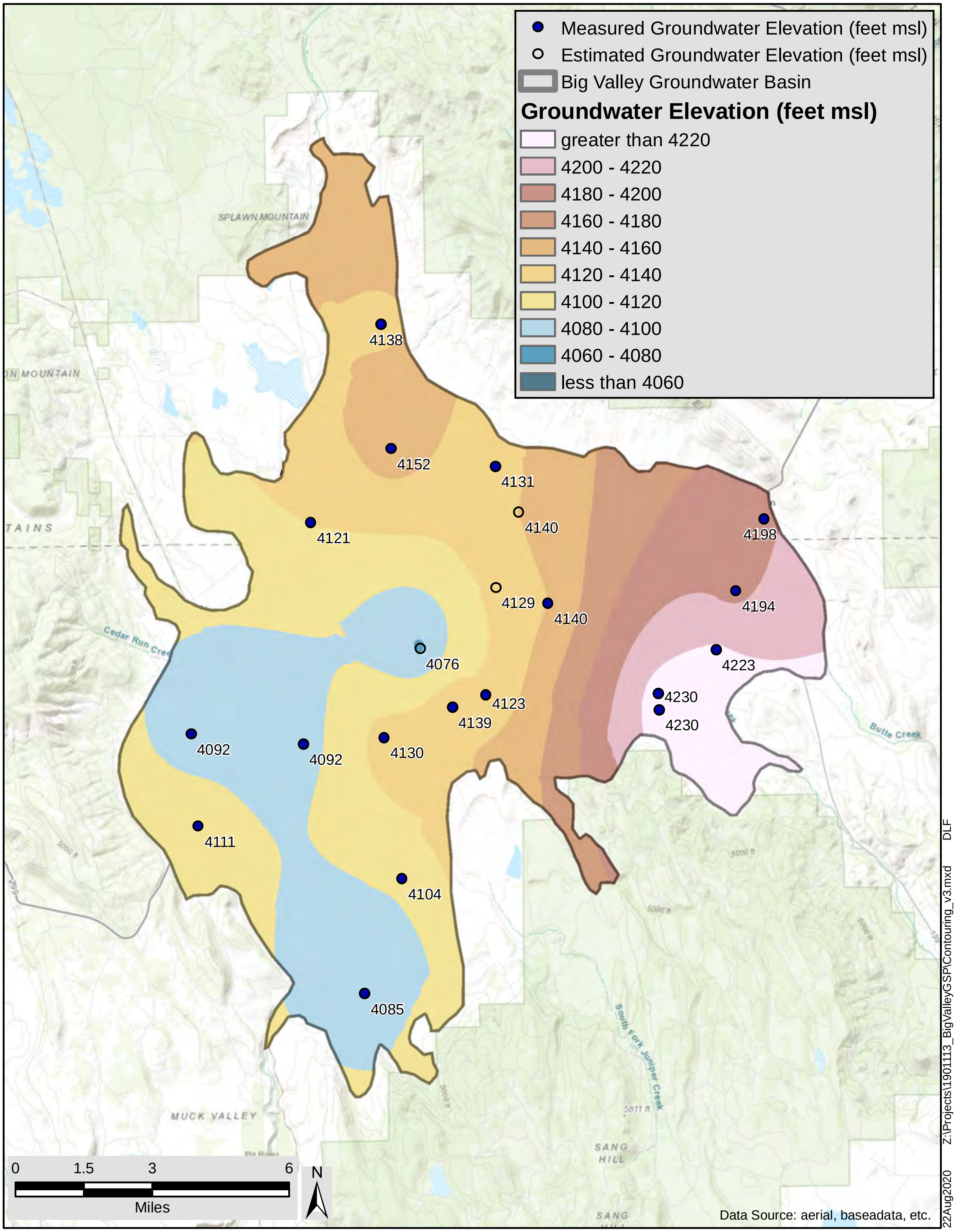
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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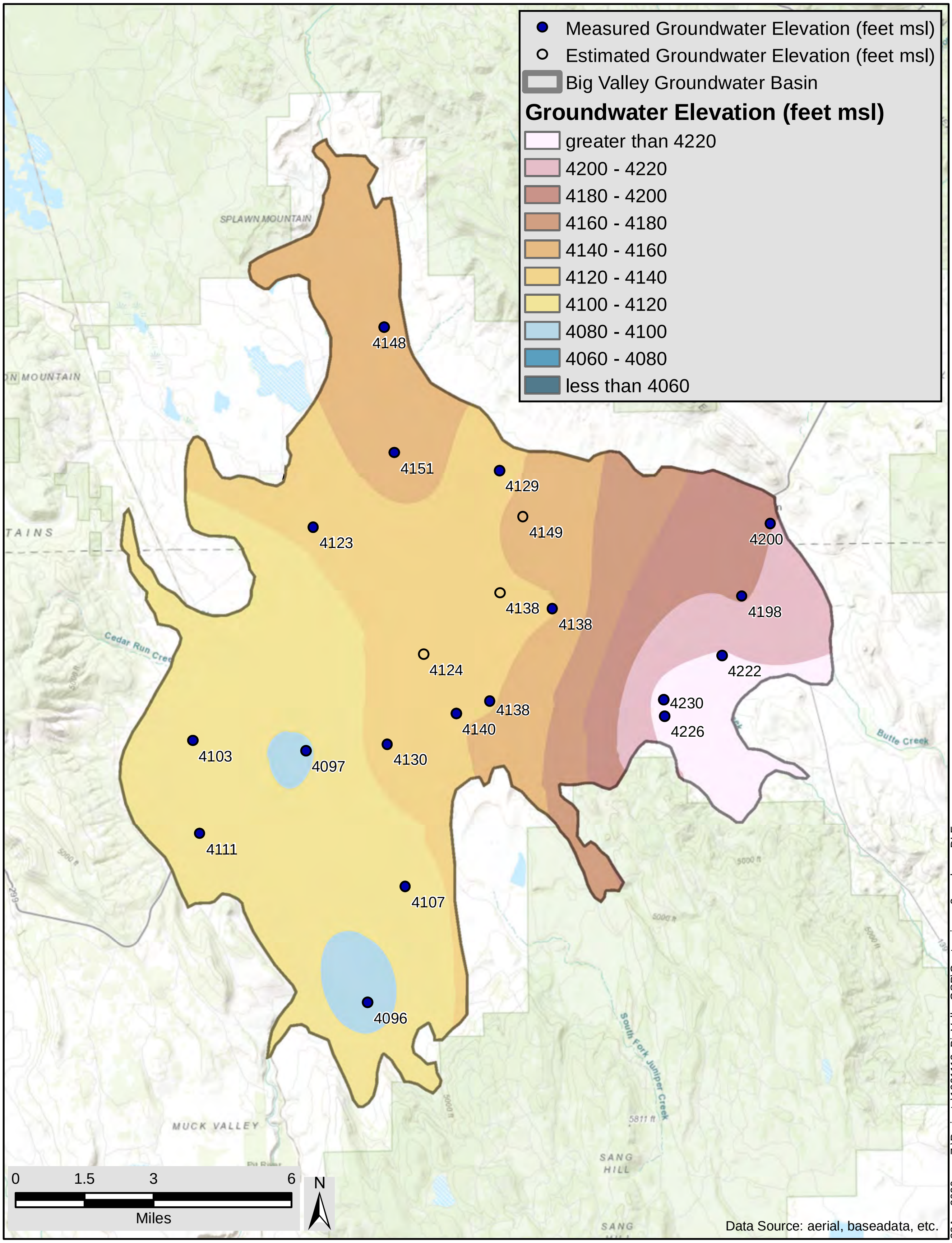
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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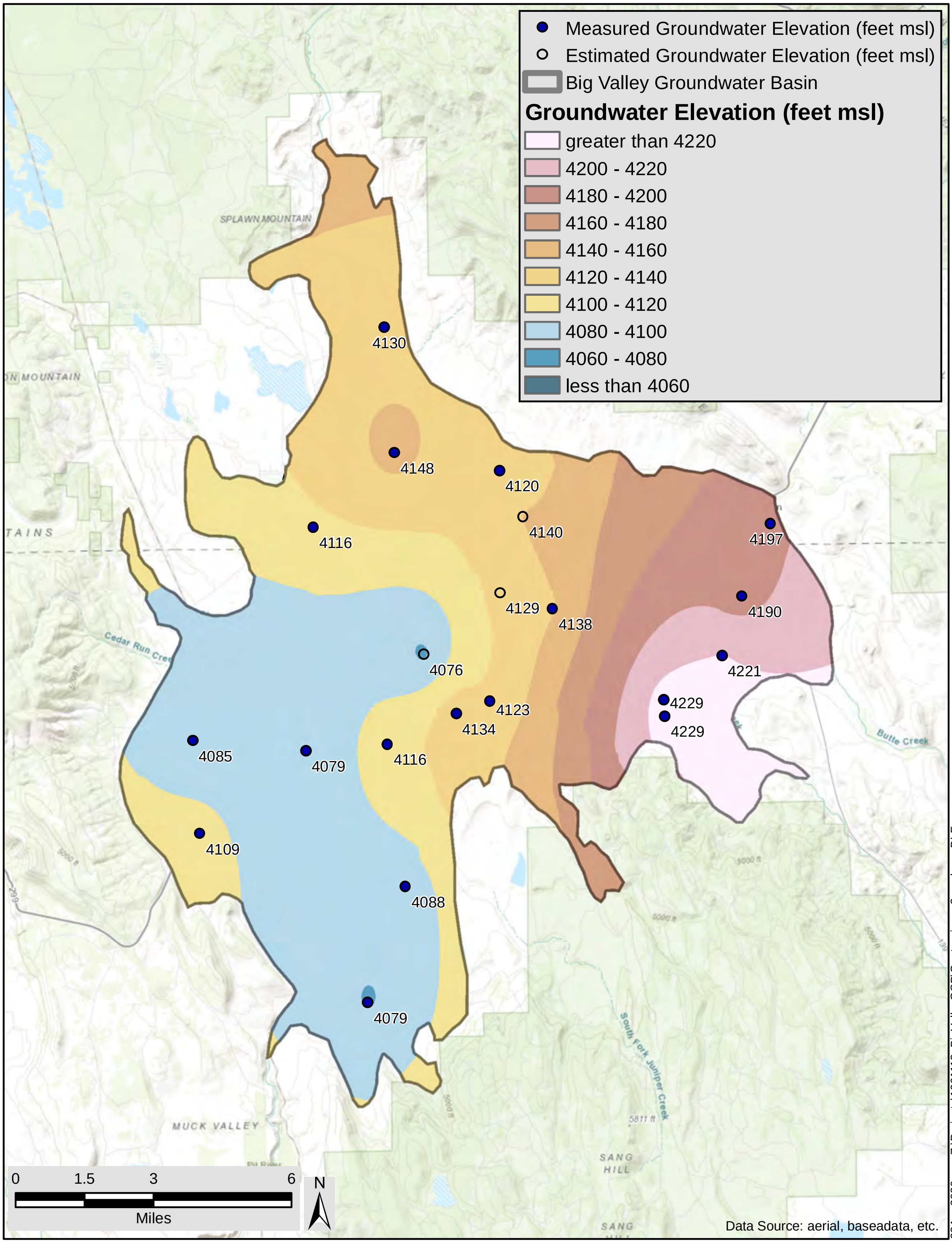
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE

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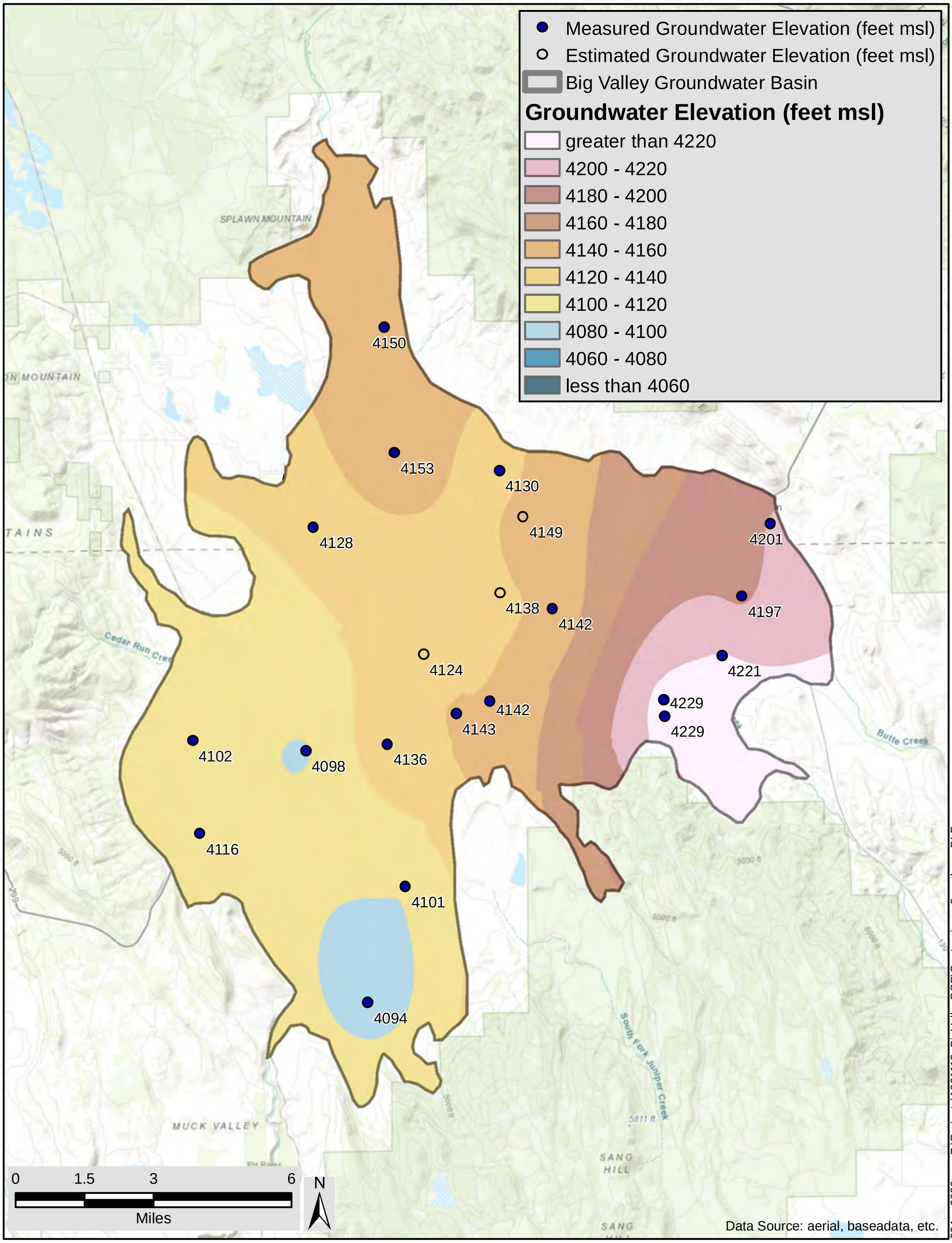

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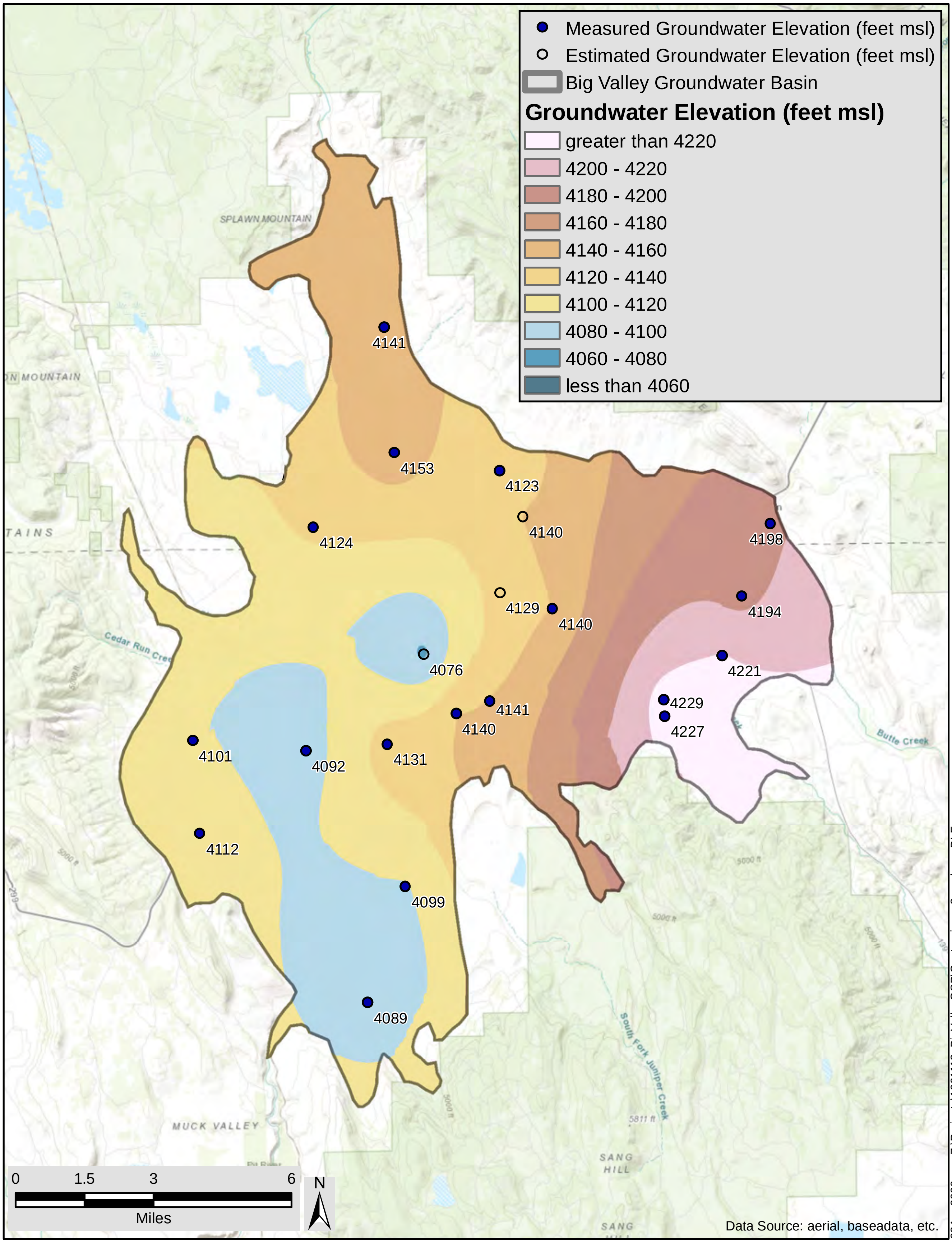
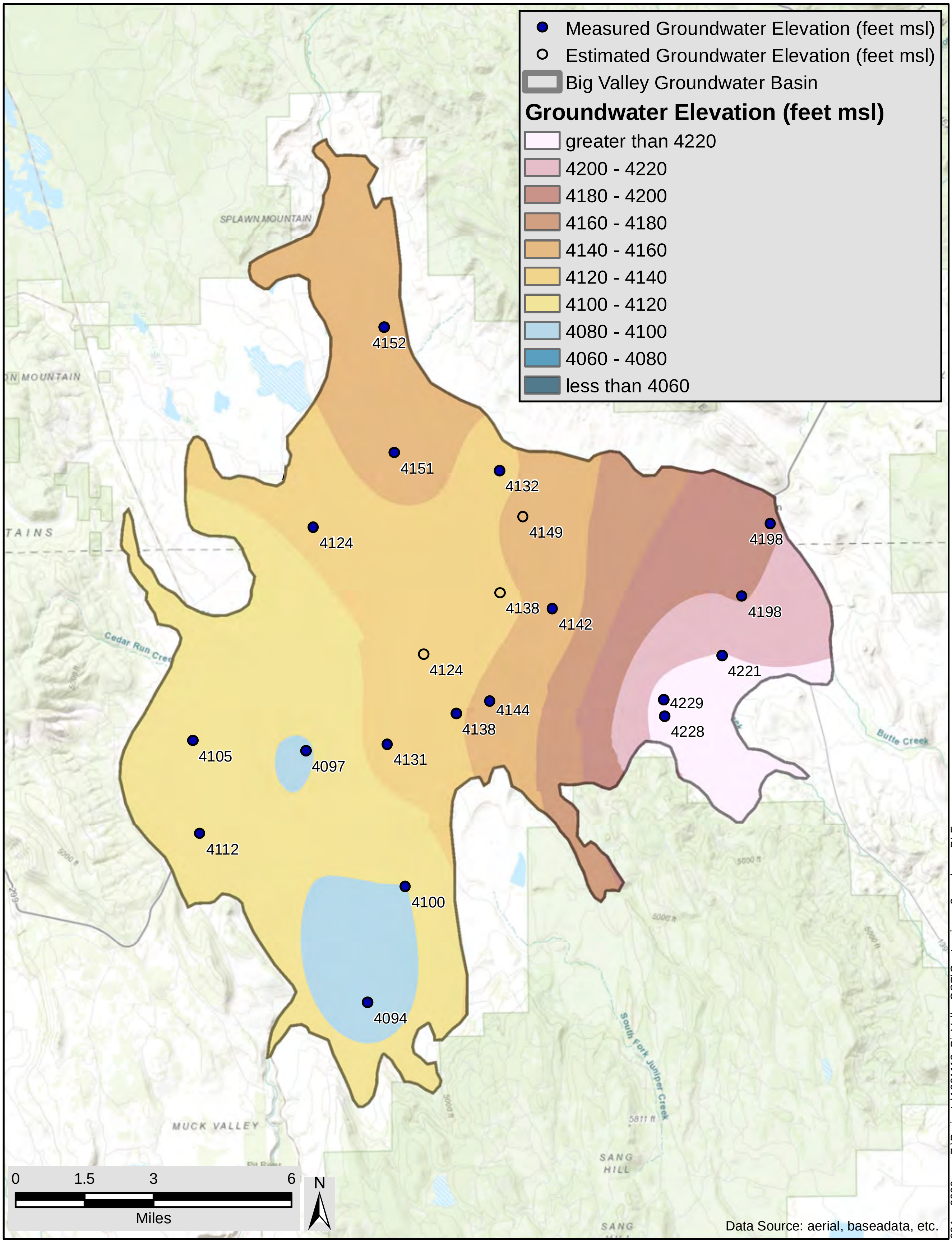
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1993		
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1993
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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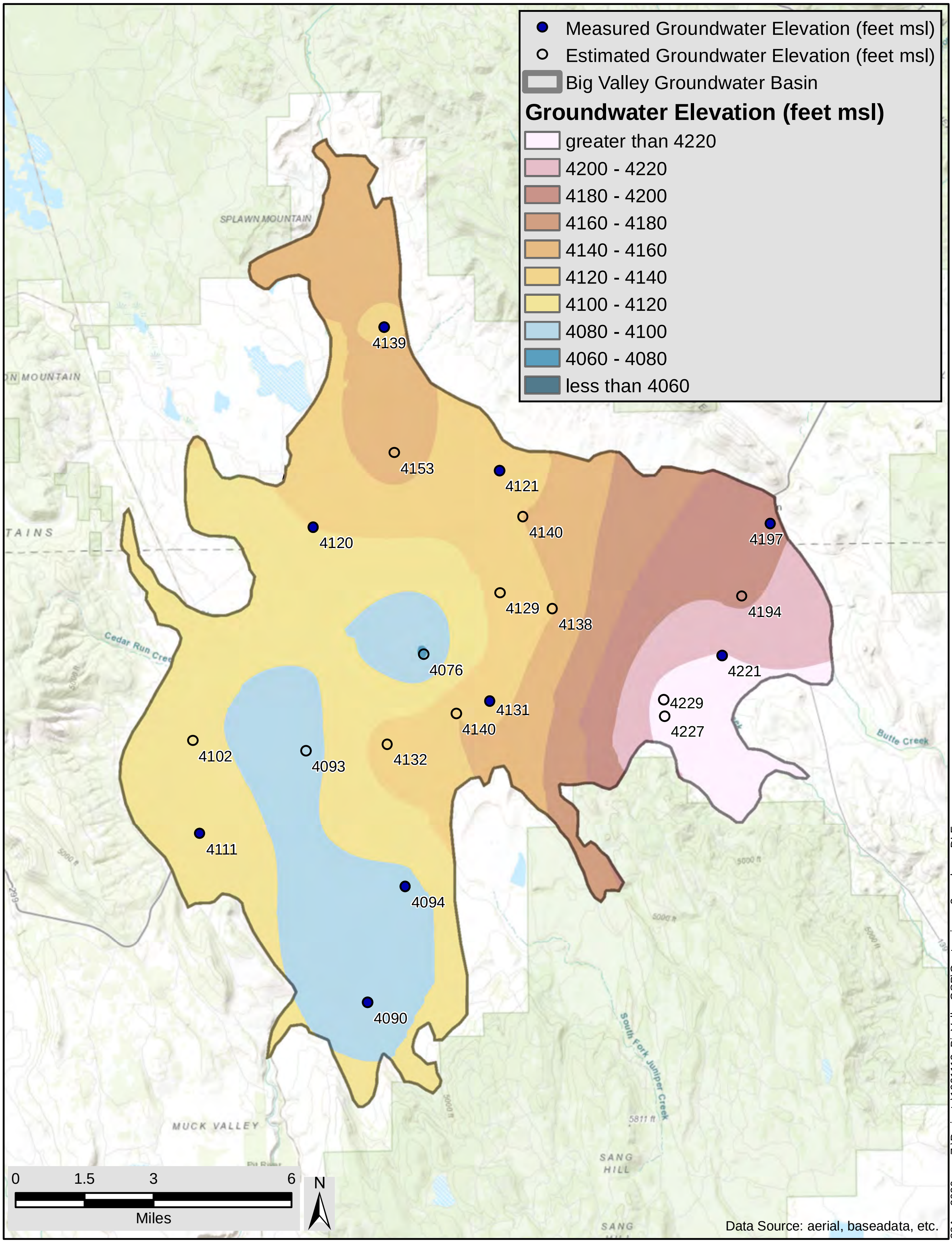
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1994
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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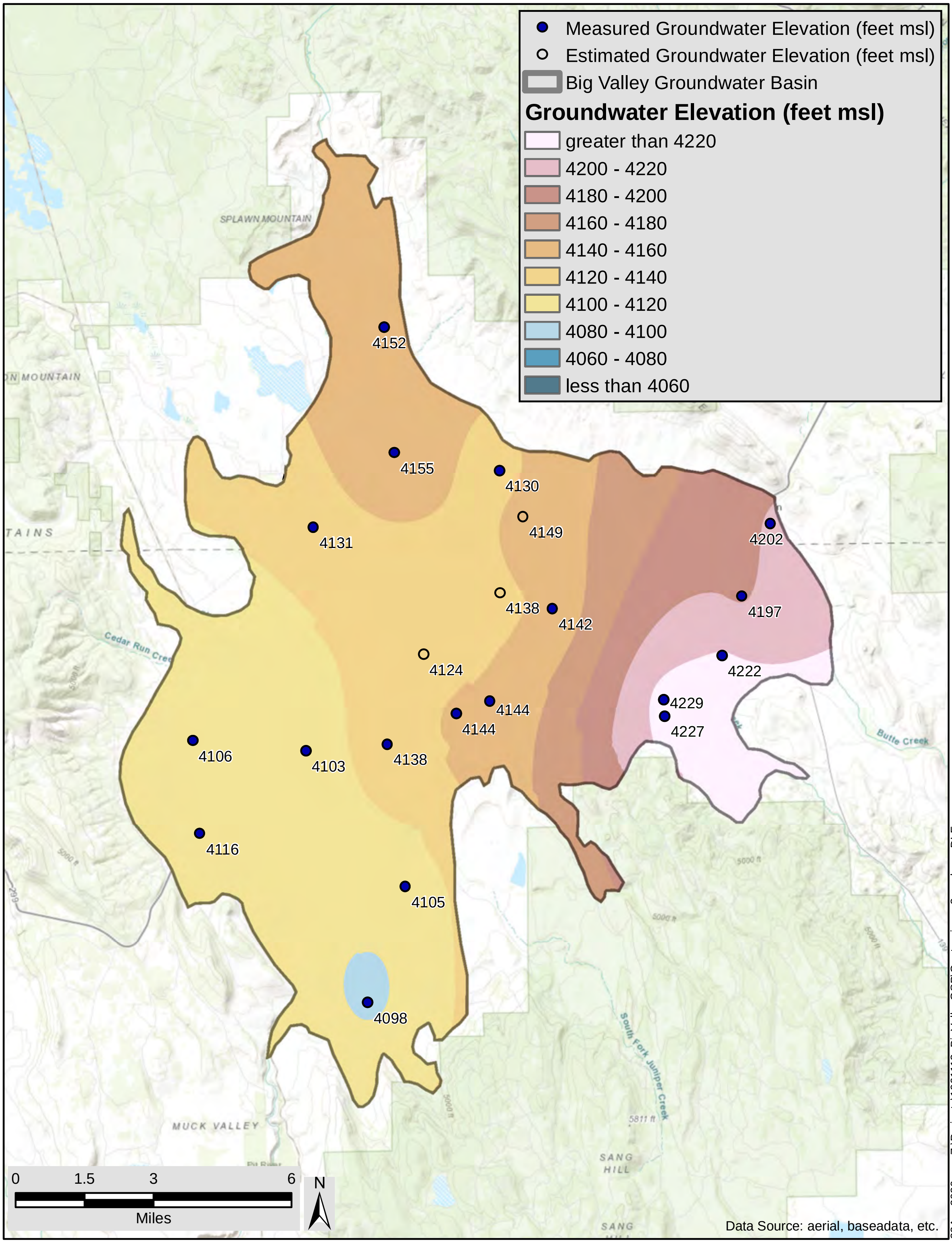
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1994		
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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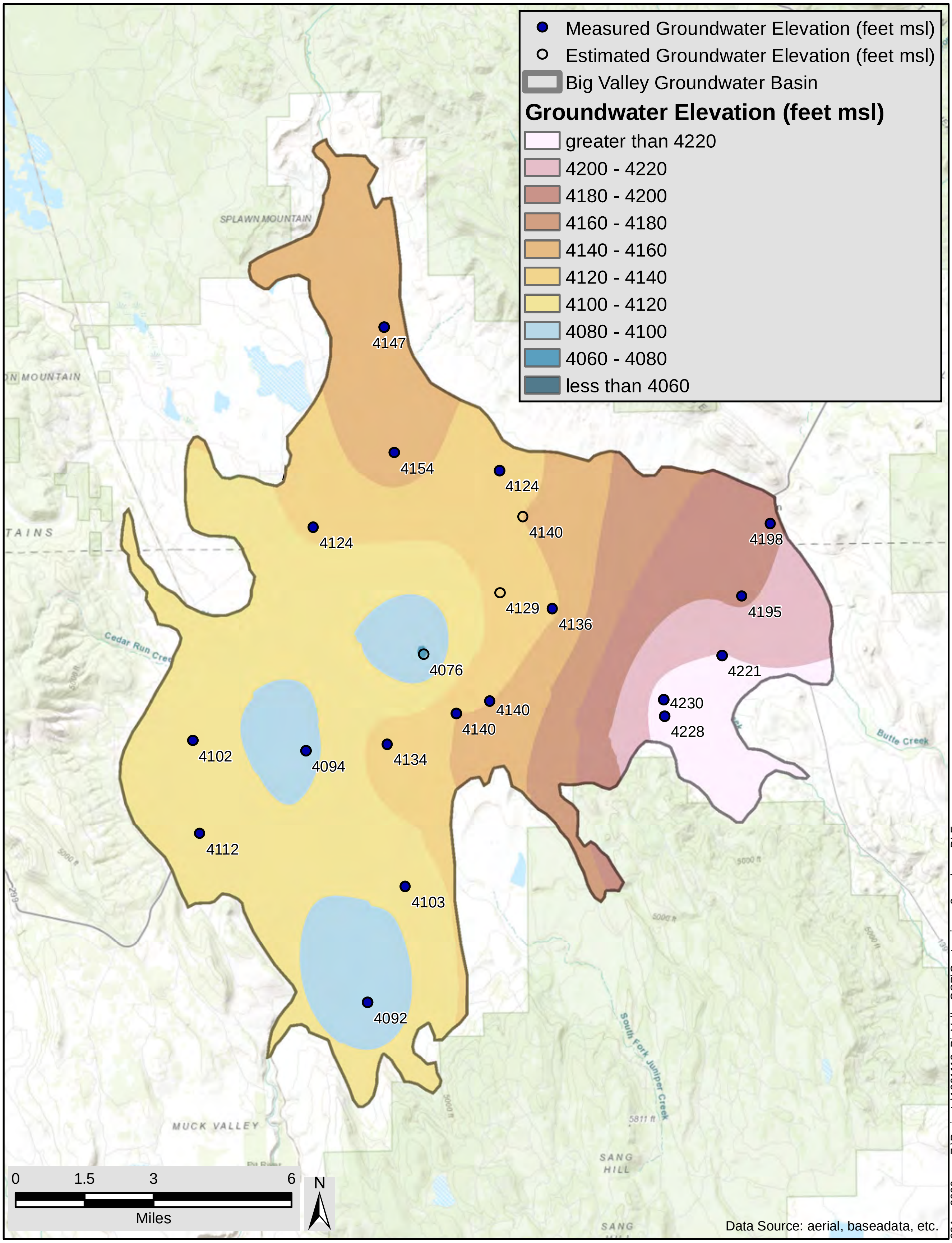
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1995
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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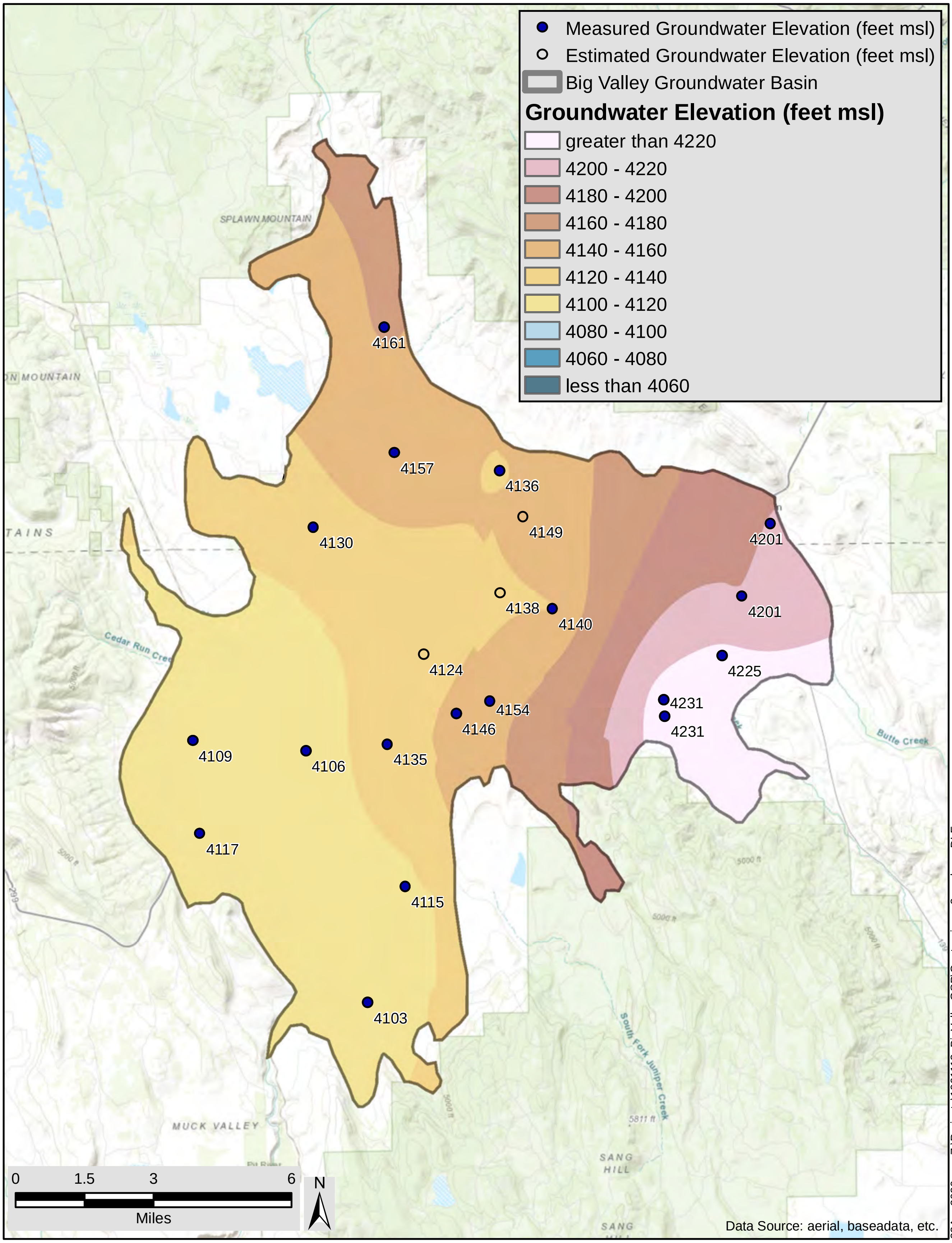
Big Valley Groundwater Basin GSAs		AUGUST 2020	DRAFT	FIGURE



