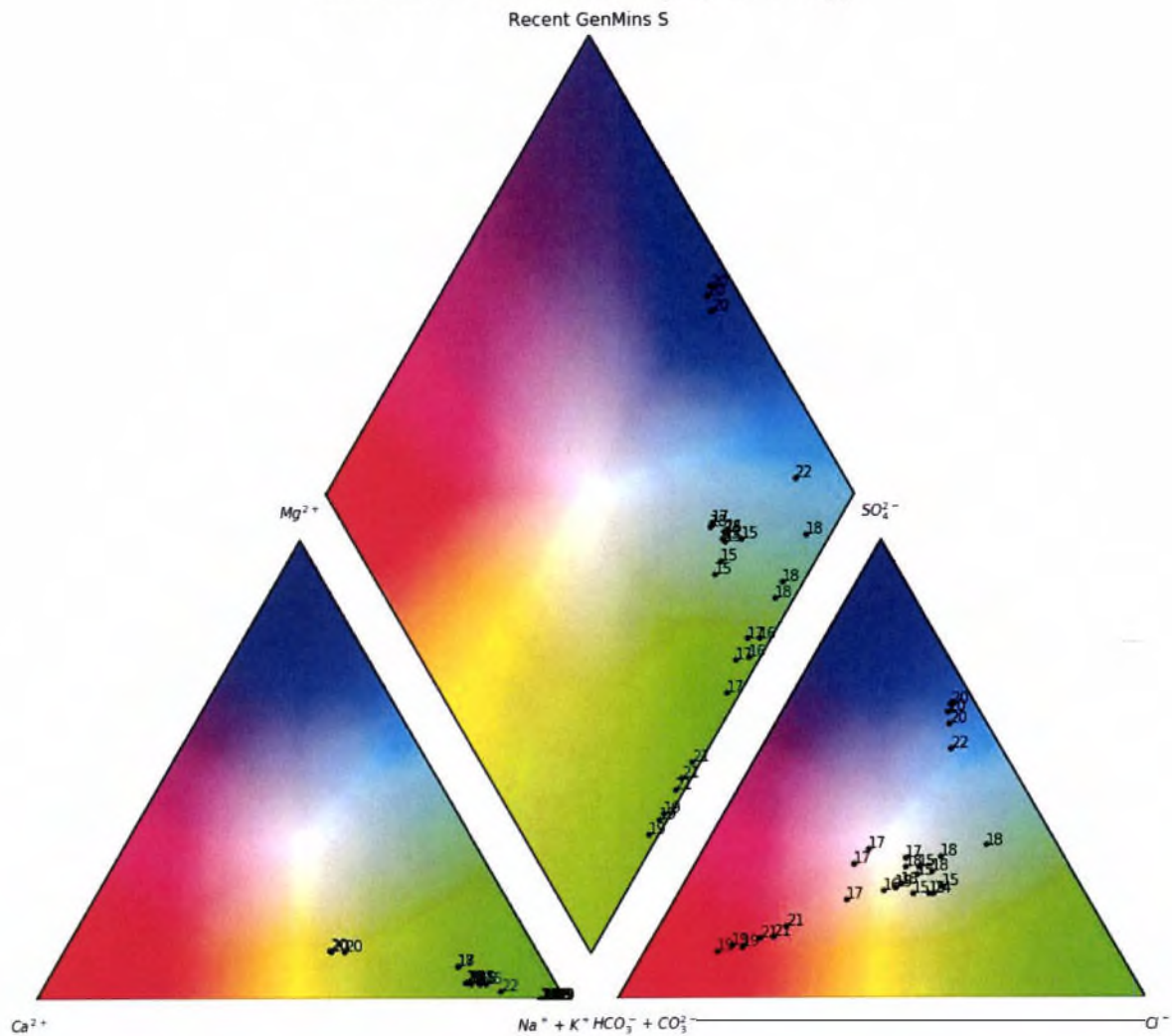


## APPENDIX B: PIPER DIAGRAMS

### Recent Data: South (Piper only)



Note: The number on the diagrams correspond to sequential well numbers assigned to each of the wells as explained in the text. Data are for the period of 2005 to 2018.

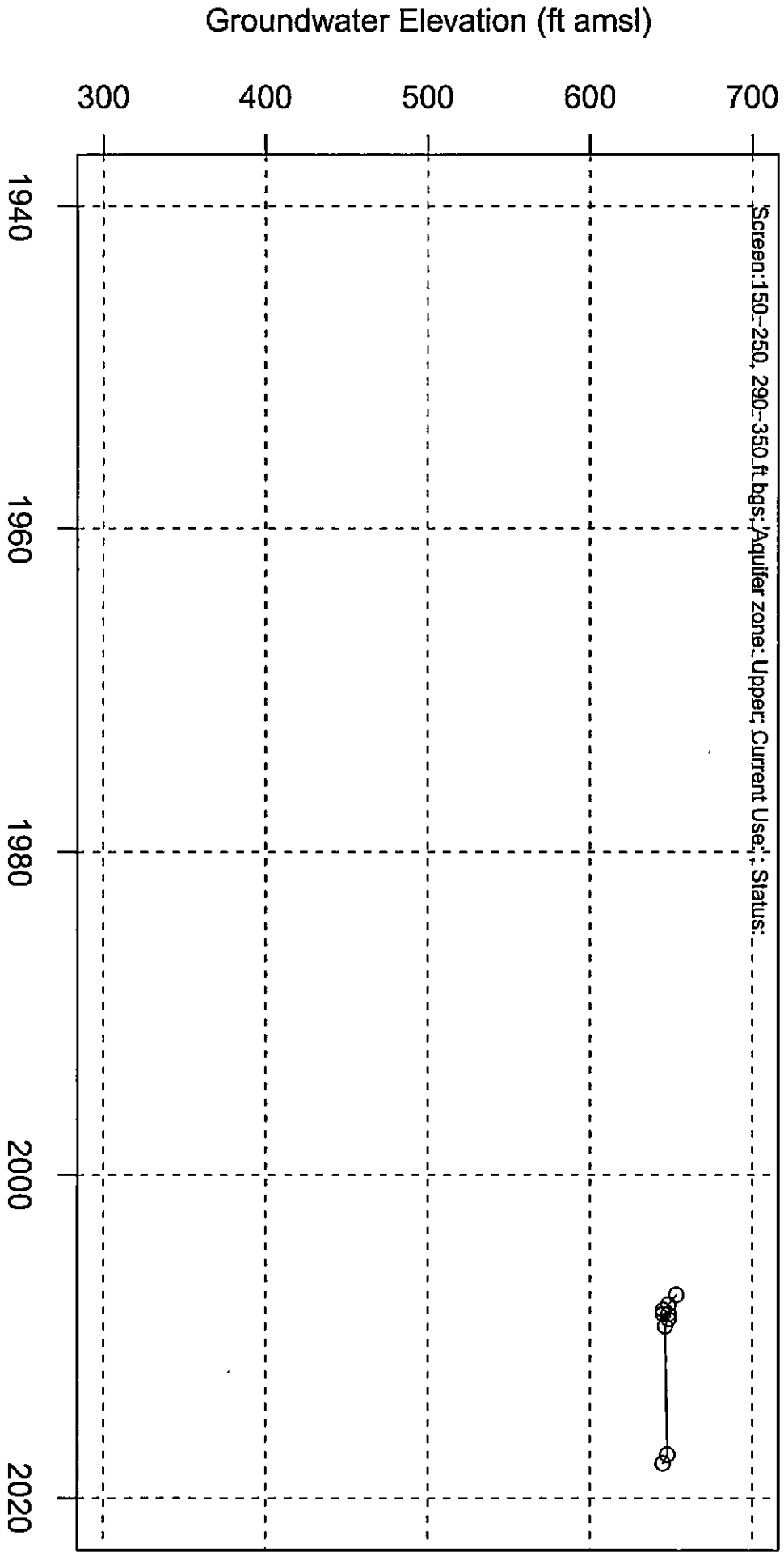


APPENDIX D3  
*Groundwater Hydrographs*



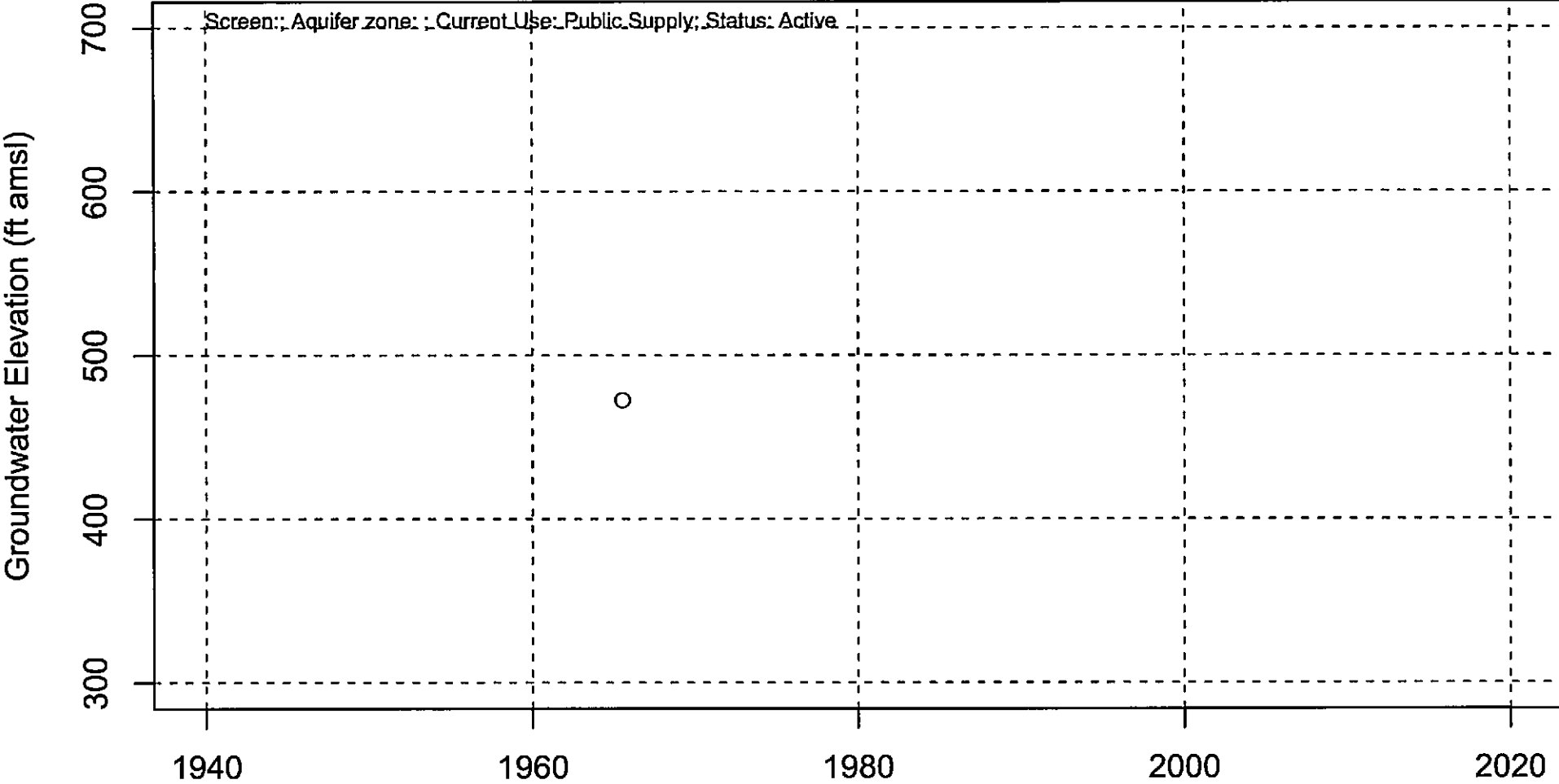


# 009S006E31E003S



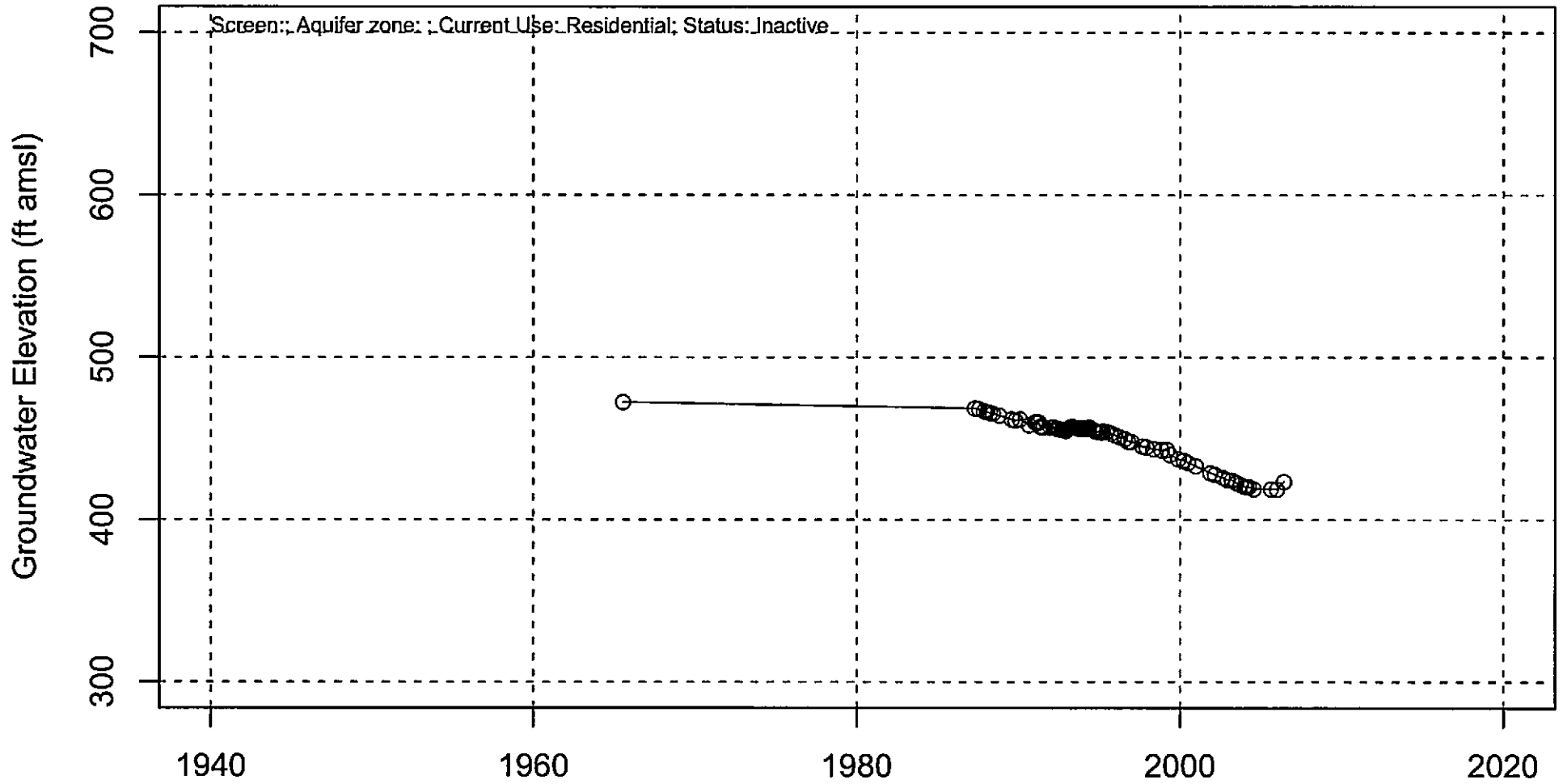
Local ID: Horse Camp ; Number of Measuring Agency(y/ies): 4