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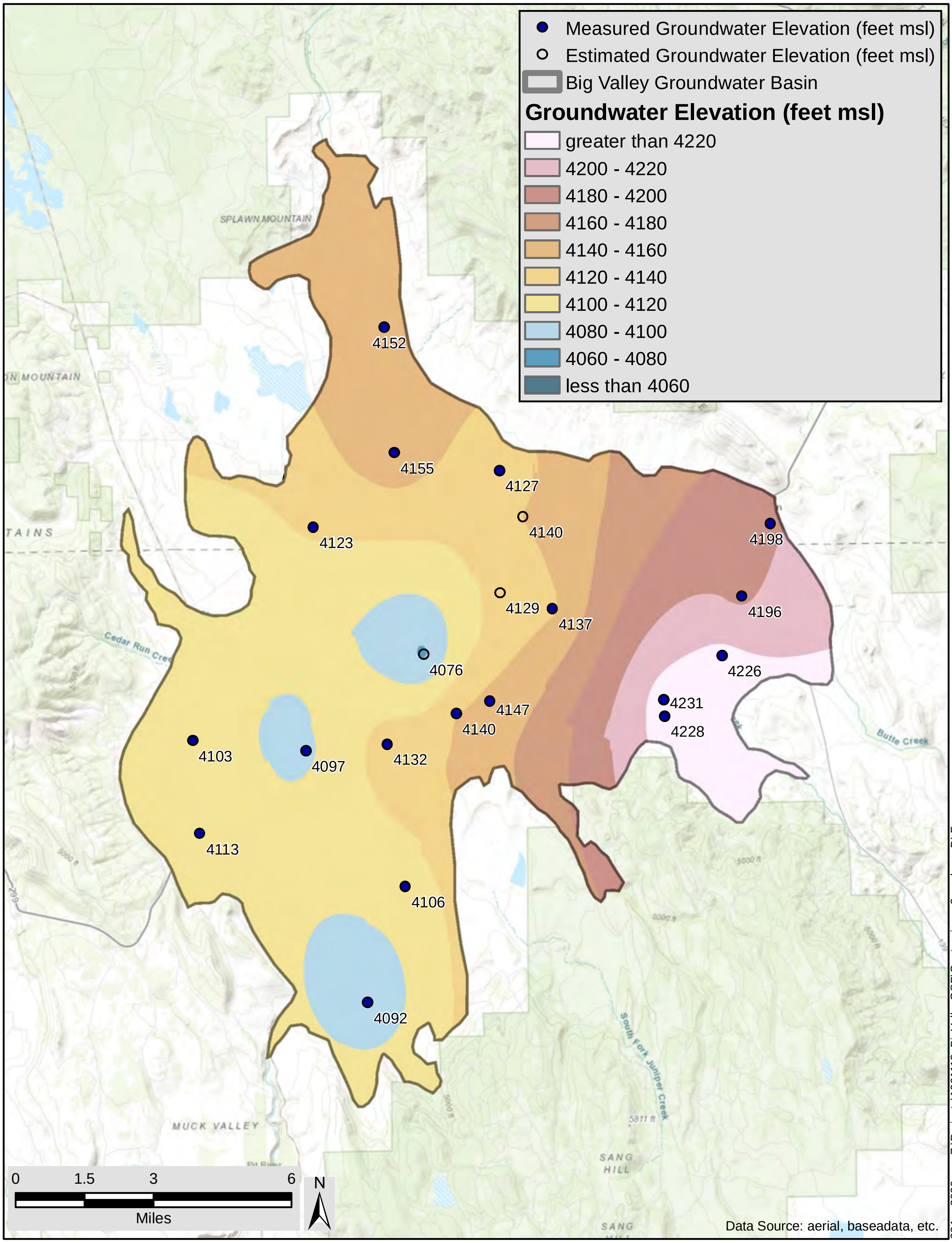
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1996
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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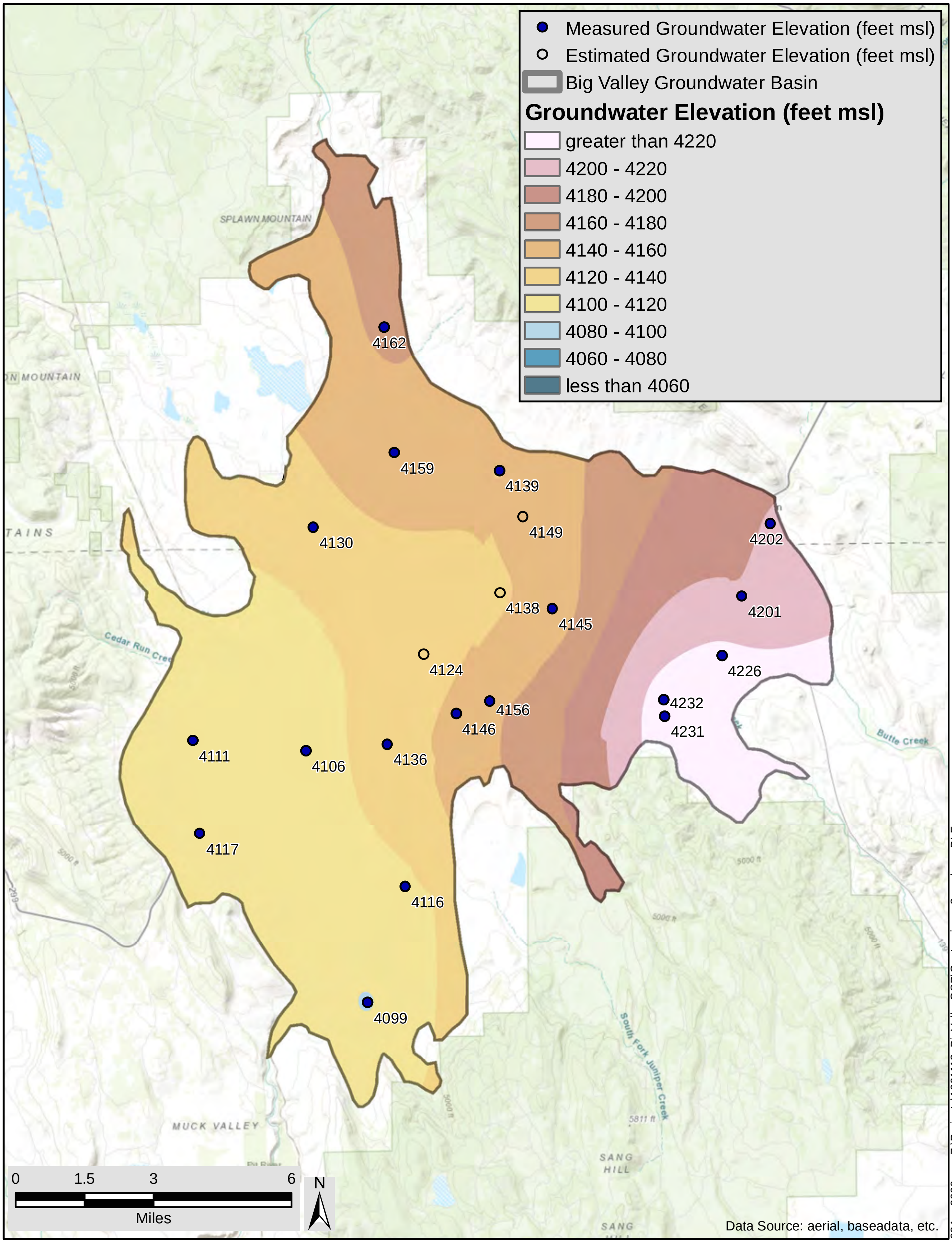
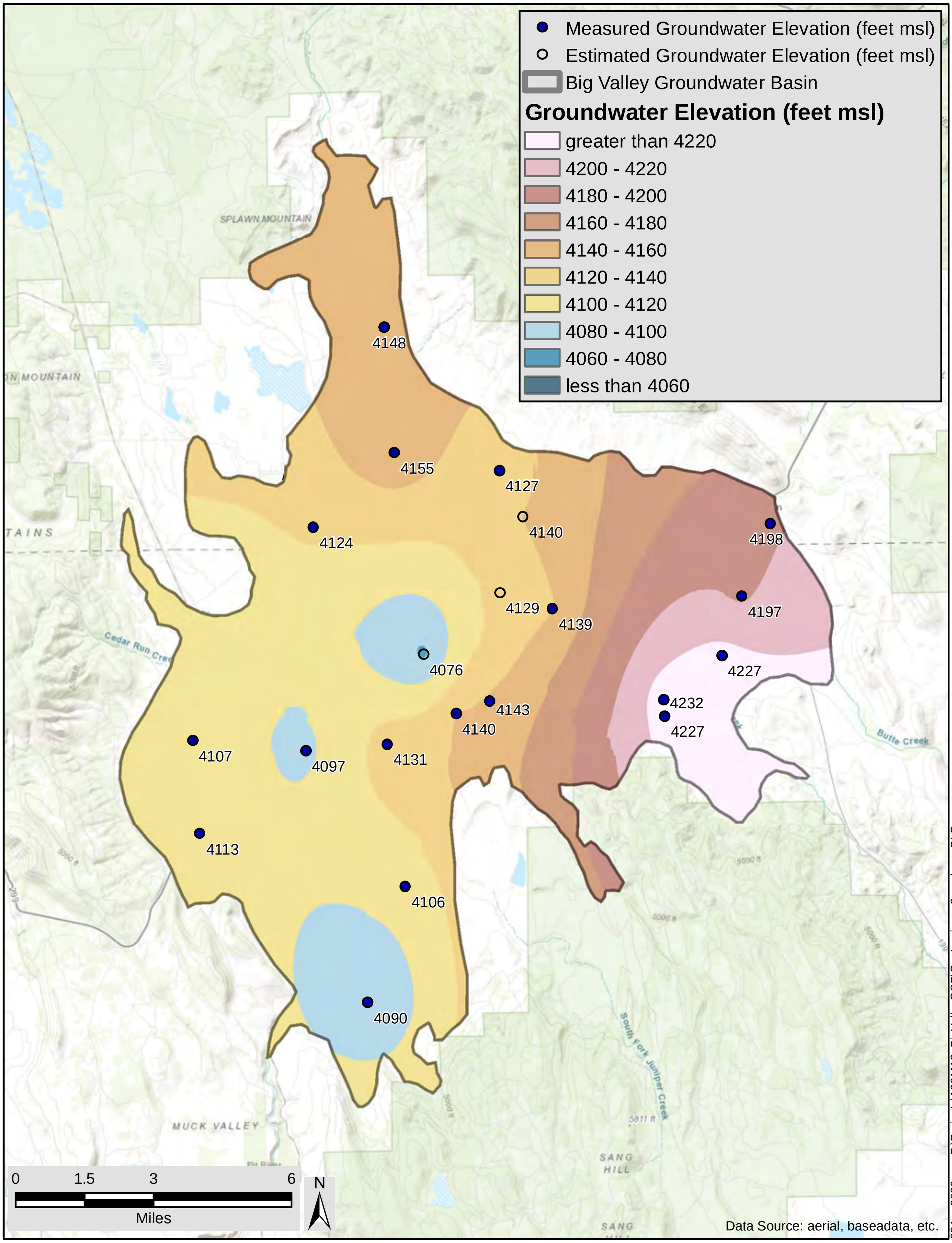
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1996
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1997
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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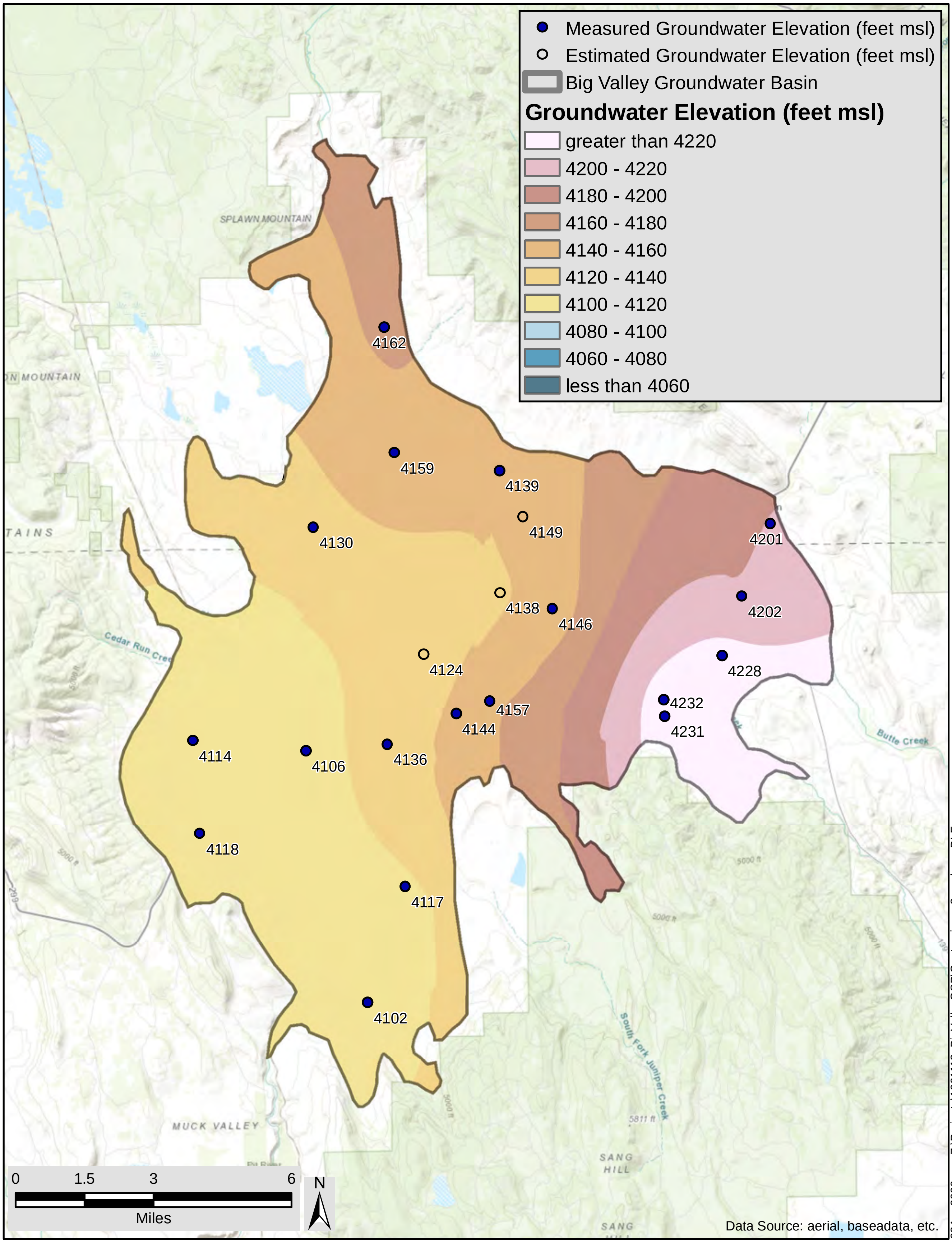
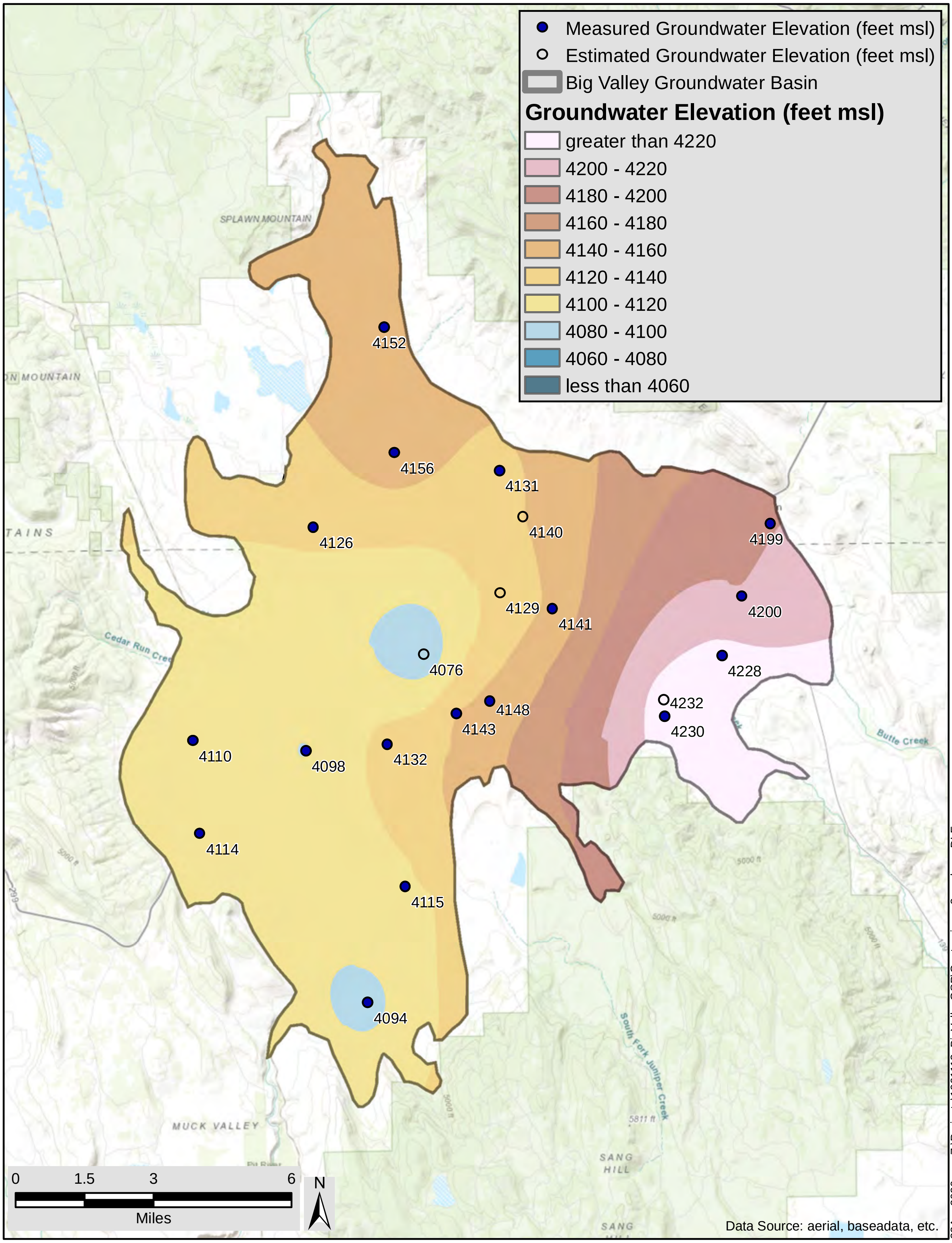
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1997
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1998
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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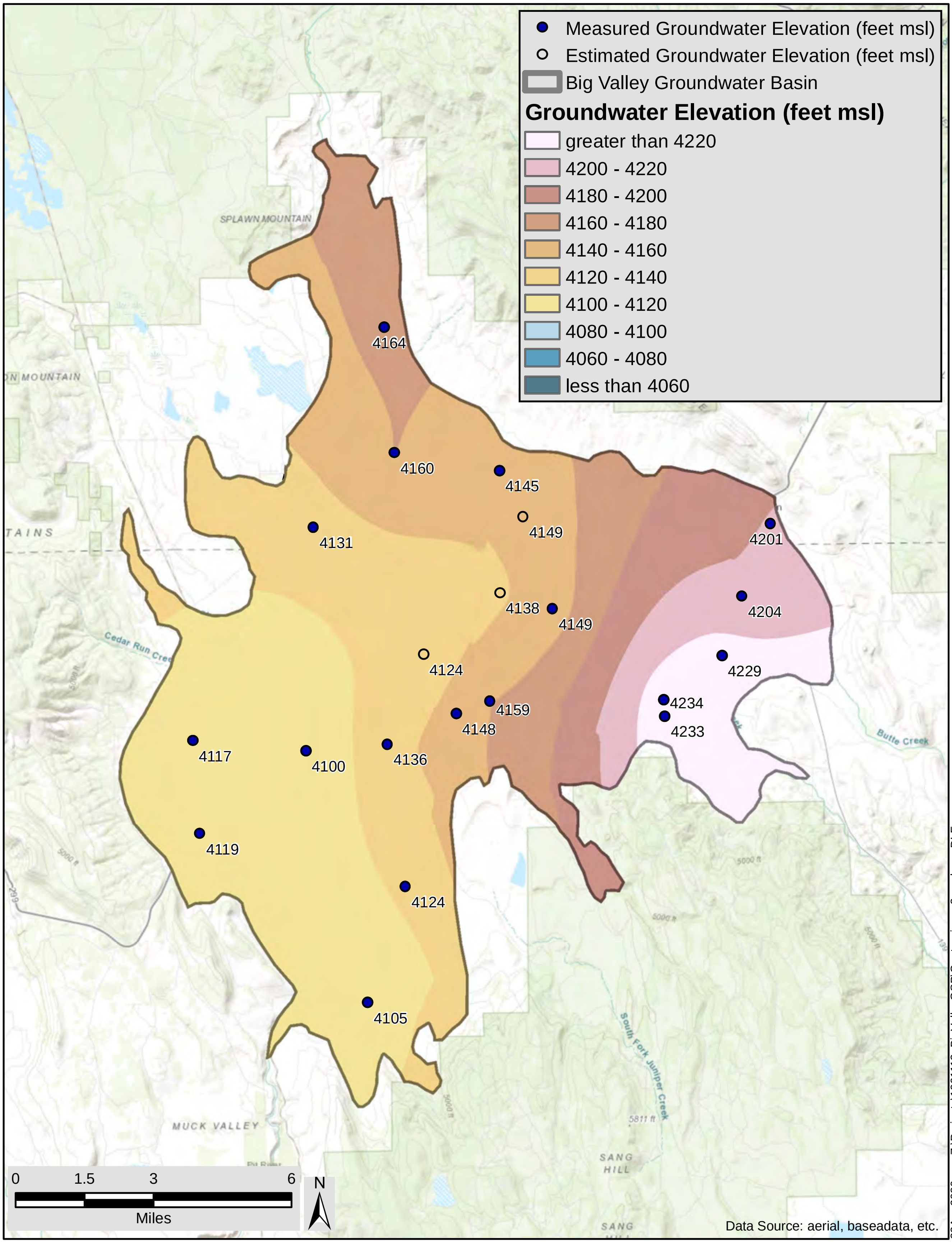
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 1998
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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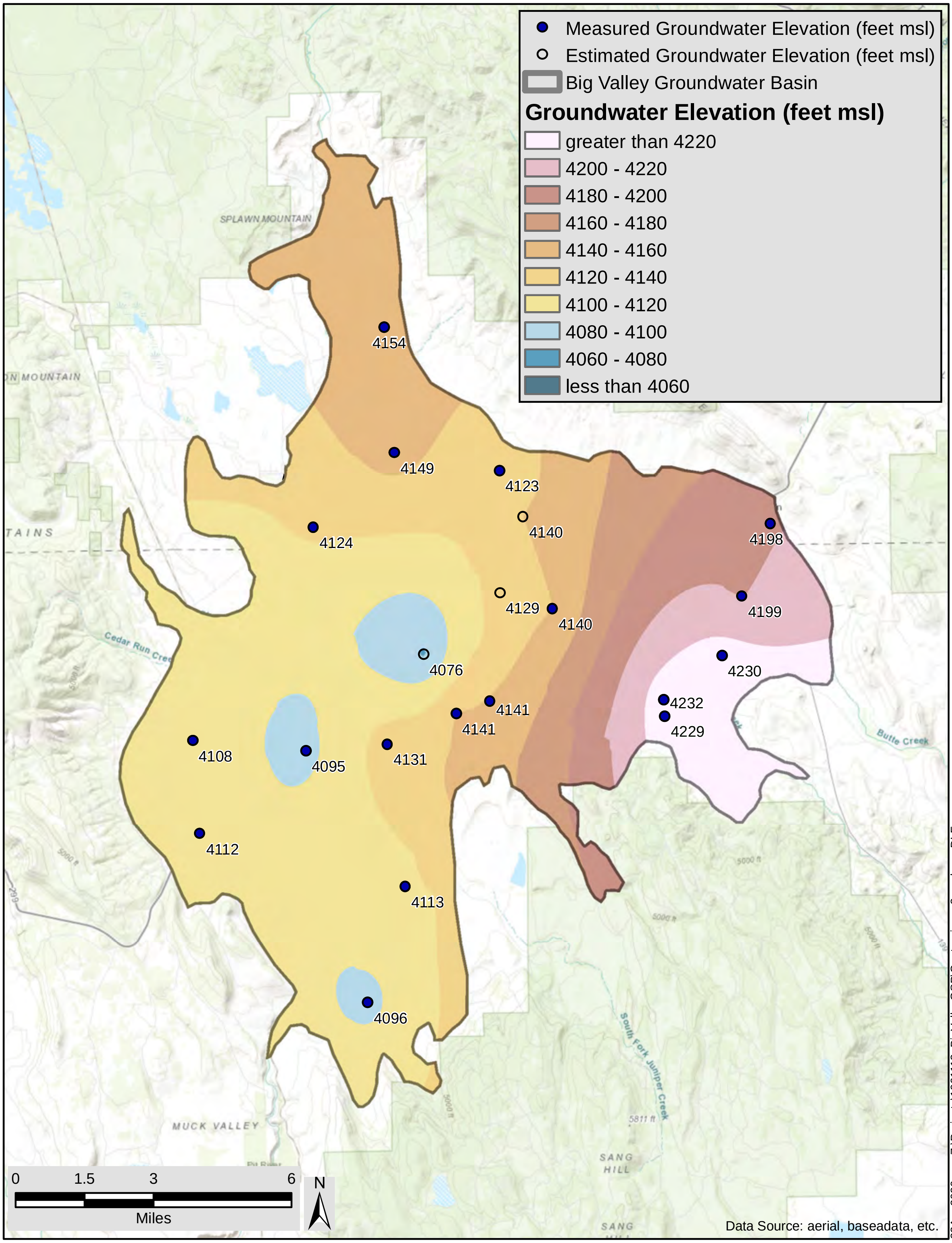
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Spring 1999
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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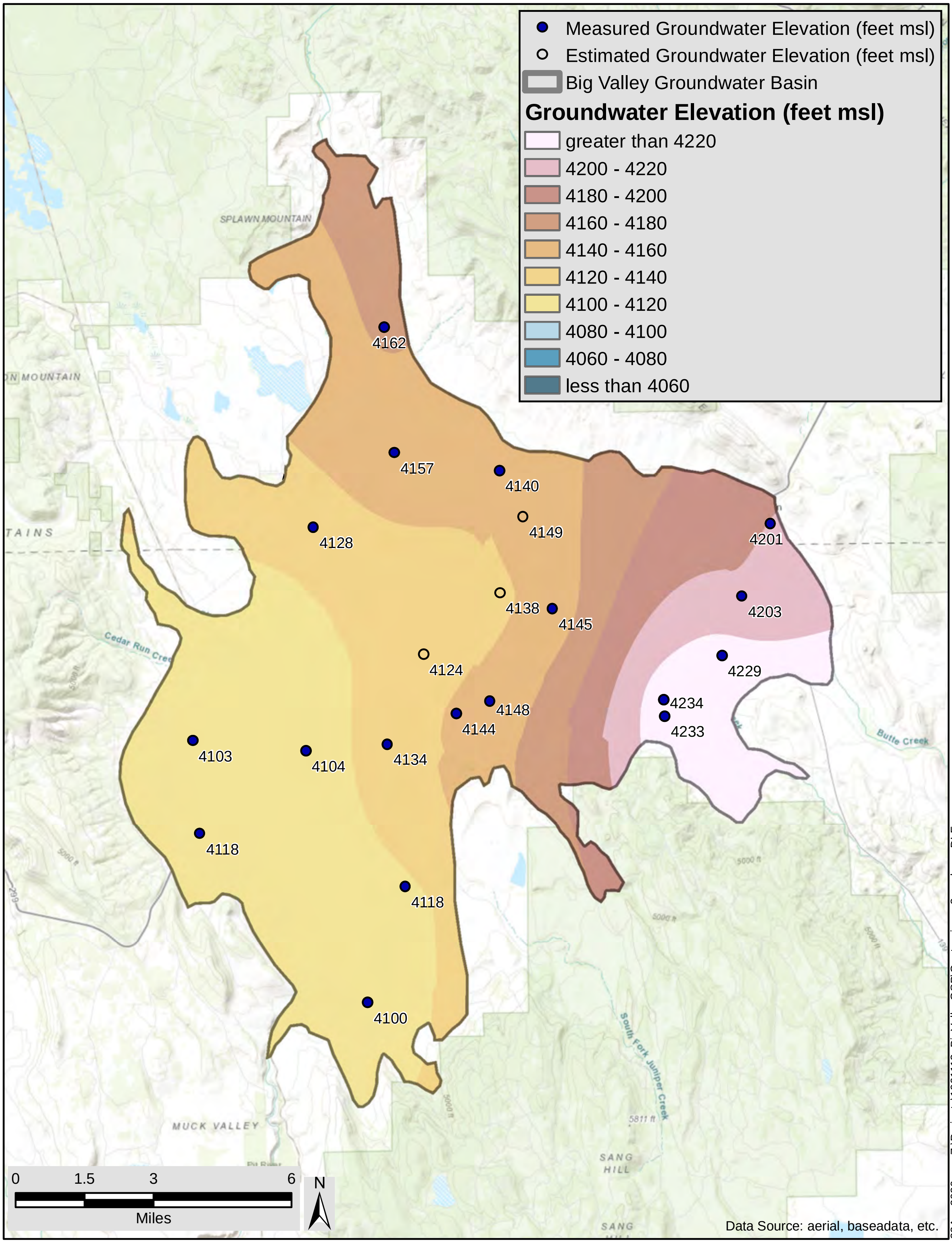

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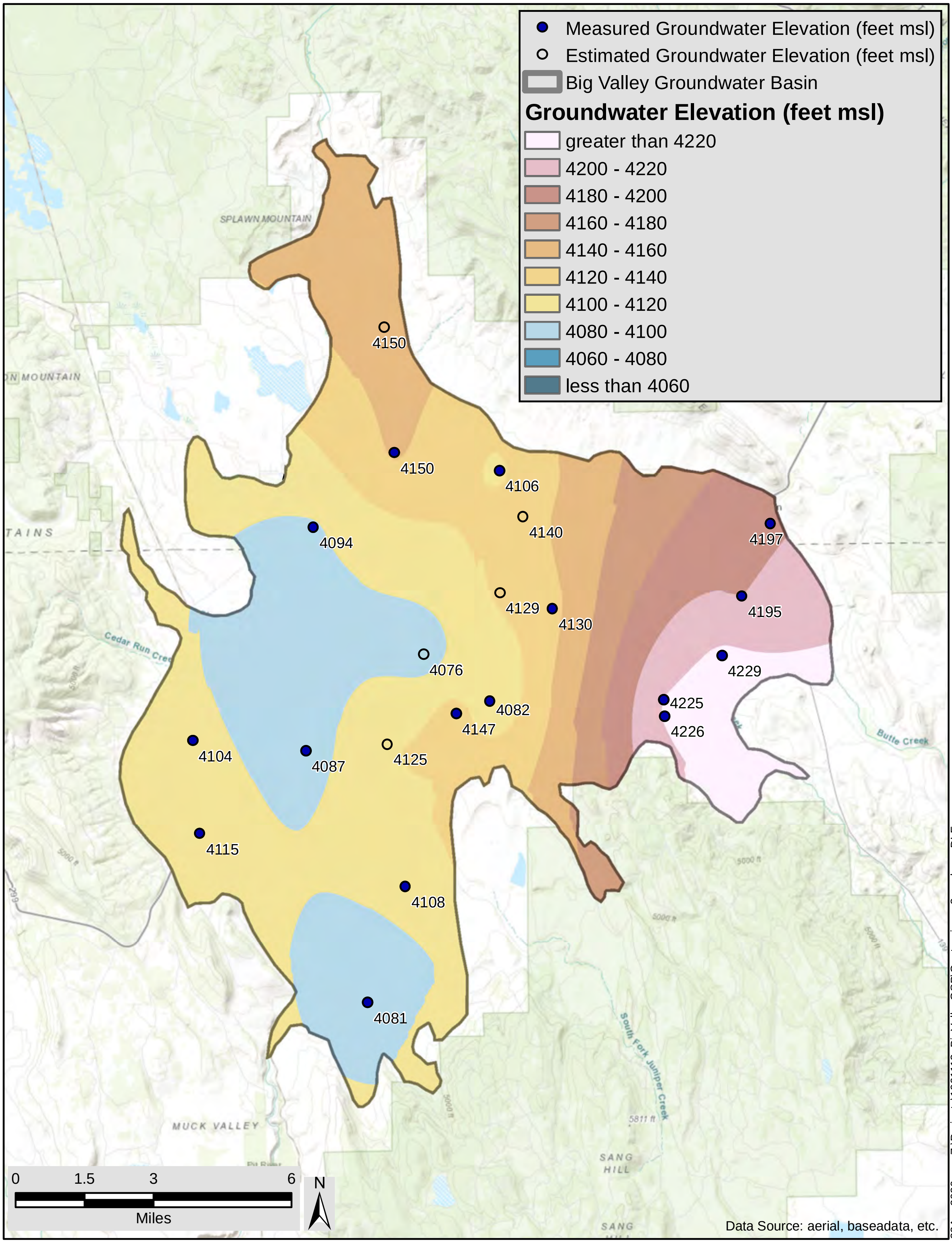

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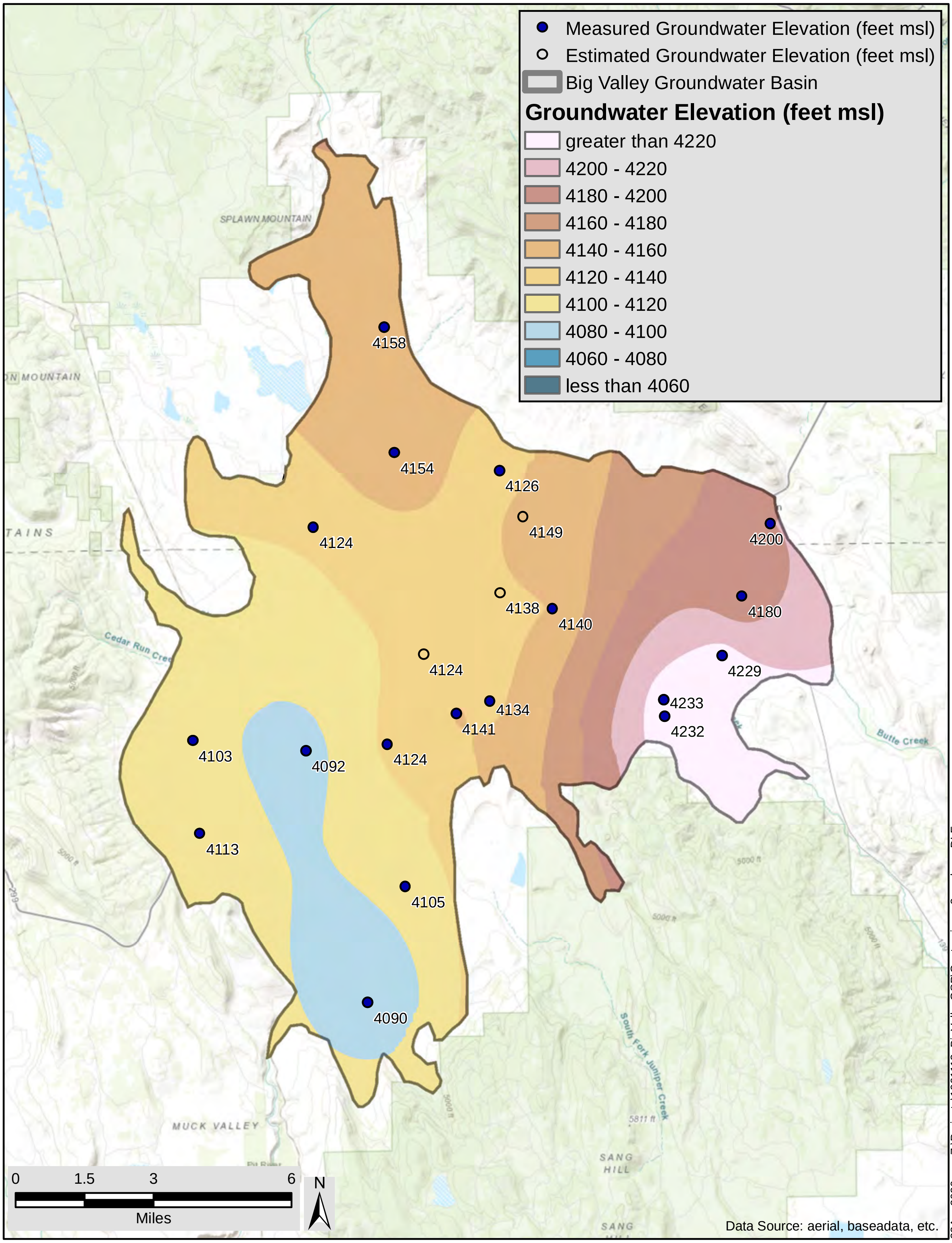

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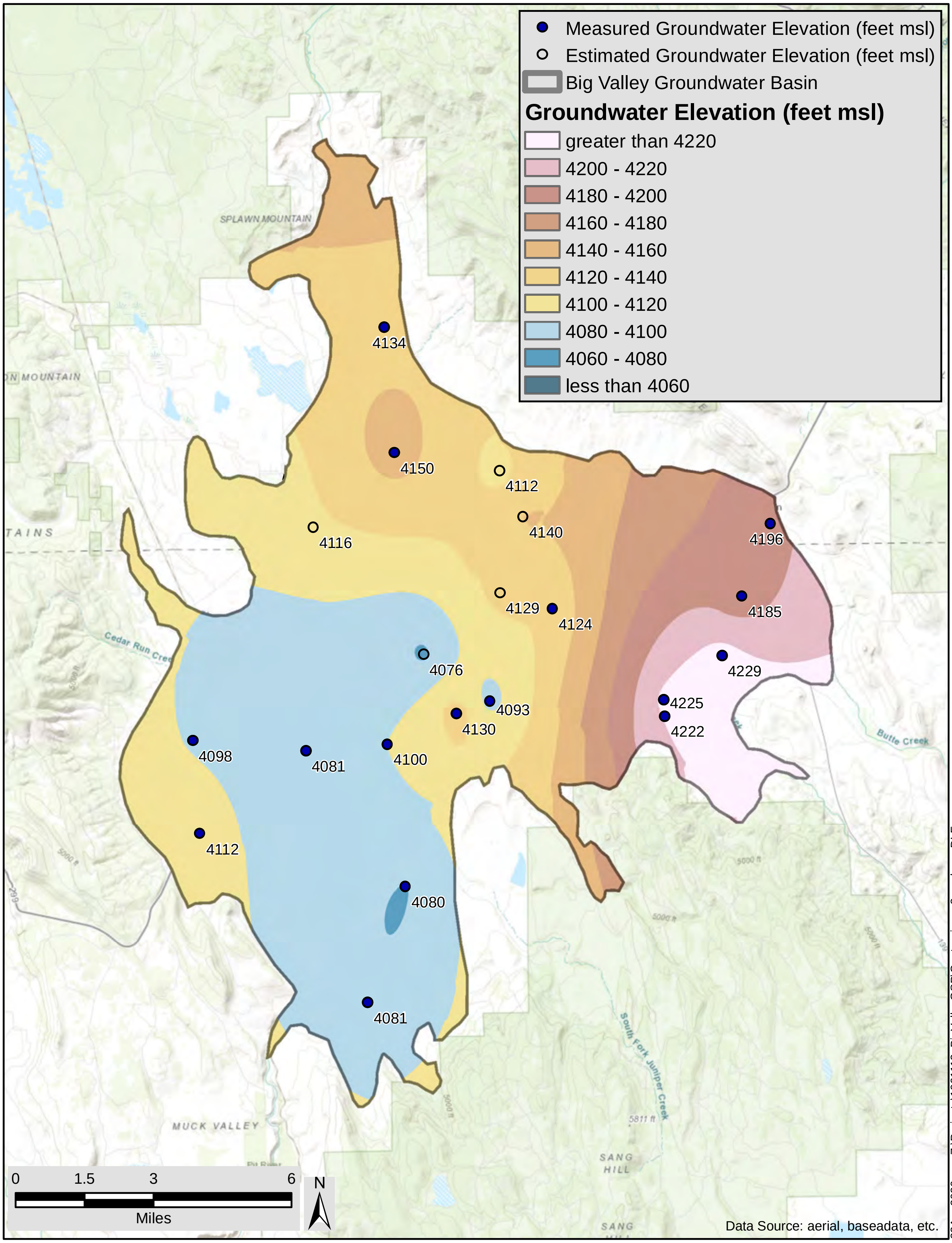

Big Valley Basin Groundwater Sustainability Plan
Modoc and Lassen Counties, California

Big Valley Groundwater Basin GSAs

GEI Consultants

Groundwater Elevations
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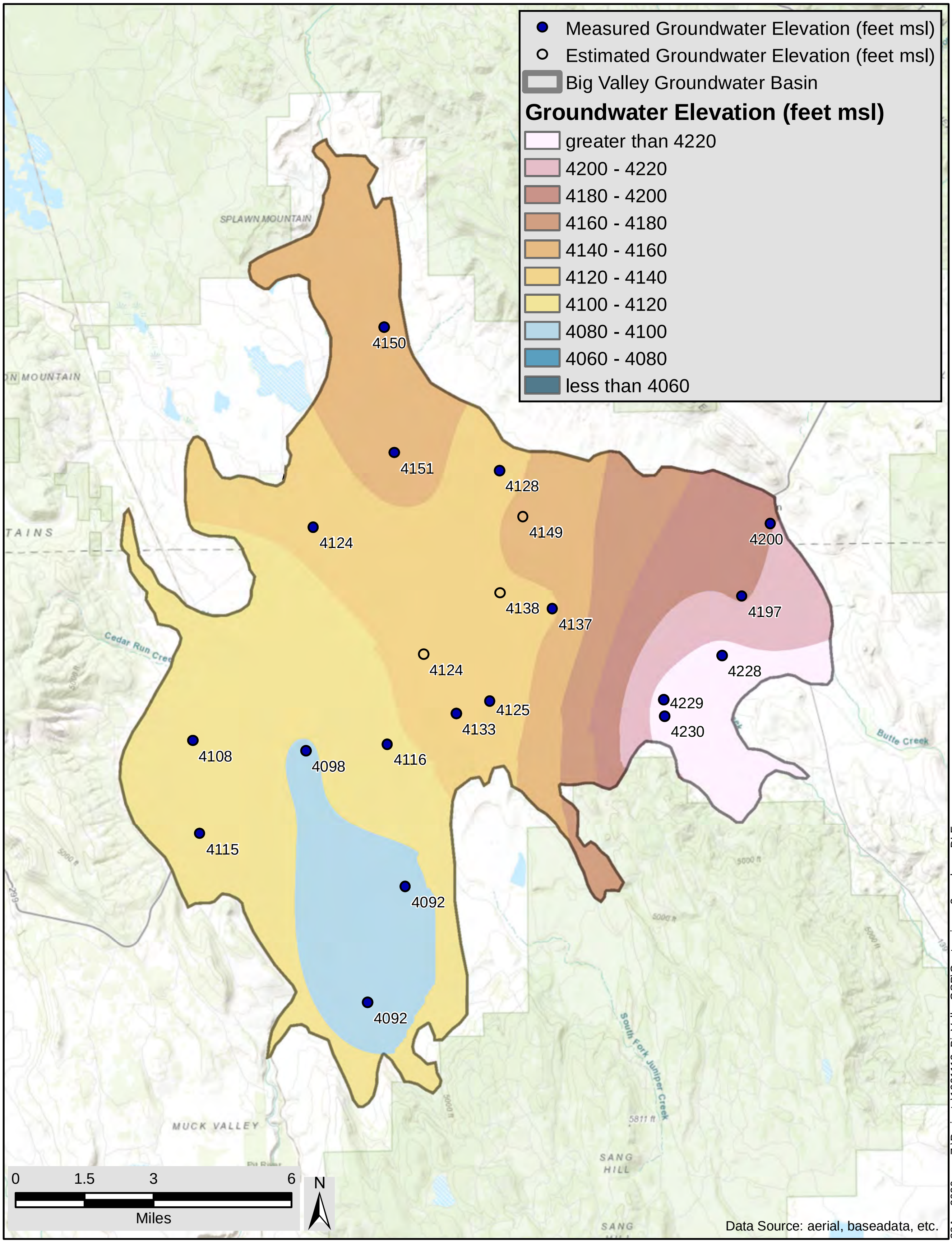

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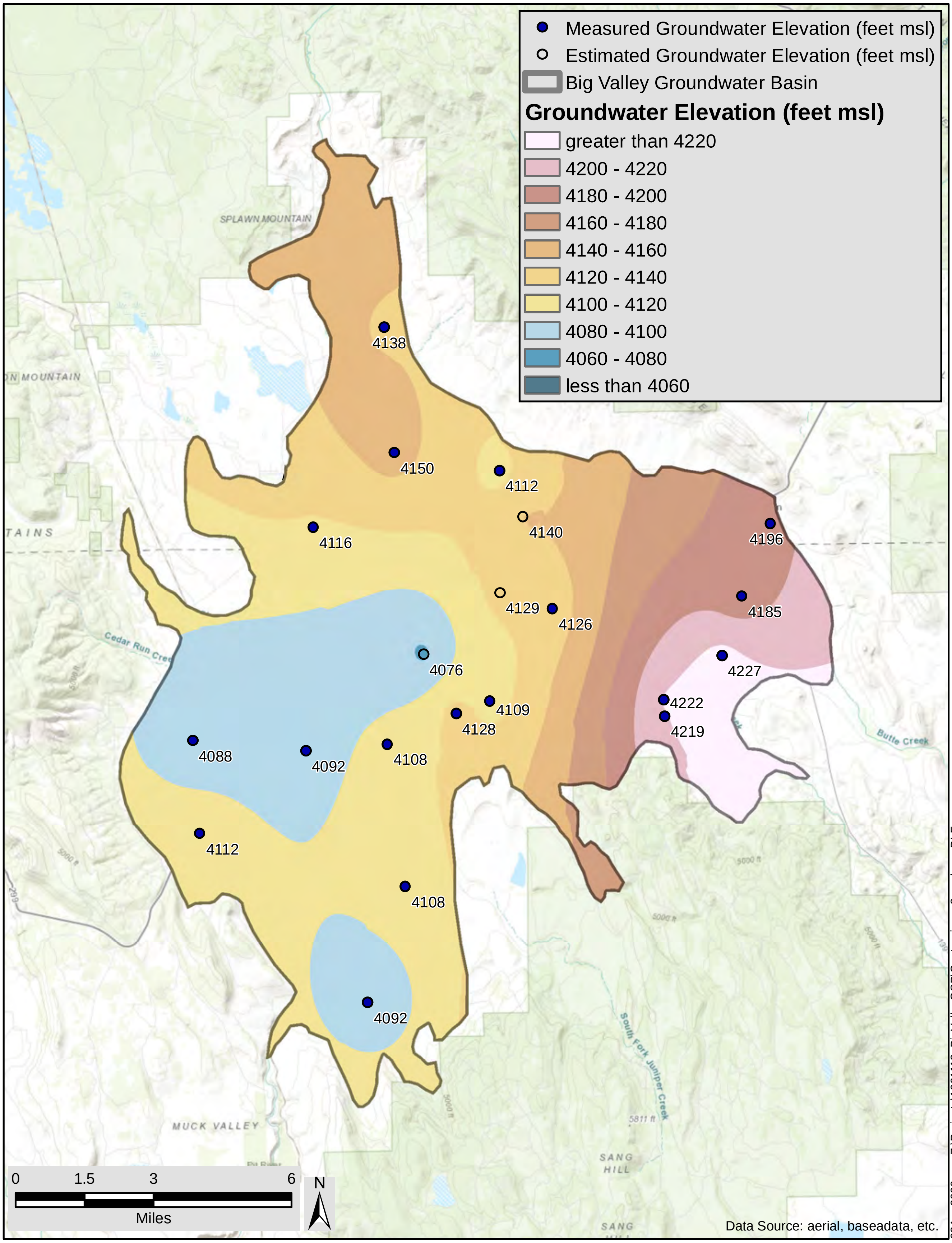

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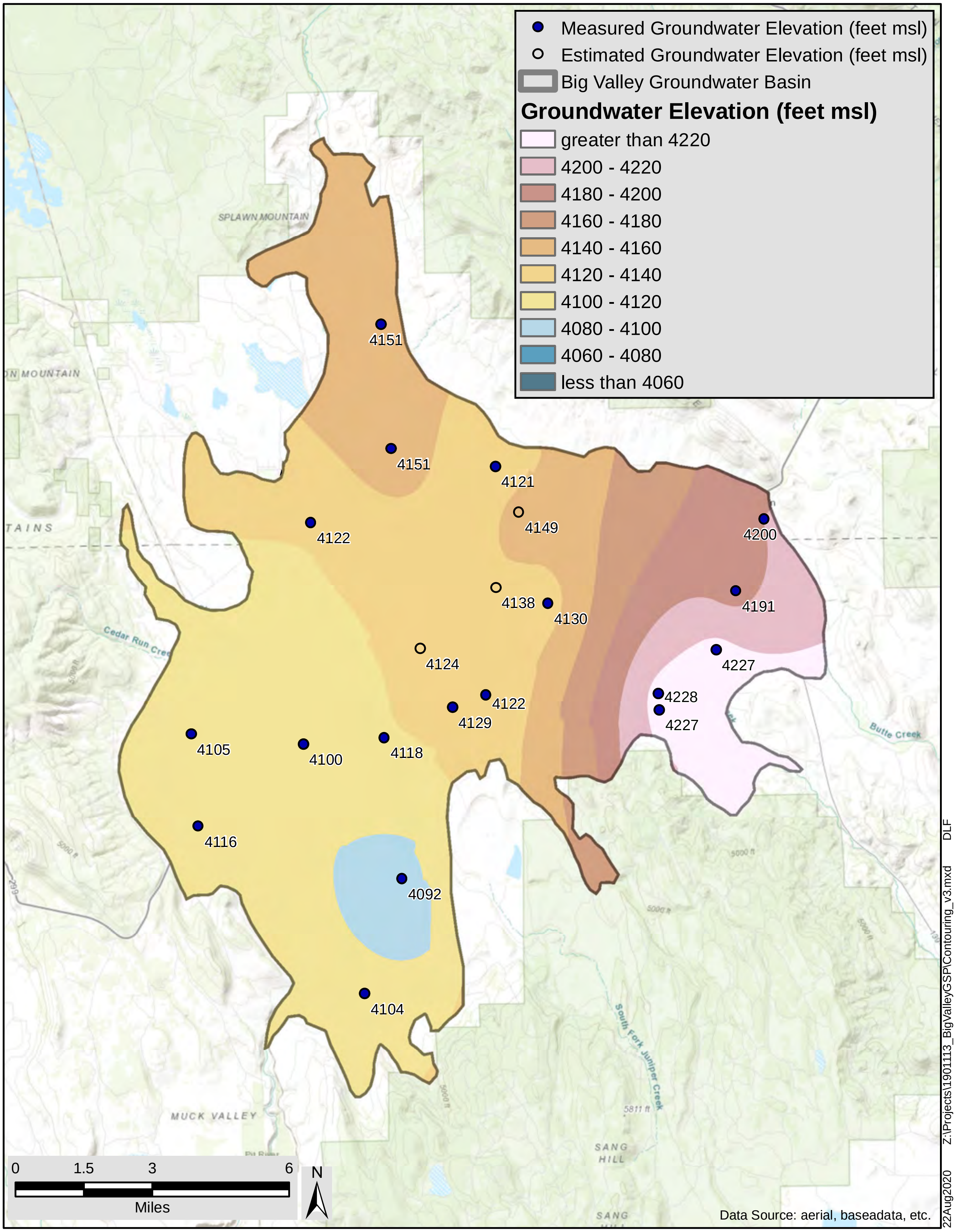

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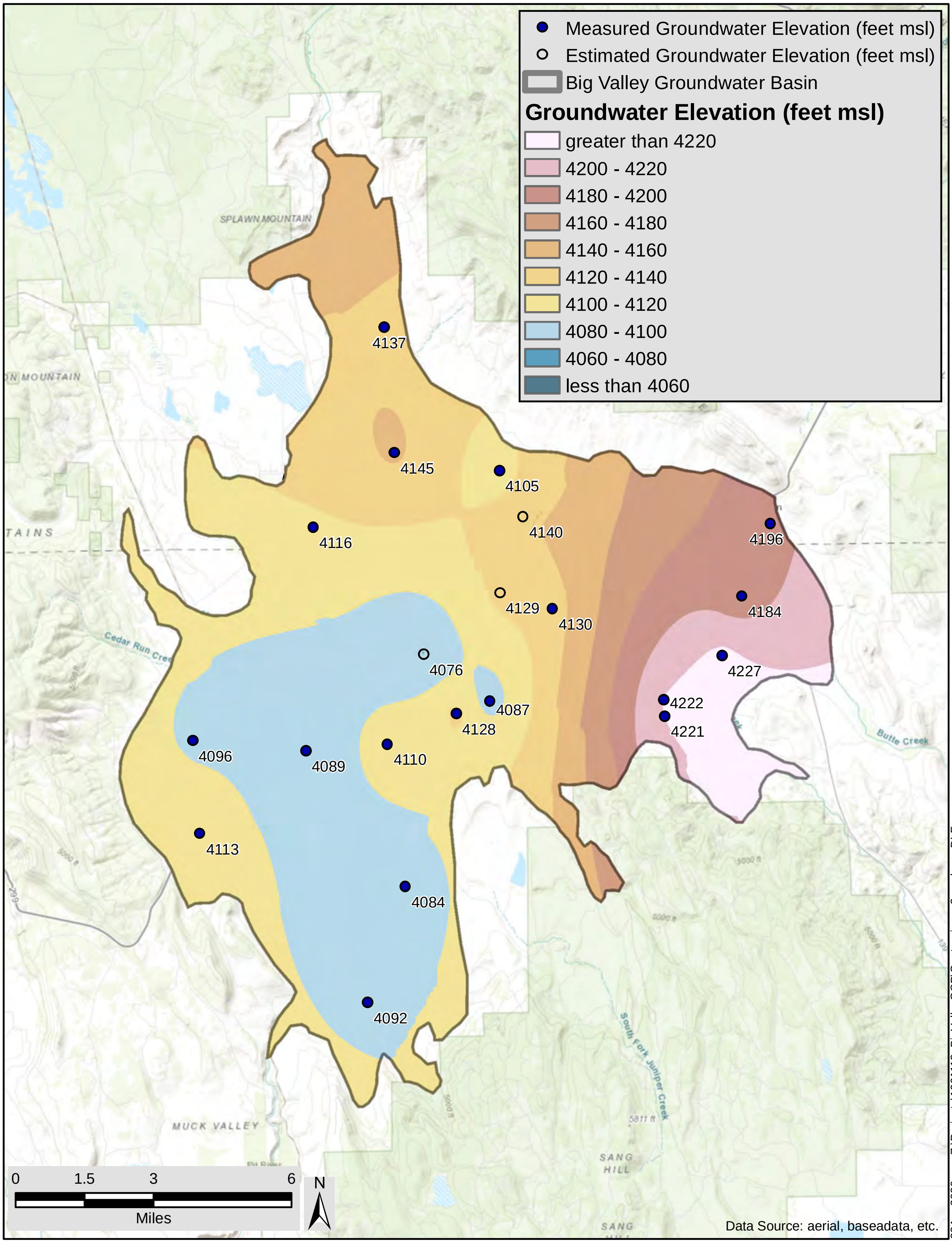

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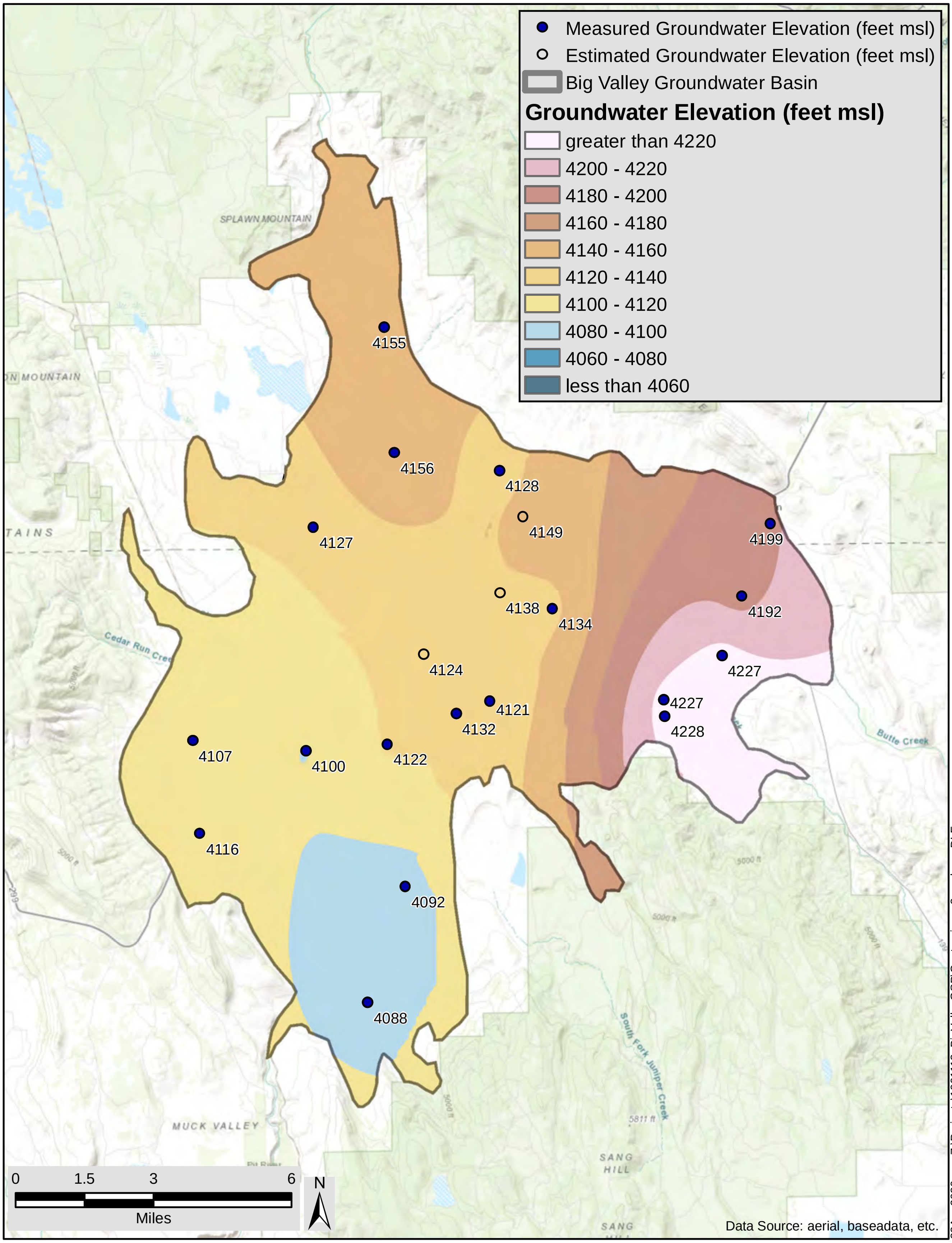
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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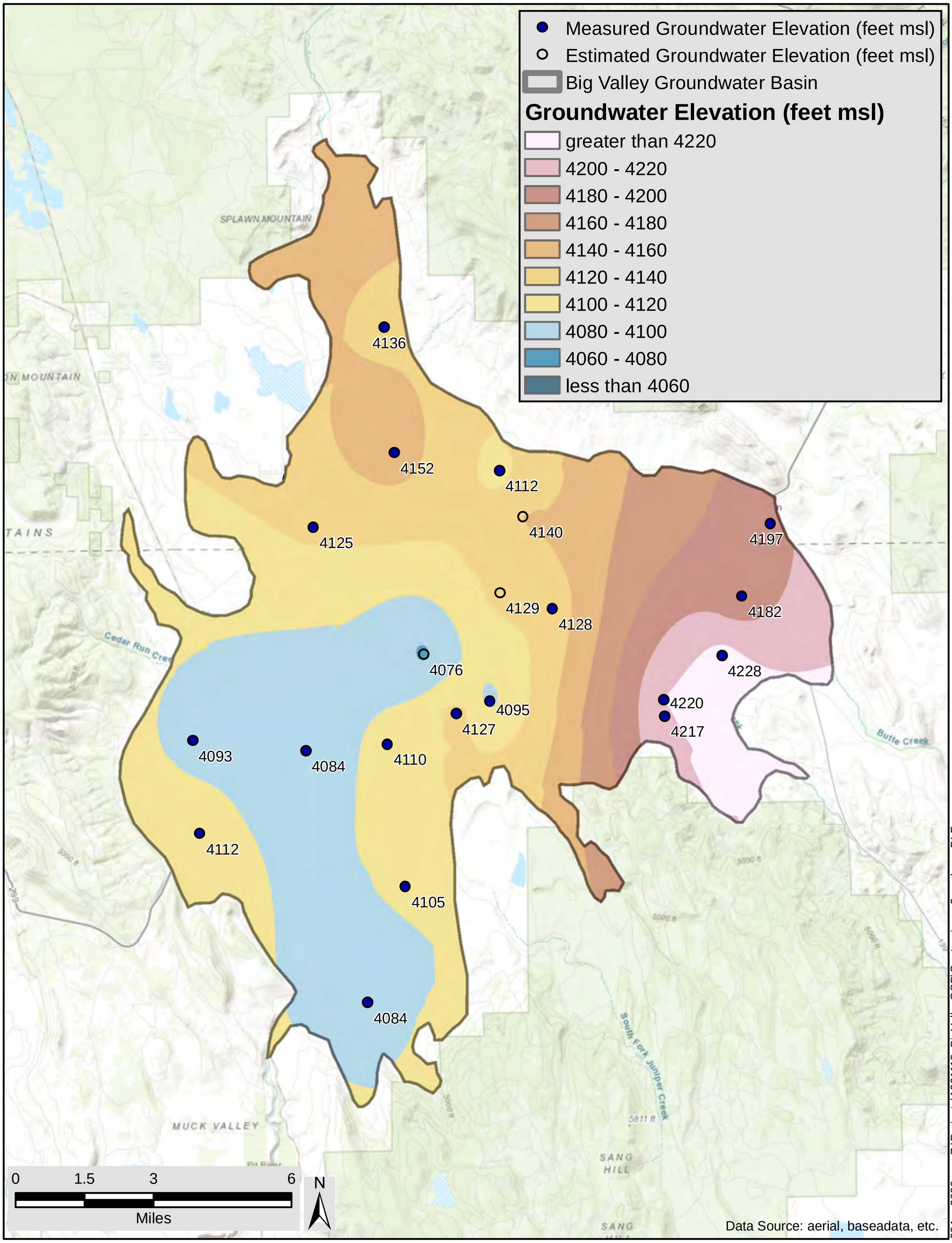

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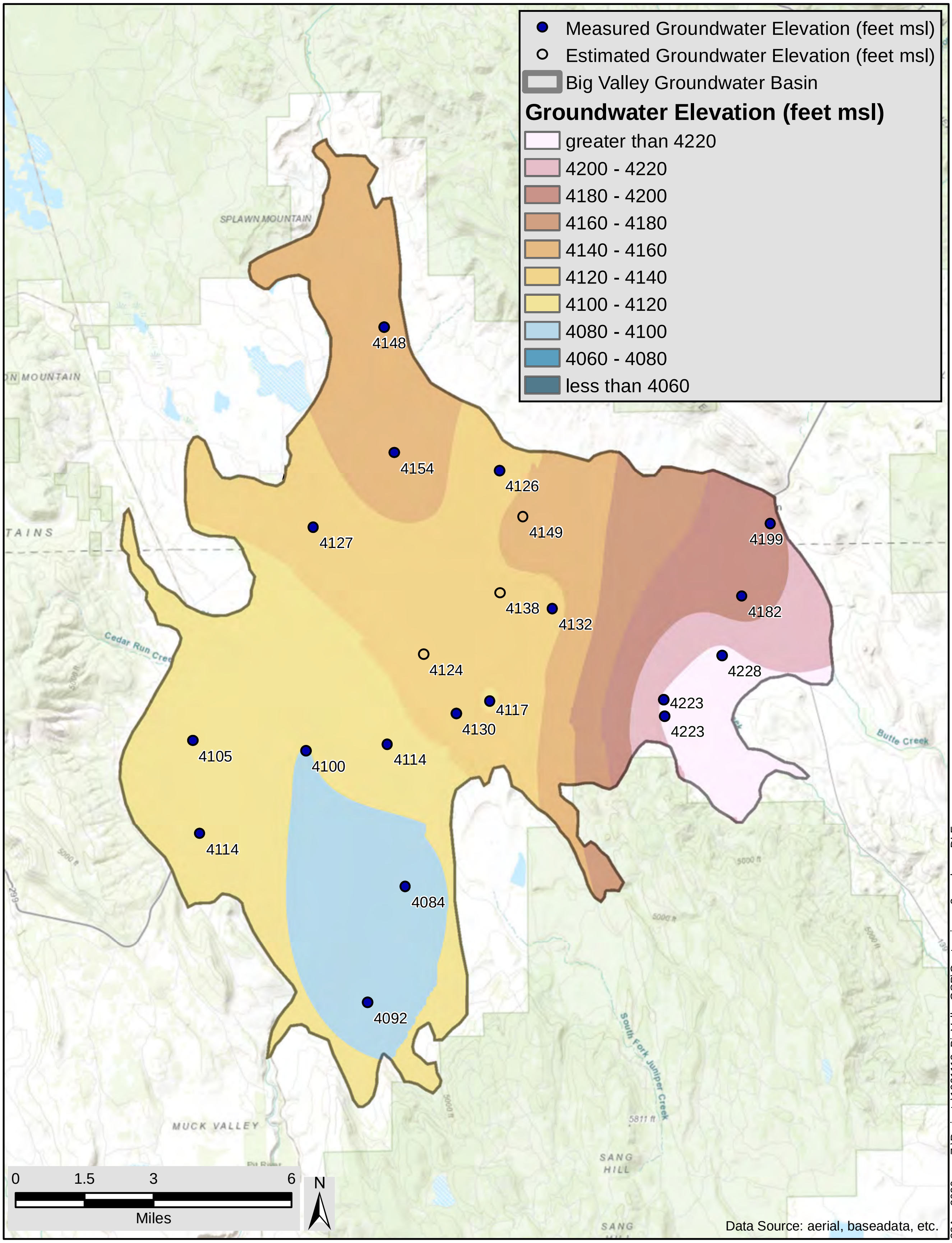

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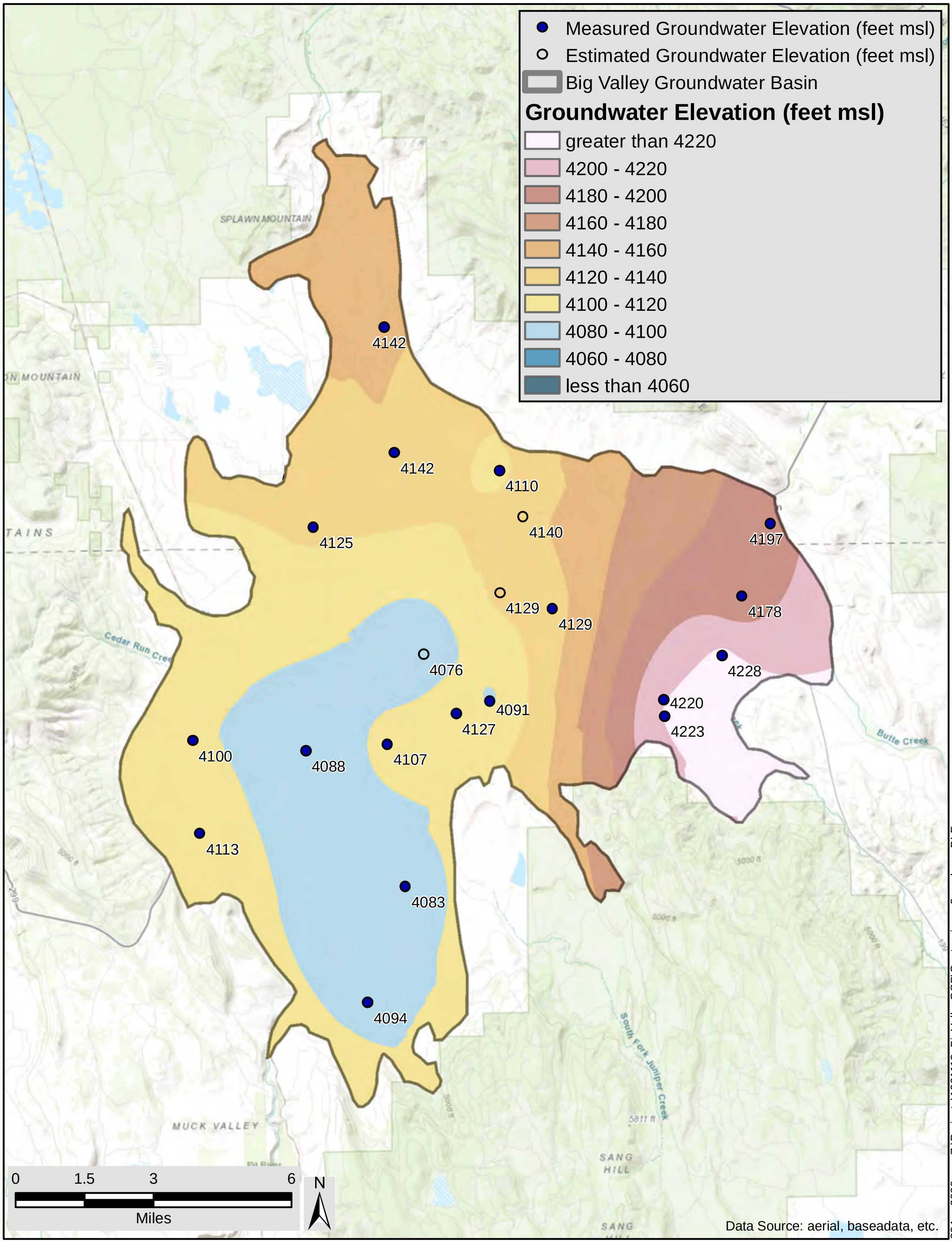
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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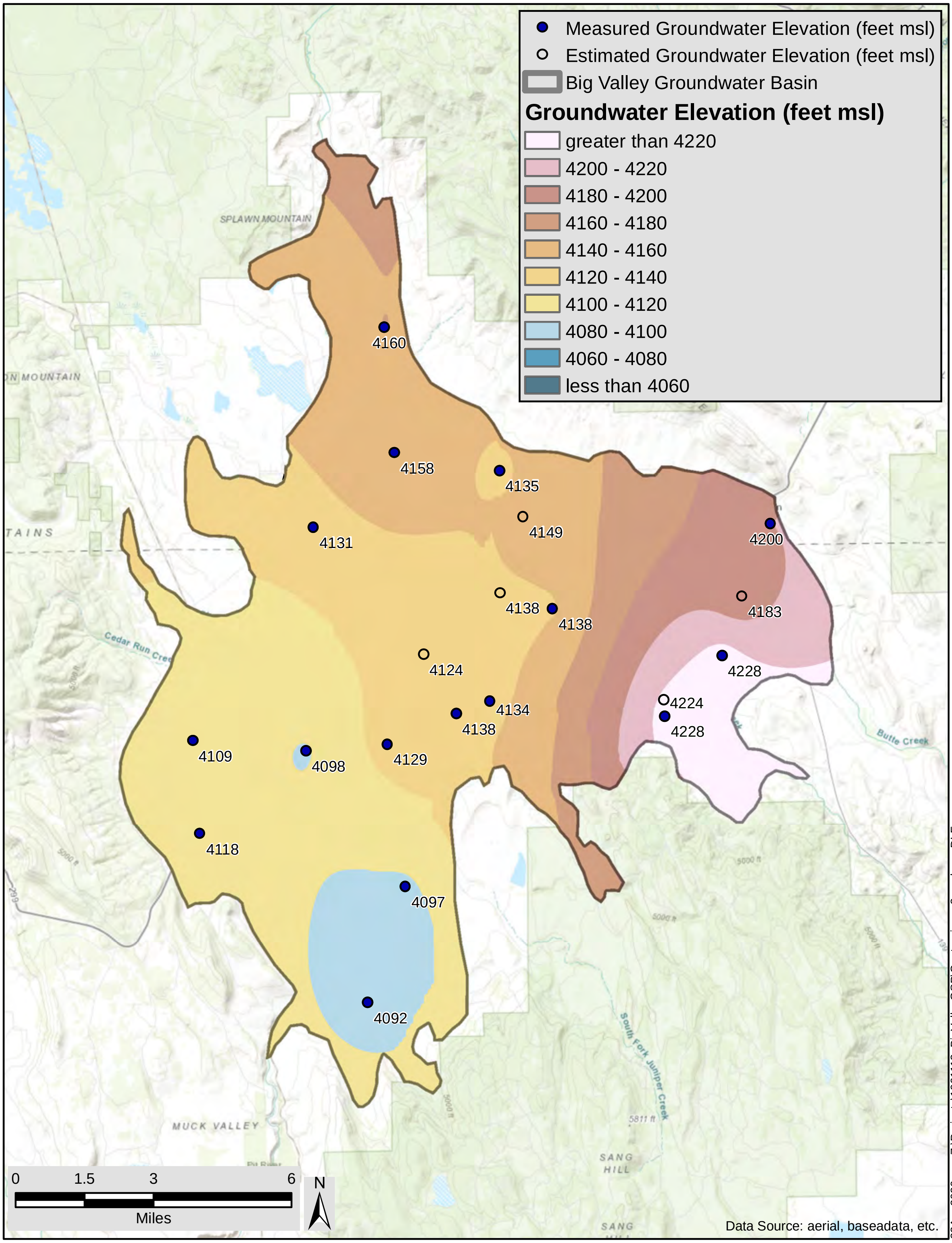
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE



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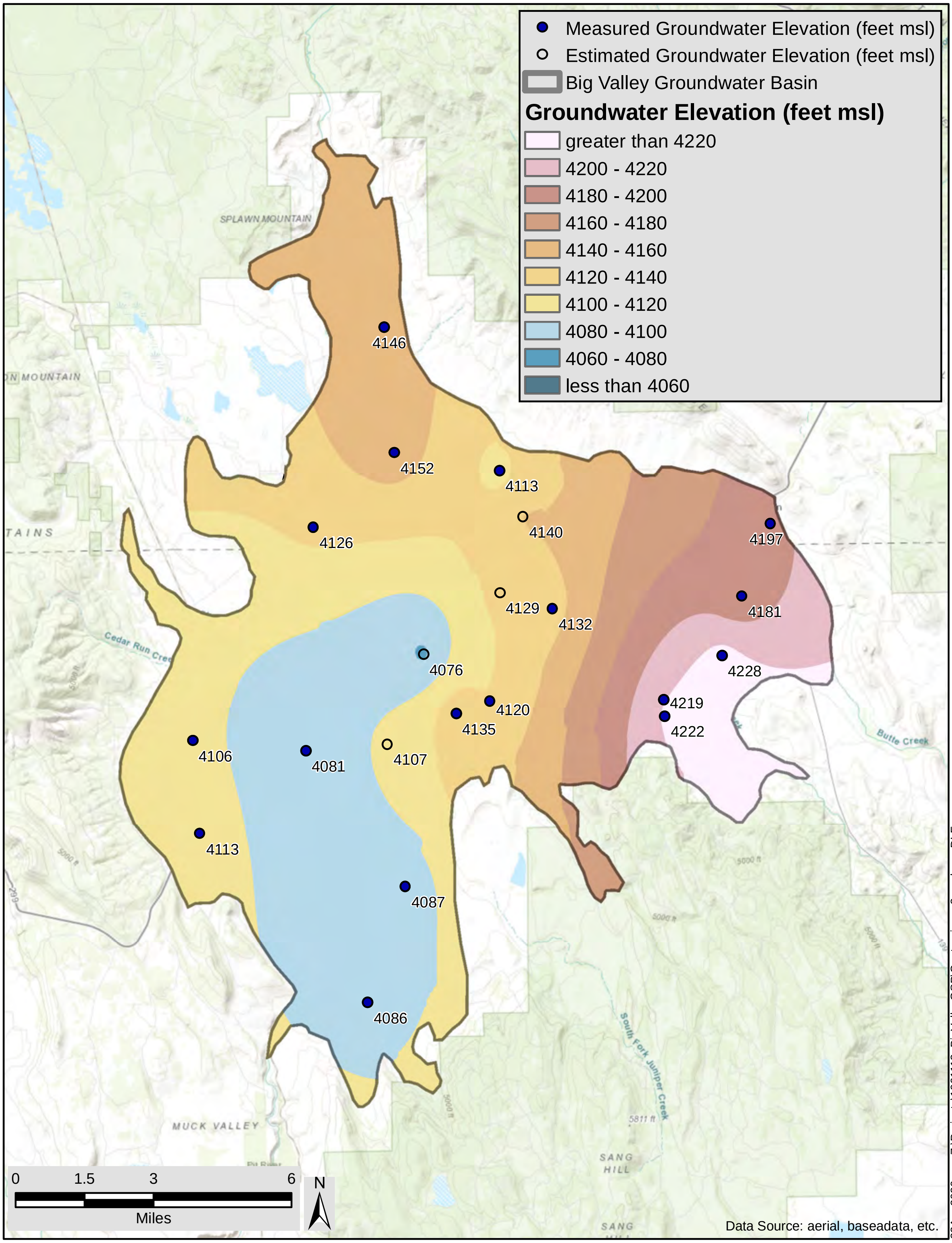