**010S005E25R001S**



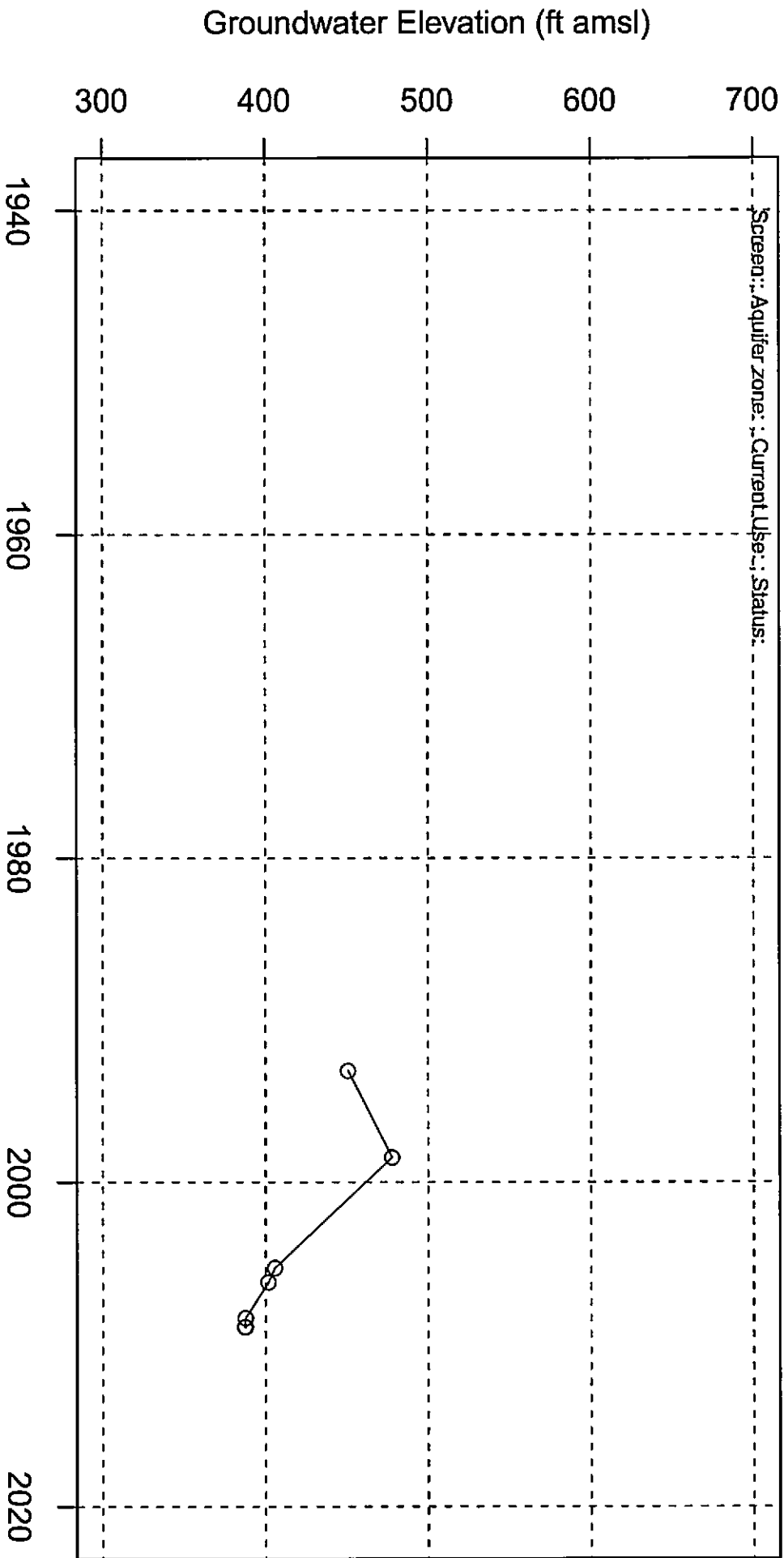
Local ID: State Park Well 1 ; Number of Measuring Agency(ies): 1

# 010S005E36A001S



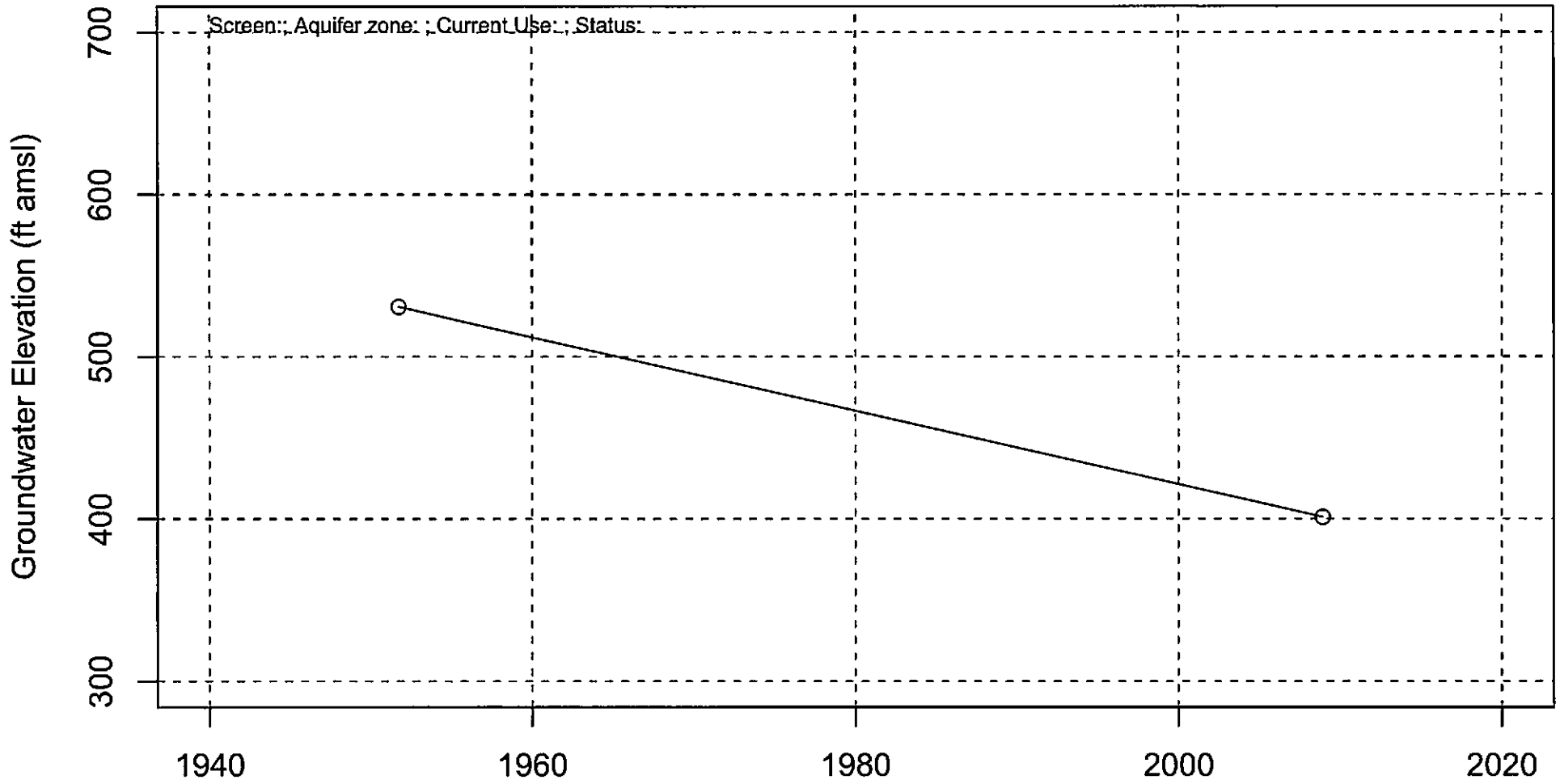
Local ID: State Park Well 2 ; Number of Measuring Agency(ies): 2

# 010S006E04Q001S



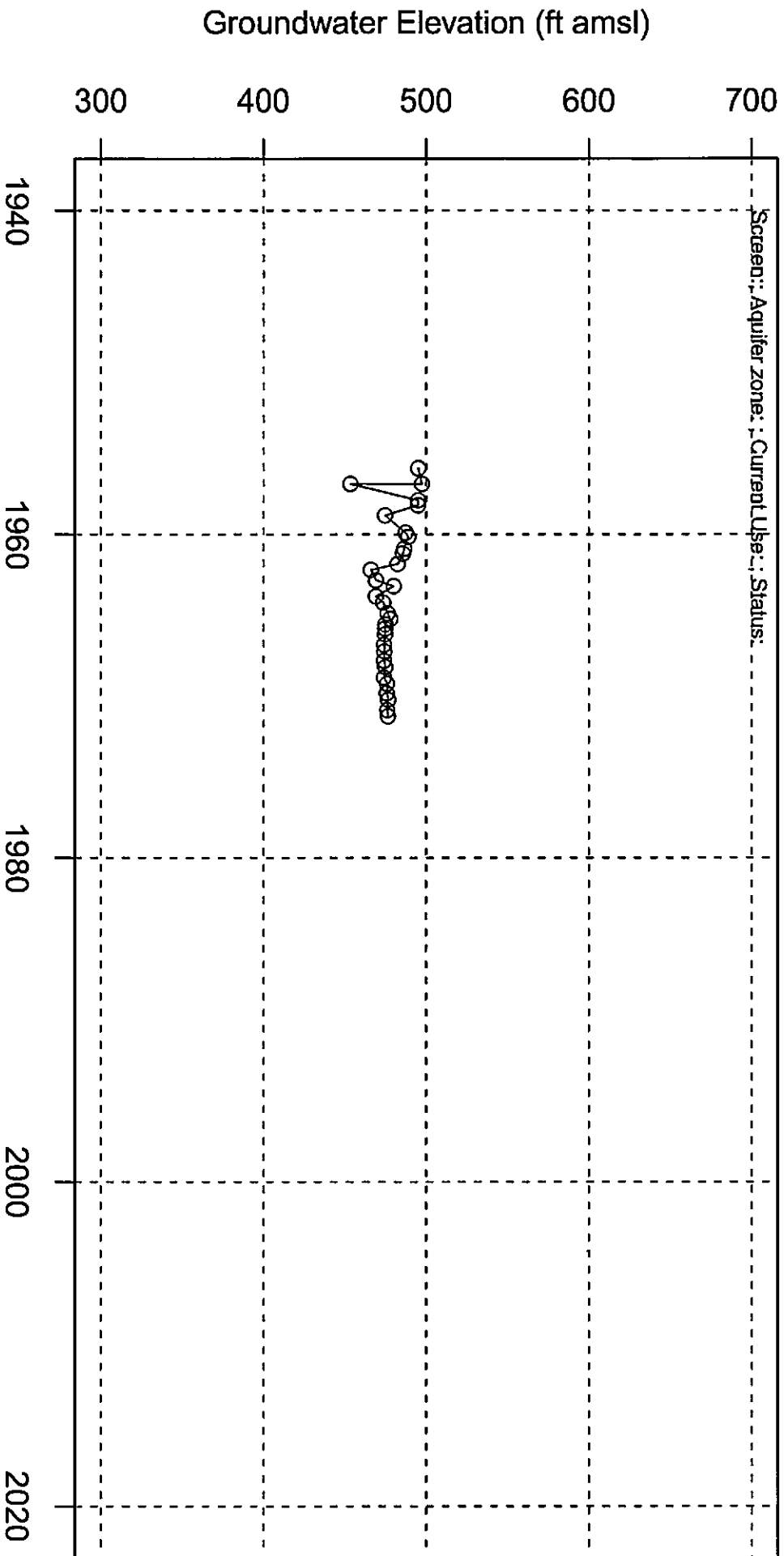
Local ID: Viking ; Number of Measuring Agenc(y/ies): 3