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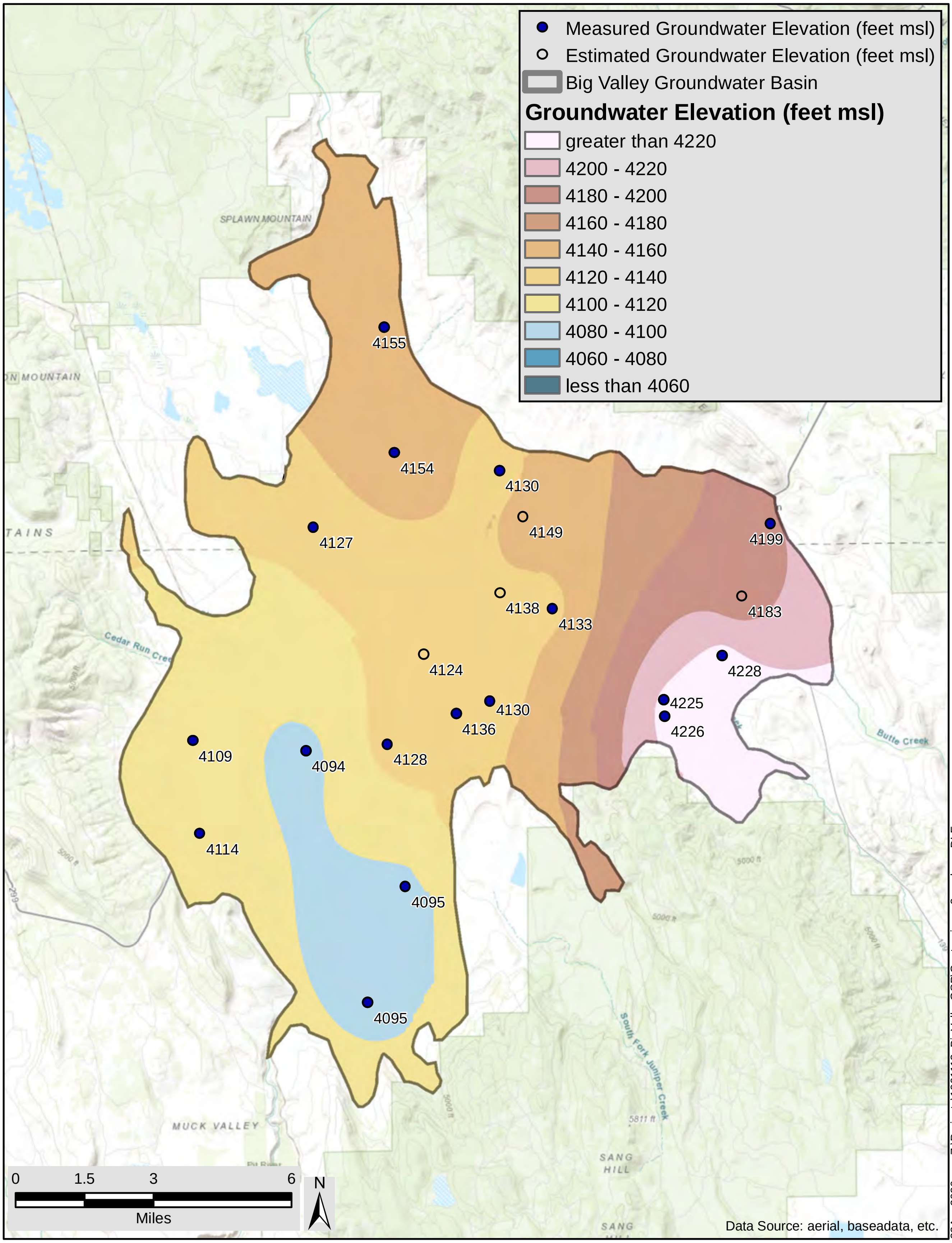

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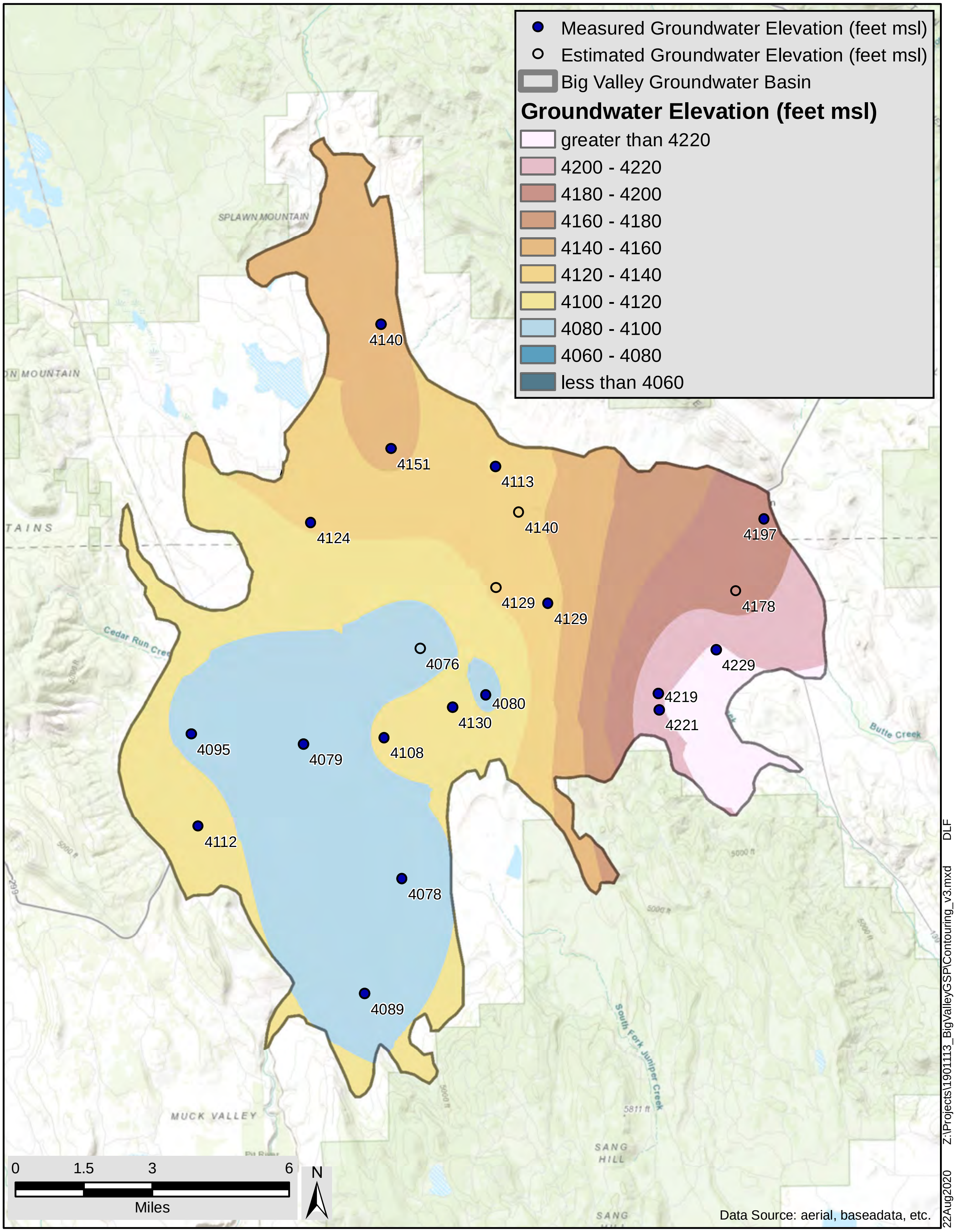

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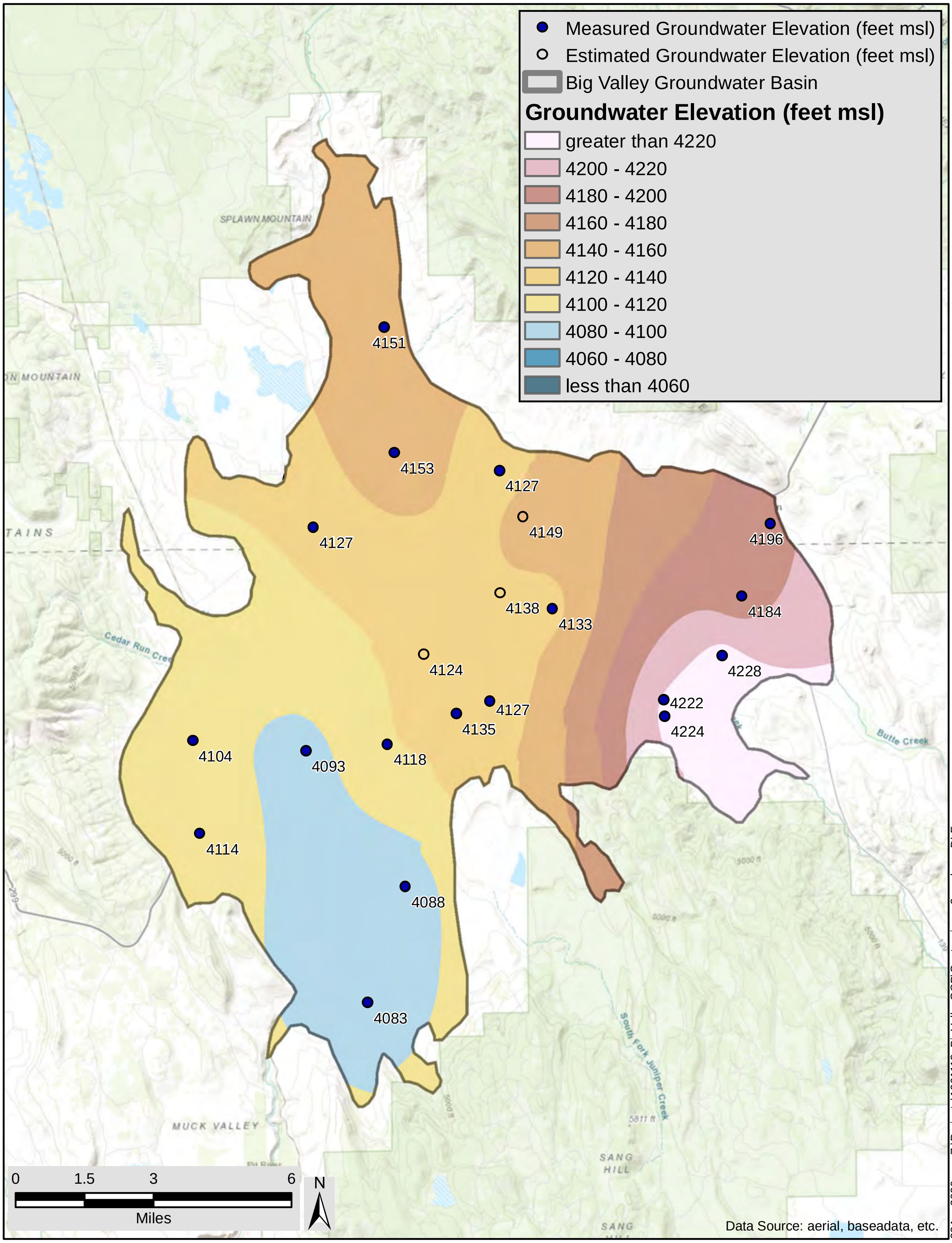

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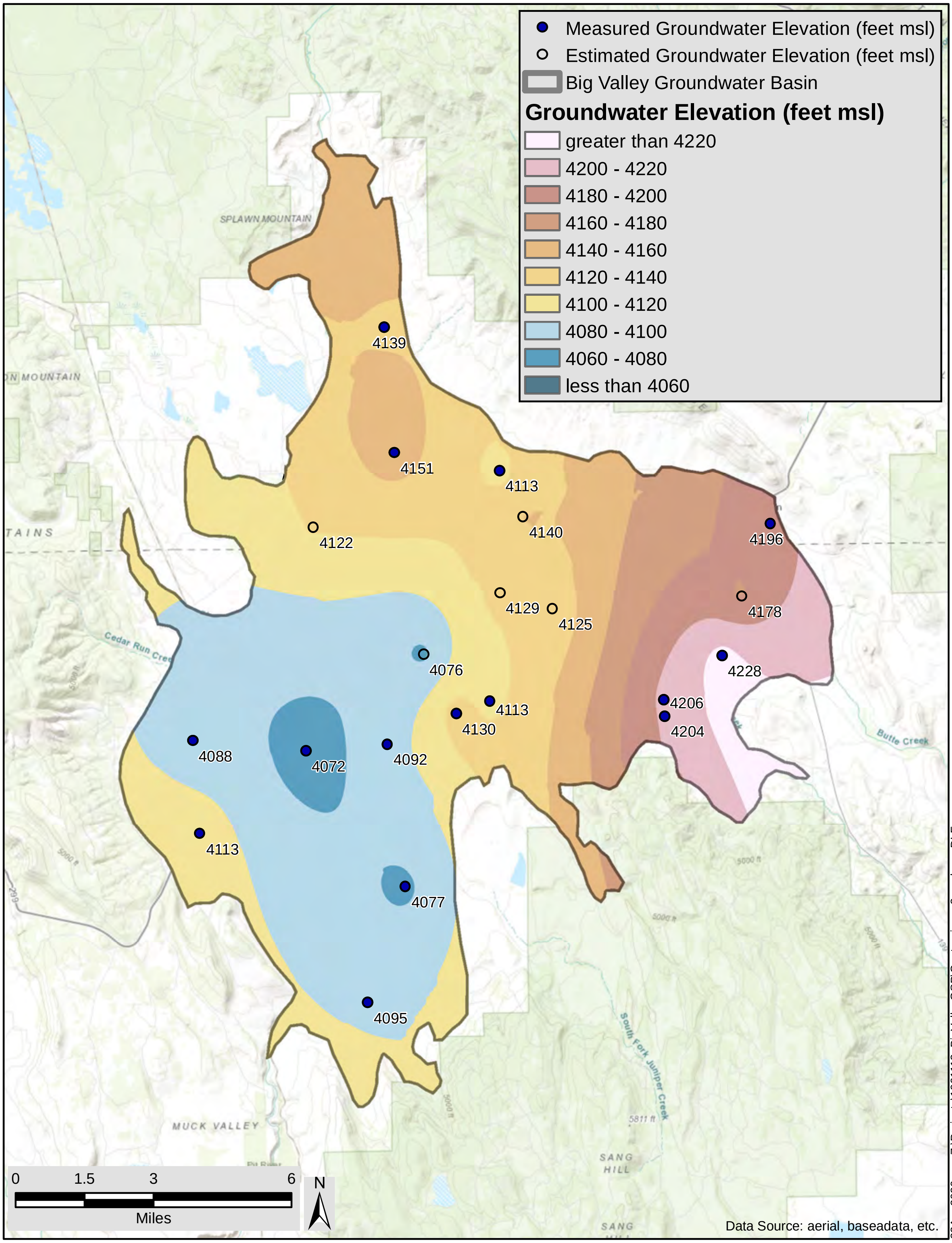

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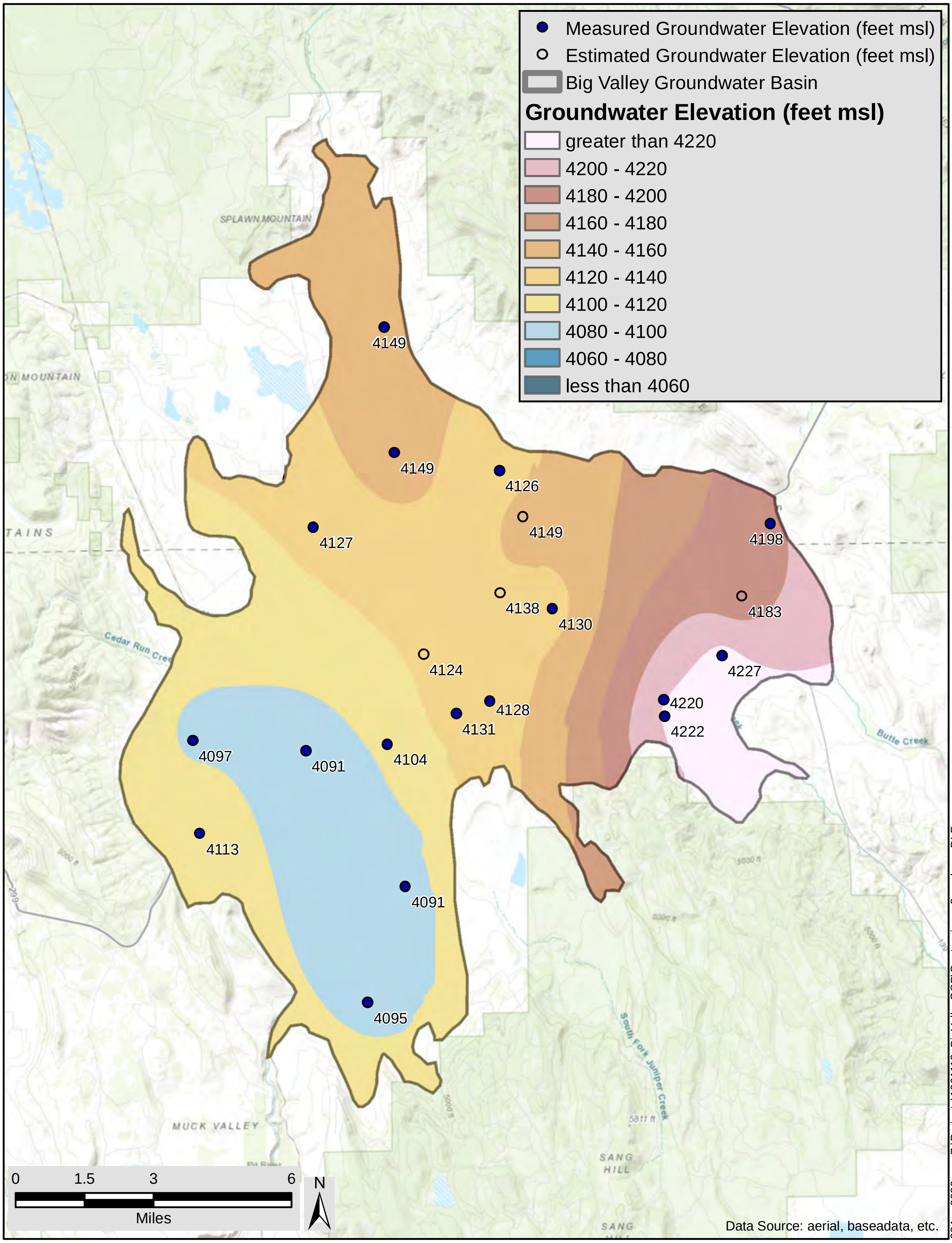

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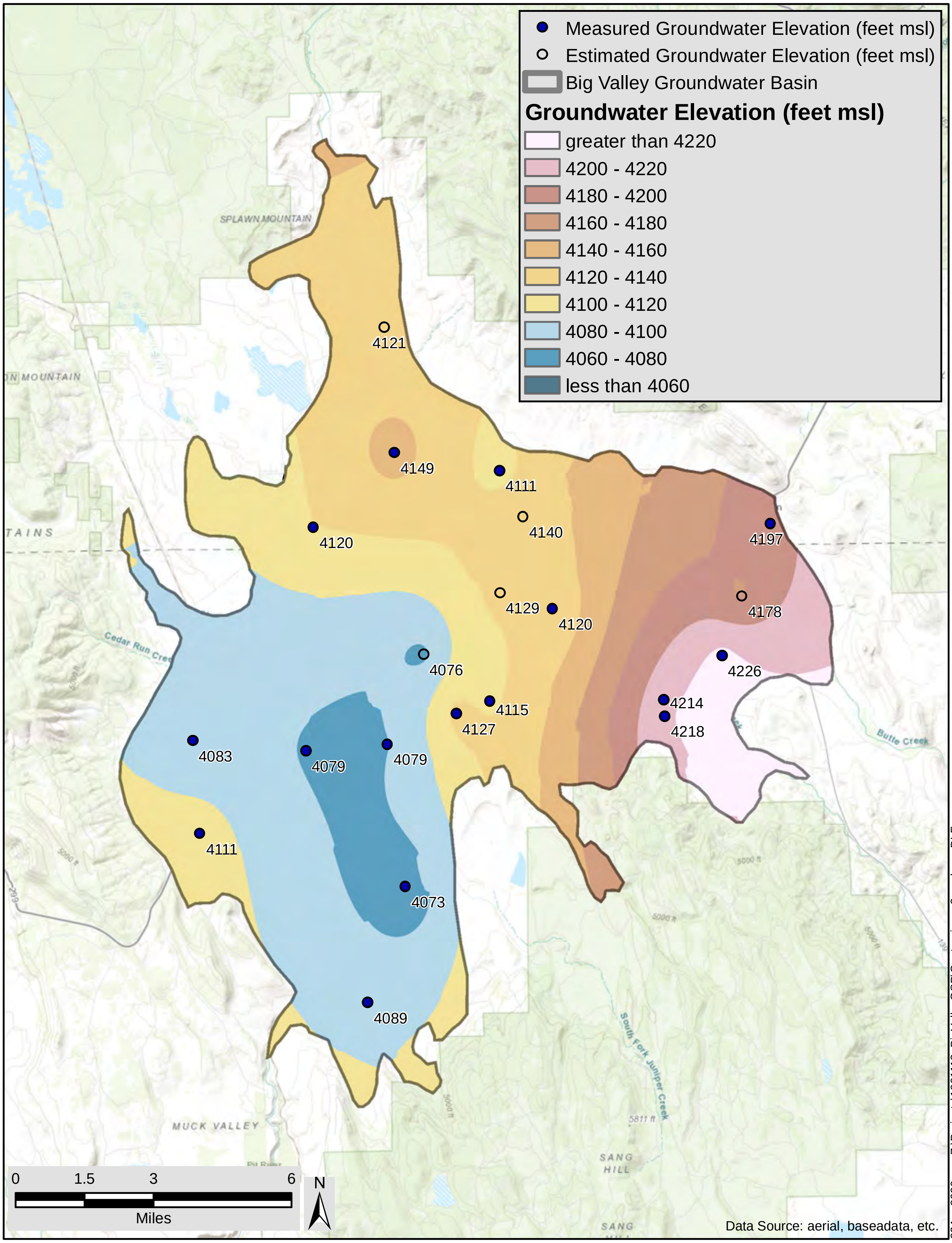

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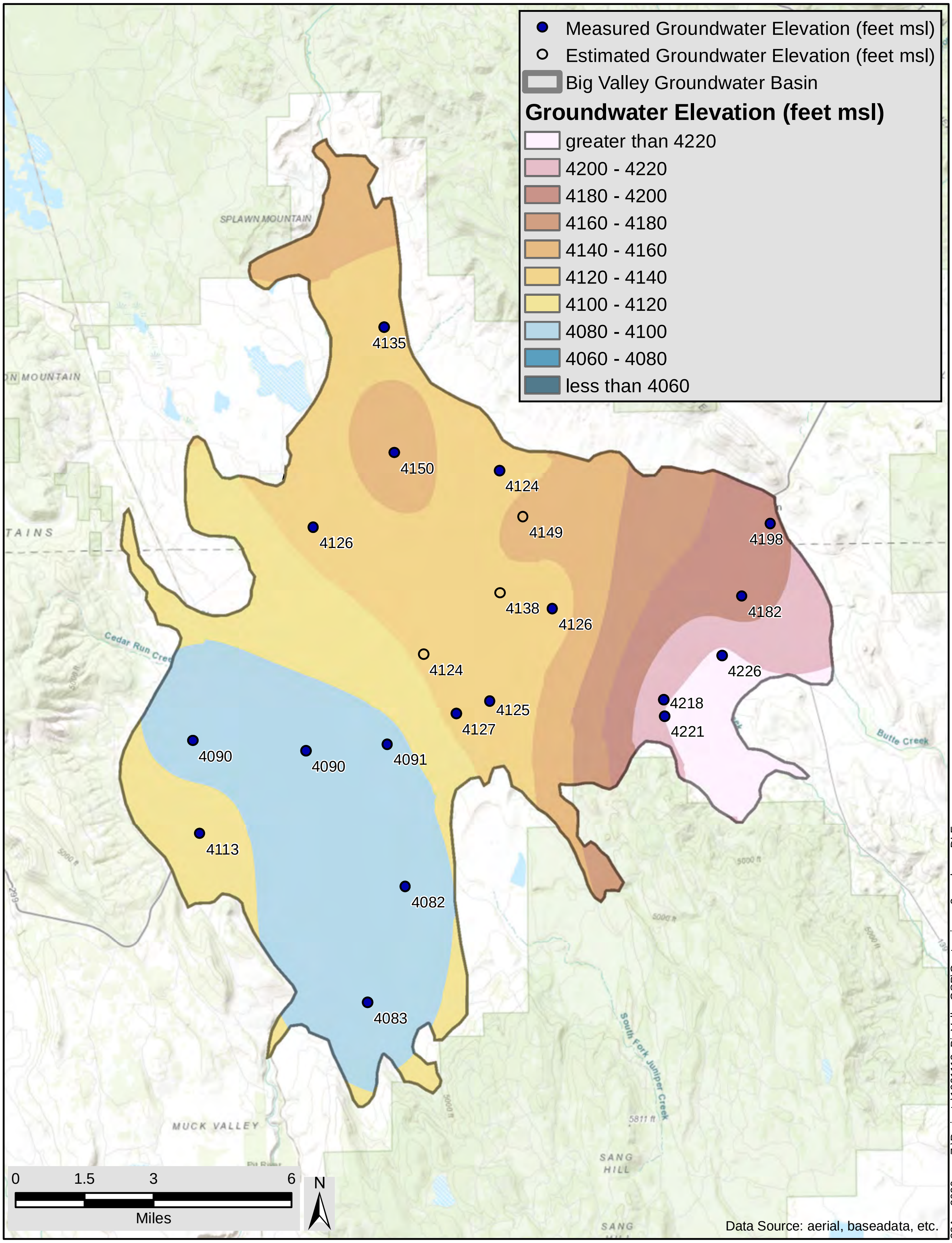

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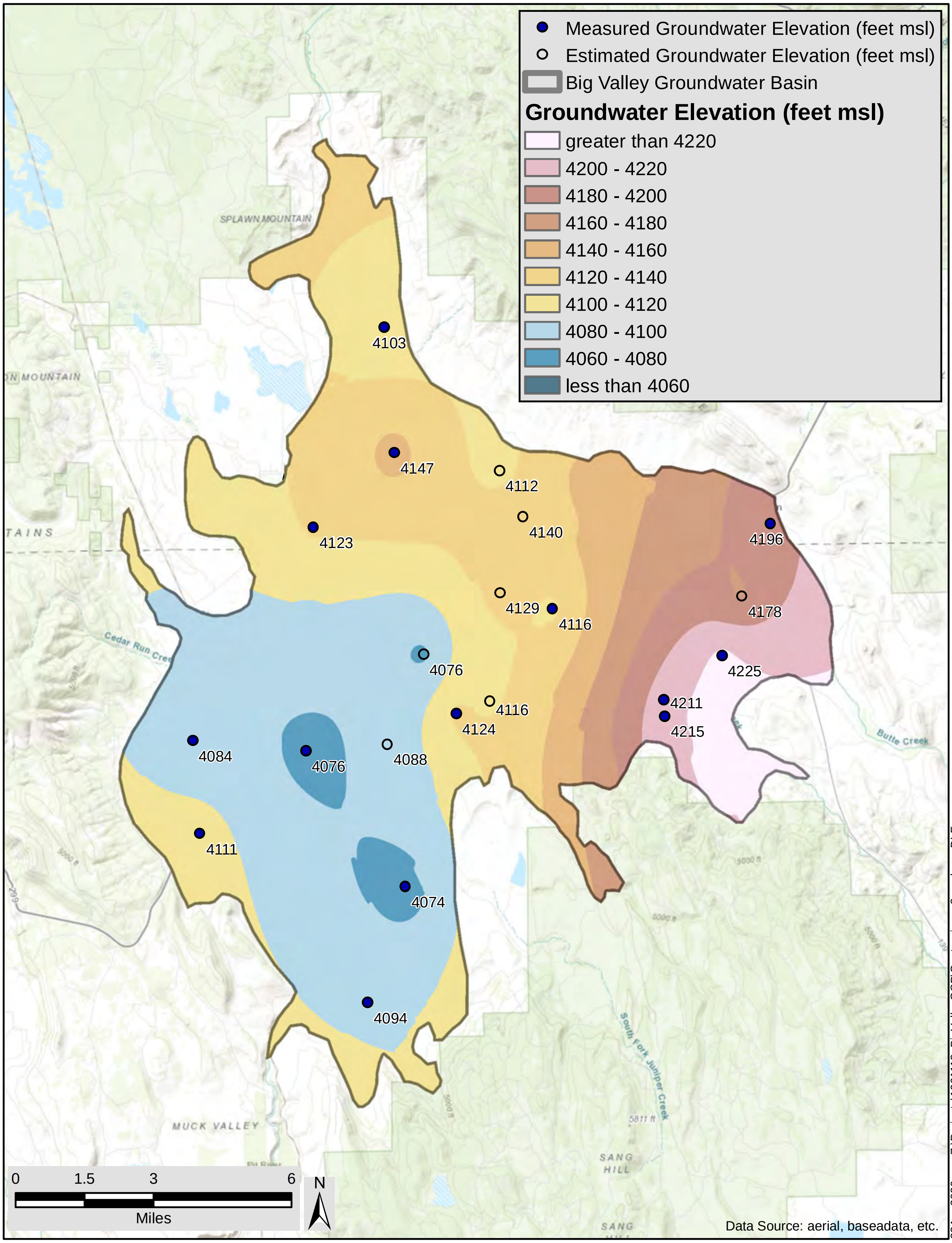

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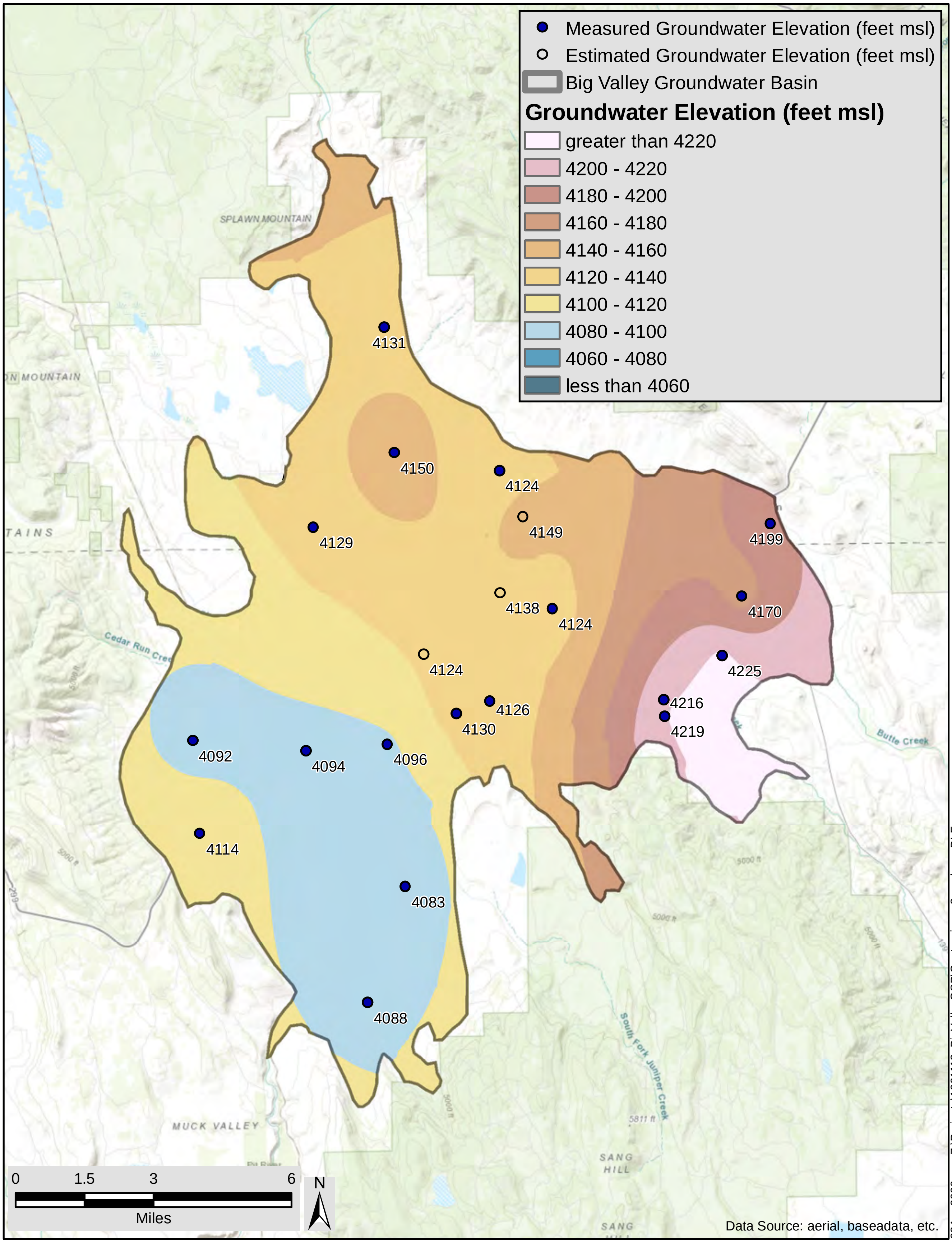

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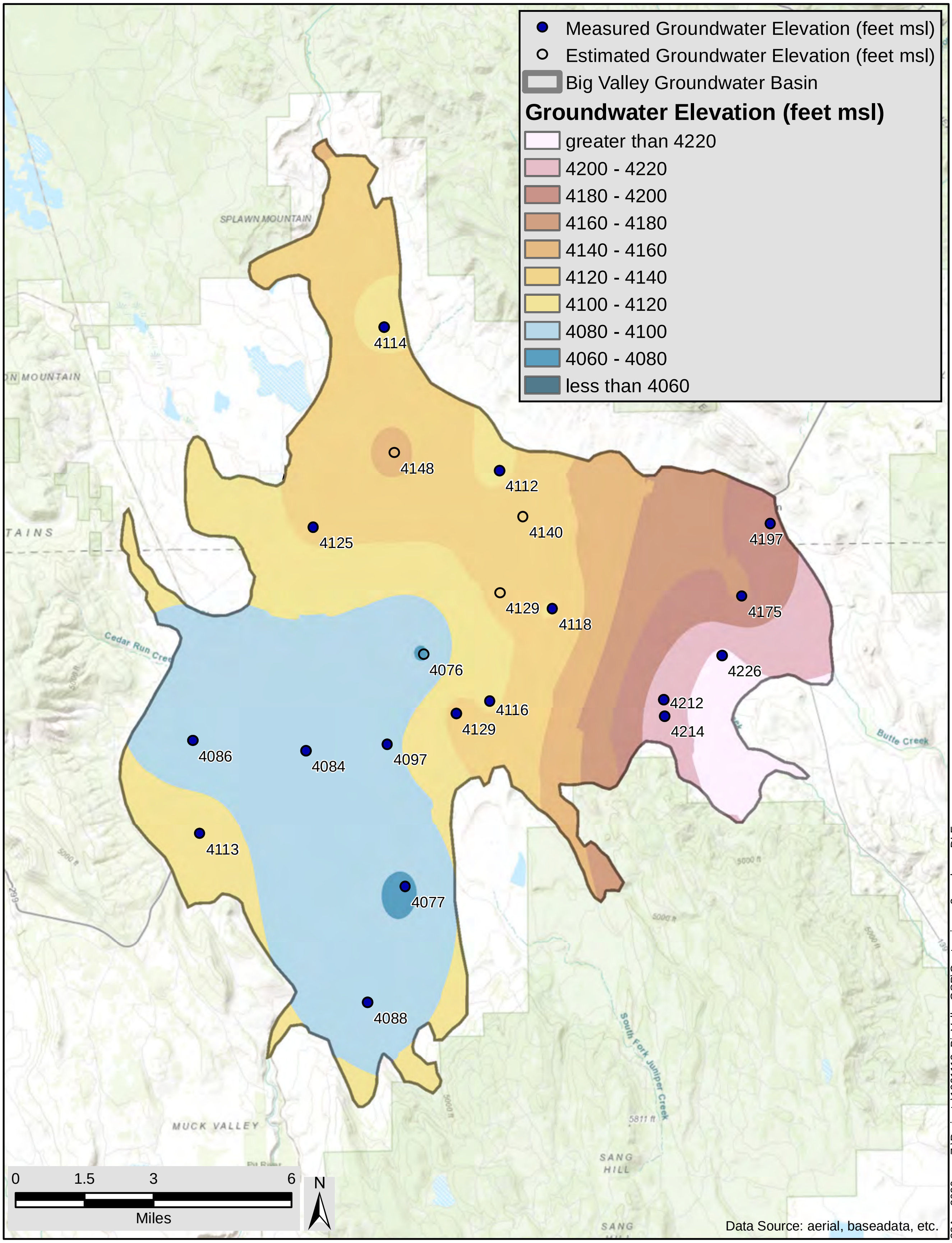

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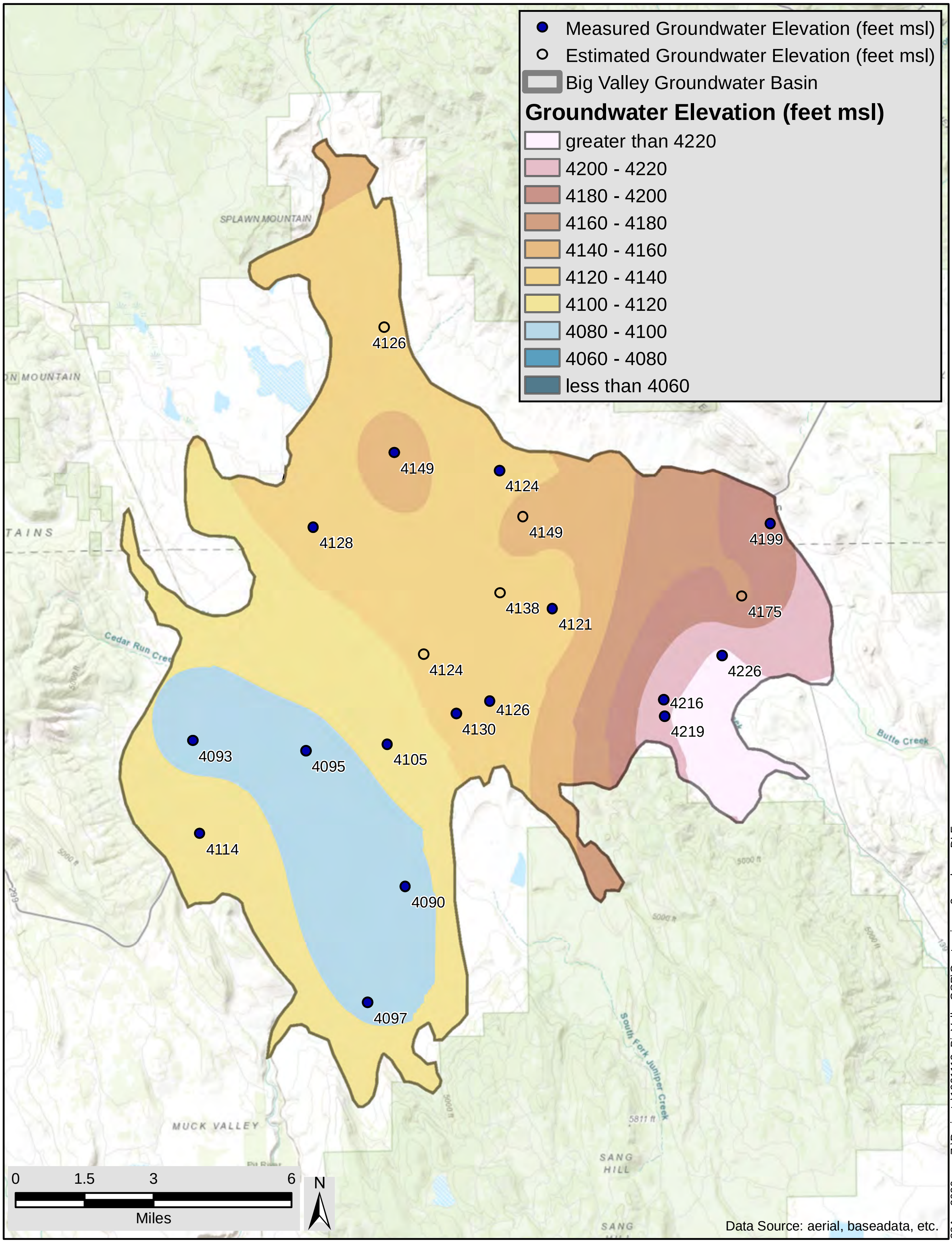

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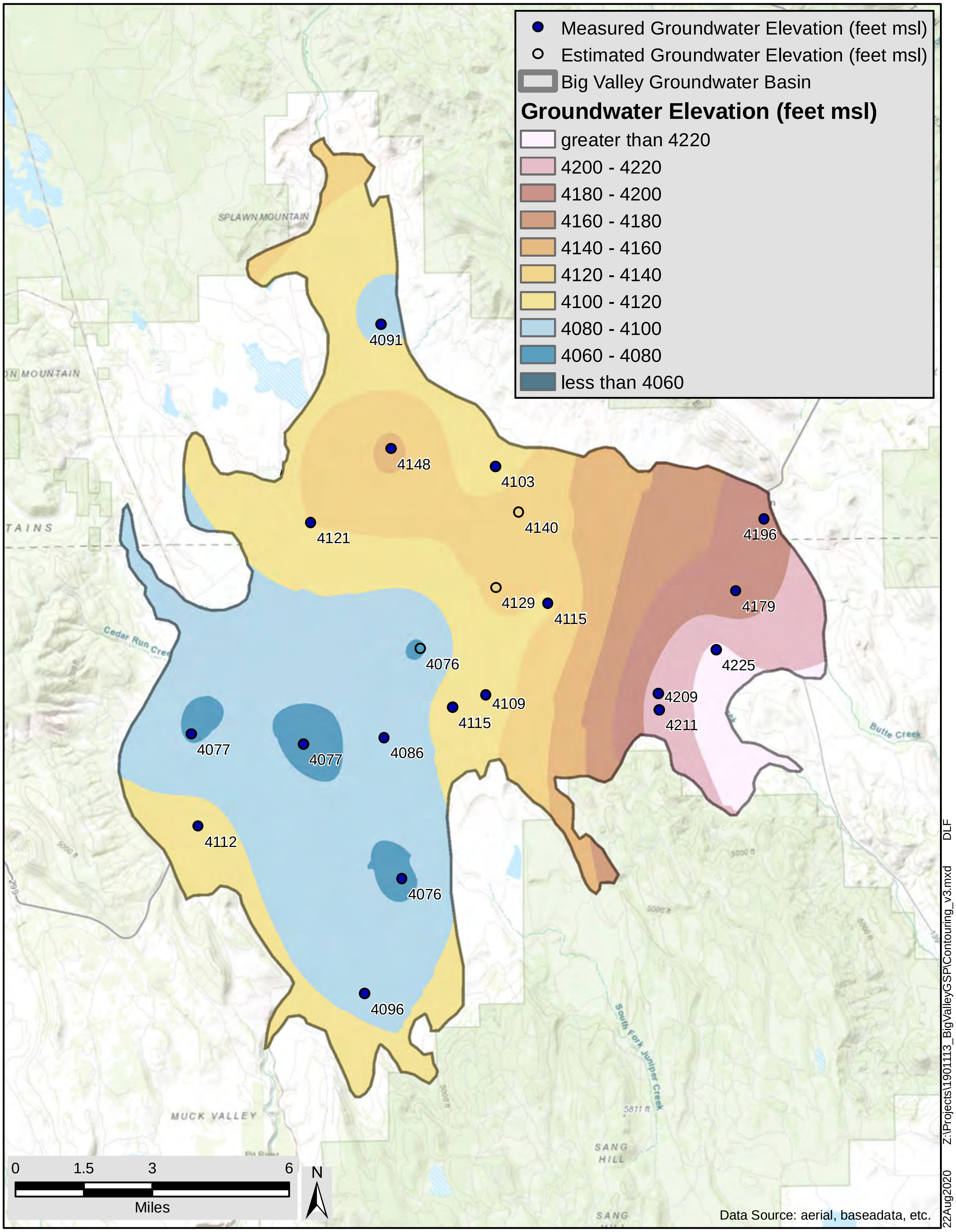

Big Valley Basin Groundwater Sustainability Plan
Modoc and Lassen Counties, California

Big Valley Groundwater Basin GSAs

GEI Consultants

Groundwater Elevations
Fall 2012

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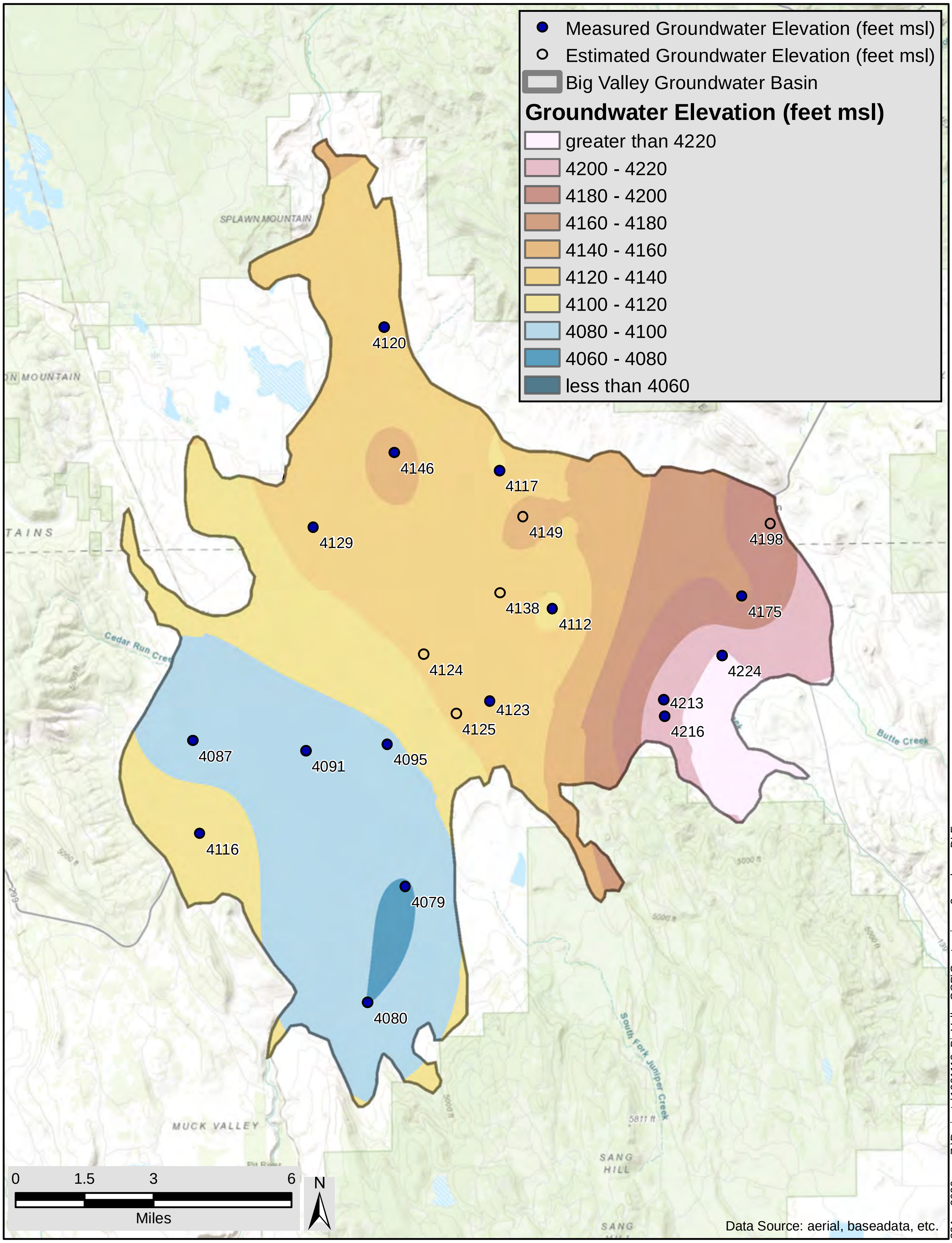

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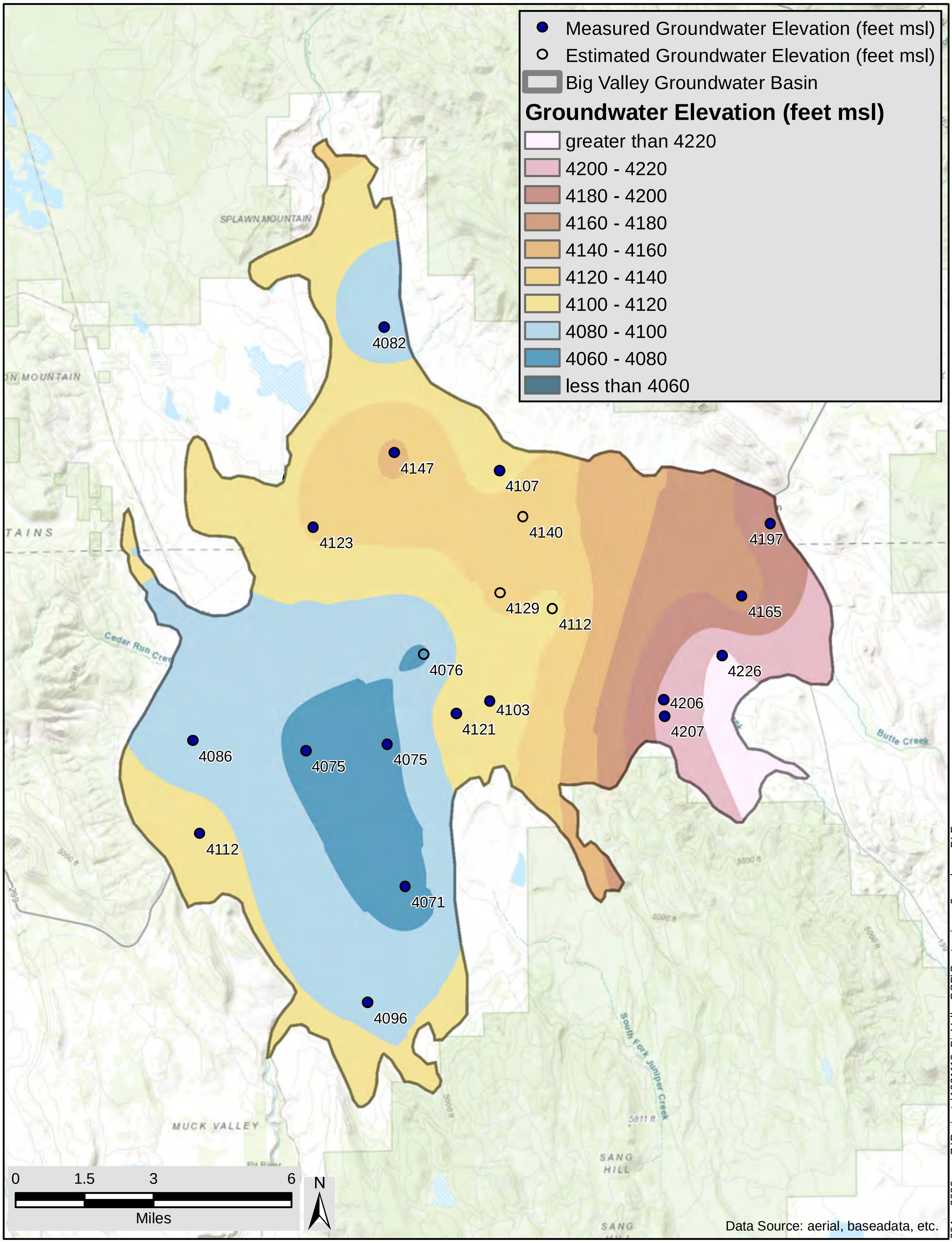

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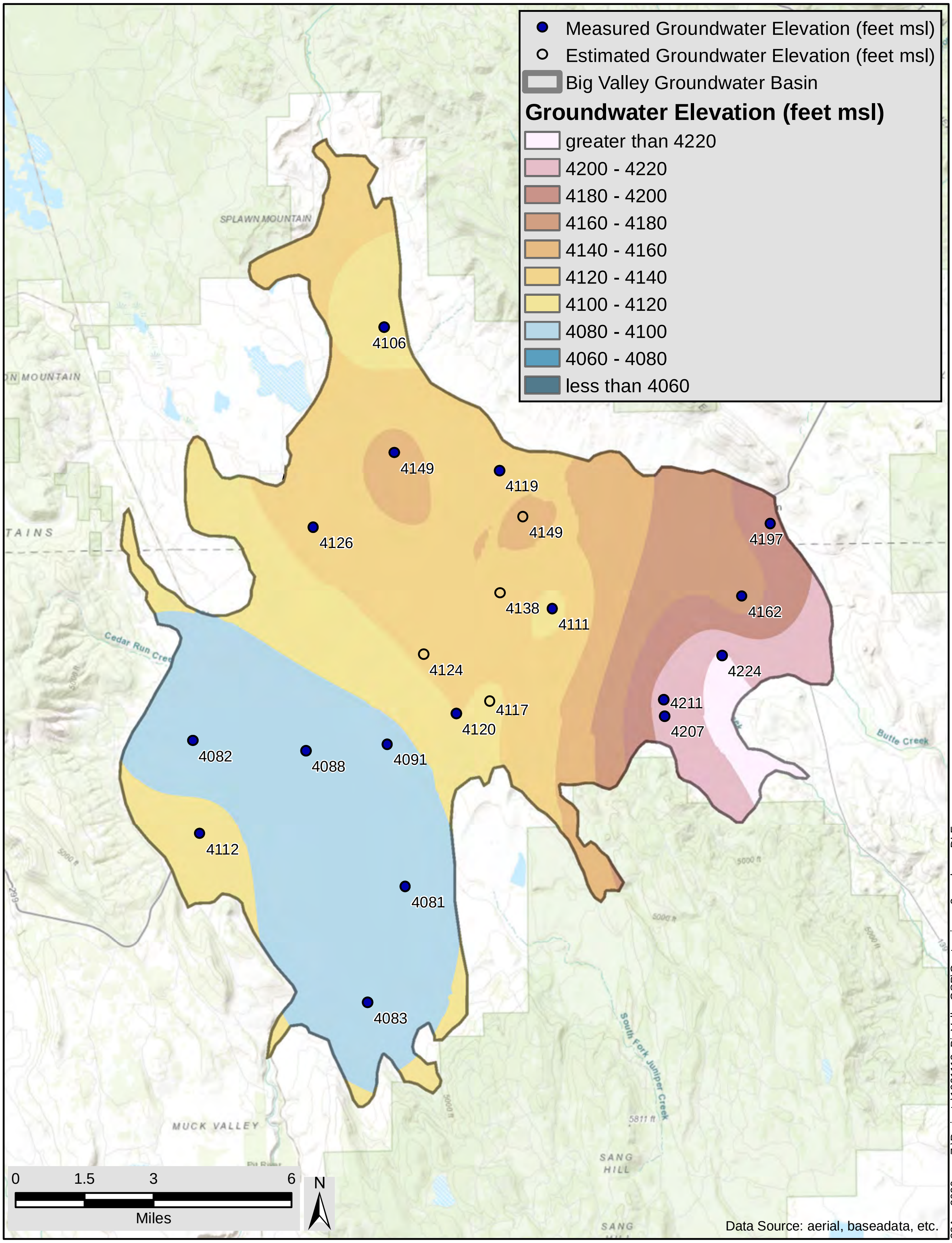

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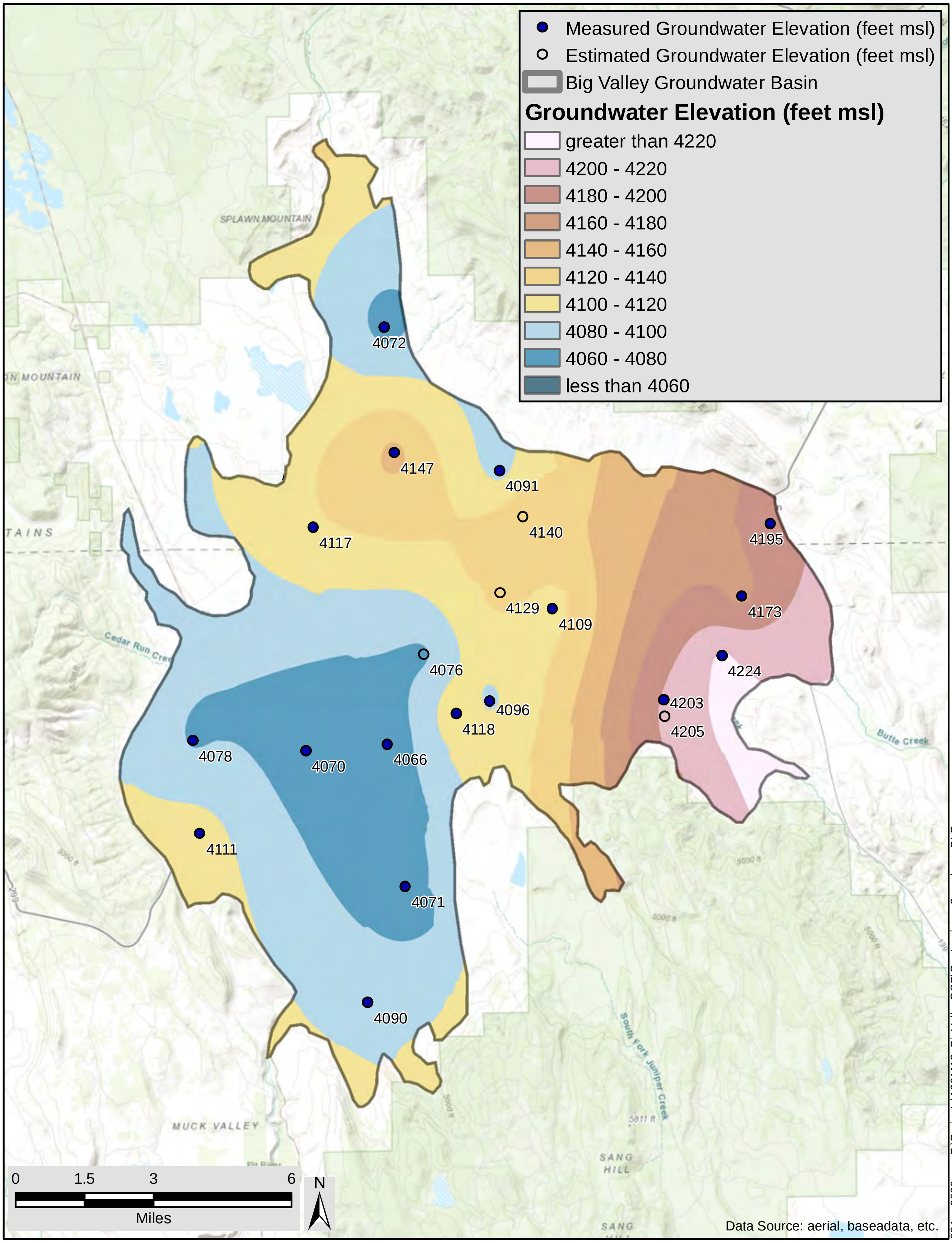

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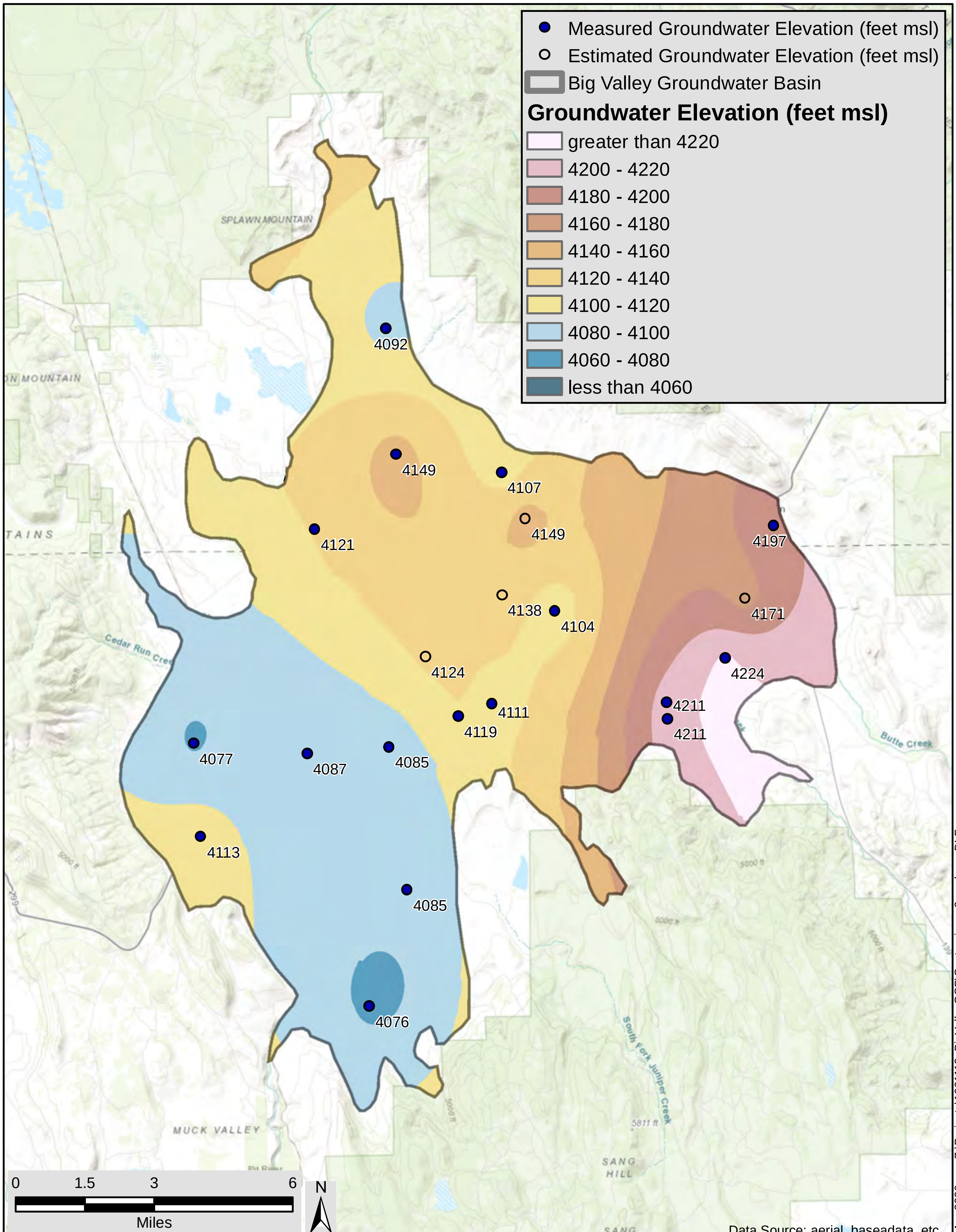

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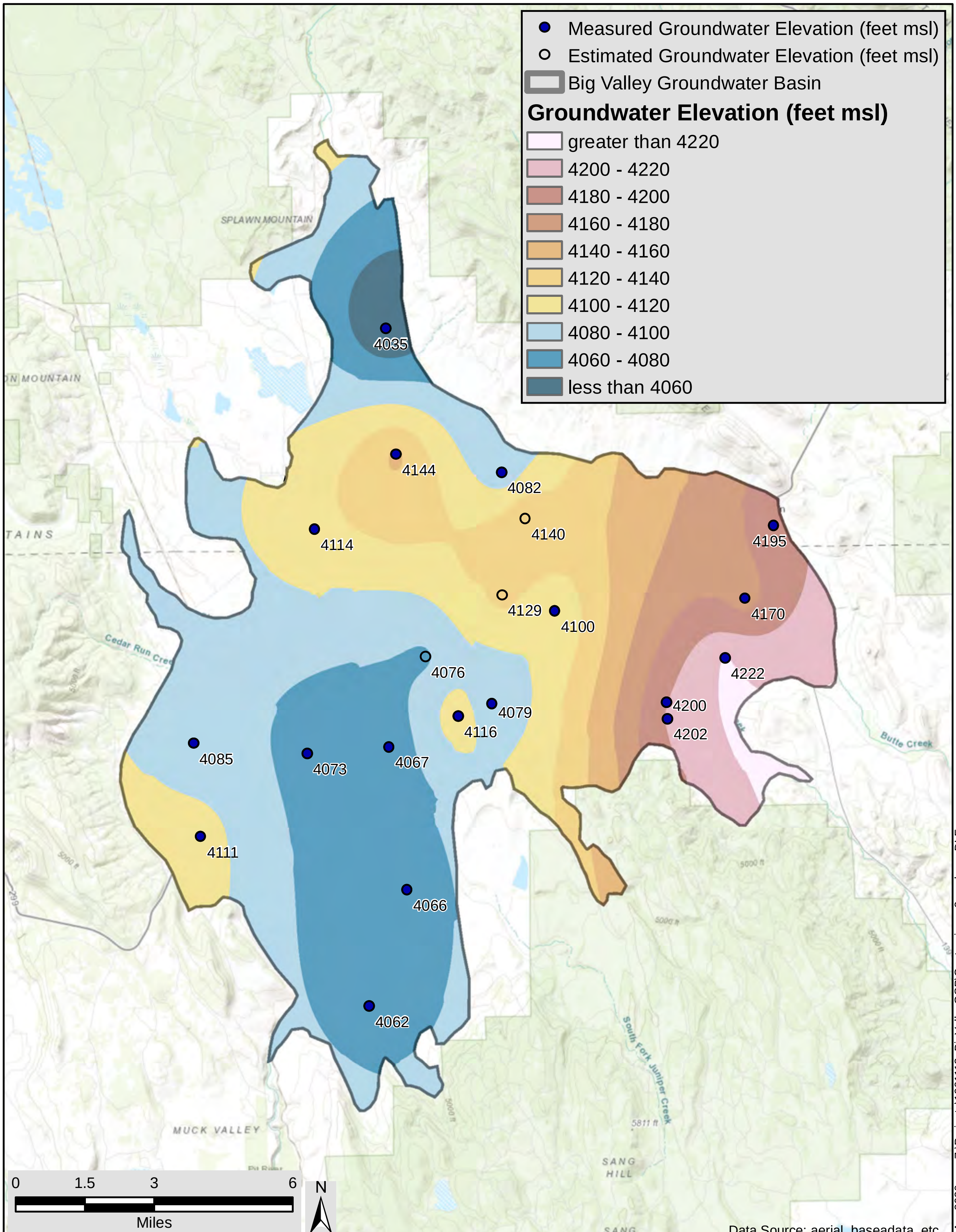

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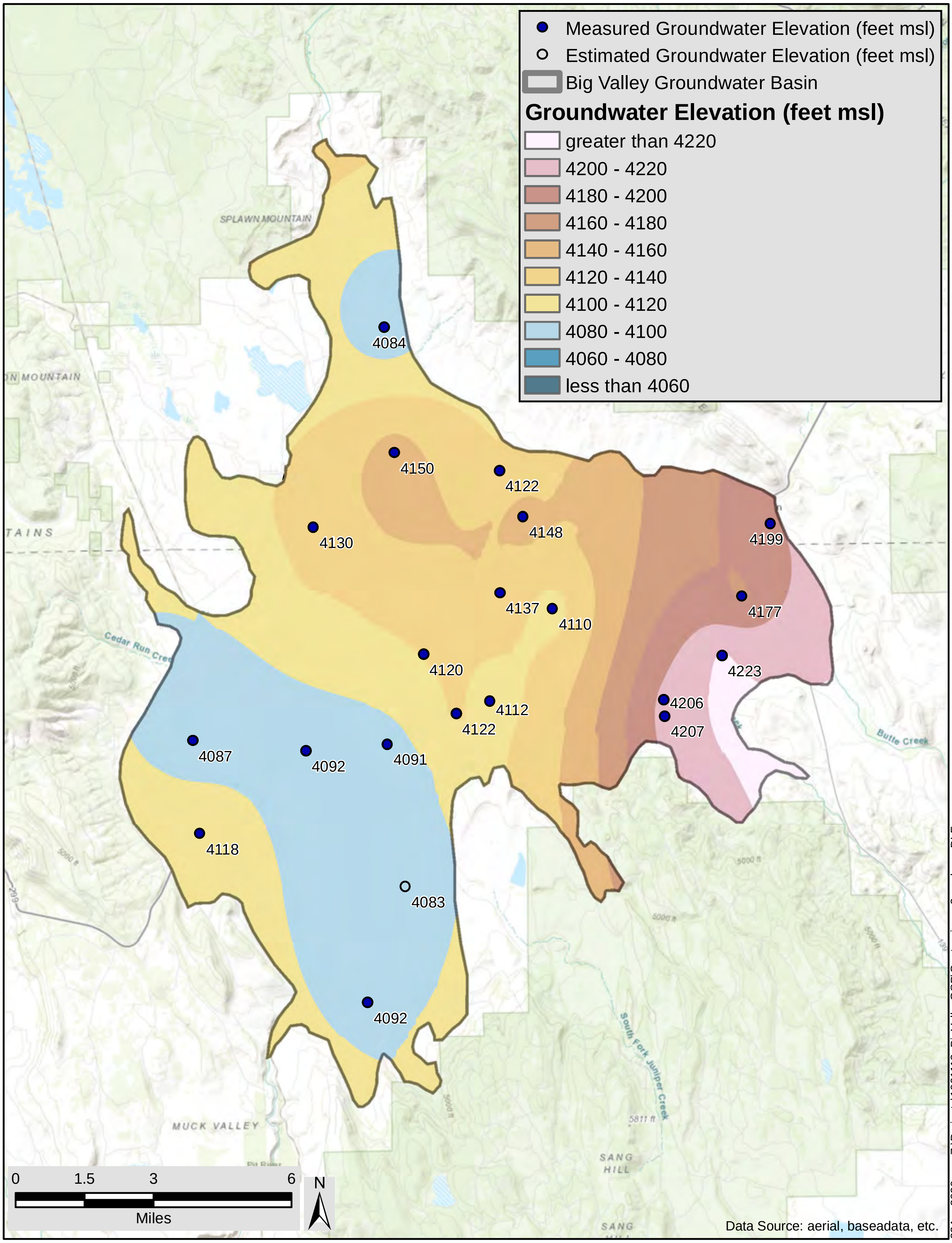

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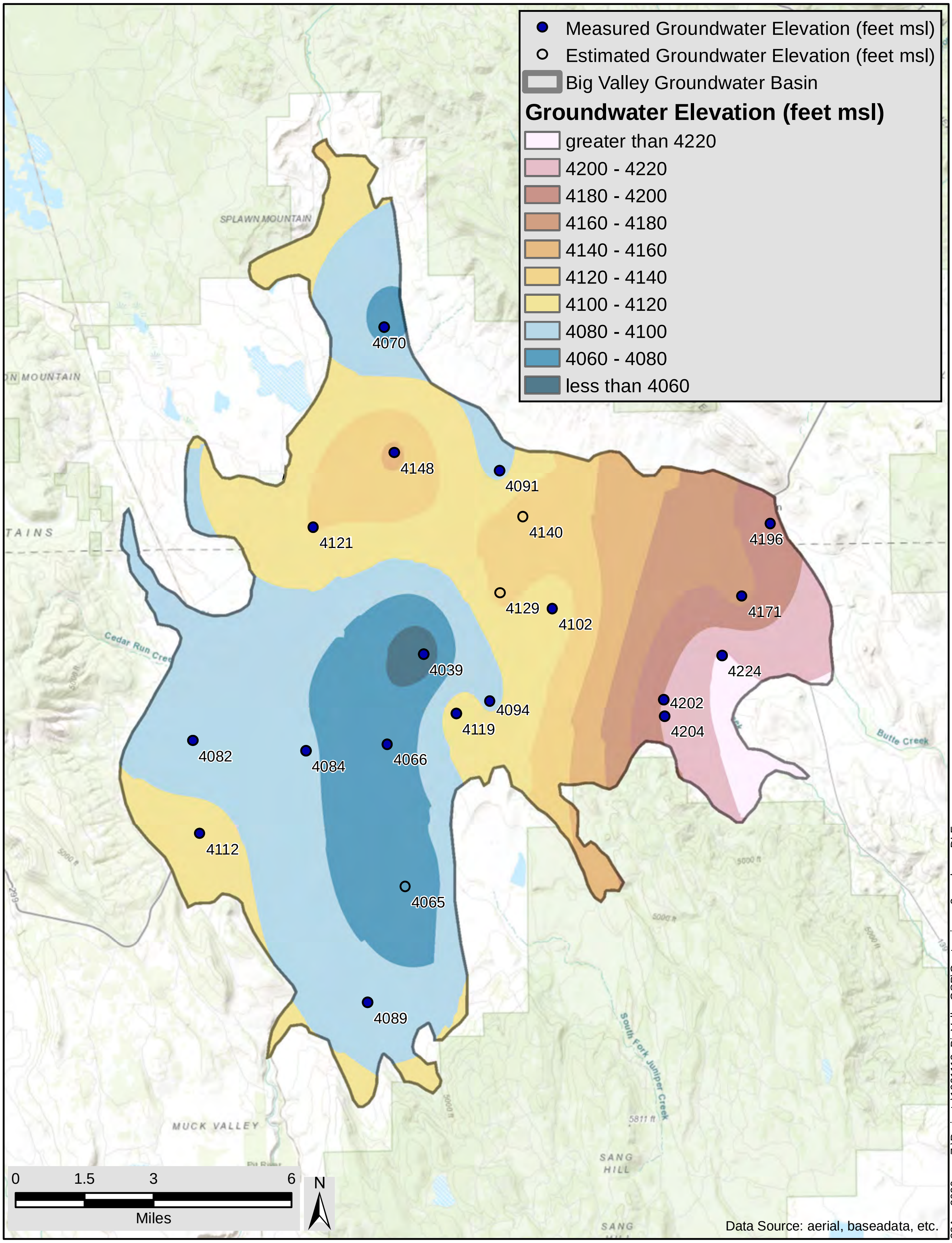

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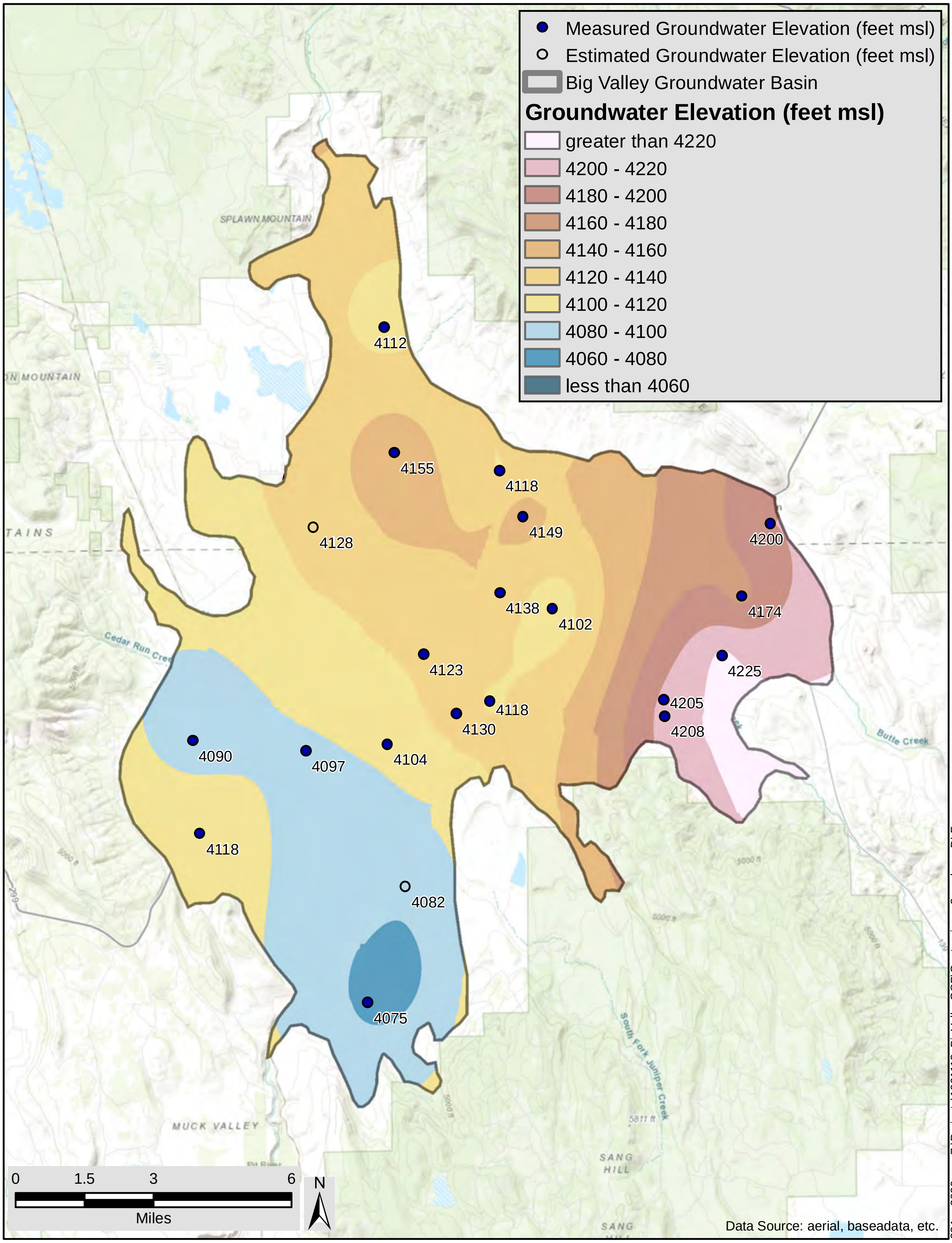