# 010S006E05F001S



Local ID: 5F1 ; Number of Measuring Agency(ies): 1

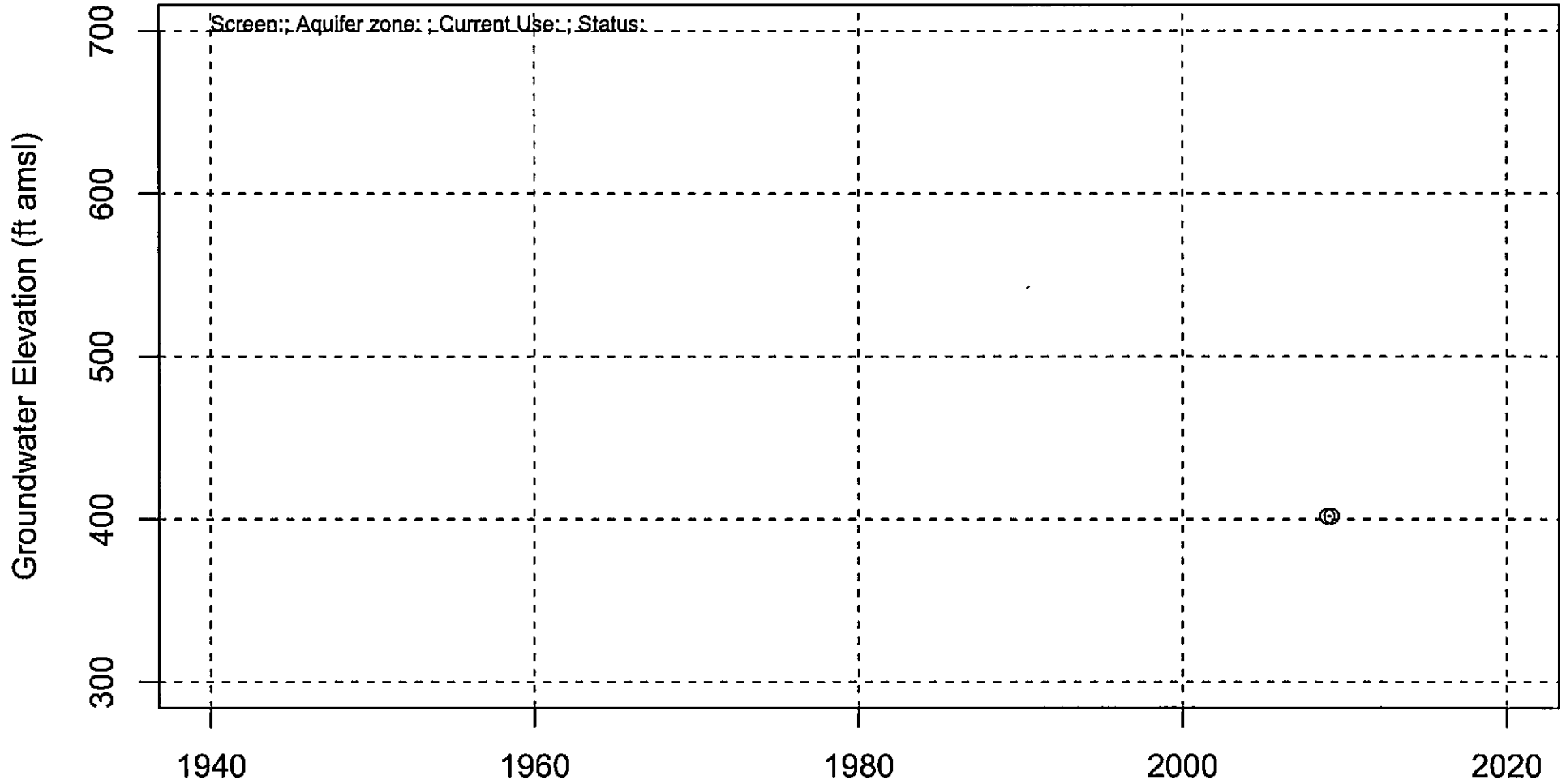
**010S006E08B001S**



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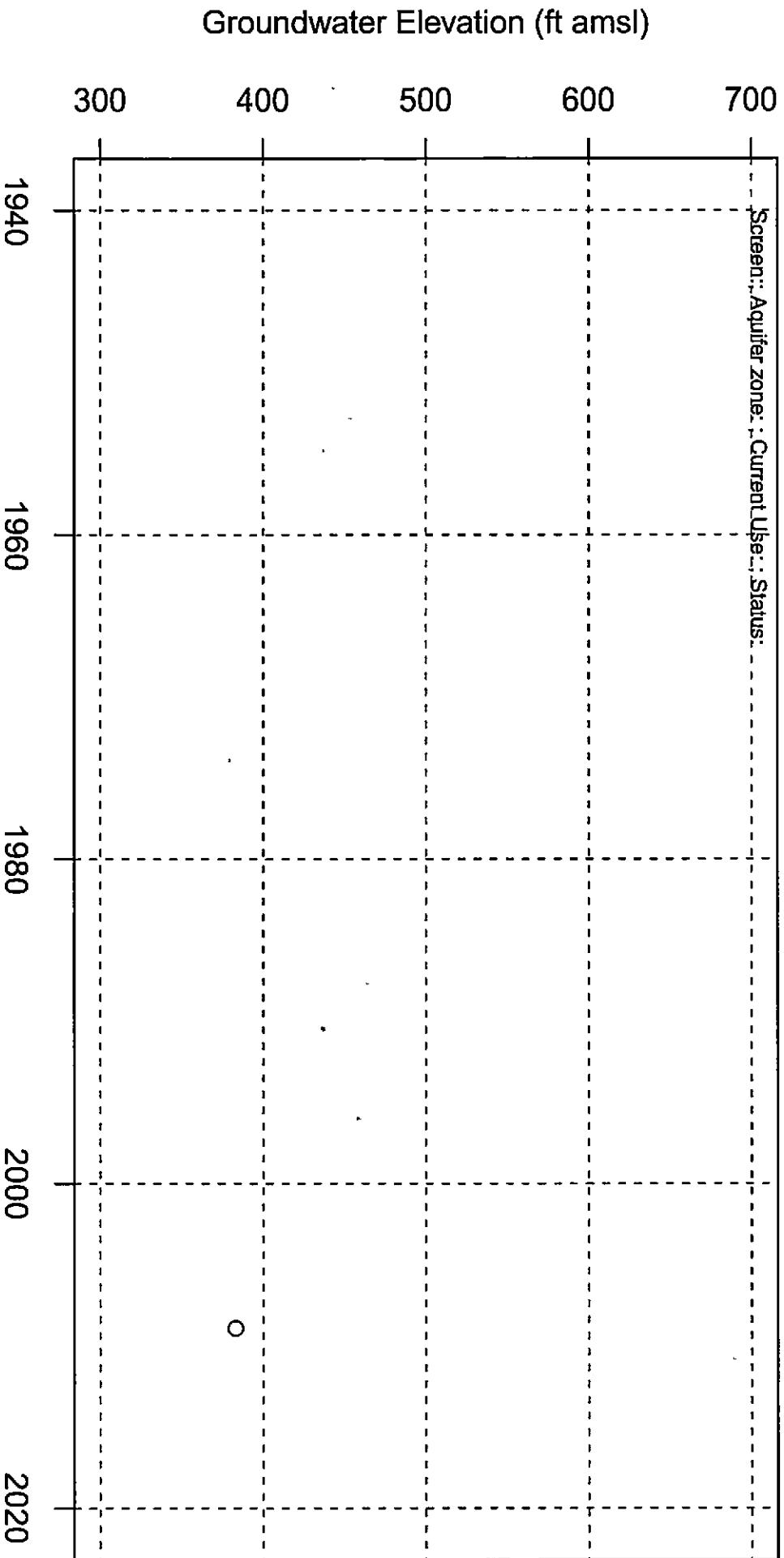
Local ID: N/A ; Number of Measuring Agency(y/ies): 2

# 010S006E08F001S



Local ID: Charmer 2 ; Number of Measuring Agency(ies): 2

**010S006E09C001S**

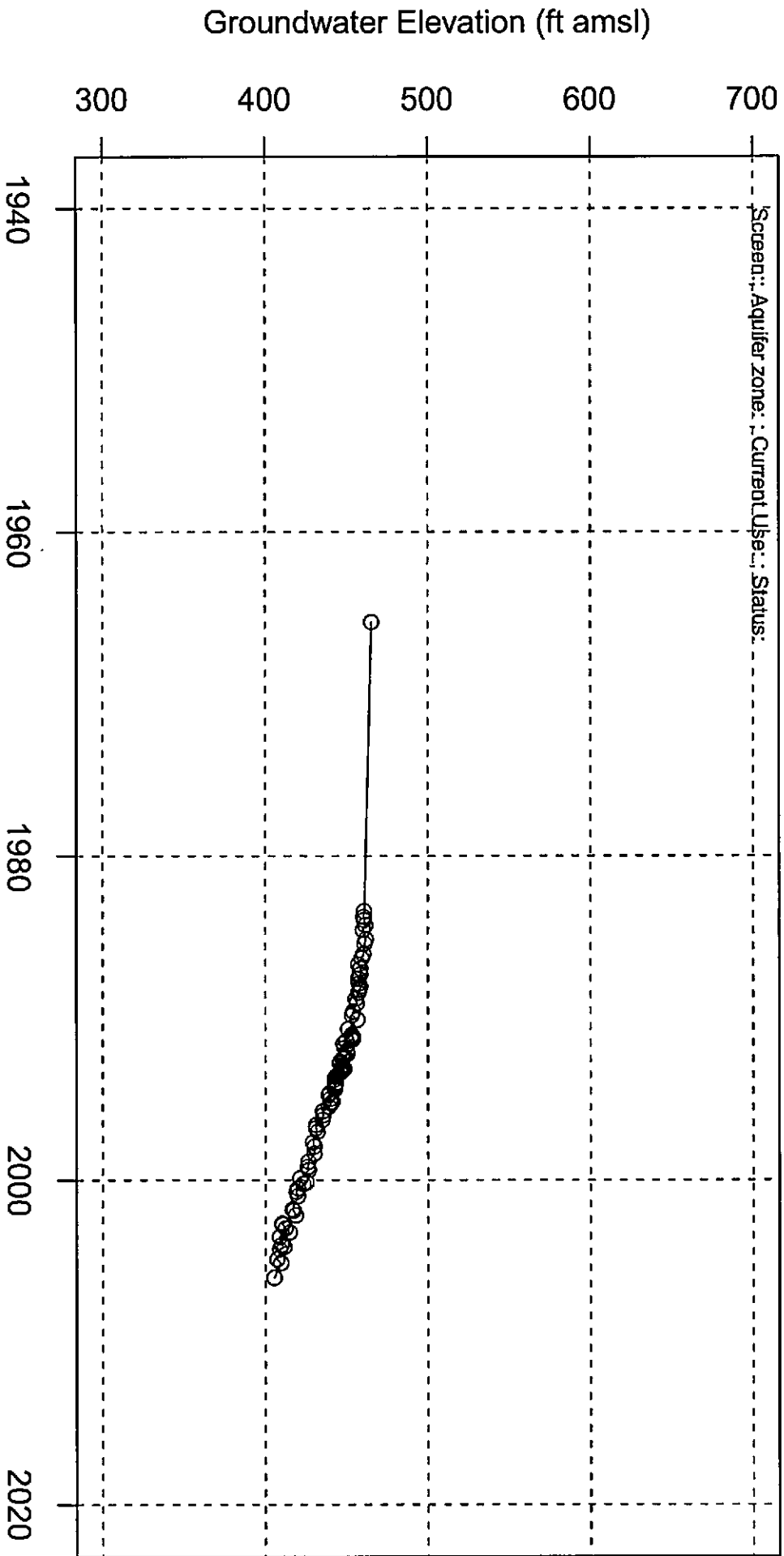


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Local ID: N/A ; Number of Measuring Agency(y/ies): 1

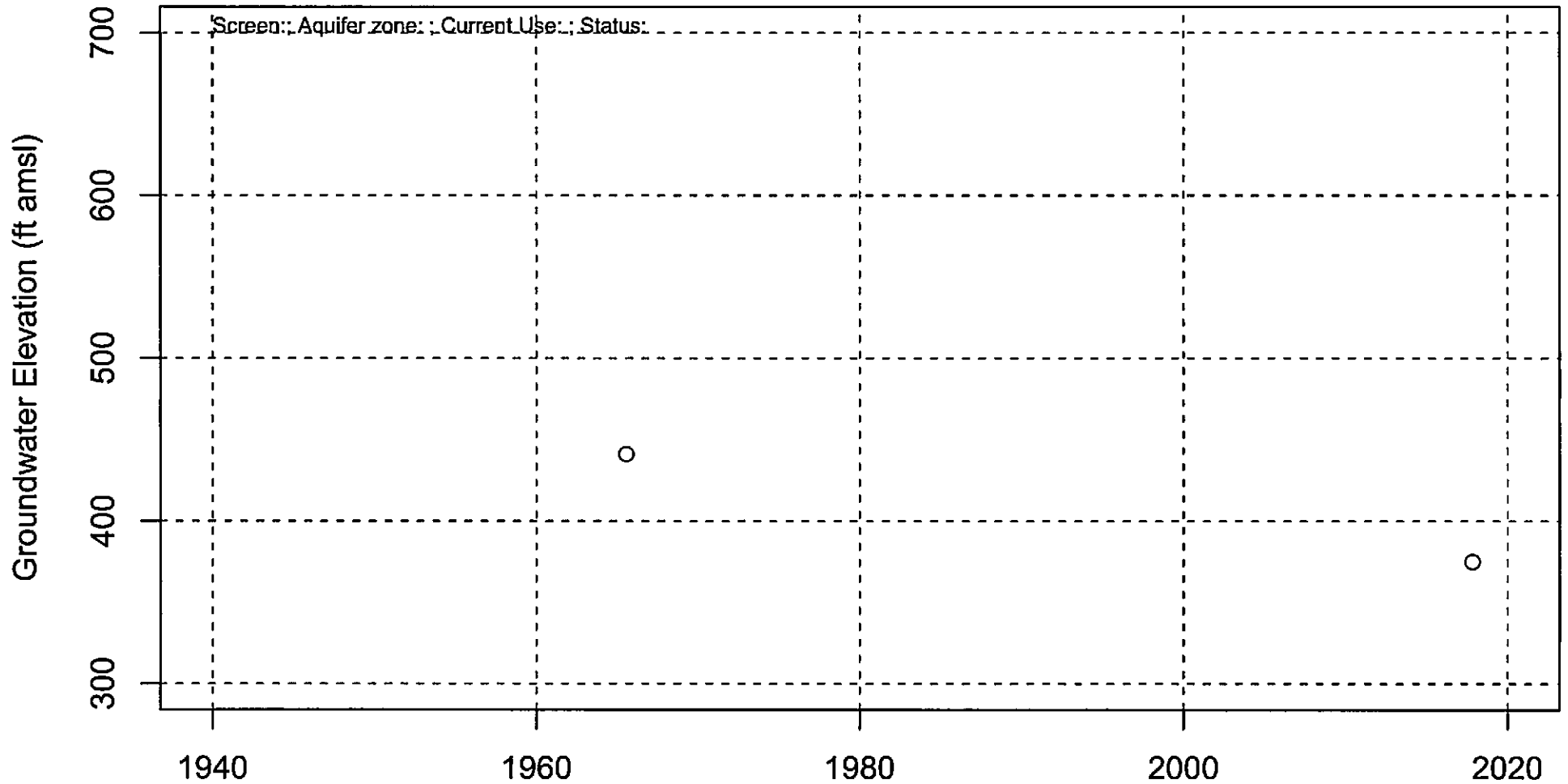


# 010S006E09L001S



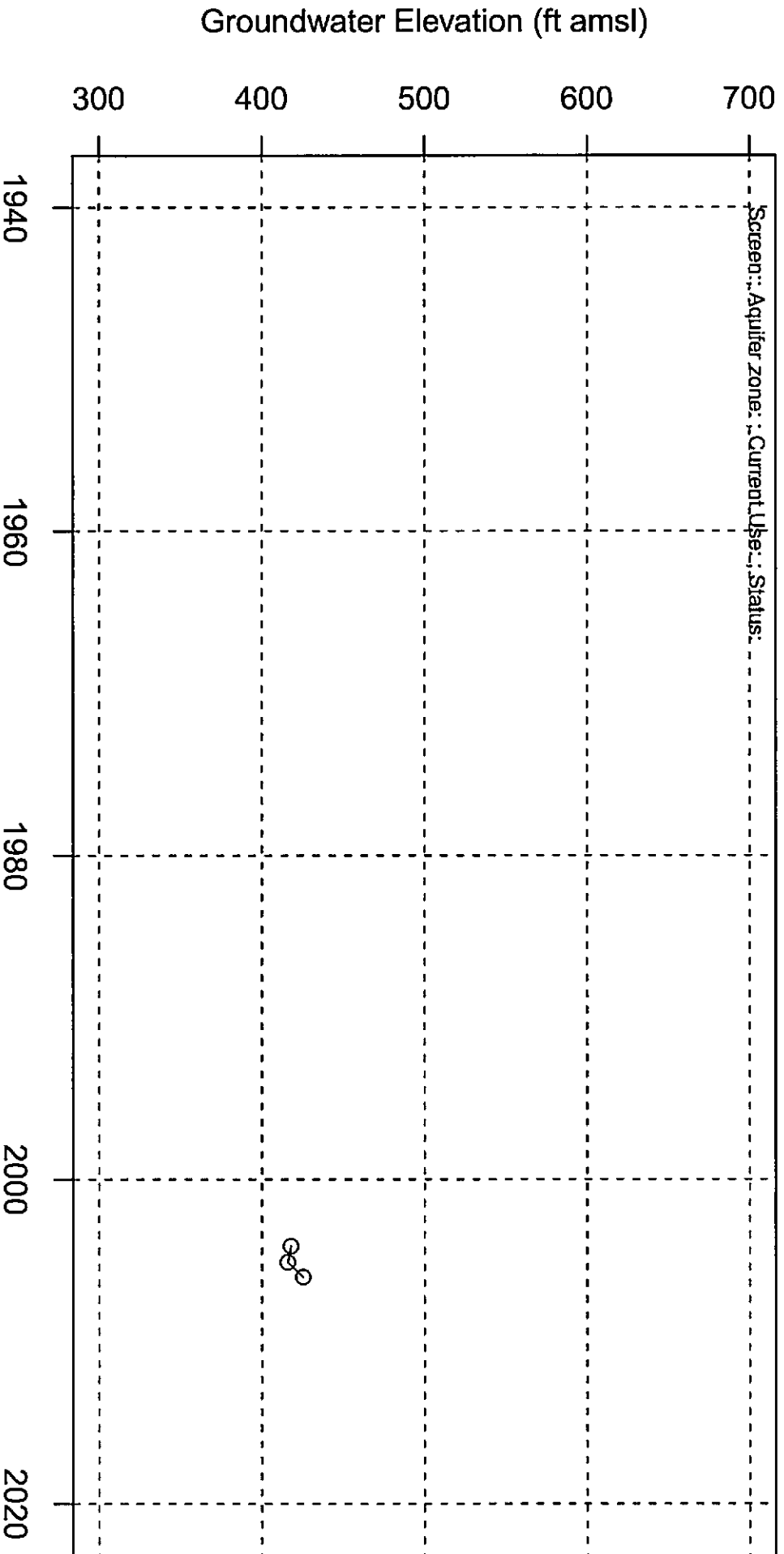
Local ID: N/A ; Number of Measuring Agency(y/ies): 2