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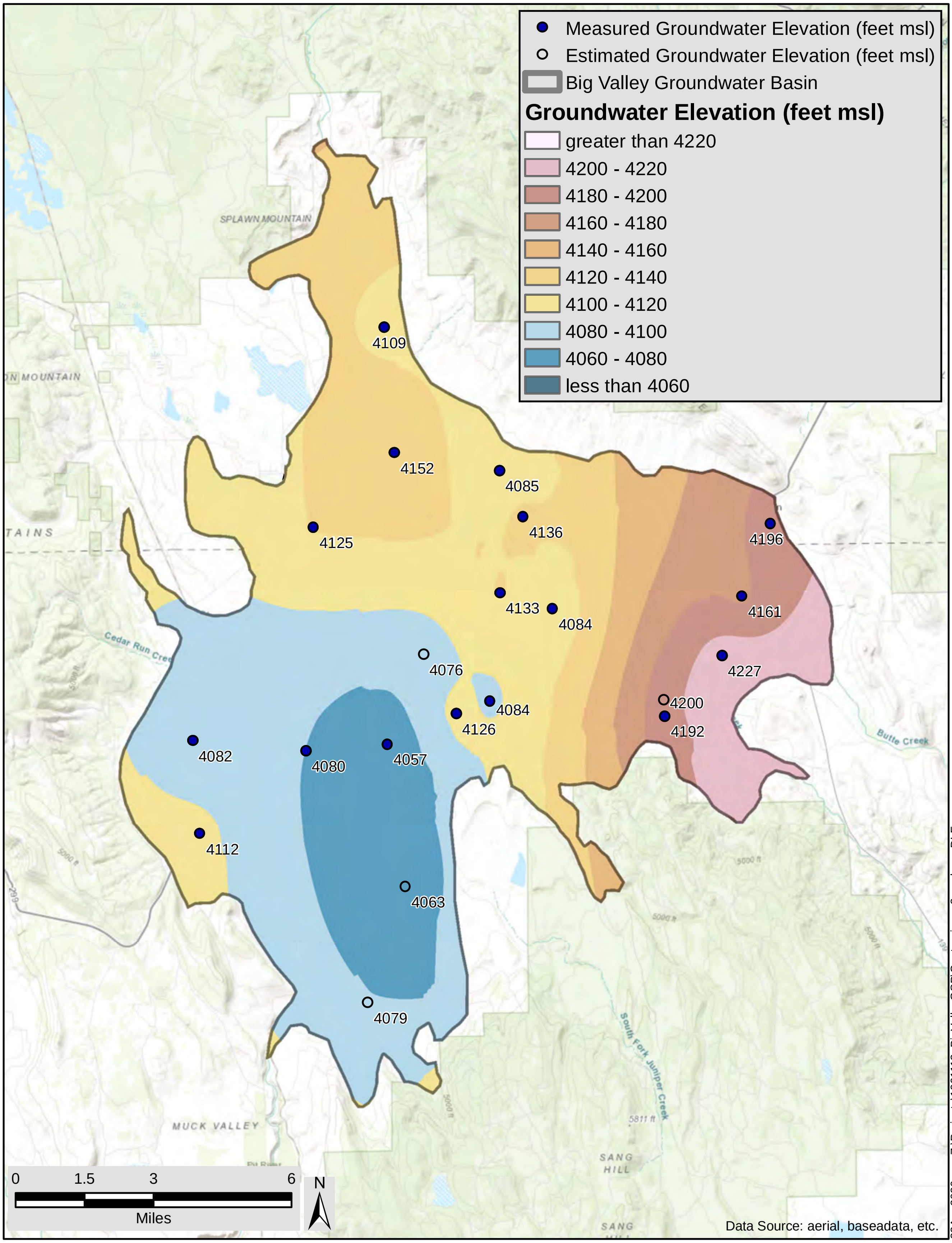

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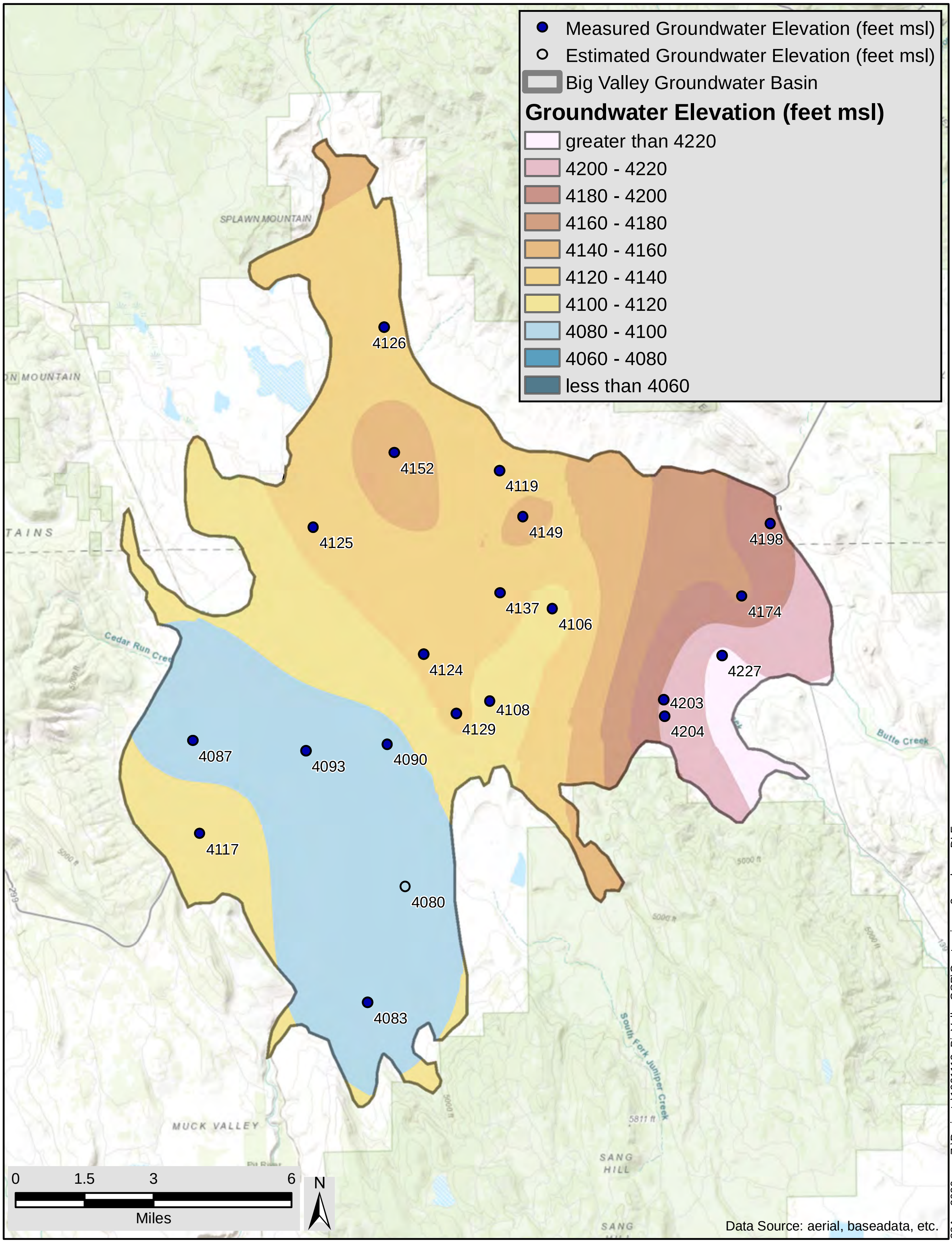

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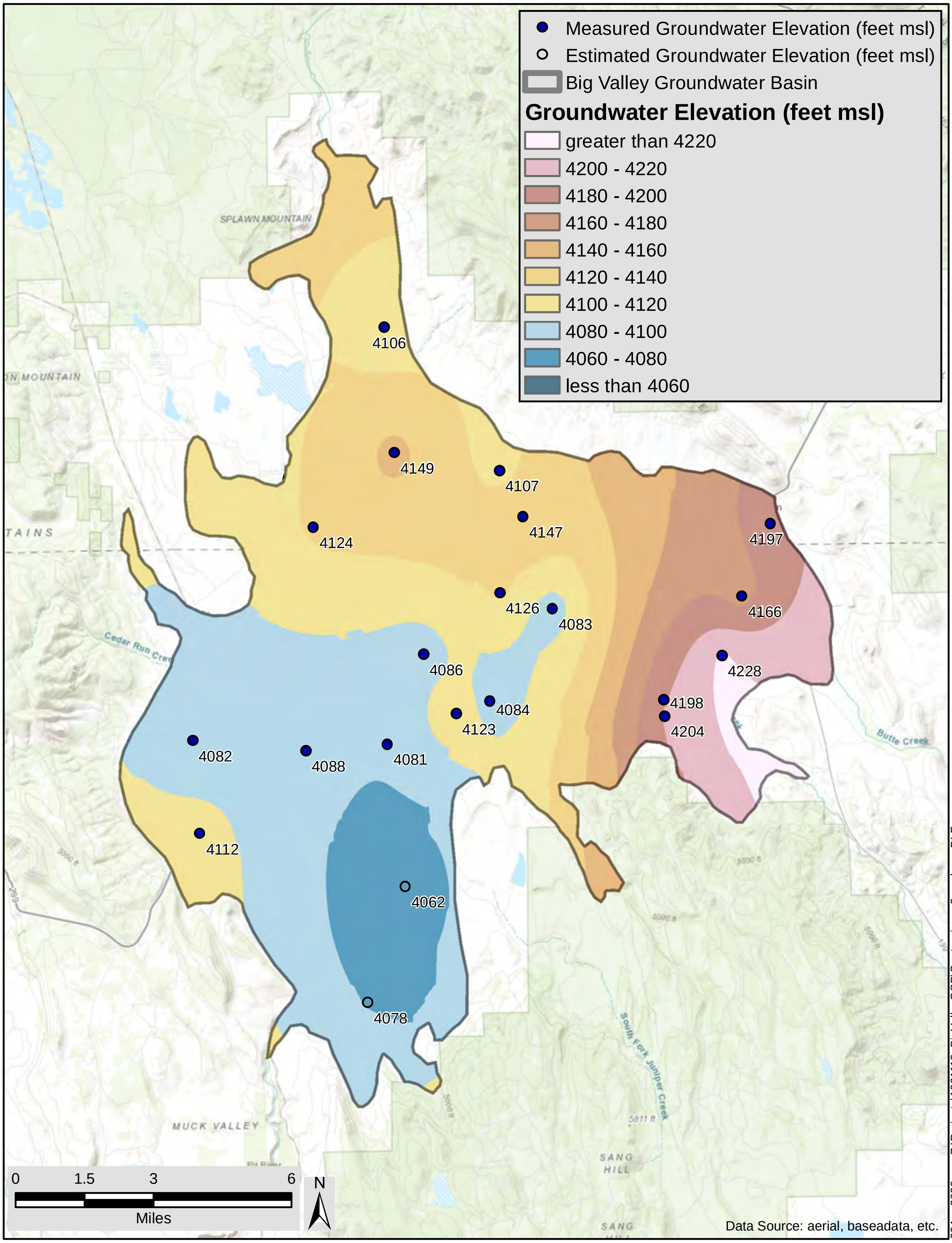

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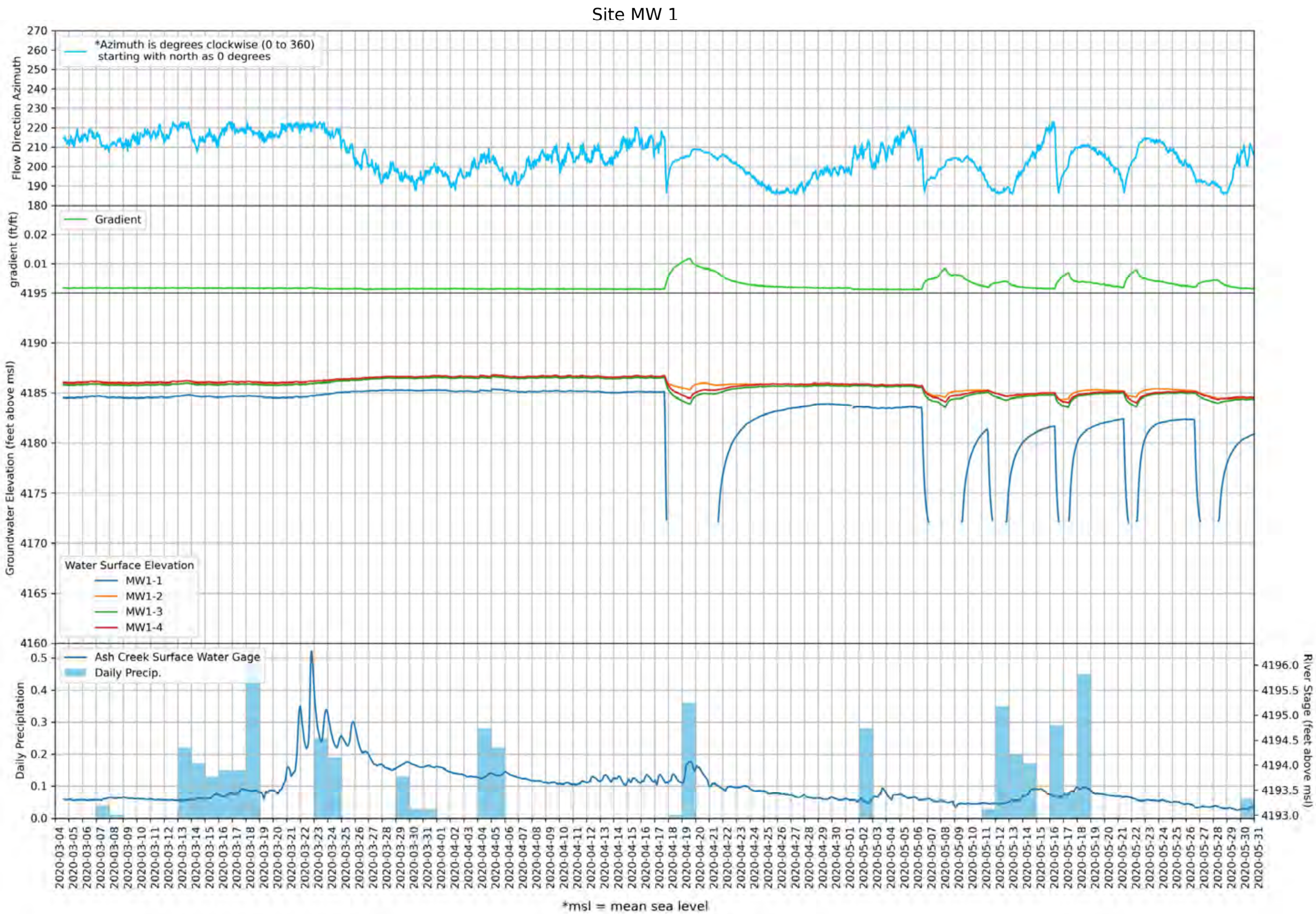
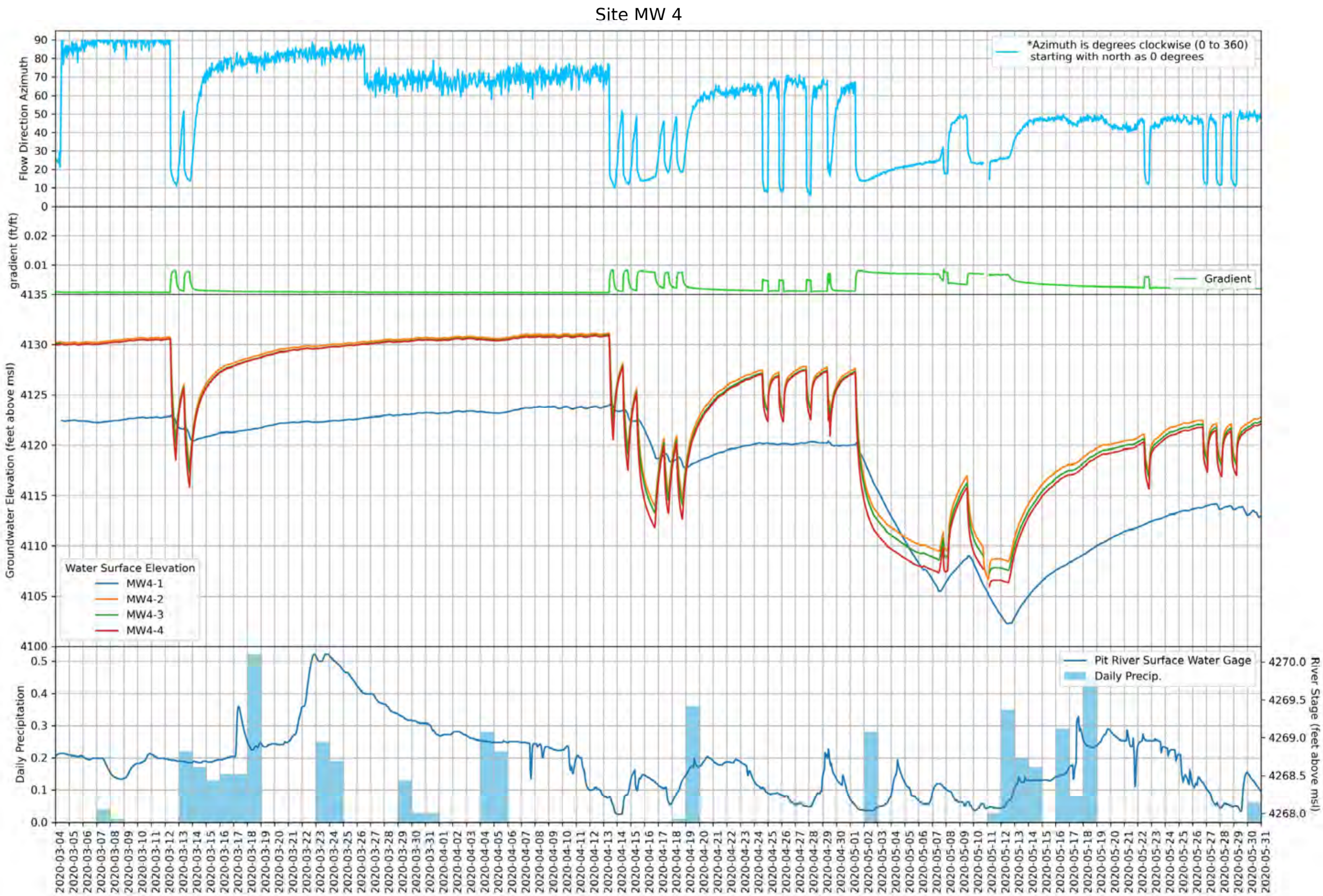
Big Valley Basin Groundwater Sustainability Plan Modoc and Lassen Counties, California	GEI Consultants	Groundwater Elevations Fall 2018
Big Valley Groundwater Basin GSAs		AUGUST 2020 DRAFT FIGURE

Appendix 5C

Transducer Data from Monitoring Well Clusters 1 and 4



Site MW 1
*Azimuth is degrees clockwise (0 to 360)
starting with north as 0 degrees
Flow Direction Azimuth
Gradient
gradient (ft/ft)
Groundwater Elevation (feet above msl)
Water Surface Elevation
MW1-1
MW1-2
MW1-3
MW1-4
Ash Creek Surface Water Gage
Daily Precip.
Daily Precipitation
River Stage (feet above msl)
*msl = mean sea level



*msl = mean sea level

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Tables

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Figures

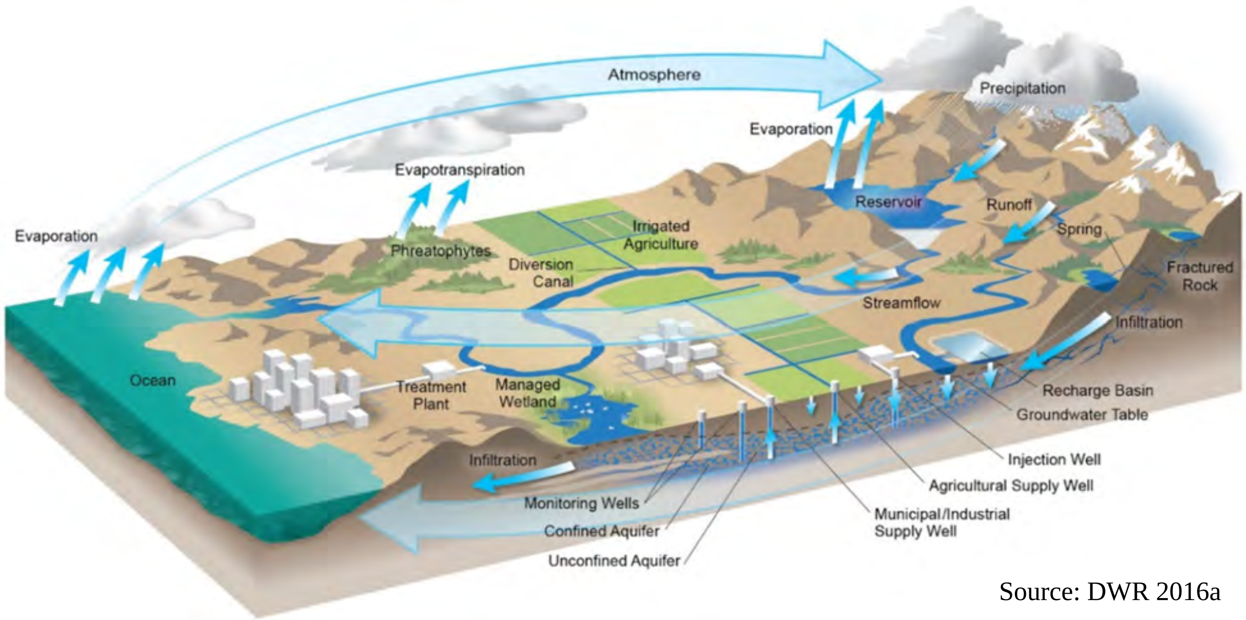
Appendices

Abbreviations and Acronyms

ACWA	Ash Creek Wildlife Area
AFY	Acre-feet per year
Basin	Big Valley Groundwater Basin
BVGB	Big Valley Groundwater Basin
CIMIS	California Irrigation Management Information System
CUP	Consumptive Use Program Model
CWC	California Water Code
DDW	Division of Drinking Water, State Water Resources Control Board
DWR	Department of Water Resources
ETo	Evapotranspiration
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IWFM	Integrated Water Flow Model
MODFLOW	USGS Modular Finite-Difference Ground-water Flow Model
PRISM	Parameter-elevation Regressions on Independent Slopes Model
USGS	United States Geologic Survey

6. Water Budget (§ 354.18)

The hydrologic cycle describes how water is moved on the earth among the oceans, atmosphere, land, surface water bodies, and groundwater bodies. **Figure 6-1** shows a depiction of the hydrologic cycle.

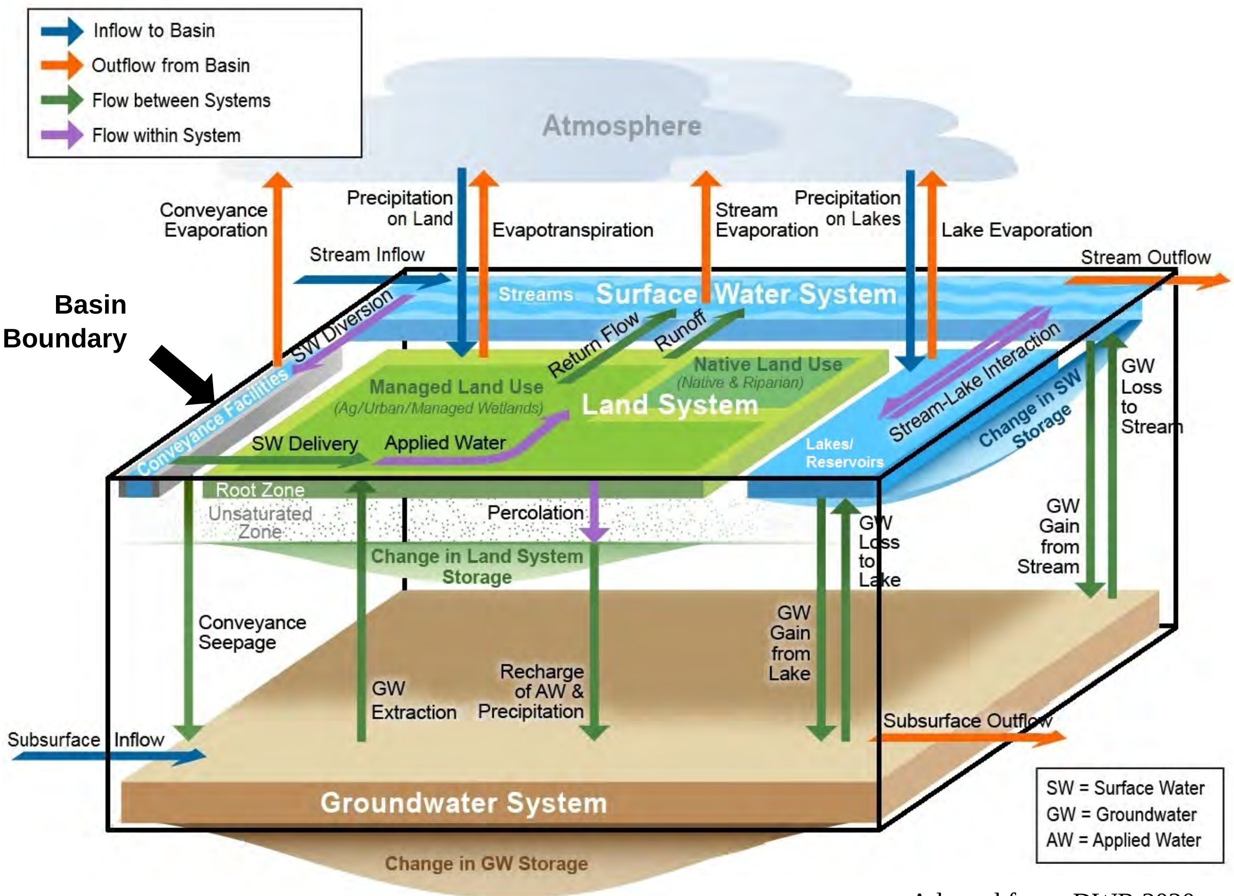


Source: DWR 2016a

Figure 6-1 Hydrologic Cycle

A water budget accounts for the movement of water among the four major systems in Big Valley: atmospheric, land surface, surface water, and groundwater. The Big Valley Groundwater Basin (BVGB) consists of the latter three (land surface, surface water, and groundwater) as shown by the black outline on **Figure 6-2.** This figure demonstrates the specific components of the water budget and exchange between the systems. The systems and the flow arrows are color coded. Inflows to the BVGB are shown with blue arrows and outflows from the BVGB are shown with orange arrows. Flows between the systems are shown with green arrows and flows within a system are shown in purple. The land system, surface water system, and groundwater system are green, blue, and brown respectively.

Like a checking account, a water budget helps the Groundwater Sustainability Agency (GSA) and stakeholders better understand the deposits and withdrawals and identify what conditions result in positive and negative balances. It should be noted that, while the development of a water budget is required by the Groundwater Sustainability Plan (GSP) regulations, the regulations don’t require actions based directly on the water budget. Actions are only required based on outcomes related to the six sustainability indicators: groundwater levels, groundwater storage, water quality, subsidence, seawater intrusion, and surface water depletions. Therefore, a water budget should be viewed as a tool to develop a common understanding of the Basin and a basis for making decisions to achieve sustainability and avoid undesirable results with the sustainability indicators.



Adapted from: DWR 2020a

Figure 6-2 Water Budget Components and Systems

6.1 Water Budget Data Sources

Each component shown in **Figure 6-2** was estimated using readily available data and assembled into a budget spreadsheet. Many groundwater basins in California utilize a numerical groundwater model, such as MODFLOW or IWFM to calculate the water budget. These models require a specialized hydrogeologist to run them and the methodology by which the water budget is calculated is not readily apparent to the lay person. For the BVGB, a non-modeling (spreadsheet) approach was used so that future iterations of the water budget could be performed by a wider range of hydrology professionals (potentially reducing future GSP implementation costs) and so that the calculations of the specific components could be understood by a broader range of people.

~~Ideally~~In concept, each component could be quantified precisely and accurately, and the budget ~~would~~ could come out balanced. In practice, ~~many~~ most of the components can only be roughly estimated, and in ~~some~~ many cases not at all. Therefore, much of the work to balance the water budget is adjusting some of the unknown or roughly estimated parameters within acceptable ranges until the budget is balanced and all components of the budget are deemed reasonable.

As such, the water budget calculations presented here are not unique and the precision of the components estimated using the water budget are within an order of magnitude. Estimation of nearly all components involves assumptions and with more basin-specific data, the accuracy and precision of many of the components are improved. Additional and improved data that is obtained results in a budget that more closely reflects the Basin conditions and allows the GSAs to make more informed decisions to sustainably maintain groundwater resources. **Appendix 6A** show the components of the water budget, their data source(s), assumptions, and relative level of precision.

Major data sources include the PRISM[1] model (NACSE 2020) for precipitation, CIMIS (DWR 2020b) for evapotranspiration data, the National Water Information System (USGS 2020b) for surface water flows, and DWR land use surveys (DWR 2020c).

6.2 Historical Water Budget

The historic water budget presented in this section covers 1984 to 2018. This period was chosen because it represents an average set of climatic conditions and ~~adequate~~ water level, land use, and climate data were available in this time frame. **Figure 6-3** shows the annual precipitation and year type for the period. The criteria for year types were critical dry below 70% of average precipitation, dry between 70 and 85% of average precipitation, normal between 85 and 115% of average precipitation, and wet years greater than 115% of average precipitation.

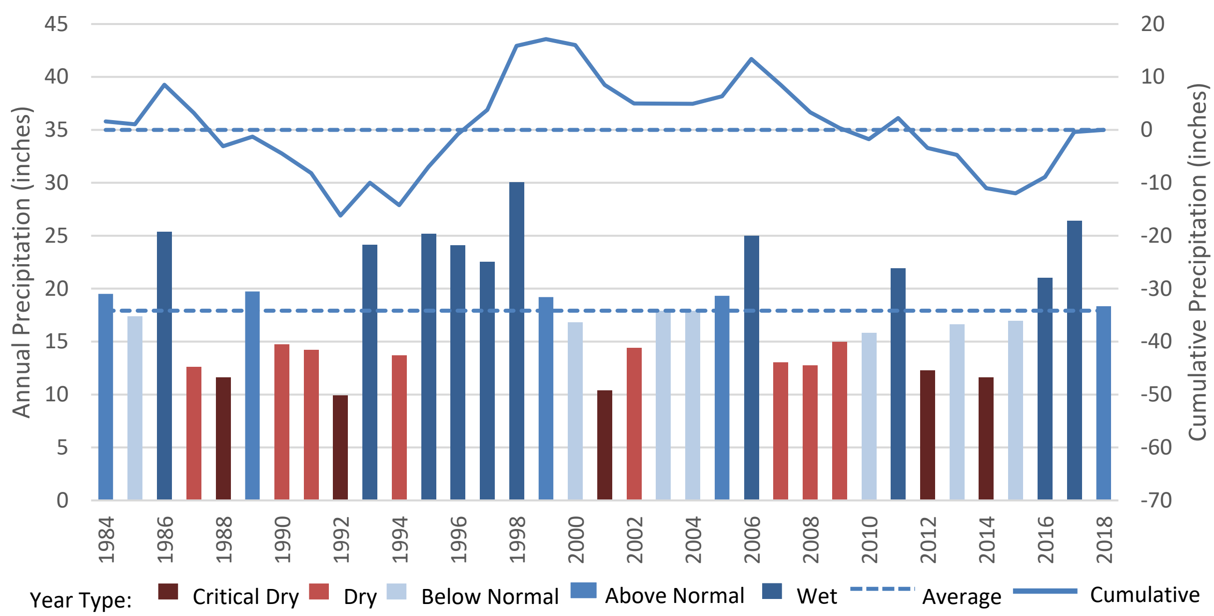


Figure 6-3 Annual and Cumulative Precipitation and Water Year Types 1984 to 2018

[1] PRISM stands for Parameter-elevation Regression on Independent Slopes Model and is provided by the Northwest Alliance for Computational Science and Engineering from Oregon State University. This model provides location-specific, historical precipitation values on monthly and annual time scales. Precipitation was evaluated at Bieber.

The budget was developed using this precipitation and other climate data (evapotranspiration) along with stream flow to estimate the inflows (credits) and outflows (debits) to the total BVGB. The budget was balanced by assuming that the land and surface water systems remain nearly in balance from year to year and allowing the groundwater system to vary. **Figure 6-4** shows the average annual values for the overall water budget. The detailed water budget for each year is included in **Appendix 6B**. **Appendix 6C** shows graphically how the water budget varies over time.

TOTAL BASIN WATER BUDGET — Acre-Feet

item	Flow Type	Origin/ Destination	Component	Acre-Feet
(1)	Inflow	Into Basin	Precipitation on Land System	136,801
(14)	Inflow	Into Basin	Precipitation on Reservoirs	501
(13)	Inflow	Into Basin	Stream Inflow	371,148
(27)	Inflow	Into Basin	Subsurface Inflow	1
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*508,451*
(5)	Outflow	Out of Basin	Evapotranspiration	154,040
(24)	Outflow	Out of Basin	Stream Evaporation	385
(23)	Outflow	Out of Basin	Reservoir Evaporation	722
(19)	Outflow	Out of Basin	Conveyance Evaporation	46
(18)	Outflow	Out of Basin	Stream Outflow	358,486
(29)	Outflow	Out of Basin	Subsurface Outflow	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*513,678*
(34)	Storage Change	(32)-(33)	Change in Total System Storage	(5,227)

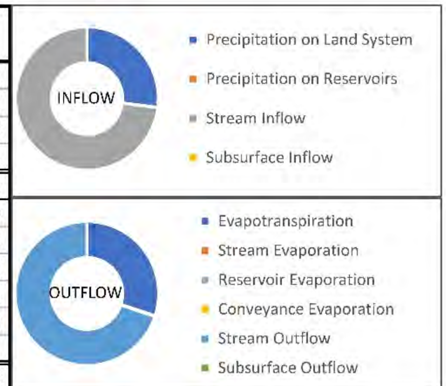


Figure 6-4 Average Total Basin Water Budget 1984-2018 (Historic)[2]

The evapotranspiration value was calculated using land use data (crop and wetland acreages) from DWR for 2014 and land use was assumed to be constant throughout the water budget period.

Using the evapotranspiration for irrigated lands, the amount of irrigation from surface water and groundwater was determined using 85% irrigation efficiency (NRCS 2020) and a respective 35%-65% split between surface water and groundwater. This surface water – groundwater split was determined from input received from local land owners, an assessment of surface water rights (areas without surface water rights were assumed to use 100% groundwater), well drilling records (areas without wells drilled were assumed to use 100% surface water), and an assessment of aerial imagery to see if water source could be determined. For the evapotranspiration associated with the Ash Creek Wildlife Area (ACWA), the habitat largely relies on surface water and very shallow subsurface[3] water that is interconnected with Ash Creek. This surface water delivery[4] was enhanced by implementation of a "pond and plug" project in 2012 to keep the water table higher and broader throughout ACWA. The ACWA also has three wells that extract groundwater from the deeper aquifers and is applied in portions of the habitat during dry months

[2] To re-emphasize, these are rough estimates and better and more accurate data is needed.
[3] Within about the top 10 feet that plant roots can access.
[4] For the purposes of the water budget, water from Ash Creek is considered "delivered" to the wetland areas.

(Fall). These groundwater-enhanced habitat areas are indicated by the light blue areas within ACWA. Based on the limited area and time groundwater is used to support the habitat, 98% of the evapotranspiration for ACWA is estimated to come from surface water and 2% from groundwater. **Figure 6-5** shows the lands with applied water and their water source based on this assessment. Stakeholders have noted that despite the efforts to improve estimates of water source and some input from local residents, **Figure 6-5** still contains significant inaccuracies and further refinement of this dataset is needed.

The water budget for the three systems (land, surface water, and groundwater) are shown on **Figures 6-6** through **6-8.** The detailed water budget for each year is included in **Appendix 6B**. **Appendix 6C** shows graphically how the system water budgets vary over time.

With the land system and surface water system assumed to be in balance, the groundwater system varies and reflects the change in water stored in the Basin. This change in storage is shown in **Figure 6-9** and is analogous to the change in storage presented in Chapter 5 which used groundwater contours to calculate the change. These two approaches show similar trends, but the magnitude of the changes differs slightly, with the groundwater contours showing a cumulative overdraft of about 120,000 acre-feet and the water budget indicating about 190,000 acre-feet. This difference may indicate that the water budget overdraft may be slightly over estimated or that the average specific yield of the basin is higher.

The GSP regulations require an estimate of the sustainable yield[5] for the basin. (§354.18(b)(7)). This requirement is interpreted as the average annual inflow to the groundwater system, which for the 34-year period of the historic water budget is approximately 39,400 acre-feet, as indicated on item 28 of **Figure 6-8** (circled in green) for the groundwater system. The estimate of annual average groundwater use is approximately 44,600 acre-feet per year (AFY).

The regulations also require a quantification of overdraft[6]. (§354.18(b)(5)) ~~Overdraft occurs when the groundwater system change in storage is negative over a long period.~~ For the water budget period of 1984 to 2018, overdraft is estimated at approximately 5,200 AFY, shown as the average groundwater system change in storage, circled in red on **Figure 6-8** (item 31).

6.3 Current Water Budget

The current water budget is demonstrated by looking at water year 2018, which is the most recent year ~~with reliable data~~of the historic water budget.