# 010S006E09N001S



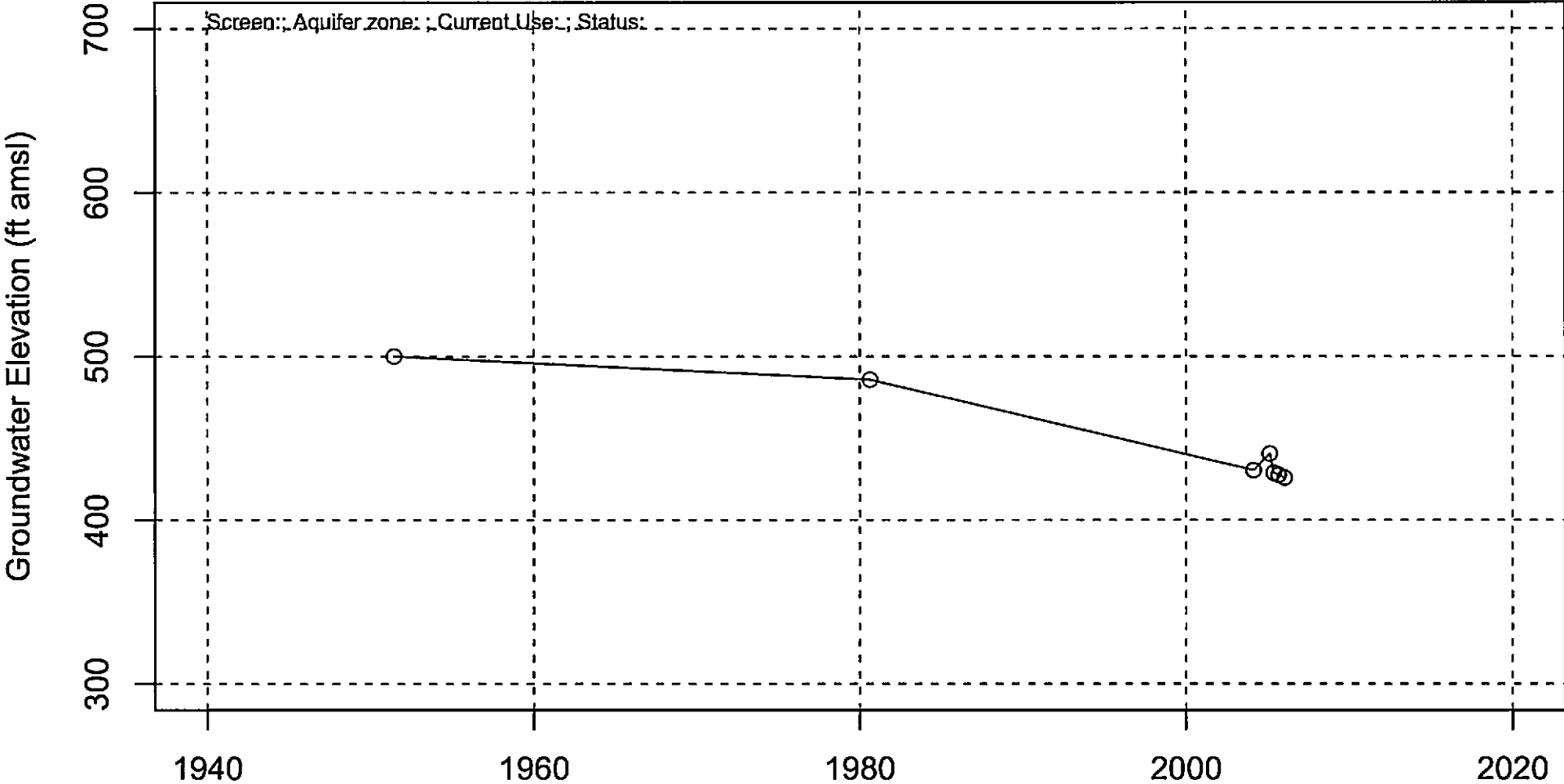
Local ID: Fortiner #1 (Allegre 1); Number of Measuring Agenc(y/ies): 3

# 010S006E10L001S



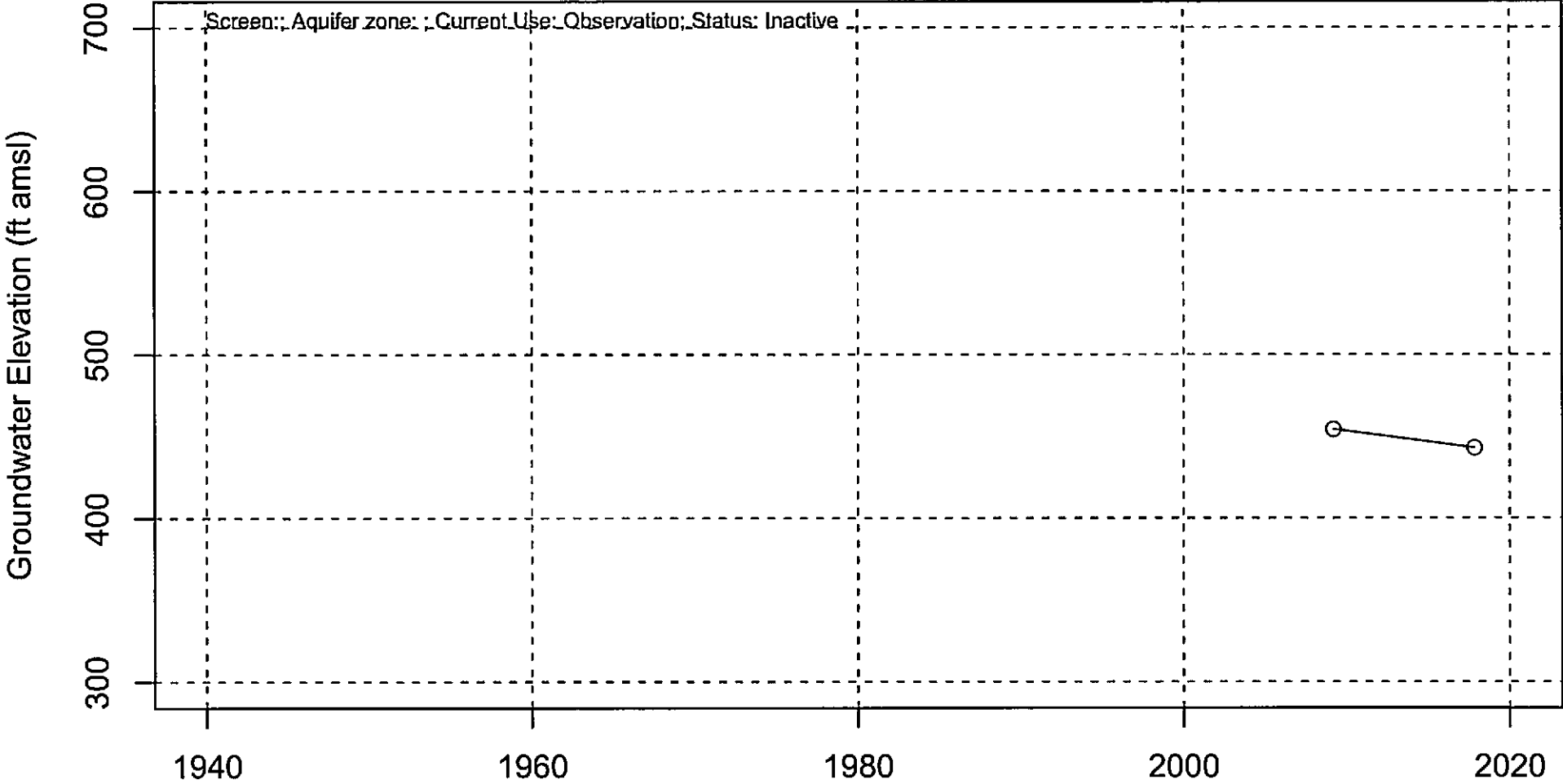
Local ID: N/A ; Number of Measuring Agency(ies): 1

010S006E10M001S



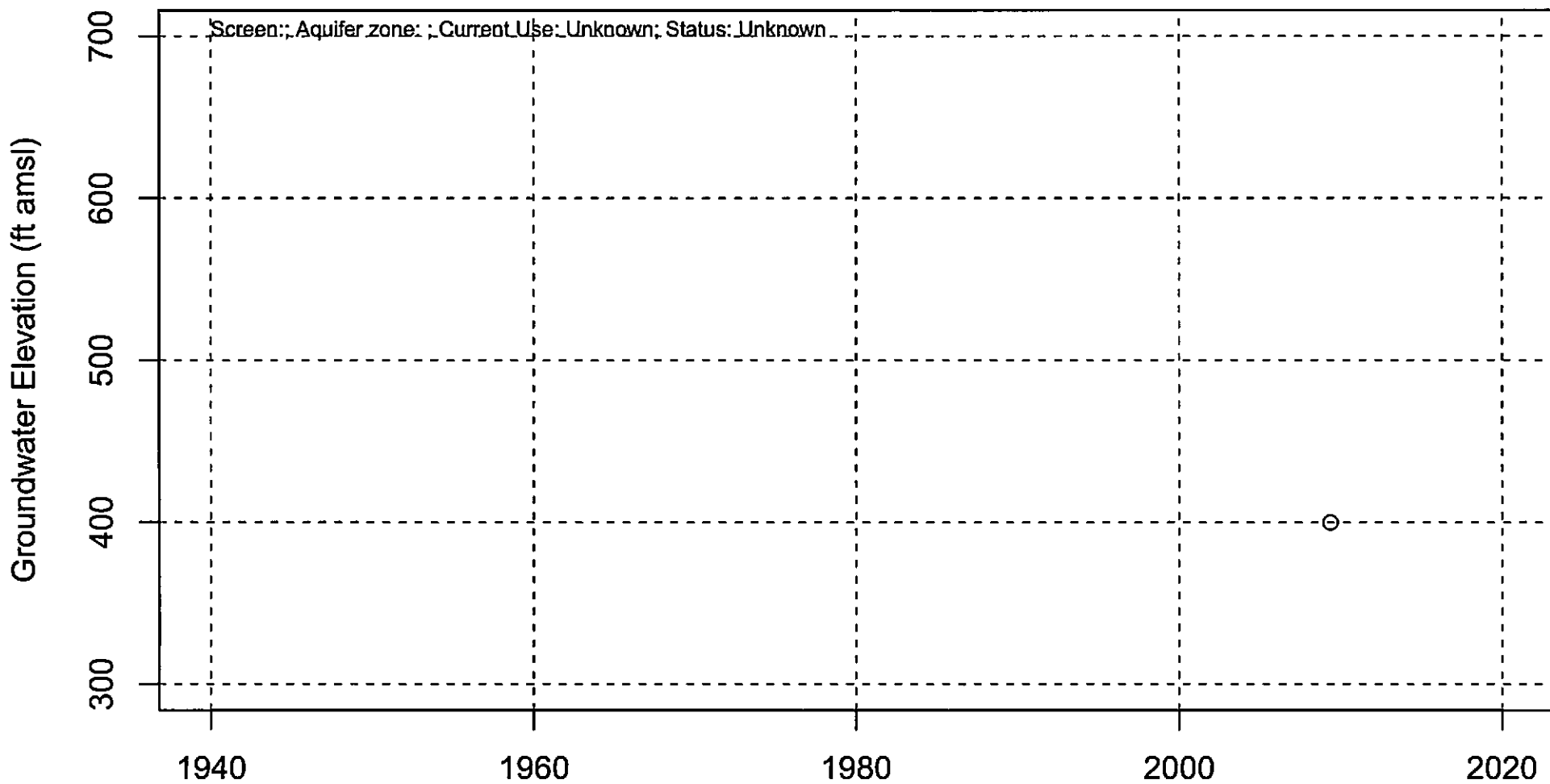
Local ID: N/A ; Number of Measuring Agency(ies): 2

# 010S006E14G001S



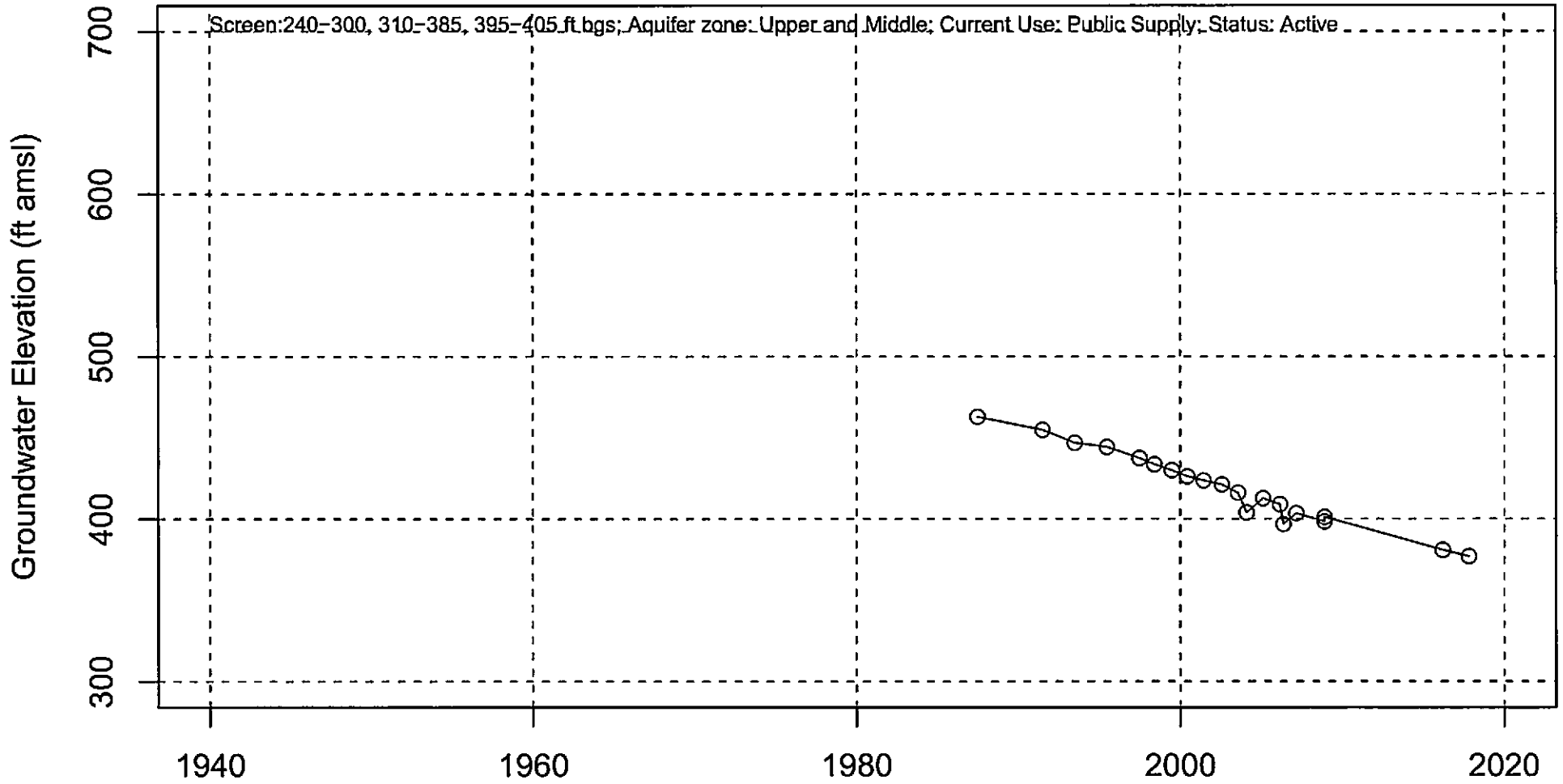
Local ID: Hanna (Flowers) ; Number of Measuring Agency(ies): 2

# 010S006E17J001S



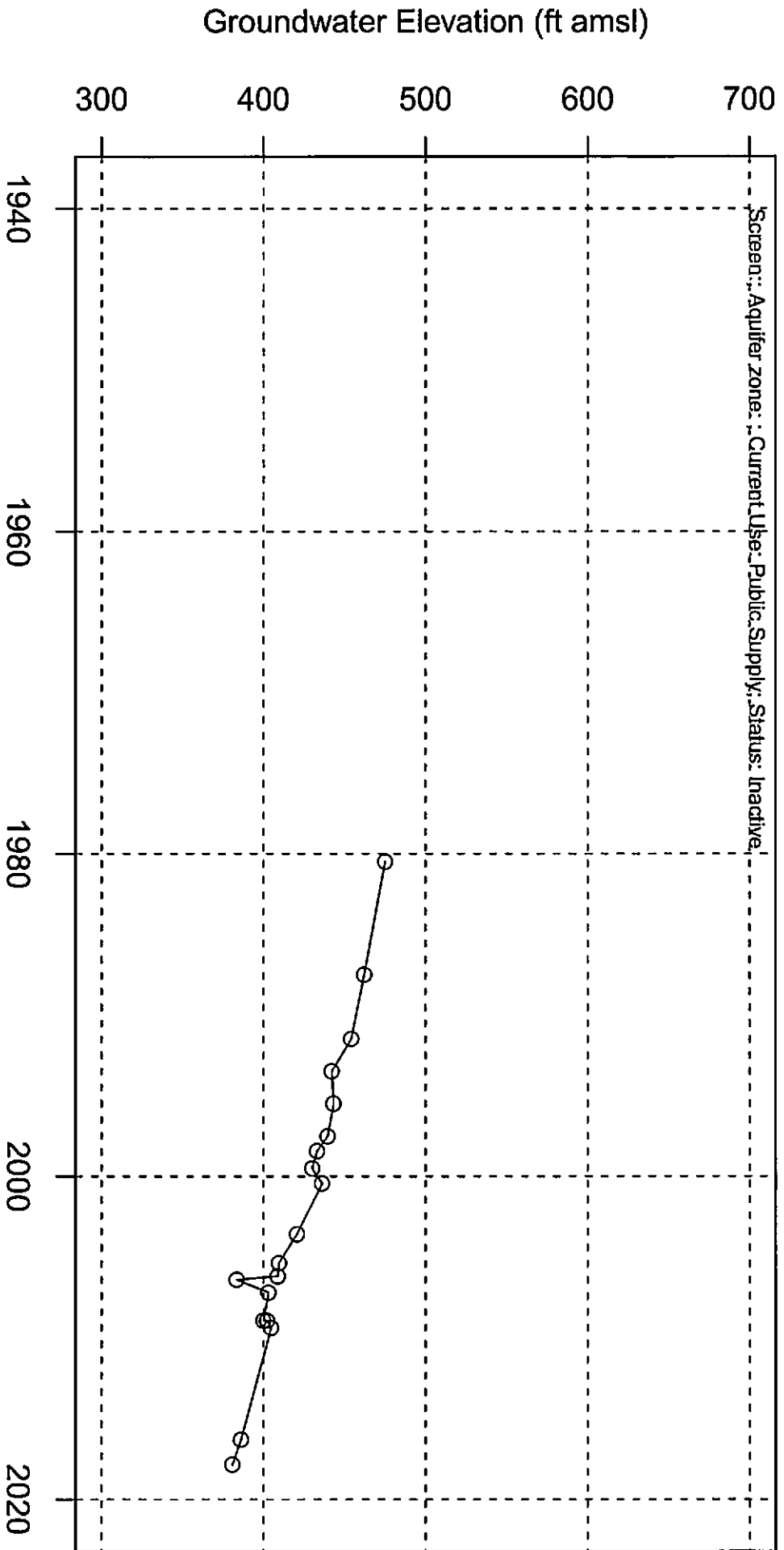
Local ID: N/A ; Number of Measuring Agency(ies): 1