[5] The state defines sustainable yield as, “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.” (California Water Code §10721(w))
[6] DWR defines overdraft as “the condition of a groundwater basin or Subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions.” (DWR 2016b)

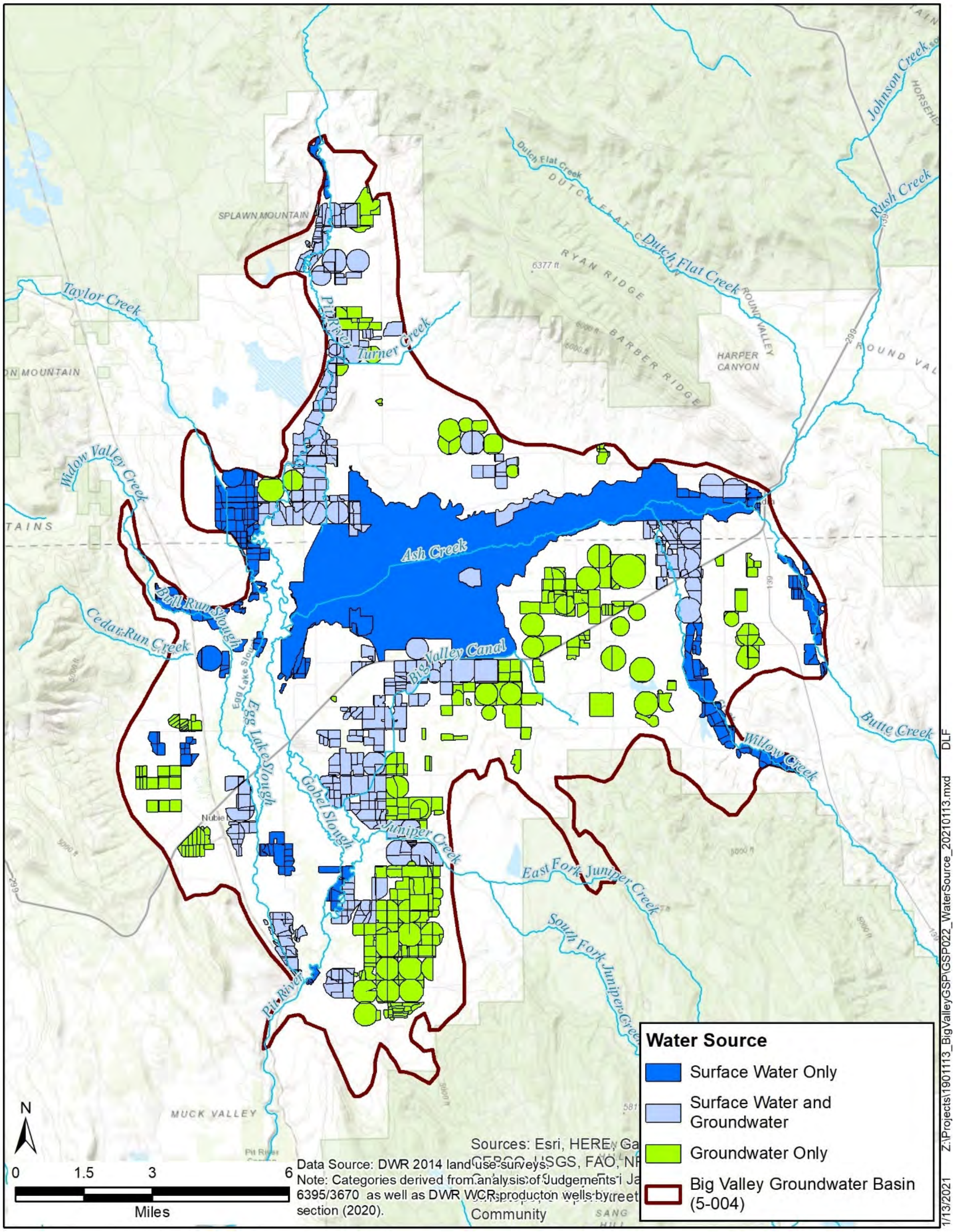


Figure 6-5 Primary Applied Water Sources

item	Flow Type	Origin/ Destination	Component	Acre-Feet
	LAND SYSTEM			
(1)	Inflow	Into Basin	Precipitation on Land System	136,801
(2)	Inflow	Between Systems	Surface Water Delivery	75,811
(3)	Inflow	Between Systems	Groundwater Extraction	44,622
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*257,234*
(5)	Outflow	Out of Basin	Evapotranspiration	154,040
(6)	Outflow	Between Systems	Runoff	83,449
(7)	Outflow	Between Systems	Return Flow	5,012
(8)	Outflow	Between Systems	Recharge of Applied Water	13,133
(9)	Outflow	Between Systems	Recharge of Precipitation	1,601
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*257,234*
(12)	Storage Change	(4)-(11)	Change in Land System Storage	-

Figure 6-6 Average Land System Water Budget 1984-2018 (Historic)

item	Flow Type	Origin/ Destination	Component	Acre-Feet
	SURFACE WATER SYSTEM			
(13)	Inflow	Into Basin	Stream Inflow	371,148
(14)	Inflow	Into Basin	Precipitation on Reservoirs	501
(6)	Inflow	Between Systems	Runoff	83,449
(7)	Inflow	Between Systems	Return Flow	5,012
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-
(16)	Inflow	Between Systems	Reservoir Gain from Groundwater	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*460,110*
(18)	Outflow	Out of Basin	Stream Outflow	358,486
(19)	Outflow	Out of Basin	Conveyance Evaporation	46
(20)	Outflow	Between Systems	Conveyance Seepage	27
(2)	Outflow	Between Systems	Surface Water Delivery	75,811
(21)	Outflow	Between Systems	Stream Loss to Groundwater	24,037
(22)	Outflow	Between Systems	Reservoir Loss to Groundwater	596
(23)	Outflow	Out of Basin	Reservoir Evaporation	722
(24)	Outflow	Out of Basin	Stream Evaporation	385
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*460,110*
(26)	Storage Change	(17)-(25)	Change in Surface Water Storage	-

Figure 6-7 Average Surface Water System Water Budget 1984-2018 (Historic)

item	Flow Type	Origin/ Destination	Component	Acre-Feet
	GROUNDWATER SYSTEM			
(8)	Inflow	Between Systems	Recharge of Applied Water	13,133
(9)	Inflow	Between Systems	Recharge of Precipitation	1,601
(10)	Inflow	Between Systems	Managed Aquifer Recharge	-
(21)	Inflow	Between Systems	Groundwater Gain from Stream	24,037
(22)	Inflow	Between Systems	Groundwater Gain from Reservoir	596
(20)	Inflow	Between Systems	Conveyance Seepage	27
(27)	Inflow	Into Basin	Subsurface Inflow	1
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*39,395*
(3)	Outflow	Between Systems	Groundwater Extraction	44,622
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-
(16)	Outflow	Between Systems	Groundwater Loss to Reservoir	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*44,622*
(31)	Storage Change	(28)-(30)	Change in Groundwater Storage	(5,227)

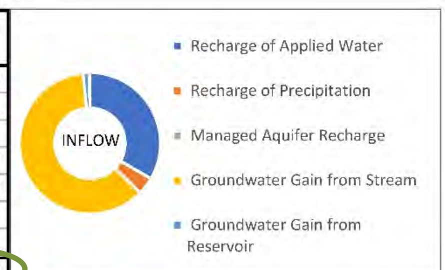


Figure 6-8 Average Groundwater System Water Budget 1984 to 2018 (Historic)

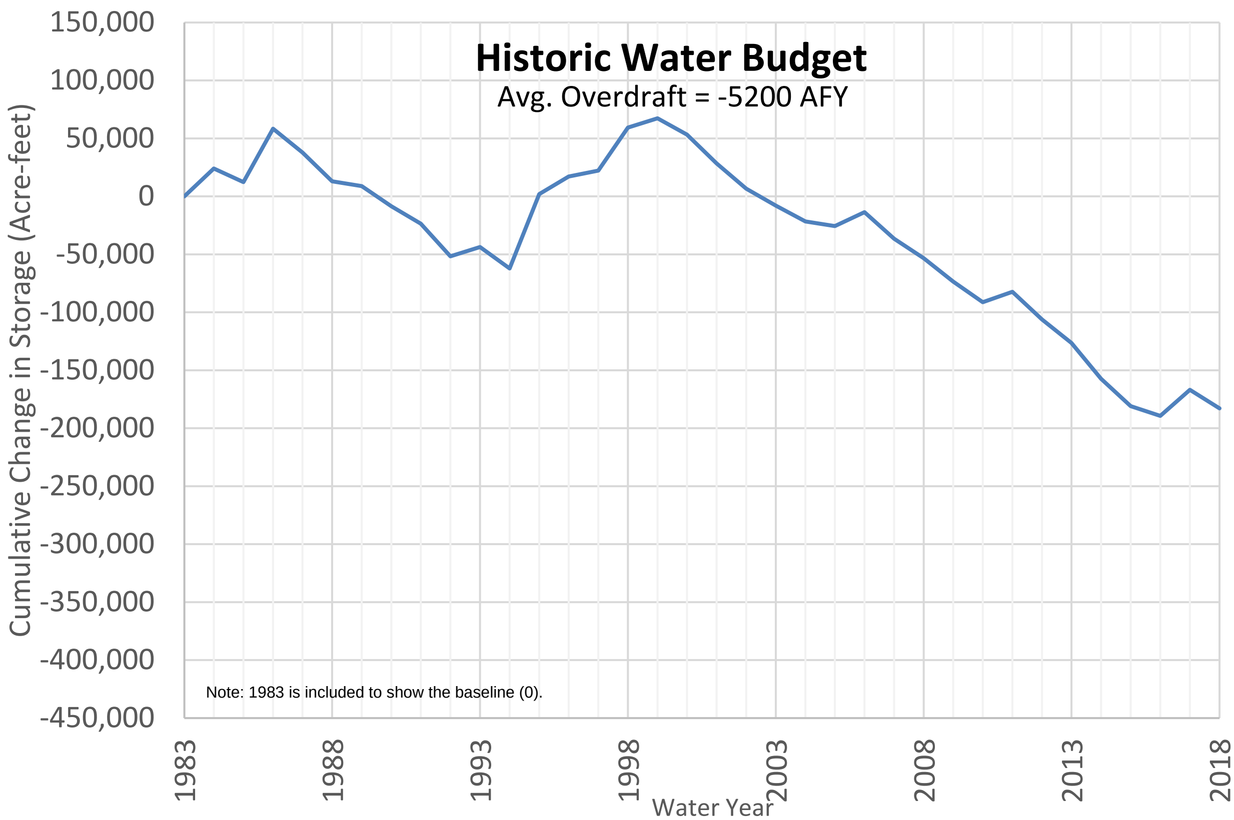


Figure 6-9 Cumulative Groundwater Change in Storage 1984 to 2018 (Historic)

6.4 Projected Water Budget

As required by the GSP Regulations, the projected water budget is developed using at least 50 years of historic climate data (precipitation, evapotranspiration, and streamflow) along with estimates of future land and water use. The climate data from 1962 to 2011 was used as an estimate of future climate baseline conditions.

6.4.1 *Projection Baseline*

The baseline projected water budget uses the most recent estimates of population and land use and keeps them constant. **Figure 6-10** shows the average annual future water budget. Long-term overdraft is projected to be about 2,100 acre-feet per year, which is less than the overdraft for the historic water budget because it uses a longer, wetter time-period for its projections. **Figure 6-11** shows the projected cumulative change in groundwater storage.

TOTAL BASIN WATER BUDGET (Acre-Feet)

Item	Flow Type	Origin/ Destination	Component	Acre-Feet
(1)	Inflow	Into Basin	Precipitation on Land System	143,208
(14)	Inflow	Into Basin	Precipitation on Reservoirs	525
(13)	Inflow	Into Basin	Stream Inflow	430,242
(27)	Inflow	Into Basin	Subsurface Inflow	1
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*573,975*
(5)	Outflow	Out of Basin	Evapotranspiration	156,873
(24)	Outflow	Out of Basin	Stream Evaporation	393
(23)	Outflow	Out of Basin	Reservoir Evaporation	741
(19)	Outflow	Out of Basin	Conveyance Evaporation	47
(18)	Outflow	Out of Basin	Stream Outflow	418,003
(29)	Outflow	Out of Basin	Subsurface Outflow	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*576,056*
(34)	Storage Change	(32)-(33)	Change in Total System Storage	(2,080)

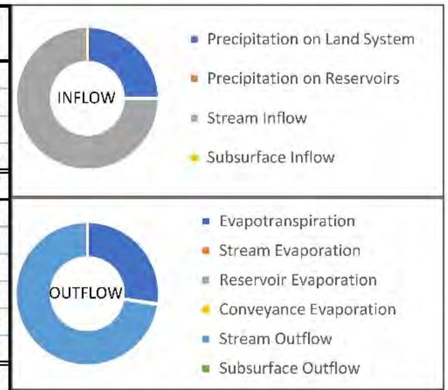


Figure 6-10 Projected Total Basin Water Budget 2019-2068 (Future Baseline)

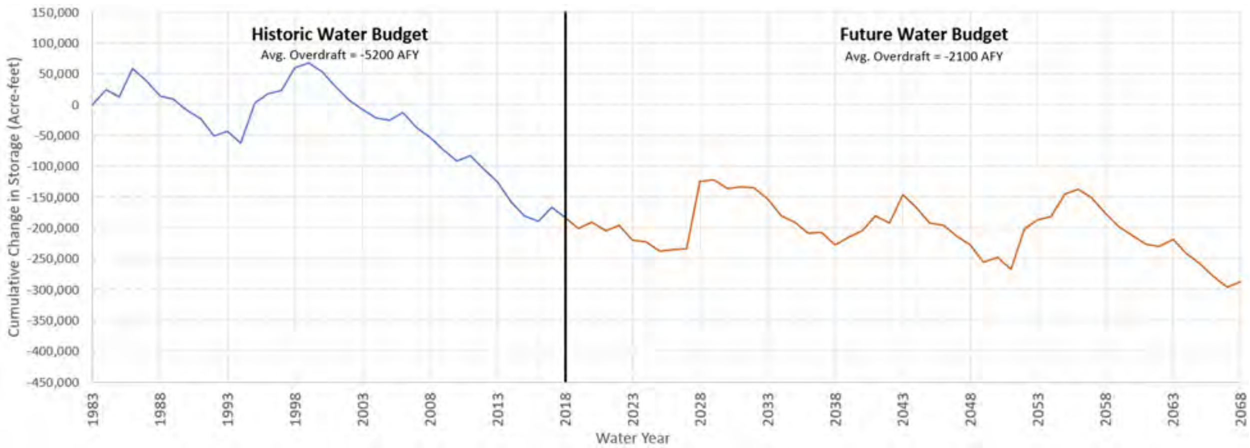


Figure 6-11 Cumulative Groundwater Change in Storage 1984 to 2068 (Future Baseline)

6.4.2 *Projection with Climate Change*

The SGMA regulations require an analysis of future conditions based on a potential change in climate. DWR provides location-specific change factors for precipitation, evapotranspiration, and streamflow based on climate change models. While there is variability in the climate change models, if the models are correct, they indicate that the future climate in Big Valley will be wetter and warmer, resulting in more precipitation, and more of that precipitation falling in the form of rain rather than snow. The change factors were applied to the baseline water budget and are shown in **Figures 6-12** and **6-13**. Land use was assumed to be constant, with conditions the same as DWR's 2014 land use survey. Future conditions with climate change projections indicate that the basin may be nearly in balance, with overdraft of only about 600 AFY.

item	Flow Type	Origin/ Destination	Component	Acre-Feet
	TOTAL BASIN WATER BUDGET			**Acre-Feet**
(1)	Inflow	Into Basin	Precipitation on Land System	152,224
(14)	Inflow	Into Basin	Precipitation on Reservoirs	558
(13)	Inflow	Into Basin	Stream Inflow	450,360
(27)	Inflow	Into Basin	Subsurface Inflow	1
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*603,143*
(5)	Outflow	Out of Basin	Evapotranspiration	165,795
(24)	Outflow	Out of Basin	Stream Evaporation	414
(23)	Outflow	Out of Basin	Reservoir Evaporation	780
(19)	Outflow	Out of Basin	Conveyance Evaporation	50
(18)	Outflow	Out of Basin	Stream Outflow	436,663
(29)	Outflow	Out of Basin	Subsurface Outflow	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*603,701*
(34)	Storage Change	(32)-(33)	Change in Total System Storage	(558)

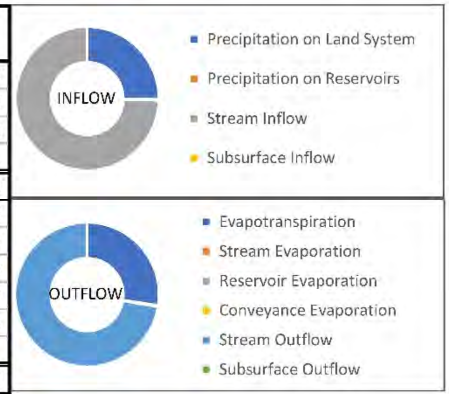


Figure 6-12 Projected Total Basin Water Budget 2019-2068 (Future with Climate Change)

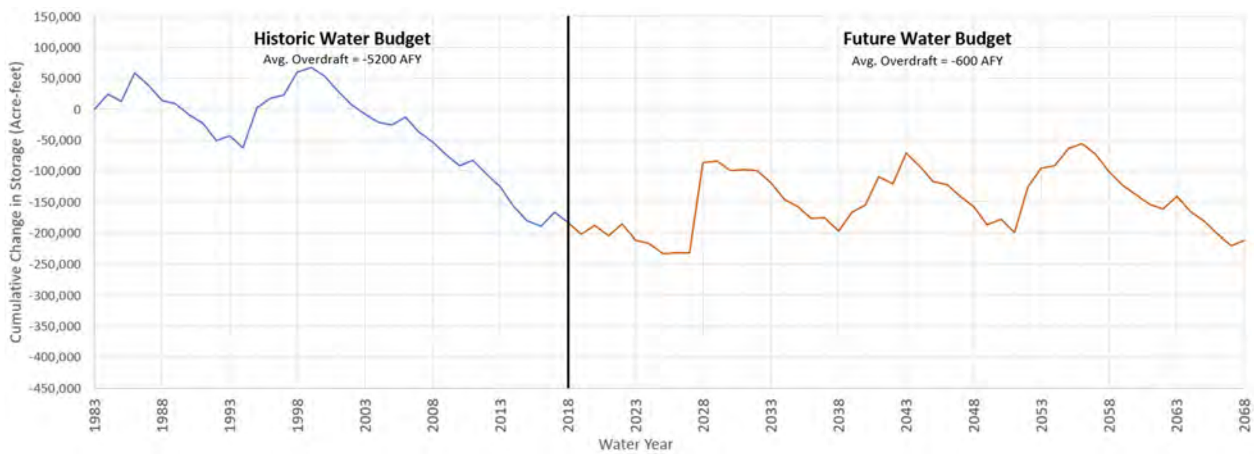


Figure 6-13 Cumulative Groundwater System Change in Storage 1984 to 2068 (Future with Climate Change)

6.5 References

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Appendix 6A

Water Budget Components

LAND SYSTEM WATER BUDGET

Item	Flow Type	Origin/ Destination	Component	Credit(+)/ Debit(-)	Relationship with Other Systems	Data Source(s)	Assumptions	Relative Level of Precision	Data Needs and Refinements
(1)	**Inflow**	Into Basin	Precipitation on Land System	+		-Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber -Basin Land area from DWR (2018). -Area of rivers, conveyance, and lakes from USGS (2020).	-Precipitation does not vary spatially throughout the Basin	High	-No refinements planned for this component -Variations in precipitation throughout the basin could be estimated with an in-depth analysis of the PRISM model
(2)	**Inflow**	Between Systems	Surface Water Delivery	+	Equal to the *Surface Water Delivery* term in the surface water system outflow	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Crop Coefficients (Kc) adapted from FAO (1998) -Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber	-Agriculture is the only sector that uses surface water -Irrigation efficiency = 85% -40% of agricultural irrigation uses surface water -98% of riparian demands are met by surface water	Low	-More detailed information on irrigation practices and associated efficiencies More detailed information of agricultural surface water vs groundwater use More detailed information on amount of groundwater pumping to support riparian habitat at the Ash Creek Wildlife Area
(3)	**Inflow**	Between Systems	Groundwater Extraction	+	Equal to the *Groundwater Extraction* term in the groundwater system outflow	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Crop Coefficients (Kc) adapted from FAO (1998) -Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber Population of Bieber from United States Census Bureau (2020) Population of Big Valley from DWR (2018)	-Irrigation efficiency = 85% -60% of agricultural irrigation uses groundwater -2% of riparian demands are met by groundwater -Per capita water use is 100 gallons/day/person -All domestic users use groundwater	Low	-More detailed information on irrigation practices and associated efficiencies More detailed information of agricultural surface water vs groundwater use More detailed information on amount of groundwater pumping to support riparian habitat at the Ash Creek Wildlife Area
(4)	**Inflow**		*Total Inflow*		*(1)+(2)+(3)*				
(5)	**Outflow**	Out of Basin	Evapotranspiration	-		-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Crop Coefficients (Kc) adapted from FAO (1998) -Land use and crop acreages from DWR (2014)	-ETo does not vary throughout the Basin -The land system remains in balance from year to year (no change in land system storage).	Moderate	-Incorporate changes in crop acreages over time by using DWR land use surveys from 1997, 2011, 2013, and 2016
(6)	**Outflow**	Between Systems	Runoff	-	Equal to the *Runoff* term in Surface Water System*	-Precipitation from PRISM Model (NACSE 2020) evaluated at Bieber	-85% of precipitation results in runoff	Low	-More detailed runoff percentage from evaluation of basin using curve number method
(7)	**Outflow**	Between Systems	Return Flow	-	Equal to the *Return Flow* term in Surface Water System*	-See surface water delivery and groundwater extraction above	-50% of agricultural inefficiency results in return flow (7.5% of applied water)	Low	-More detailed information on irrigation practices and associated efficiencies
(8)	**Outflow**	Between Systems	Recharge of Applied Water	-	Equal to the *Recharge of Applied Water* term in the groundwater system	-See surface water delivery and groundwater extraction above	-50% of agricultural inefficiency results in recharge of grounwater (7.5% of applied water)	Low	-More detailed information on irrigation practices and associated efficiencies
(9)	**Outflow**	Between Systems	Recharge of Precipitation	-	Equal to the *Recharge of Precipitation* term in the groundwater system	-Precipitation from PRISM Model (NACSE 2020) evaluated at Bieber	-2% of precipitation results in recharge to groundwater	Moderate	
(10)	**Outflow**	Between Systems	Managed Aquifer Recharge	-	Equal to the *Managed Aquifer Recharge* term in the groundwater system	No managed recharge currently occurs in the Big Valley Groundwater basin			
(11)	**Outflow**		*Total Outflow*		*(5)+(6)+(7)+(8)+(9)+(10)*				
(12)	**Storage Change**		Change in Land System Storage		*(4)-(11)*				

SURFACE WATER SYSTEM WATER BUDGET

Item	Flow Type	Origin/ Destination	Component	Credit(+)/ Debit(-)	Relationship with Other Systems	Data Source(s)	Assumptions	Relative Level of Precision	Data Needs and Refinements
(13)	Inflow	Into Basin	Stream Inflow	+		-Historic and current data from Pit River gage at Canby -Historic data from gage on Pit River north of Lookout (where it enters basin), Ash Creek at Adin, Widow Valley Creek, Willow Creek	-Historic relationship between flow at Canby and flow at historic gages is the same as current. E.g. flow during winter events is about 40% higher than Canby once the Pit River reaches Big Valley -Watershed areas outside of those with historic gage measurements have same runoff per acre as the gaged watersheds	Moderate	-Additional data from new gages
(14)	Inflow	Into Basin	Precipitation on Lakes	+		-Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber -Area of rivers, conveyance, and lakes from USGS (2020).	-precipitation does not vary spatially throughout the Basin	High	-No refinements planned for this component
(6)	Inflow	Between Systems	Runoff	+	Equal to the *Runoff* term in land system (6)	-Precipitation from PRISM Model (NACSE 2020) evaluated at Bieber		Low	
(7)	Inflow	Between Systems	Return Flow	+	Equal to the *Return Flow* term in the land system (7)	-See surface water delivery and groundwater extraction above		Low	
(15)	Inflow	Between Systems	Stream Gain from Groundwater	+	Equal to the *Groundwater Loss to Stream* term in the groundwater system	-None	-Assumed to be 0 until further analysis of transducer data from new monitoring wells	Low	-Analysis of transducer data from new monitoring wells and groundwater contours
(16)	Inflow	Between Systems	Lake Gain from Groundwater	+	Equal to the *Groundwater Loss to Lake* term in the groundwater system	-None	-Assumed to be 0 because most lakes are above the groundwater levels	High	-No refinements planned for this component
(17)	Inflow		*Total Inflow*		*(13)+(14)+(6)+(7)+(15)+(16)*				
(18)	Outflow	Out of Basin	Stream Outflow	-		-Estimated based on this water budget -Estimates verified using analysis of historic gage data from Pit River south of Bieber (exit from Basin)	-The surface water system remains in balance from year to year (no change in surface water storage)	Low	-No refinements planned for this component
(19)	Outflow	Out of Basin	Conveyance Evaporation	-		-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of conveyance from USGS (2020)	-Each year, conveyance is full from May to September and empty from October to April	Moderate	-No refinements planned for this component
(20)	Outflow	Between Systems	Conveyance Seepage	-	Equal to the *Conveyance Seepage* term in the groundwater system	-Area of conveyance from USGS (2020)	-Each year, conveyance is full from May to September and empty from October to April -Seepage rate of 0.01 ft/day	Moderate	-No refinements planned for this component
(2)	Outflow	Between Systems	Surface Water Delivery	-	Equal to the *Surface Water Delivery* term in land system (2)	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Crop Coefficients (Kc) adapted from FAO (1998) -Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber		Low	
(21)	Outflow	Between Systems	Stream Loss to Groundwater	-	Equal to the *Gain from Stream* term in the groundwater system	-Historic and current data from Pit River gage at Canby -Historic data from gage on Pit River north of Lookout (where it enters Basin), Ash Creek at Adin, Widow Valley Creek, Willow Creek, Pit River at exit from Basin.	-Calculated from the historic inflow - outflow relationship.	Low	-Additional data from new gages
(22)	Outflow	Between Systems	Lake Loss to Groundwater	-	Equal to the *Groundwater Gain from Lake* term in the groundwater system	-Area of lakes from USGS (2020)	-Each year, lakes are full (100%) and surface area drops throughout summer to 10% in September, then gradually refill over the winter. -Seepage rate of 0.01 ft/day	Moderate	-No refinements planned for this component
(23)	Outflow	Out of Basin	Lake Evaporation	-		-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of lakes from USGS (2020)	-Each year, lakes are full (100%) and surface area drops throughout summer to 10% in September, then gradually refill over the winter.	High	
(24)	Outflow	Out of Basin	Stream Evaporation	-		-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of streams from USGS (2020)		High	
(25)	Outflow		*Total Outflow*		*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*				
(26)	Storage Change		Change in Surface Water Storage		*(17)-(25)*				

GROUNDWATER SYSTEM WATER BUDGET

Item	Flow Type	Origin/ Destination	Component	Credit(+)/ Debit(-)	Relationship with Other Systems	Data Source(s)	Assumptions	Relative Level of Precision	Data Needs and Refinements
(8)	**Inflow**	Between Systems	Recharge of Applied Water	+	Equal to the *Recharge of Applied Water* term in the land system (8)	-See surface water delivery and groundwater extraction above		Low	
(9)	**Inflow**	Between Systems	Recharge of Precipitation	+	Equal to the *Recharge of Precipitation* term in the land system (9)	-Precipitation from PRISM Model (NACSE 2020) evaluated at Bieber		Low	
(10)	**Inflow**	Between Systems	Managed Aquifer Recharge	+	Equal to the *Managed Aquifer Recharge* term in the land system (10)	No managed recharge currently occurs in the Big Valley Groundwater basin			
(21)	**Inflow**	Between Systems	Groundwater Gain from Stream	+	Equal to the *Stream Loss to Groundwater* term in the surface water system (21)	-Historic and current data from Pit River gage at Canby -Historic data from gage on Pit River north of Lookout (where it enters Basin), Ash Creek at Adin, Widow Valley Creek, Willow Creek, Pit River at exit from Basin.		Low	
(22)	**Inflow**	Between Systems	Groundwater Gain from Lake	+	Equal to the *Lake Loss to Groundwater* term in the surface water system (22)	-Area of lakes from USGS (2020)		Moderate	
(20)	**Inflow**	Between Systems	Conveyance Seepage	+	Equal to the *Conveyance Seepage* term in the surface water system (20)	-Area of conveyance from USGS (2020)		Moderate	
(27)	**Inflow**	Into Basin	Subsurface Inflow	+			-No subsurface inflow occurs in the BVGB	Moderate	-Further analysis of transducer data from new monitoring wells -Analysis of potential inflow near Adin
(28)	**Inflow**		*Total Inflow*		*(8)+(9)+(10)+(21)+(22)+(20)+(27)*				
(3)	**Outflow**	Between Systems	Groundwater Extraction	-	Equal to the *Groundwater Extraction* term in the land system (3)	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Crop Coefficients (Kc) adapted from FAO (1998) -Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber Population of Bieber from United States Census Bureau (2020) Population of Big Valley from DWR (2018)		Low	
(15)	**Outflow**	Between Systems	Groundwater Loss to Stream	-	Equal to the *Stream Gain from Groundwater* term in the surface water system (15)	-None		Low	
(16)	**Outflow**	Between Systems	Groundwater Loss to Lake	-	Equal to the *Lake Gain from Groundwater* term in the surface water system (16)	-None		High	
(29)	**Outflow**	Out of Basin	Subsurface Outflow	-			-No subsurface outflow occurs in the BVGB	Moderate	-Will revisit this if additional information becomes available to indicated subsurface outflow
(30)	**Outflow**		*Total Outflow*		*(3)+(15)+(16)+(29)*				
(31)	**Storage Change**		Change in Groundwater Storage		(28)-(30)				

TOTAL WATER BUDGET

Item	Flow Type	Origin/ Destination	Component	Credit(+)/ Debit(-)	Relationship with Other Systems	Data Source(s)	Assumptions	Relative Level of Precision	Data Needs and Refinements
(1)	Inflow	Into Basin	Precipitation on Land System	+	Equal to the *Precipitation* term in the	-Monthly precipitation from PRISM Model (NACSE		High	
(14)	Inflow	Into Basin	Precipitation on Lakes	+	Equal to the *Precipitation on Lakes* term in the surface water system	-Monthly precipitation from PRISM Model (NACSE 2020) evaluated at Bieber -Area of rivers, conveyance, and lakes from USGS (2020).		High	
(13)	Inflow	Into Basin	Stream Inflow	+	Equal to the *Stream Inflow* term in the surface water system	-Historic and current data from Pit River gage at Canby -Historic data from gage on Pit River north of Lookout (where it enters basin), Ash Creek at Adin, Widow Valley Creek, Willow Creek		Moderate	
(27)	Inflow	Into Basin	Subsurface Inflow	+	Equal to the *Subsurface Inflow* term in the groundwater system			Moderate	
(32)	Inflow		*Total Inflow*		*(1)+(14)+(13)+(27)*				
(5)	Outflow	Out of Basin	Evapotranspiration	-	Equal to the *Evapotranspiration*	-Reference Evapotranspiration (ETo) from CIMIS		Moderate	
(24)	Outflow	Out of Basin	Stream Evaporation	-	Equal to the *Stream Evaporation* term in the surface water system	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of streams from USGS (2020)		High	
(23)	Outflow	Out of Basin	Lake Evaporation	-	Equal to the *Lake Evaporation* term in the surface water system	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of lakes from USGS (2020)		High	
(19)	Outflow	Out of Basin	Conveyance Evaporation	-	Equal to the *Conveyance Evaporation* term in the surface water system	-Reference Evapotranspiration (ETo) from CIMIS spatial data model evaluated at Bieber (DWR 2020b) -Area of conveyance from USGS (2020)		Moderate	
(18)	Outflow	Out of Basin	Stream Outflow	-	Equal to the *Stream Outflow* term in the surface water system	-Estimated based on this water budget -Estimates verified using analysis of historic gage data from Pit River south of Bieber (exit from Basin)		Low	
(29)	Outflow	Out of Basin	Subsurface Outflow	-	Equal to the *Subsurface Outflow* term in the groundwater system			Moderate	
(33)	Outflow		*Total Outflow*		*(5)+(24)+(23)+(19)+(18)+(29)*				
(34)	Storage Change		Change in Total System Storage		(32)-(33)				

Appendix 6B

Historic Water Budget Details

	LAND SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	Average (1984-2018)	1984	1985	1986	1987	1988
(1)	Inflow	Into Basin	Precipitation on Land System	135,134	147,084	131,102	191,338	95,141	87,753
(2)	Inflow	Between Systems	Surface Water Delivery	83,368	73,276	83,420	80,966	86,167	93,463
(3)	Inflow	Between Systems	Groundwater Extraction	47,590	41,183	47,063	45,543	49,031	53,443
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*266,092*	*261,543*	*261,585*	*317,847*	*230,338*	*234,659*
(5)	Outflow	Out of Basin	Evapotranspiration	128,739	116,331	127,810	132,234	127,160	136,155
(6)	Outflow	Between Systems	Runoff	114,864	125,022	111,436	162,637	80,870	74,590
(7)	Outflow	Between Systems	Return Flow	5,800	5,014	5,733	5,547	5,976	6,516
(8)	Outflow	Between Systems	Recharge of Applied Water	13,923	12,234	13,919	13,509	14,384	15,600
(9)	Outflow	Between Systems	Recharge of Precipitation	2,703	2,942	2,622	3,827	1,903	1,755
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*266,029*	*261,543*	*261,521*	*317,754*	*230,292*	*234,616*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	64	-	64	93	46	43

	SURFACE WATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	Average (1984-2018)	1984	1985	1986	1987	1988
(13)	Inflow	Into Basin	Stream Inflow	371,148	808,462	310,960	878,565	161,807	162,980
(14)	Inflow	Into Basin	Precipitation on Lakes	998	573	756	1,219	402	545
(6)	Inflow	Between Systems	Runoff	114,864	125,022	111,436	162,637	80,870	74,590
(7)	Inflow	Between Systems	Return Flow	5,800	5,014	5,733	5,547	5,976	6,516
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*492,811*	*939,071*	*428,885*	*1,047,968*	*249,054*	*244,631*
(18)	Outflow	Out of Basin	Stream Outflow	379,320	810,919	320,769	888,490	145,199	133,122
(19)	Outflow	Out of Basin	Conveyance Evaporation	821	783	827	813	815	900
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	83,368	73,276	83,420	80,966	86,167	93,463
(21)	Outflow	Between Systems	Stream Loss to Groundwater	24,037	49,085	18,460	72,401	11,524	11,579
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,553	1,439	1,643	1,564	1,588	1,668
(24)	Outflow	Out of Basin	Stream Evaporation	2,128	1,983	2,184	2,150	2,177	2,315
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*492,811*	*939,071*	*428,885*	*1,047,968*	*249,054*	*244,631*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

	GROUNDWATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	Average (1984-2018)	1984	1985	1986	1987	1988
(8)	Inflow	Between Systems	Recharge of Applied Water	13,923	12,234	13,919	13,509	14,384	15,600
(9)	Inflow	Between Systems	Recharge of Precipitation	2,703	2,942	2,622	3,827	1,903	1,755
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	24,037	49,085	18,460	72,401	11,524	11,579
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*42,246*	*65,845*	*36,584*	*91,321*	*29,394*	*30,517*
(3)	Outflow	Between Systems	Groundwater Extraction	47,590	41,183	47,063	45,543	49,031	53,443
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*47,590*	*41,183*	*47,063*	*45,543*	*49,031*	*53,443*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	(5,344)	24,662	(10,478)	45,778	(19,636)	(22,925)

	TOTAL BASIN WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	Average (1984-2018)	1984	1985	1986	1987	1988
(1)	Inflow	Into Basin	Precipitation on Land System	135,134	147,084	131,102	191,338	95,141	87,753
(14)	Inflow	Into Basin	Precipitation on Lakes	998	573	756	1,219	402	545
(13)	Inflow	Into Basin	Stream Inflow	371,148	808,462	310,960	878,565	161,807	162,980
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*507,280*	*956,119*	*442,817*	*1,071,121*	*257,350*	*251,278*
(5)	Outflow	Out of Basin	Evapotranspiration	128,739	116,331	127,810	132,234	127,160	136,155
(24)	Outflow	Out of Basin	Stream Evaporation	2,128	1,983	2,184	2,150	2,177	2,315
(23)	Outflow	Out of Basin	Lake Evaporation	1,553	1,439	1,643	1,564	1,588	1,668
(19)	Outflow	Out of Basin	Conveyance Evaporation	821	783	827	813	815	900
(18)	Outflow	Out of Basin	Stream Outflow	379,320	810,919	320,769	888,490	145,199	133,122
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*512,561*	*931,457*	*453,232*	*1,025,251*	*276,940*	*274,161*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	(5,280)	24,662	(10,415)	45,871	(19,590)	(22,883)

item	Flow Type	Origin/ Destination	Component	1989	1990	1991	1992	1993	1994
LAND SYSTEM WATER BUDGET									
(1)	Inflow	Into Basin	Precipitation on Land System	148,818	111,048	107,203	74,635	181,839	103,208
(2)	Inflow	Between Systems	Surface Water Delivery	80,214	80,462	85,865	90,902	80,059	84,544
(3)	Inflow	Between Systems	Groundwater Extraction	46,379	45,973	49,539	52,304	46,333	48,114
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*275,411*	*237,484*	*242,607*	*217,841*	*308,231*	*235,866*
(5)	Outflow	Out of Basin	Evapotranspiration	126,799	121,773	128,898	131,311	130,905	126,046
(6)	Outflow	Between Systems	Runoff	126,495	94,391	91,123	63,440	154,563	87,727
(7)	Outflow	Between Systems	Return Flow	5,655	5,603	6,041	6,378	5,650	5,864
(8)	Outflow	Between Systems	Recharge of Applied Water	13,414	13,442	14,349	15,182	13,389	14,115
(9)	Outflow	Between Systems	Recharge of Precipitation	2,976	2,221	2,144	1,493	3,637	2,064
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*275,339*	*237,430*	*242,555*	*217,805*	*308,143*	*235,815*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	72	54	52	36	88	50

item	Flow Type	Origin/ Destination	Component	1989	1990	1991	1992	1993	1994
SURFACE WATER SYSTEM WATER BUDGET									
(13)	Inflow	Into Basin	Stream Inflow	390,854	133,594	263,663	76,254	602,999	167,393
(14)	Inflow	Into Basin	Precipitation on Lakes	1,044	911	348	386	1,518	2,017
(6)	Inflow	Between Systems	Runoff	126,495	94,391	91,123	63,440	154,563	87,727
(7)	Inflow	Between Systems	Return Flow	5,655	5,603	6,041	6,378	5,650	5,864
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*524,048*	*234,499*	*361,174*	*146,458*	*764,729*	*263,000*
(18)	Outflow	Out of Basin	Stream Outflow	415,719	137,926	253,032	41,694	646,693	160,562
(19)	Outflow	Out of Basin	Conveyance Evaporation	799	785	838	860	816	830
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	80,214	80,462	85,865	90,902	80,059	84,544
(21)	Outflow	Between Systems	Stream Loss to Groundwater	22,175	10,212	16,260	7,546	32,039	11,784
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,503	1,493	1,488	1,626	1,492	1,562
(24)	Outflow	Out of Basin	Stream Evaporation	2,054	2,036	2,107	2,246	2,045	2,134
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*524,048*	*234,499*	*361,174*	*146,458*	*764,729*	*263,000*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

item	Flow Type	Origin/ Destination	Component	1989	1990	1991	1992	1993	1994
GROUNDWATER SYSTEM WATER BUDGET									
(8)	Inflow	Between Systems	Recharge of Applied Water	13,414	13,442	14,349	15,182	13,389	14,115
(9)	Inflow	Between Systems	Recharge of Precipitation	2,976	2,221	2,144	1,493	3,637	2,064
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	22,175	10,212	16,260	7,546	32,039	11,784
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*40,149*	*27,459*	*34,338*	*25,805*	*50,649*	*29,547*
(3)	Outflow	Between Systems	Groundwater Extraction	46,379	45,973	49,539	52,304	46,333	48,114
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*46,379*	*45,973*	*49,539*	*52,304*	*46,333*	*48,114*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	(6,231)	(18,514)	(15,201)	(26,499)	4,316	(18,567)

item	Flow Type	Origin/ Destination	Component	1989	1990	1991	1992	1993	1994
TOTAL BASIN WATER BUDGET									
(1)	Inflow	Into Basin	Precipitation on Land System	148,818	111,048	107,203	74,635	181,839	103,208
(14)	Inflow	Into Basin	Precipitation on Lakes	1,044	911	348	386	1,518	2,017
(13)	Inflow	Into Basin	Stream Inflow	390,854	133,594	263,663	76,254	602,999	167,393
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*540,716*	*245,553*	*371,214*	*151,275*	*786,355*	*272,617*
(5)	Outflow	Out of Basin	Evapotranspiration	126,799	121,773	128,898	131,311	130,905	126,046
(24)	Outflow	Out of Basin	Stream Evaporation	2,054	2,036	2,107	2,246	2,045	2,134
(23)	Outflow	Out of Basin	Lake Evaporation	1,503	1,493	1,488	1,626	1,492	1,562
(19)	Outflow	Out of Basin	Conveyance Evaporation	799	785	838	860	816	830
(18)	Outflow	Out of Basin	Stream Outflow	415,719	137,926	253,032	41,694	646,693	160,562
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*546,874*	*264,014*	*386,363*	*177,737*	*781,951*	*291,134*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	(6,158)	(18,460)	(15,149)	(26,462)	4,404	(18,517)