# 010S006E18J001S



Local ID: ID4-18 ; Number of Measuring Agency(ies): 4

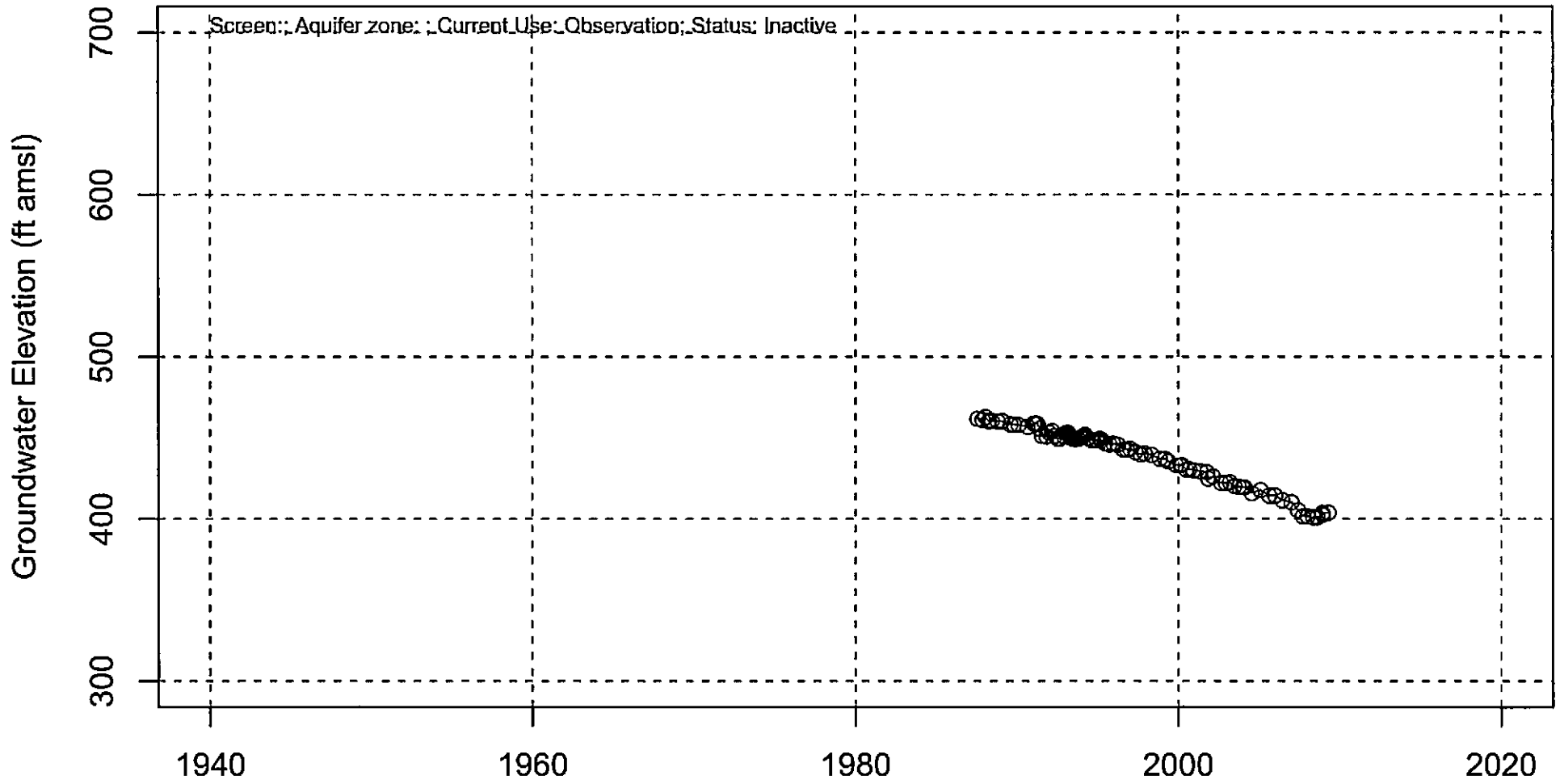
# 010S006E18R001S



Local ID: ID4-3 ; Number of Measuring Agency(y/ies): 5

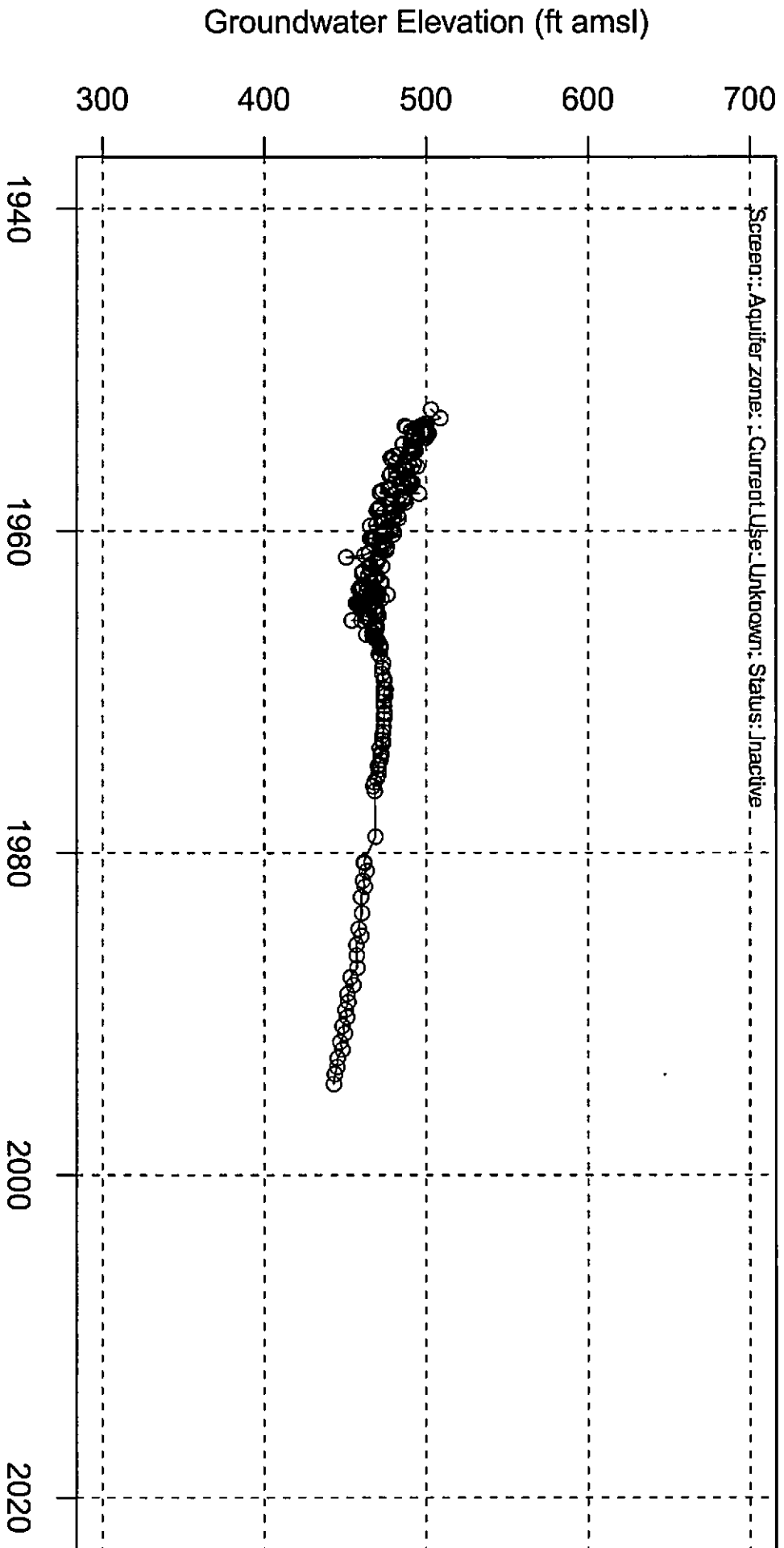


# 010S006E20L001S



Local ID: Empty Irrigation ; Number of Measuring Agenc(y/ies): 3

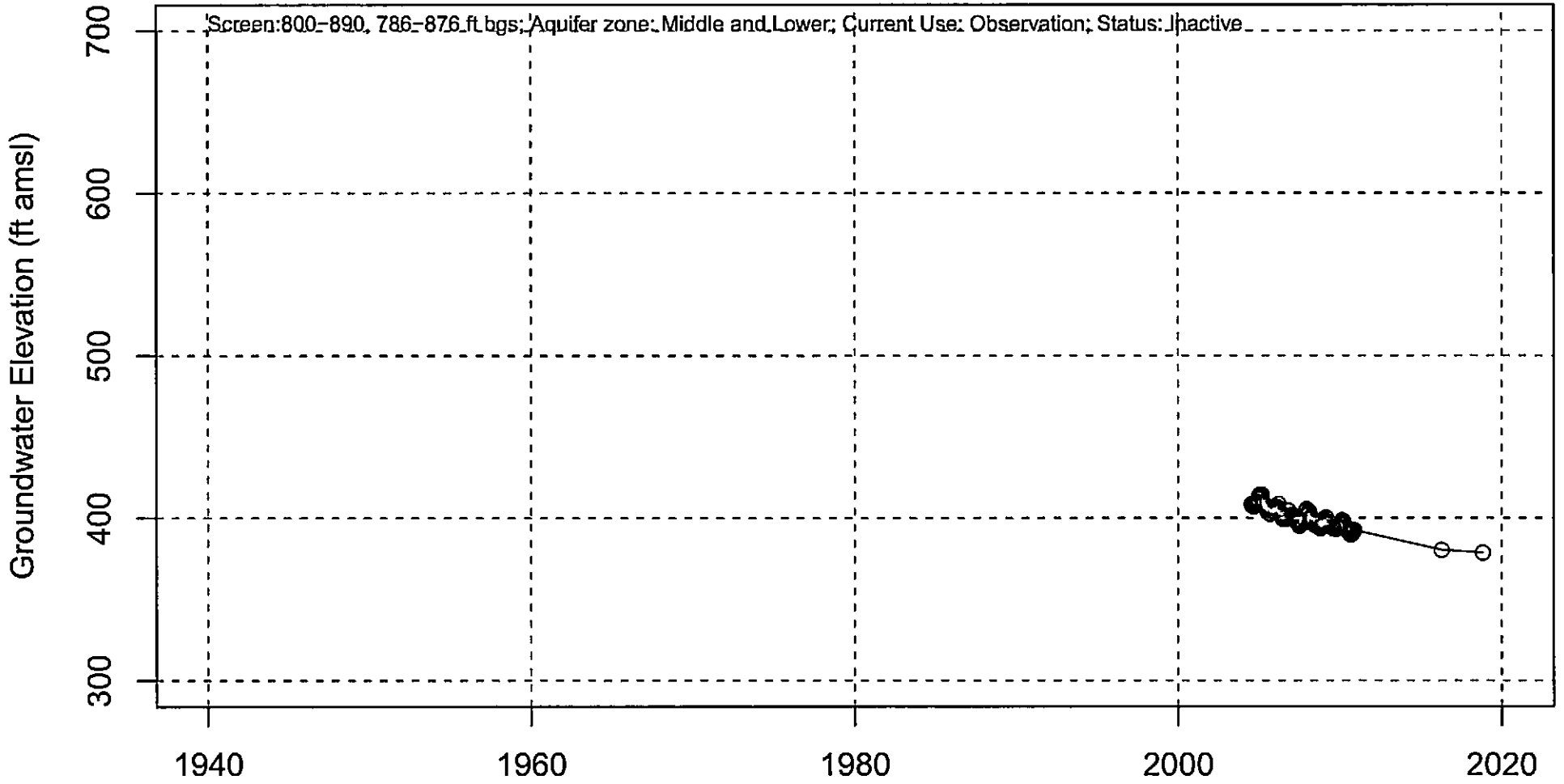
# 010S006E21A001S



Local ID: 21A1 ; Number of Measuring Agency(y/ies): 2

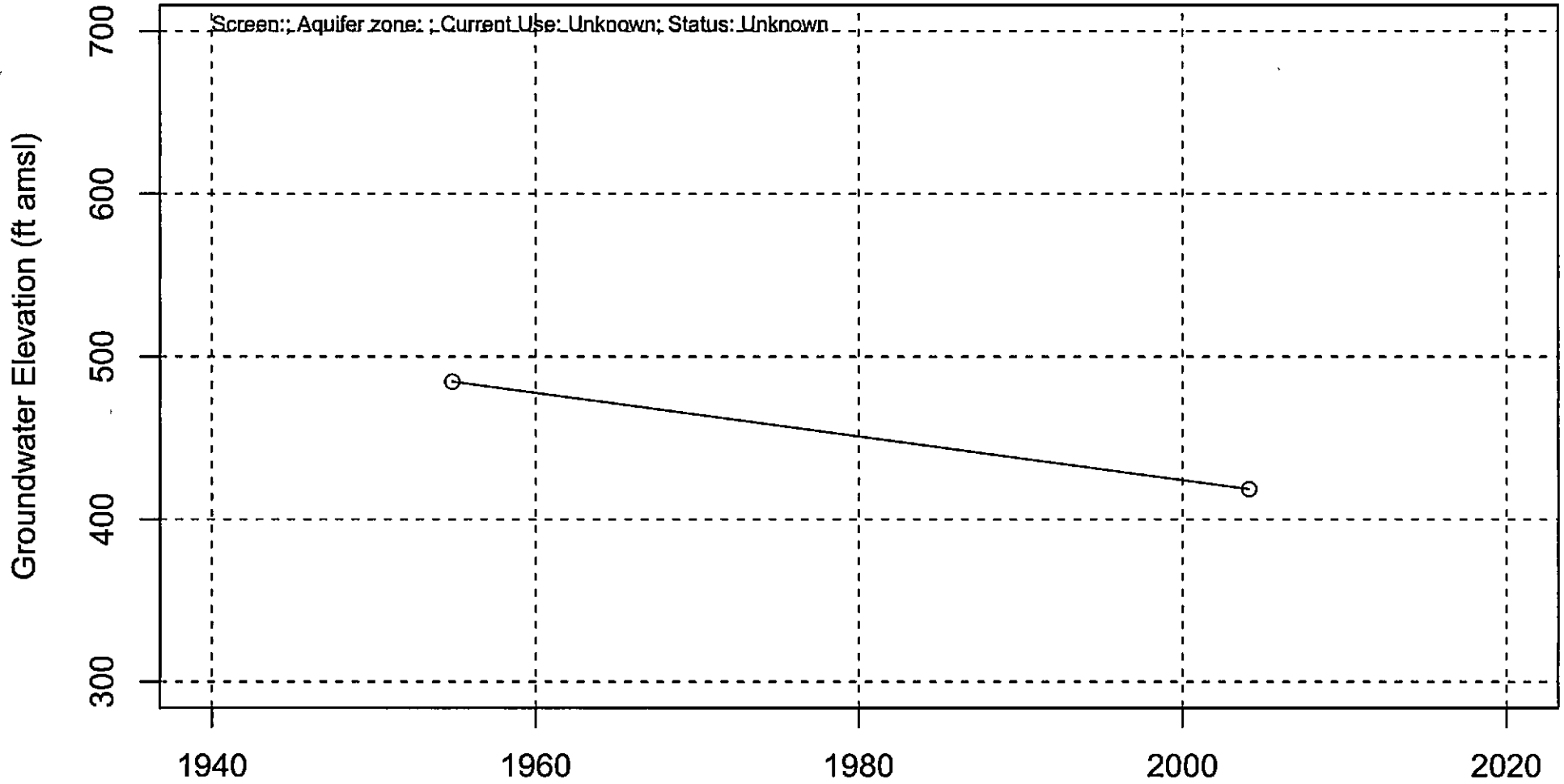
January 2020

# 010S006E21A002S



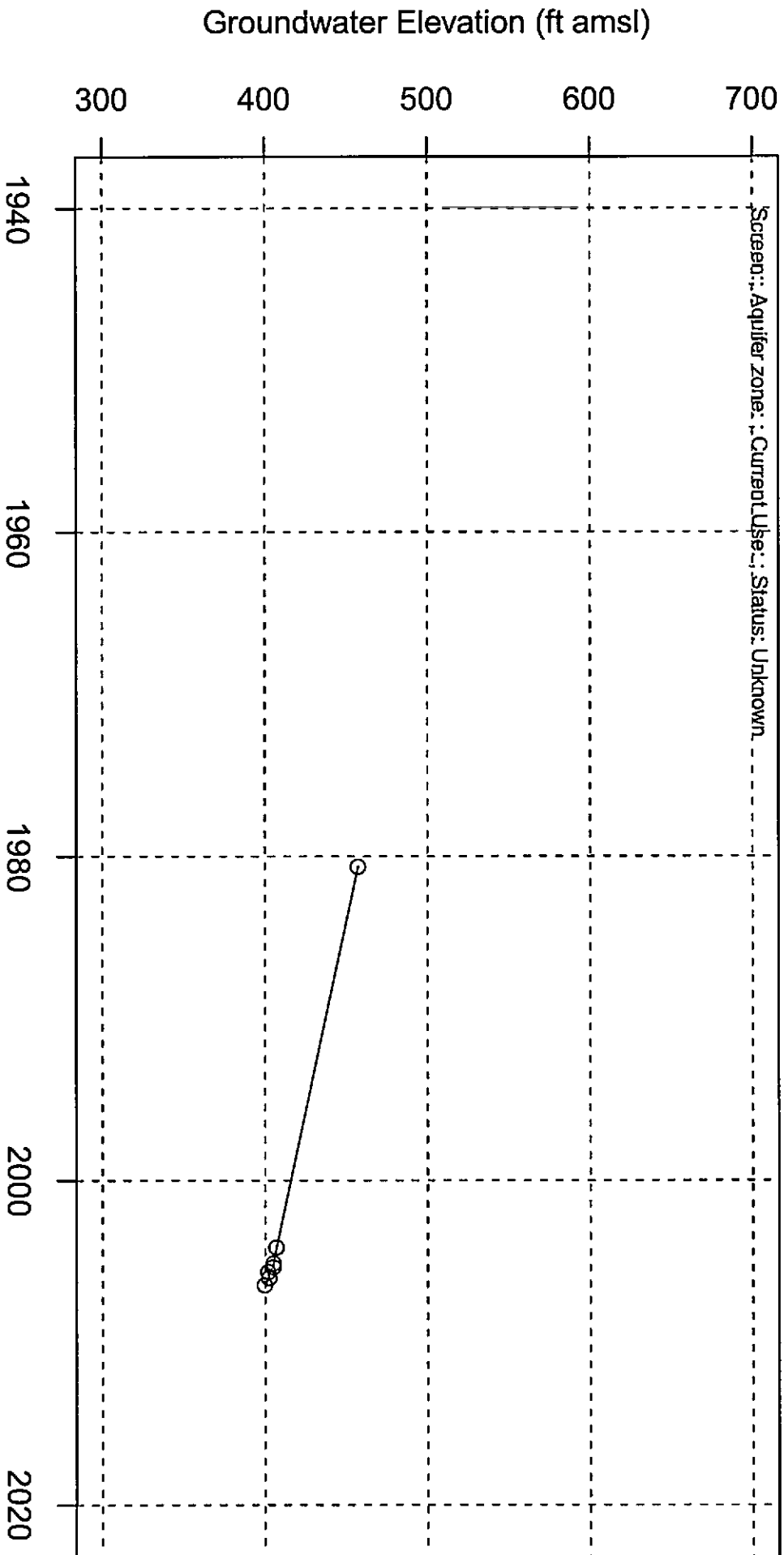
Local ID: MW-1 ; Number of Measuring Agency(ies): 5

# 010S006E21B001S



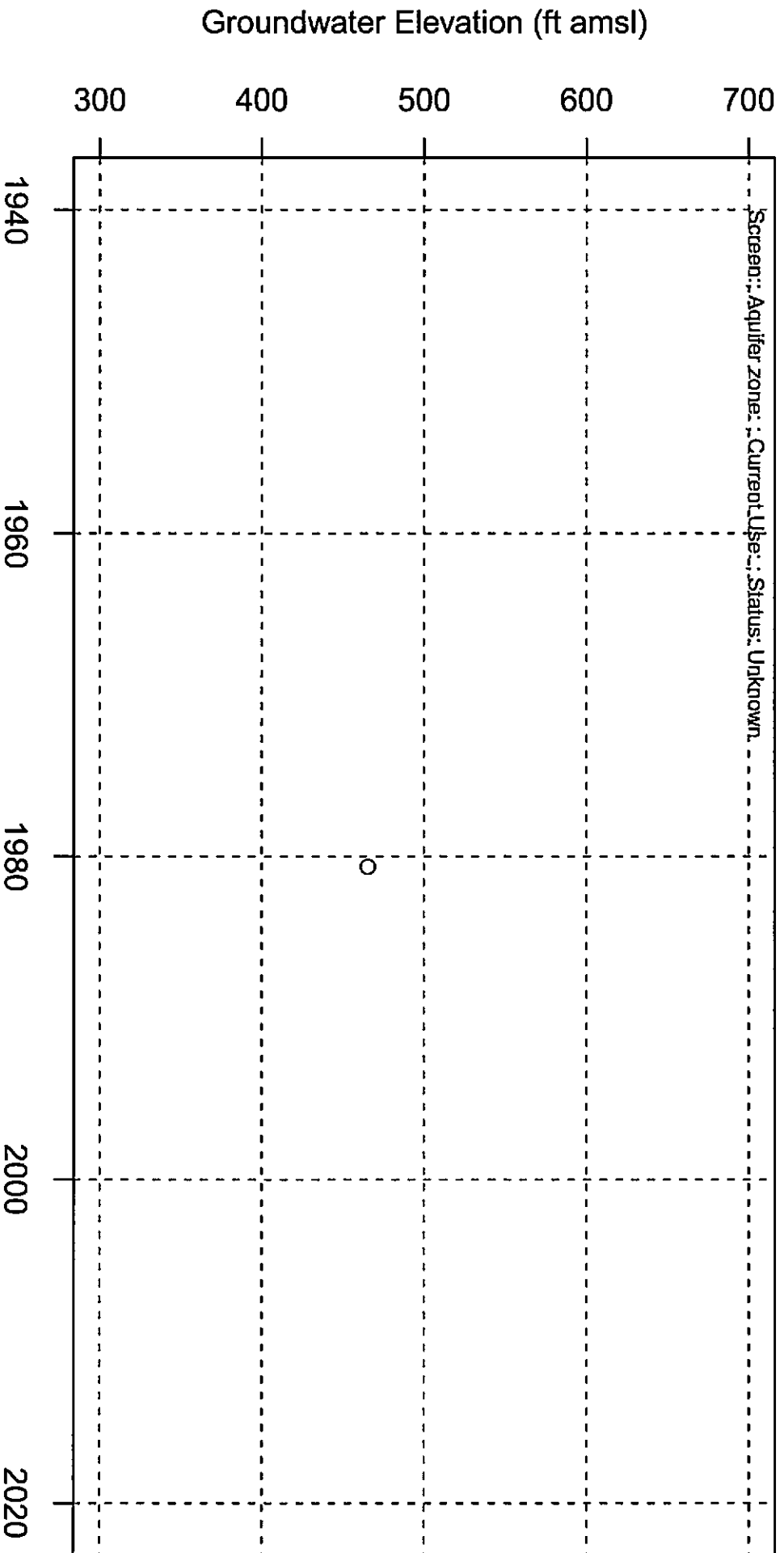
Local ID: N/A ; Number of Measuring Agency(ies): 2

# 010S006E21B002S



Local ID: N/A ; Number of Measuring Agency(ies): 2

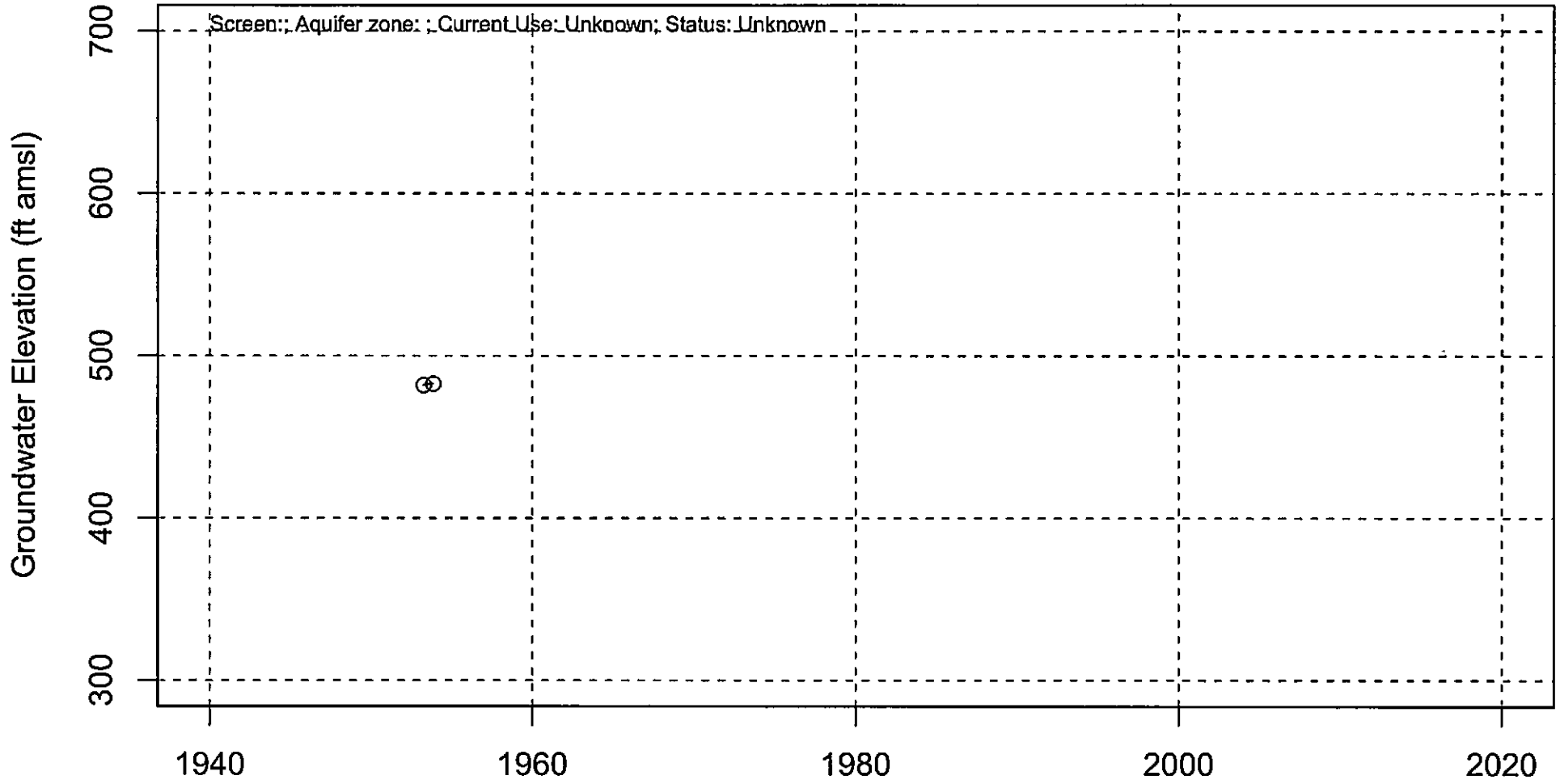
**010S006E21F001S**



Local ID: N/A ; Number of Measuring Agenc(y/ies): 1

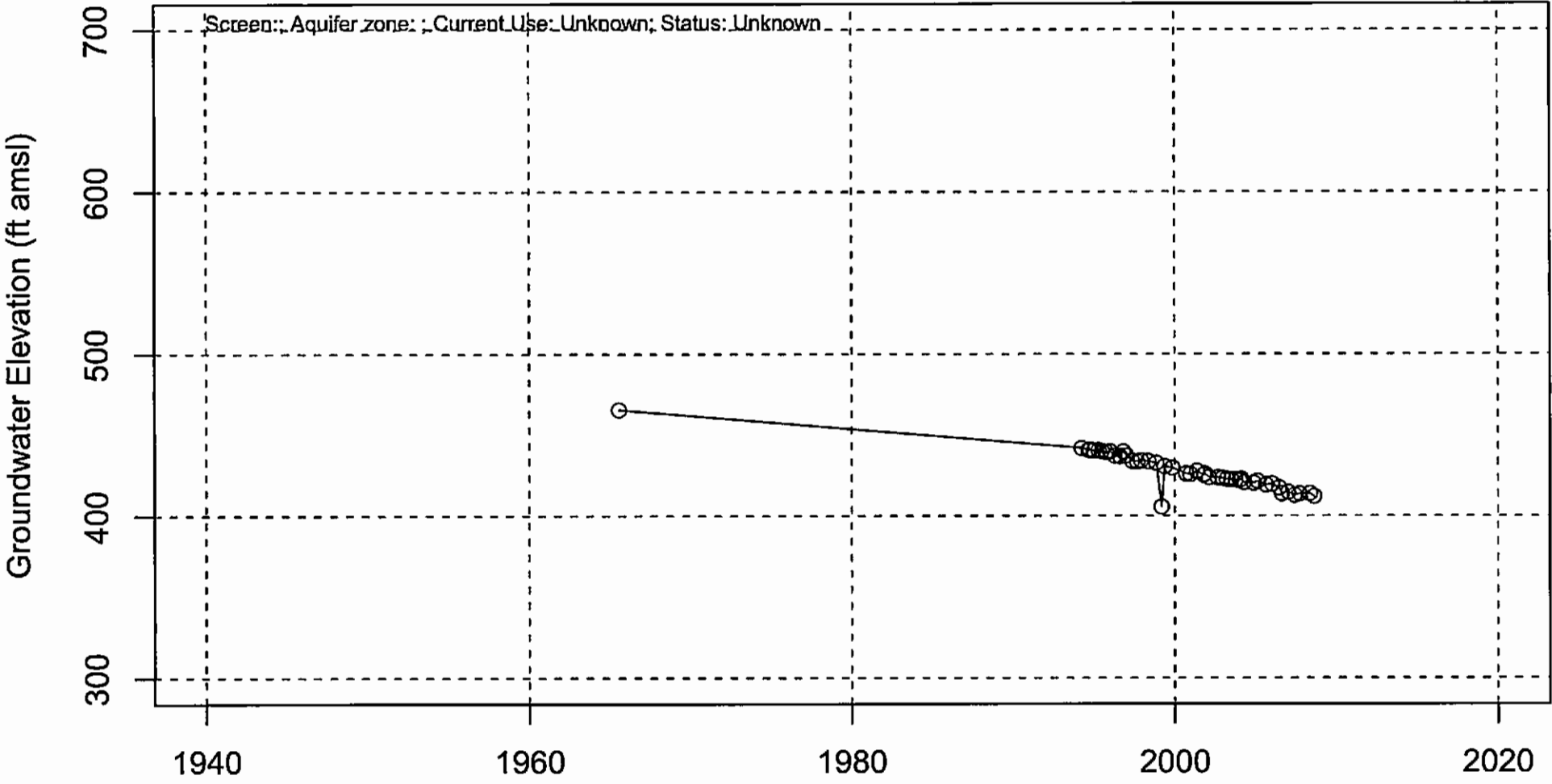
January 2020

# 010S006E22A001S



Local ID: N/A ; Number of Measuring Agency(ies): 1

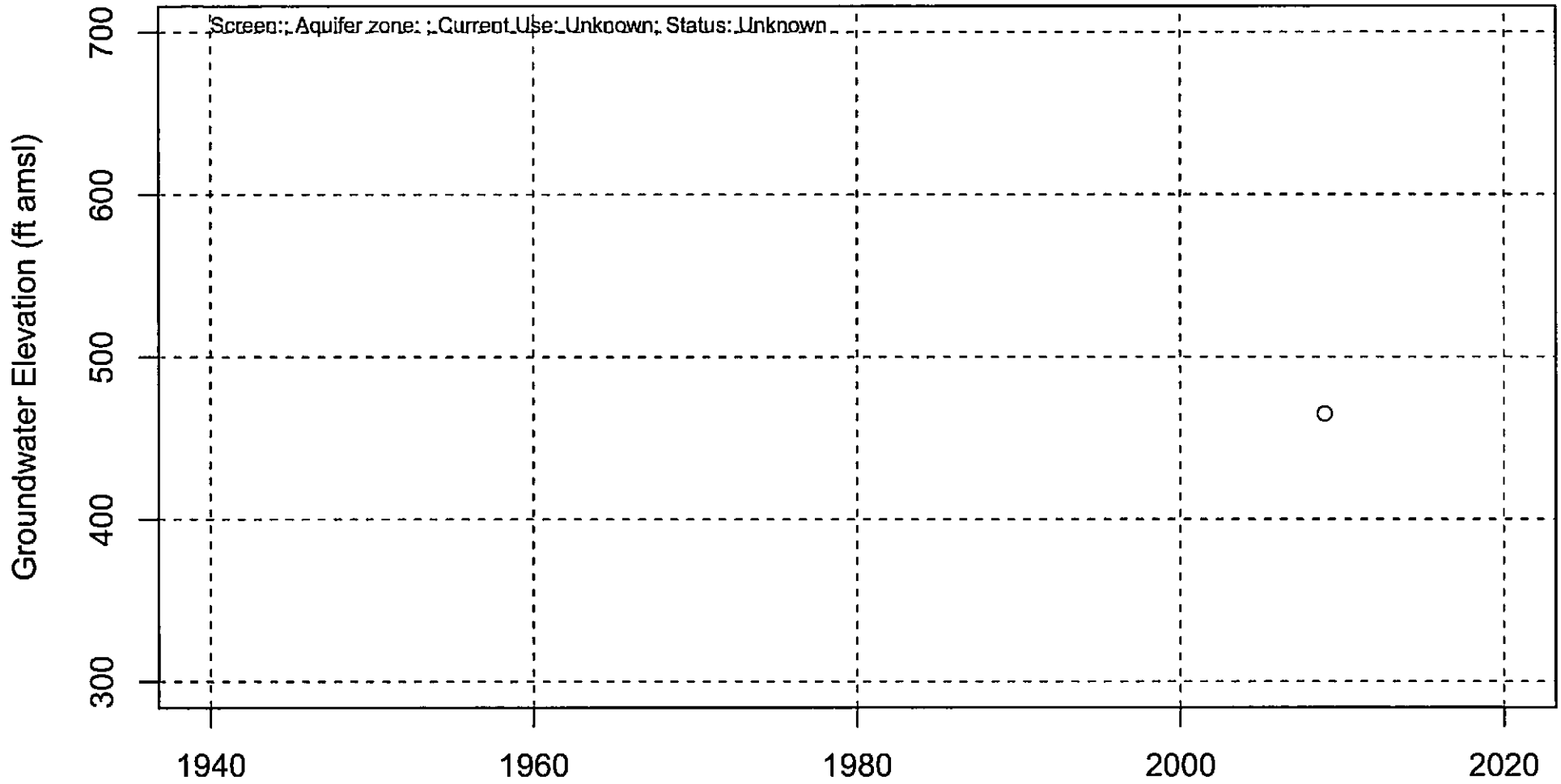
# 010S006E23M001S



Local ID: Potato Field ; Number of Measuring Agency(ies): 3

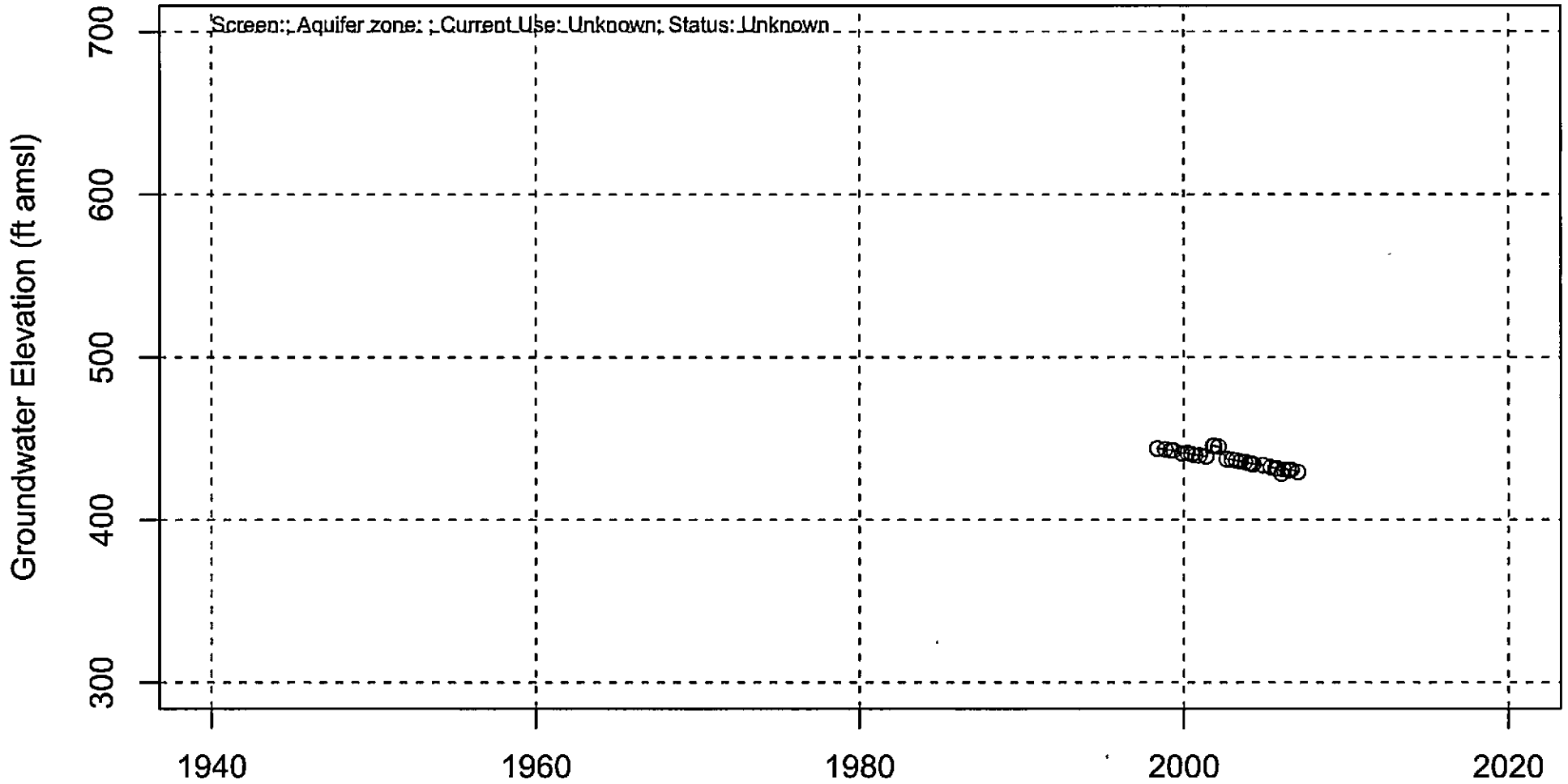