LAND SYSTEM WATER BUDGET									
item	Flow Type	Origin/ Destination	Component	1995	1996	1997	1998	1999	2000
(1)	Inflow	Into Basin	Precipitation on Land System	189,905	181,537	169,776	226,318	144,747	126,578
(2)	Inflow	Between Systems	Surface Water Delivery	72,909	78,370	82,675	72,108	82,077	84,765
(3)	Inflow	Between Systems	Groundwater Extraction	42,025	44,842	46,927	41,431	47,198	48,547
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*304,839*	*304,750*	*299,378*	*339,857*	*274,022*	*259,890*
(5)	Outflow	Out of Basin	Evapotranspiration	122,209	128,163	132,070	125,740	128,551	129,629
(6)	Outflow	Between Systems	Runoff	161,420	154,307	144,310	192,371	123,035	107,592
(7)	Outflow	Between Systems	Return Flow	5,122	5,465	5,718	5,049	5,754	5,918
(8)	Outflow	Between Systems	Recharge of Applied Water	12,198	13,097	13,802	12,062	13,717	14,158
(9)	Outflow	Between Systems	Recharge of Precipitation	3,798	3,631	3,396	4,526	2,895	2,532
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*304,747*	*304,662*	*299,296*	*339,747*	*273,952*	*259,828*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	92	88	82	110	70	61

SURFACE WATER SYSTEM WATER BUDGET									
item	Flow Type	Origin/ Destination	Component	1995	1996	1997	1998	1999	2000
(13)	Inflow	Into Basin	Stream Inflow	912,444	780,720	614,680	832,300	691,739	240,124
(14)	Inflow	Into Basin	Precipitation on Lakes	1,949	1,474	1,193	2,101	1,011	1,044
(6)	Inflow	Between Systems	Runoff	161,420	154,307	144,310	192,371	123,035	107,592
(7)	Inflow	Between Systems	Return Flow	5,122	5,465	5,718	5,049	5,754	5,918
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*1,080,935*	*941,965*	*765,902*	*1,031,820*	*821,539*	*354,677*
(18)	Outflow	Out of Basin	Stream Outflow	916,329	816,120	644,515	897,886	697,247	248,582
(19)	Outflow	Out of Basin	Conveyance Evaporation	741	785	830	749	814	836
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	72,909	78,370	82,675	72,108	82,077	84,765
(21)	Outflow	Between Systems	Stream Loss to Groundwater	86,149	41,575	32,583	56,285	36,166	15,166
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,345	1,490	1,569	1,330	1,552	1,586
(24)	Outflow	Out of Basin	Stream Evaporation	1,878	2,040	2,146	1,878	2,100	2,159
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*1,080,935*	*941,965*	*765,902*	*1,031,820*	*821,539*	*354,677*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

GROUNDWATER SYSTEM WATER BUDGET									
item	Flow Type	Origin/ Destination	Component	1995	1996	1997	1998	1999	2000
(8)	Inflow	Between Systems	Recharge of Applied Water	12,198	13,097	13,802	12,062	13,717	14,158
(9)	Inflow	Between Systems	Recharge of Precipitation	3,798	3,631	3,396	4,526	2,895	2,532
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	86,149	41,575	32,583	56,285	36,166	15,166
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*103,728*	*59,886*	*51,364*	*74,457*	*54,362*	*33,440*
(3)	Outflow	Between Systems	Groundwater Extraction	42,025	44,842	46,927	41,431	47,198	48,547
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*42,025*	*44,842*	*46,927*	*41,431*	*47,198*	*48,547*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	61,703	15,044	4,437	33,026	7,163	(15,107)

TOTAL BASIN WATER BUDGET									
item	Flow Type	Origin/ Destination	Component	1995	1996	1997	1998	1999	2000
(1)	Inflow	Into Basin	Precipitation on Land System	189,905	181,537	169,776	226,318	144,747	126,578
(14)	Inflow	Into Basin	Precipitation on Lakes	1,949	1,474	1,193	2,101	1,011	1,044
(13)	Inflow	Into Basin	Stream Inflow	912,444	780,720	614,680	832,300	691,739	240,124
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*1,104,299*	*963,730*	*785,650*	*1,060,719*	*837,497*	*367,746*
(5)	Outflow	Out of Basin	Evapotranspiration	122,209	128,163	132,070	125,740	128,551	129,629
(24)	Outflow	Out of Basin	Stream Evaporation	1,878	2,040	2,146	1,878	2,100	2,159
(23)	Outflow	Out of Basin	Lake Evaporation	1,345	1,490	1,569	1,330	1,552	1,586
(19)	Outflow	Out of Basin	Conveyance Evaporation	741	785	830	749	814	836
(18)	Outflow	Out of Basin	Stream Outflow	916,329	816,120	644,515	897,886	697,247	248,582
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*1,042,503*	*948,598*	*781,131*	*1,027,583*	*830,264*	*382,792*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	61,795	15,132	4,519	33,136	7,234	(15,046)

item	LAND SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2001	2002	2003	2004	2005	2006
(1)	Inflow	Into Basin	Precipitation on Land System	78,329	108,636	134,947	135,022	145,727	188,398
(2)	Inflow	Between Systems	Surface Water Delivery	88,557	87,835	82,497	85,444	77,755	79,668
(3)	Inflow	Between Systems	Groundwater Extraction	50,682	50,336	47,185	48,729	44,032	45,803
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*217,569*	*246,807*	*264,628*	*269,195*	*267,514*	*313,869*
(5)	Outflow	Out of Basin	Evapotranspiration	128,419	131,436	127,627	131,455	122,313	130,971
(6)	Outflow	Between Systems	Runoff	66,580	92,340	114,705	114,769	123,868	160,138
(7)	Outflow	Between Systems	Return Flow	6,179	6,137	5,751	5,939	5,364	5,583
(8)	Outflow	Between Systems	Recharge of Applied Water	14,787	14,669	13,781	14,266	12,984	13,317
(9)	Outflow	Between Systems	Recharge of Precipitation	1,567	2,173	2,699	2,700	2,915	3,768
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*217,531*	*246,754*	*264,562*	*269,129*	*267,443*	*313,778*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	38	53	66	66	71	92

item	SURFACE WATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2001	2002	2003	2004	2005	2006
(13)	Inflow	Into Basin	Stream Inflow	100,742	153,035	219,963	295,581	381,347	735,770
(14)	Inflow	Into Basin	Precipitation on Lakes	541	742	1,193	1,065	1,108	1,366
(6)	Inflow	Between Systems	Runoff	66,580	92,340	114,705	114,769	123,868	160,138
(7)	Inflow	Between Systems	Return Flow	6,179	6,137	5,751	5,939	5,364	5,583
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*174,041*	*252,254*	*341,611*	*417,354*	*511,687*	*902,857*
(18)	Outflow	Out of Basin	Stream Outflow	70,489	147,020	238,861	307,951	406,267	778,989
(19)	Outflow	Out of Basin	Conveyance Evaporation	868	854	815	832	788	828
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	88,557	87,835	82,497	85,444	77,755	79,668
(21)	Outflow	Between Systems	Stream Loss to Groundwater	8,684	11,116	14,228	17,745	21,733	38,213
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,644	1,629	1,526	1,609	1,487	1,502
(24)	Outflow	Out of Basin	Stream Evaporation	2,214	2,215	2,100	2,189	2,073	2,072
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*174,041*	*252,254*	*341,611*	*417,354*	*511,687*	*902,857*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

item	GROUNDWATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2001	2002	2003	2004	2005	2006
(8)	Inflow	Between Systems	Recharge of Applied Water	14,787	14,669	13,781	14,266	12,984	13,317
(9)	Inflow	Between Systems	Recharge of Precipitation	1,567	2,173	2,699	2,700	2,915	3,768
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	8,684	11,116	14,228	17,745	21,733	38,213
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*26,622*	*29,541*	*32,292*	*36,295*	*39,215*	*56,882*
(3)	Outflow	Between Systems	Groundwater Extraction	50,682	50,336	47,185	48,729	44,032	45,803
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*50,682*	*50,336*	*47,185*	*48,729*	*44,032*	*45,803*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	(24,060)	(20,795)	(14,893)	(12,433)	(4,817)	11,079

item	TOTAL BASIN WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2001	2002	2003	2004	2005	2006
(1)	Inflow	Into Basin	Precipitation on Land System	78,329	108,636	134,947	135,022	145,727	188,398
(14)	Inflow	Into Basin	Precipitation on Lakes	541	742	1,193	1,065	1,108	1,366
(13)	Inflow	Into Basin	Stream Inflow	100,742	153,035	219,963	295,581	381,347	735,770
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*179,612*	*262,413*	*356,102*	*431,668*	*528,182*	*925,534*
(5)	Outflow	Out of Basin	Evapotranspiration	128,419	131,436	127,627	131,455	122,313	130,971
(24)	Outflow	Out of Basin	Stream Evaporation	2,214	2,215	2,100	2,189	2,073	2,072
(23)	Outflow	Out of Basin	Lake Evaporation	1,644	1,629	1,526	1,609	1,487	1,502
(19)	Outflow	Out of Basin	Conveyance Evaporation	868	854	815	832	788	828
(18)	Outflow	Out of Basin	Stream Outflow	70,489	147,020	238,861	307,951	406,267	778,989
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*203,634*	*283,155*	*370,929*	*444,036*	*532,928*	*914,363*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	(24,022)	(20,742)	(14,827)	(12,368)	(4,746)	11,170

item	LAND SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2007	2008	2009	2010	2011	2012
(1)	Inflow	Into Basin	Precipitation on Land System	98,081	96,272	112,782	119,190	165,178	92,352
(2)	Inflow	Between Systems	Surface Water Delivery	87,225	85,939	85,918	79,962	76,188	88,131
(3)	Inflow	Between Systems	Groundwater Extraction	49,544	48,994	49,010	45,501	43,568	49,971
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*234,849*	*231,205*	*247,710*	*244,653*	*284,933*	*230,454*
(5)	Outflow	Out of Basin	Evapotranspiration	128,876	127,082	129,216	122,000	123,105	129,268
(6)	Outflow	Between Systems	Runoff	83,369	81,831	95,865	101,312	140,401	78,499
(7)	Outflow	Between Systems	Return Flow	6,038	5,972	5,974	5,544	5,309	6,090
(8)	Outflow	Between Systems	Recharge of Applied Water	14,557	14,348	14,345	13,355	12,734	14,705
(9)	Outflow	Between Systems	Recharge of Precipitation	1,962	1,925	2,256	2,384	3,304	1,847
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*234,802*	*231,158*	*247,656*	*244,595*	*284,853*	*230,409*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	48	47	55	58	80	45

item	SURFACE WATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2007	2008	2009	2010	2011	2012
(13)	Inflow	Into Basin	Stream Inflow	127,762	240,456	143,169	103,605	629,359	125,535
(14)	Inflow	Into Basin	Precipitation on Lakes	669	462	739	845	1,122	628
(6)	Inflow	Between Systems	Runoff	83,369	81,831	95,865	101,312	140,401	78,499
(7)	Inflow	Between Systems	Return Flow	6,038	5,972	5,974	5,544	5,309	6,090
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*217,838*	*328,720*	*245,746*	*211,306*	*776,191*	*210,752*
(18)	Outflow	Out of Basin	Stream Outflow	114,328	221,343	143,012	116,583	660,855	106,593
(19)	Outflow	Out of Basin	Conveyance Evaporation	855	837	817	805	798	832
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	87,225	85,939	85,918	79,962	76,188	88,131
(21)	Outflow	Between Systems	Stream Loss to Groundwater	9,941	15,181	10,657	8,818	33,265	9,837
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,660	1,628	1,589	1,492	1,461	1,582
(24)	Outflow	Out of Basin	Stream Evaporation	2,245	2,208	2,168	2,063	2,040	2,193
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*217,838*	*328,720*	*245,746*	*211,306*	*776,191*	*210,752*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

item	GROUNDWATER SYSTEM WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2007	2008	2009	2010	2011	2012
(8)	Inflow	Between Systems	Recharge of Applied Water	14,557	14,348	14,345	13,355	12,734	14,705
(9)	Inflow	Between Systems	Recharge of Precipitation	1,962	1,925	2,256	2,384	3,304	1,847
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	9,941	15,181	10,657	8,818	33,265	9,837
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*28,044*	*33,039*	*28,842*	*26,140*	*50,887*	*27,974*
(3)	Outflow	Between Systems	Groundwater Extraction	49,544	48,994	49,010	45,501	43,568	49,971
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*49,544*	*48,994*	*49,010*	*45,501*	*43,568*	*49,971*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	(21,500)	(15,955)	(20,168)	(19,361)	7,319	(21,997)

item	TOTAL BASIN WATER BUDGET								
item	Flow Type	Origin/ Destination	Component	2007	2008	2009	2010	2011	2012
(1)	Inflow	Into Basin	Precipitation on Land System	98,081	96,272	112,782	119,190	165,178	92,352
(14)	Inflow	Into Basin	Precipitation on Lakes	669	462	739	845	1,122	628
(13)	Inflow	Into Basin	Stream Inflow	127,762	240,456	143,169	103,605	629,359	125,535
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*226,513*	*337,189*	*256,689*	*223,640*	*795,659*	*218,515*
(5)	Outflow	Out of Basin	Evapotranspiration	128,876	127,082	129,216	122,000	123,105	129,268
(24)	Outflow	Out of Basin	Stream Evaporation	2,245	2,208	2,168	2,063	2,040	2,193
(23)	Outflow	Out of Basin	Lake Evaporation	1,660	1,628	1,589	1,492	1,461	1,582
(19)	Outflow	Out of Basin	Conveyance Evaporation	855	837	817	805	798	832
(18)	Outflow	Out of Basin	Stream Outflow	114,328	221,343	143,012	116,583	660,855	106,593
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*247,965*	*353,098*	*276,802*	*242,943*	*788,260*	*240,467*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	(21,452)	(15,908)	(20,113)	(19,303)	7,399	(21,952)

LAND SYSTEM WATER BUDGET

item	Flow Type	Origin/ Destination	Component	2013	2014	2015	2016	2017	2018
(1)	Inflow	Into Basin	Precipitation on Land System	125,448	87,678	127,785	158,468	199,103	138,264
(2)	Inflow	Between Systems	Surface Water Delivery	86,791	92,729	87,371	85,368	82,968	85,294
(3)	Inflow	Between Systems	Groundwater Extraction	49,519	52,729	49,269	48,625	47,432	48,860
(4)	Inflow	*(1)+(2)+(3)*	*Total Inflow*	*261,757*	*233,135*	*264,425*	*292,462*	*329,502*	*272,418*
(5)	Outflow	Out of Basin	Evapotranspiration	132,031	134,914	132,614	134,339	136,547	131,859
(6)	Outflow	Between Systems	Runoff	106,630	74,526	108,617	134,698	169,237	117,524
(7)	Outflow	Between Systems	Return Flow	6,036	6,427	6,003	5,926	5,781	5,956
(8)	Outflow	Between Systems	Recharge of Applied Water	14,490	15,471	14,573	14,252	13,858	14,246
(9)	Outflow	Between Systems	Recharge of Precipitation	2,509	1,754	2,556	3,169	3,982	2,765
(10)	Outflow	Between Systems	Managed Aquifer Recharge	-	-	-	-	-	-
(11)	Outflow	*(5)+(6)+(7)+(8)+(9)+(10)*	*Total Outflow*	*261,696*	*233,092*	*264,363*	*292,385*	*329,406*	*272,351*
(12)	Storage Change	**(4)-(11)**	Change in Land System Storage	61	43	62	77	97	67

SURFACE WATER SYSTEM WATER BUDGET

item	Flow Type	Origin/ Destination	Component	2013	2014	2015	2016	2017	2018
(13)	Inflow	Into Basin	Stream Inflow	142,221	52,739	82,881	374,311	809,028	243,145
(14)	Inflow	Into Basin	Precipitation on Lakes	864	527	910	1,163	1,563	945
(6)	Inflow	Between Systems	Runoff	106,630	74,526	108,617	134,698	169,237	117,524
(7)	Inflow	Between Systems	Return Flow	6,036	6,427	6,003	5,926	5,781	5,956
(15)	Inflow	Between Systems	Stream Gain from Groundwater	-	-	-	-	-	-
(16)	Inflow	Between Systems	Lake Gain from Groundwater	-	-	-	-	-	-
(17)	Inflow	*(13)+(14)+(6)+(7)+(15)+(16)*	*Total Inflow*	*255,751*	*134,220*	*198,411*	*516,099*	*985,609*	*367,570*
(18)	Outflow	Out of Basin	Stream Outflow	152,078	28,669	96,946	403,172	847,439	260,813
(19)	Outflow	Out of Basin	Conveyance Evaporation	834	846	806	832	822	844
(20)	Outflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(2)	Outflow	Between Systems	Surface Water Delivery	86,791	92,729	87,371	85,368	82,968	85,294
(21)	Outflow	Between Systems	Stream Loss to Groundwater	10,613	6,452	7,854	21,405	49,248	15,306
(22)	Outflow	Between Systems	Lake Loss to Groundwater	1,138	1,138	1,138	1,138	1,138	1,138
(23)	Outflow	Out of Basin	Lake Evaporation	1,642	1,672	1,640	1,575	1,500	1,568
(24)	Outflow	Out of Basin	Stream Evaporation	2,208	2,268	2,210	2,162	2,048	2,162
(25)	Outflow	*(18)+(19)+(20)+(2)+(21)+(22)+(23)+(24)*	*Total Outflow*	*255,751*	*134,220*	*198,411*	*516,099*	*985,609*	*367,570*
(26)	Storage Change	**(17)-(25)**	Change in Surface Water Storage	-	-	-	-	-	-

GROUNDWATER SYSTEM WATER BUDGET

item	Flow Type	Origin/ Destination	Component	2013	2014	2015	2016	2017	2018
(8)	Inflow	Between Systems	Recharge of Applied Water	14,490	15,471	14,573	14,252	13,858	14,246
(9)	Inflow	Between Systems	Recharge of Precipitation	2,509	1,754	2,556	3,169	3,982	2,765
(10)	Inflow	Between Systems	Managed Aquifer Recharge						
(21)	Inflow	Between Systems	Groundwater Gain from Stream	10,613	6,452	7,854	21,405	49,248	15,306
(22)	Inflow	Between Systems	Groundwater Gain from Lake	1,138	1,138	1,138	1,138	1,138	1,138
(20)	Inflow	Between Systems	Conveyance Seepage	446	446	446	446	446	446
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(28)	Inflow	*(8)+(9)+(10)+(21)+(22)+(20)+(27)*	*Total Inflow*	*29,196*	*25,261*	*26,567*	*40,411*	*68,672*	*33,902*
(3)	Outflow	Between Systems	Groundwater Extraction	49,519	52,729	49,269	48,625	47,432	48,860
(15)	Outflow	Between Systems	Groundwater Loss to Stream	-	-	-	-	-	-
(16)	Outflow	Between Systems	Groundwater Loss to Lake	-	-	-	-	-	-
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(30)	Outflow	*(3)+(15)+(16)+(29)*	*Total Outflow*	*49,519*	*52,729*	*49,269*	*48,625*	*47,432*	*48,860*
(31)	Storage Change	**(28)-(30)**	Change in Groundwater Storage	(20,322)	(27,468)	(22,703)	(8,214)	21,240	(14,958)

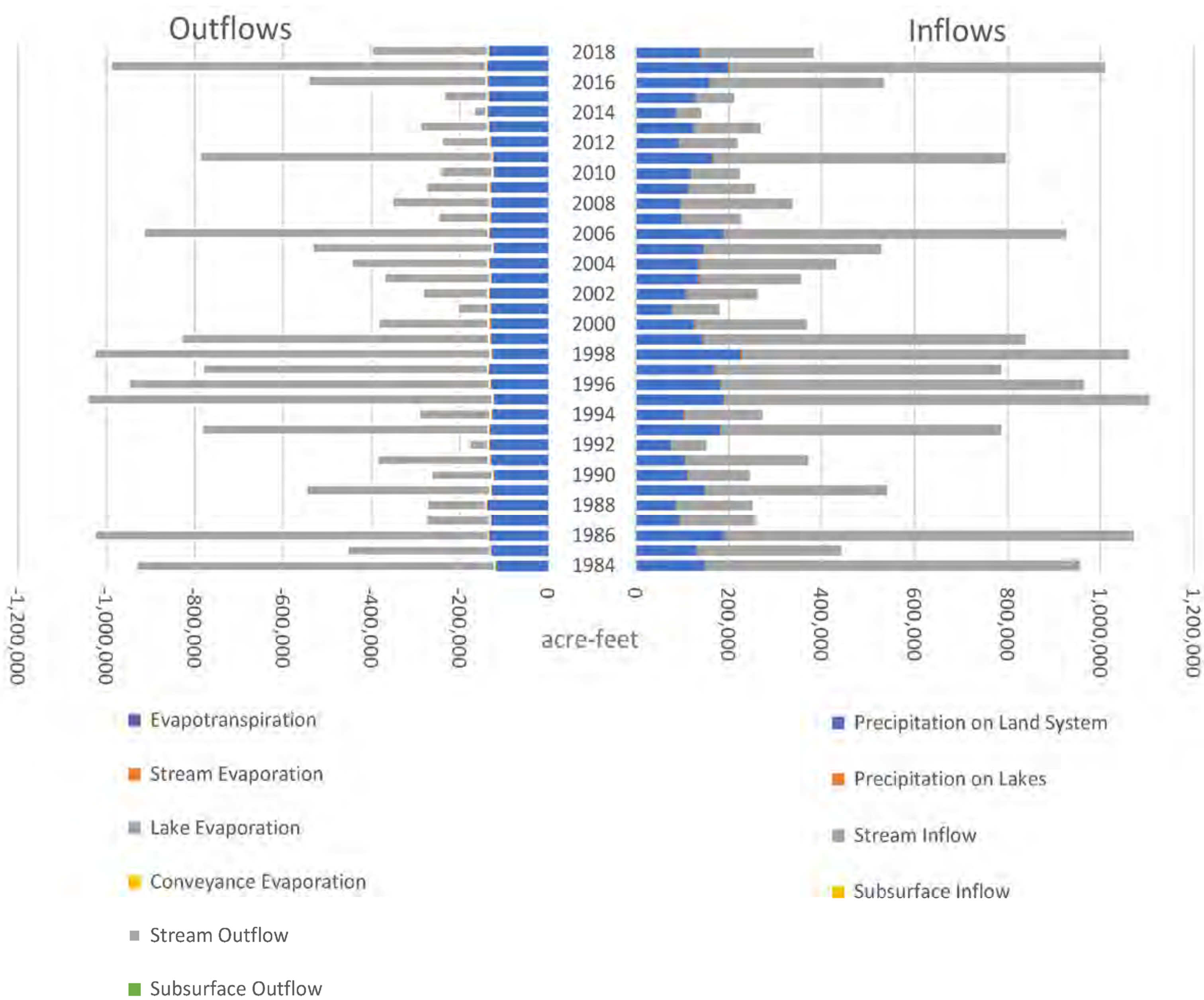
TOTAL BASIN WATER BUDGET

item	Flow Type	Origin/ Destination	Component	2013	2014	2015	2016	2017	2018
(1)	Inflow	Into Basin	Precipitation on Land System	125,448	87,678	127,785	158,468	199,103	138,264
(14)	Inflow	Into Basin	Precipitation on Lakes	864	527	910	1,163	1,563	945
(13)	Inflow	Into Basin	Stream Inflow	142,221	52,739	82,881	374,311	809,028	243,145
(27)	Inflow	Into Basin	Subsurface Inflow	-	-	-	-	-	-
(32)	Inflow	*(1)+(14)+(13)+(27)*	*Total Inflow*	*268,532*	*140,944*	*211,576*	*533,943*	*1,009,693*	*382,353*
(5)	Outflow	Out of Basin	Evapotranspiration	132,031	134,914	132,614	134,339	136,547	131,859
(24)	Outflow	Out of Basin	Stream Evaporation	2,208	2,268	2,210	2,162	2,048	2,162
(23)	Outflow	Out of Basin	Lake Evaporation	1,642	1,672	1,640	1,575	1,500	1,568
(19)	Outflow	Out of Basin	Conveyance Evaporation	834	846	806	832	822	844
(18)	Outflow	Out of Basin	Stream Outflow	152,078	28,669	96,946	403,172	847,439	260,813
(29)	Outflow	Out of Basin	Subsurface Outflow	-	-	-	-	-	-
(33)	Outflow	*(5)+(24)+(23)+(19)+(18)+(29)*	*Total Outflow*	*288,794*	*168,369*	*234,217*	*542,080*	*988,356*	*397,244*
(34)	Storage Change	**(32)-(33)**	Change in Total System Storage	(20,262)	(27,425)	(22,641)	(8,137)	21,337	(14,891)

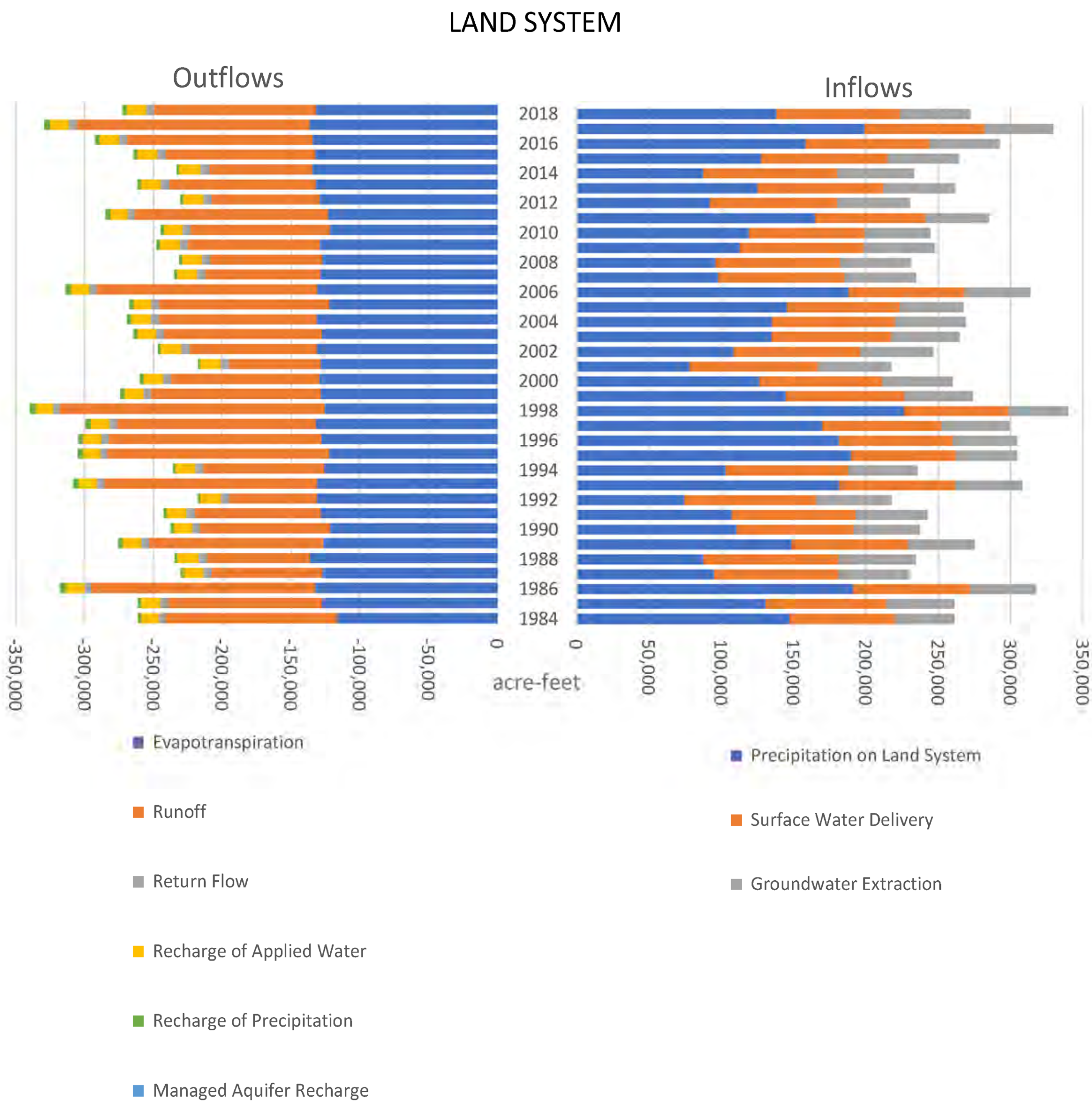
Appendix 6C

Historic Water Budget Bar Charts

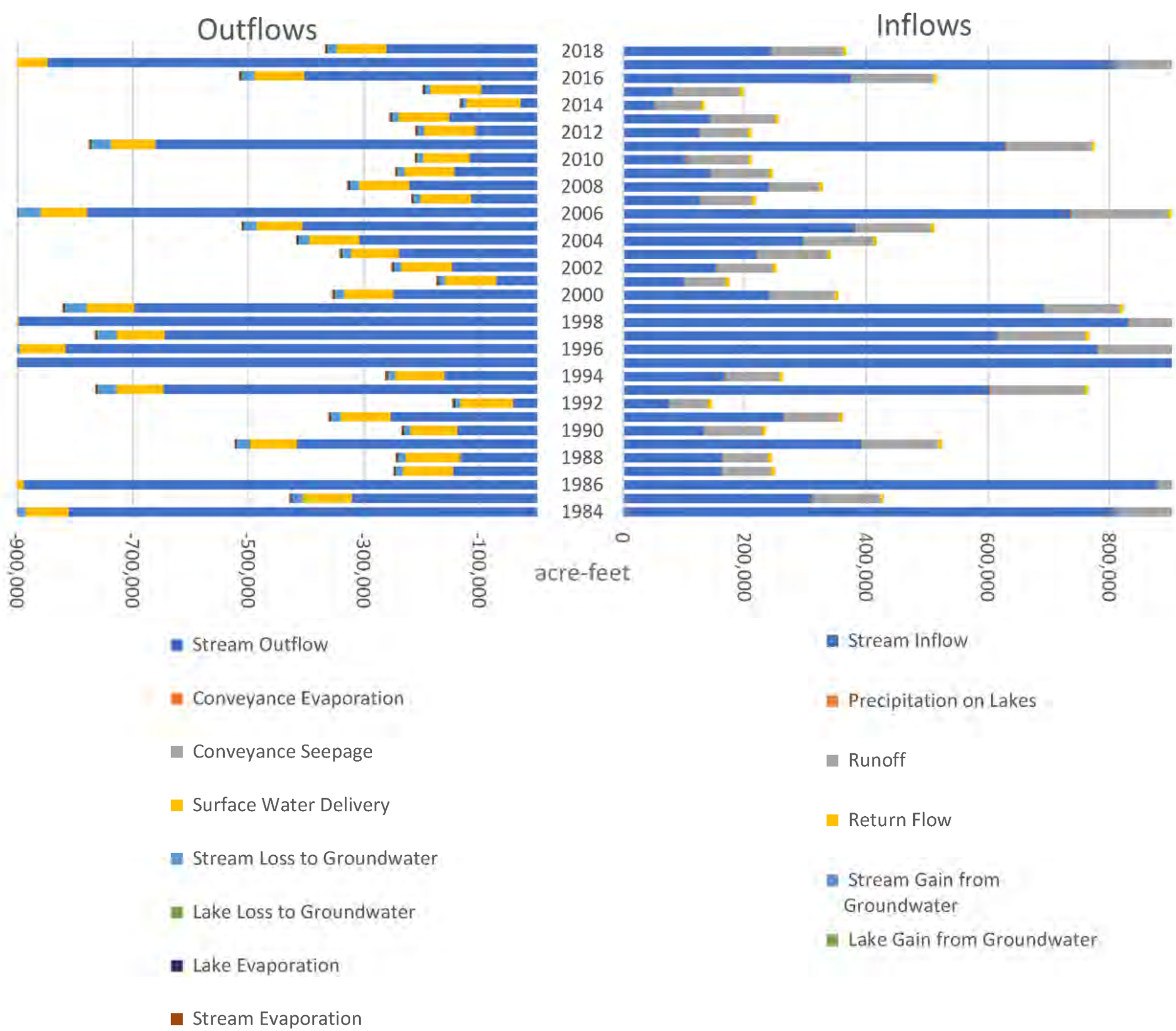
TOTAL BASIN

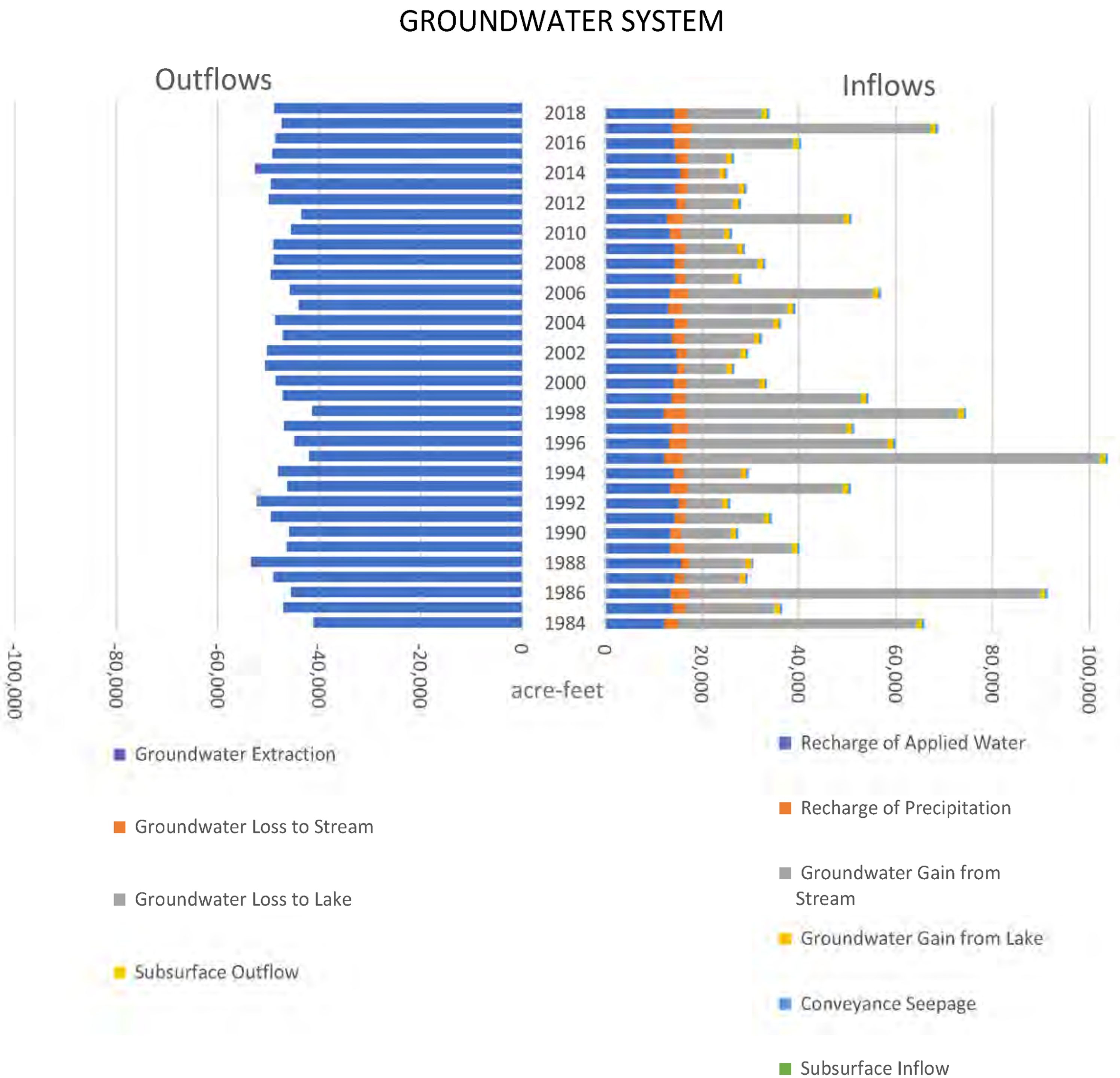


Outflows
Inflows
2018
2016
2014
2012
2010
2008
2006
2004
2002
2000
1998
1996
1994
1992
1990
1988
1986
1984
-1,200,000
-1,000,000
-800,000
-600,000
-400,000
-200,000
0
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
acre-feet
Evapotranspiration
Stream Evaporation
Lake Evaporation
Conveyance Evaporation
Stream Outflow
Subsurface Outflow
Precipitation on Land System
Precipitation on Lakes
Stream Inflow
Subsurface Inflow


LAND SYSTEM
Outflows
Inflows
2018
2016
2014
2012
2010
2008
2006
2004
2002
2000
1998
1996
1994
1992
1990
1988
1986
1984
-350,000
-300,000
-250,000
-200,000
-150,000
-100,000
-50,000
0
acre-feet
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
Evapotranspiration
Runoff
Return Flow
Recharge of Applied Water
Recharge of Precipitation
Managed Aquifer Recharge
Precipitation on Land System
Surface Water Delivery
Groundwater Extraction

SURFACE WATER SYSTEM





GROUNDWATER SYSTEM
Outflows
Inflows
2018
2016
2014
2012
2010
2008
2006
2004
2002
2000
1998
1996
1994
1992
1990
1988
1986
1984
-100,000
-80,000
-60,000
-40,000
-20,000
0
0
20,000
40,000
60,000
80,000
100,000
acre-feet
Groundwater Extraction
Groundwater Loss to Stream
Groundwater Loss to Lake
Subsurface Outflow
Recharge of Applied Water
Recharge of Precipitation
Groundwater Gain from Stream
Groundwater Gain from Lake
Conveyance Seepage
Subsurface Inflow