# 010S006E24K002S



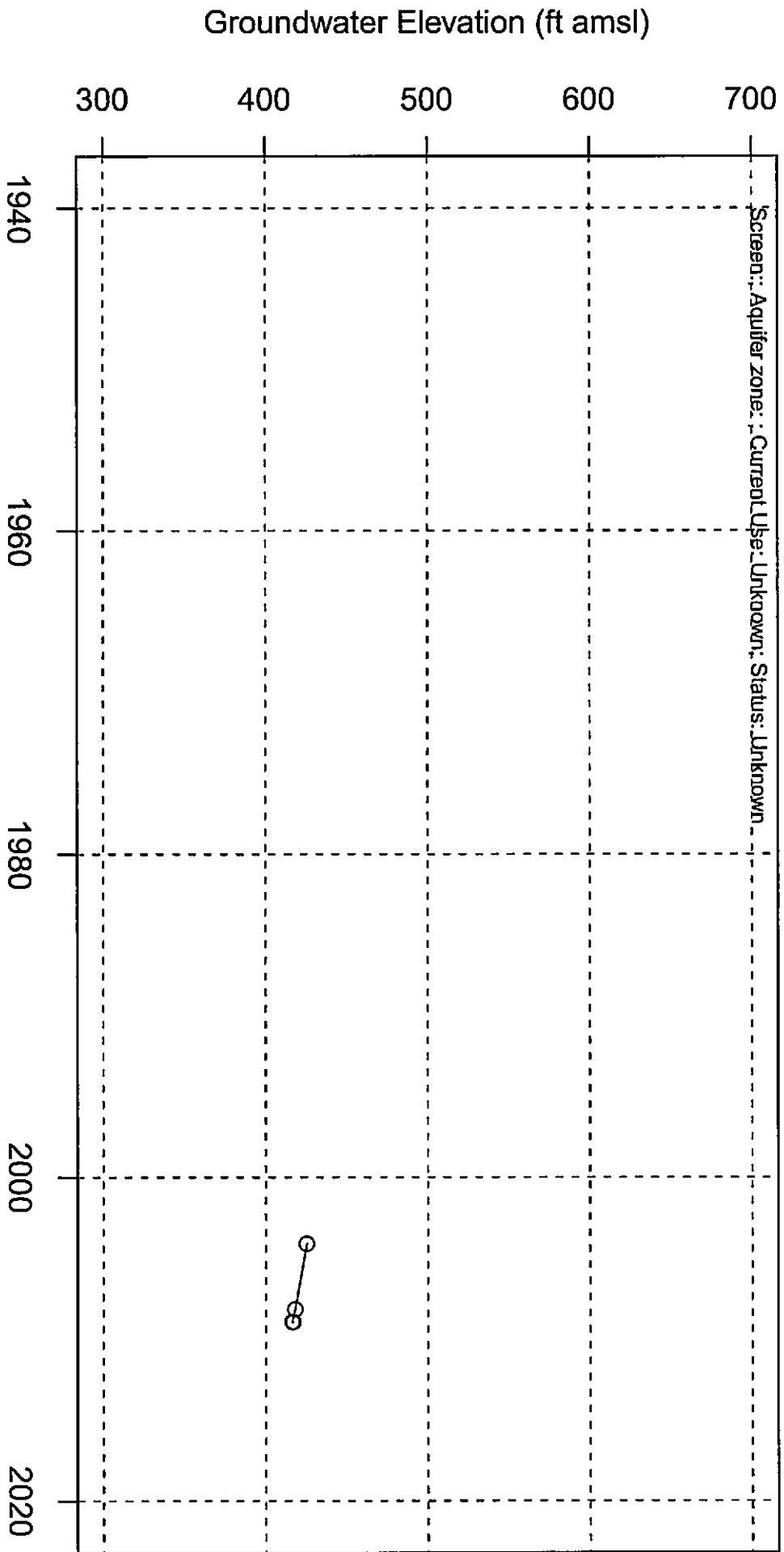
Local ID: Bad Donkey Ranch 2 ; Number of Measuring Agency(ies): 1

# 010S006E25R001S



Local ID: Gray Irrigation ; Number of Measuring Agency(ies): 3

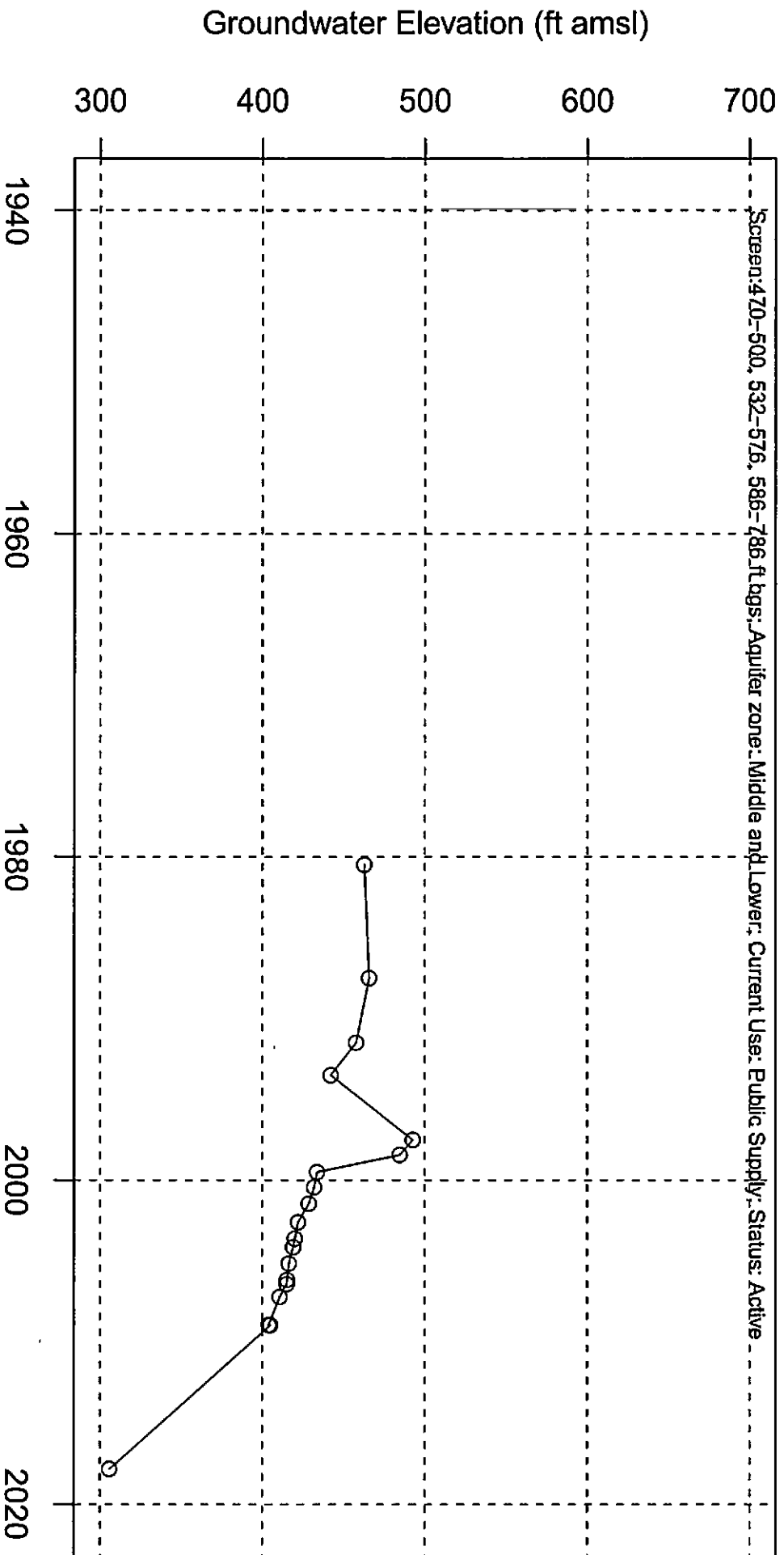
# 010S006E28Q001S



Local ID: Reiners ; Number of Measuring Agency(ies): 2

January 2020

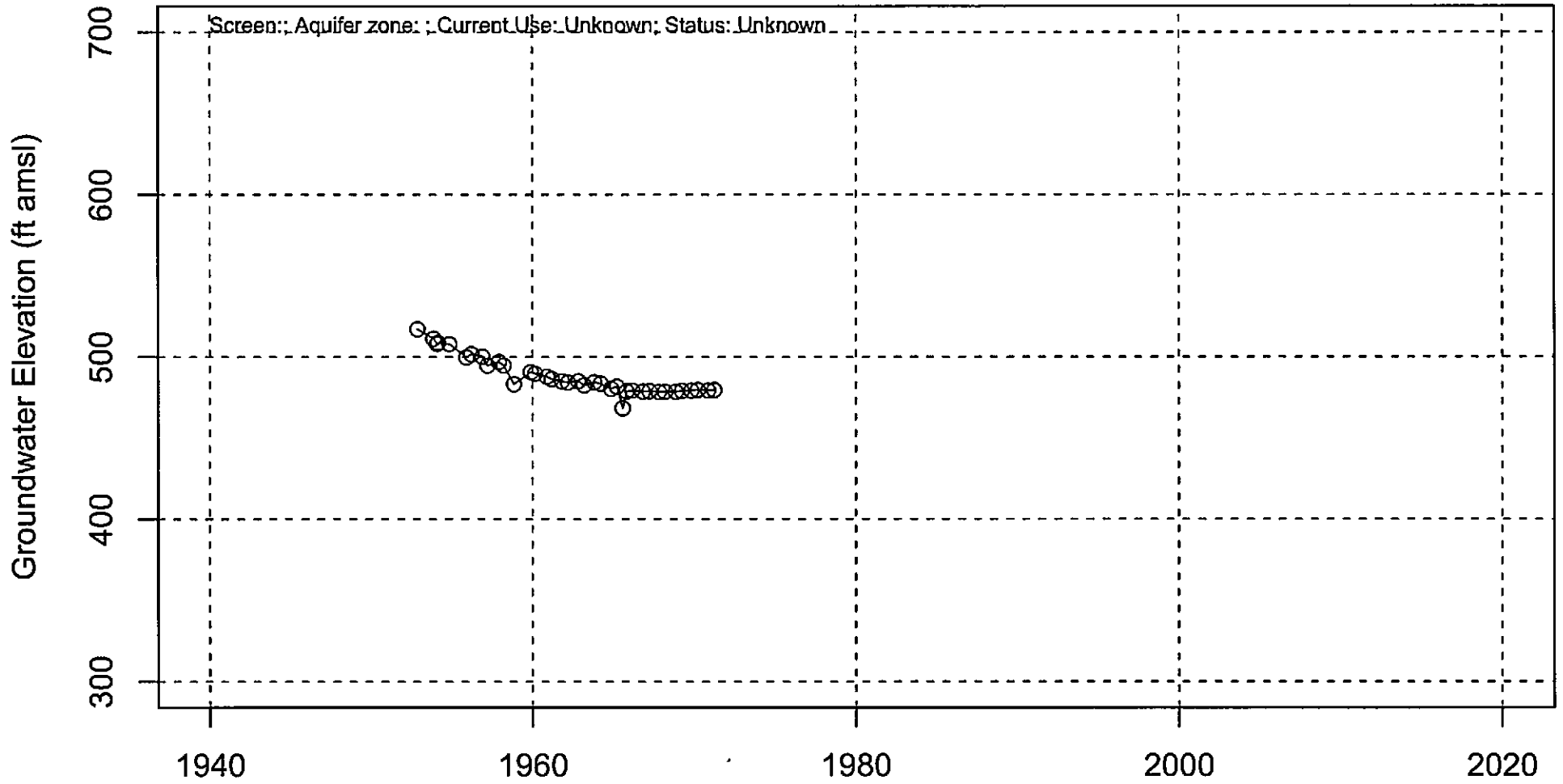
# 010S006E29K002S



Local ID: ID4-4 ; Number of Measuring Agency(y/ies): 3

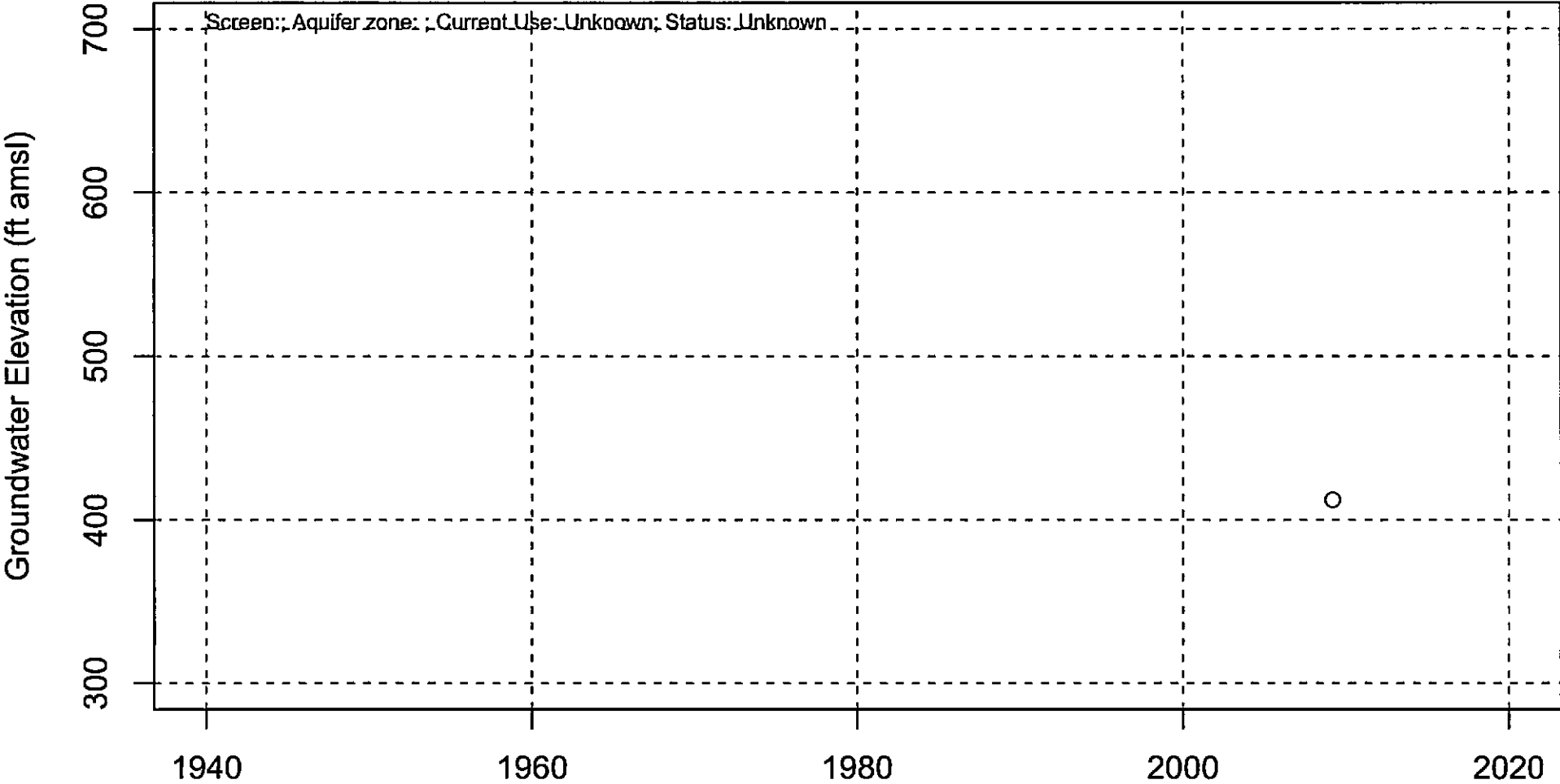
January 2020

# 010S006E29N001S



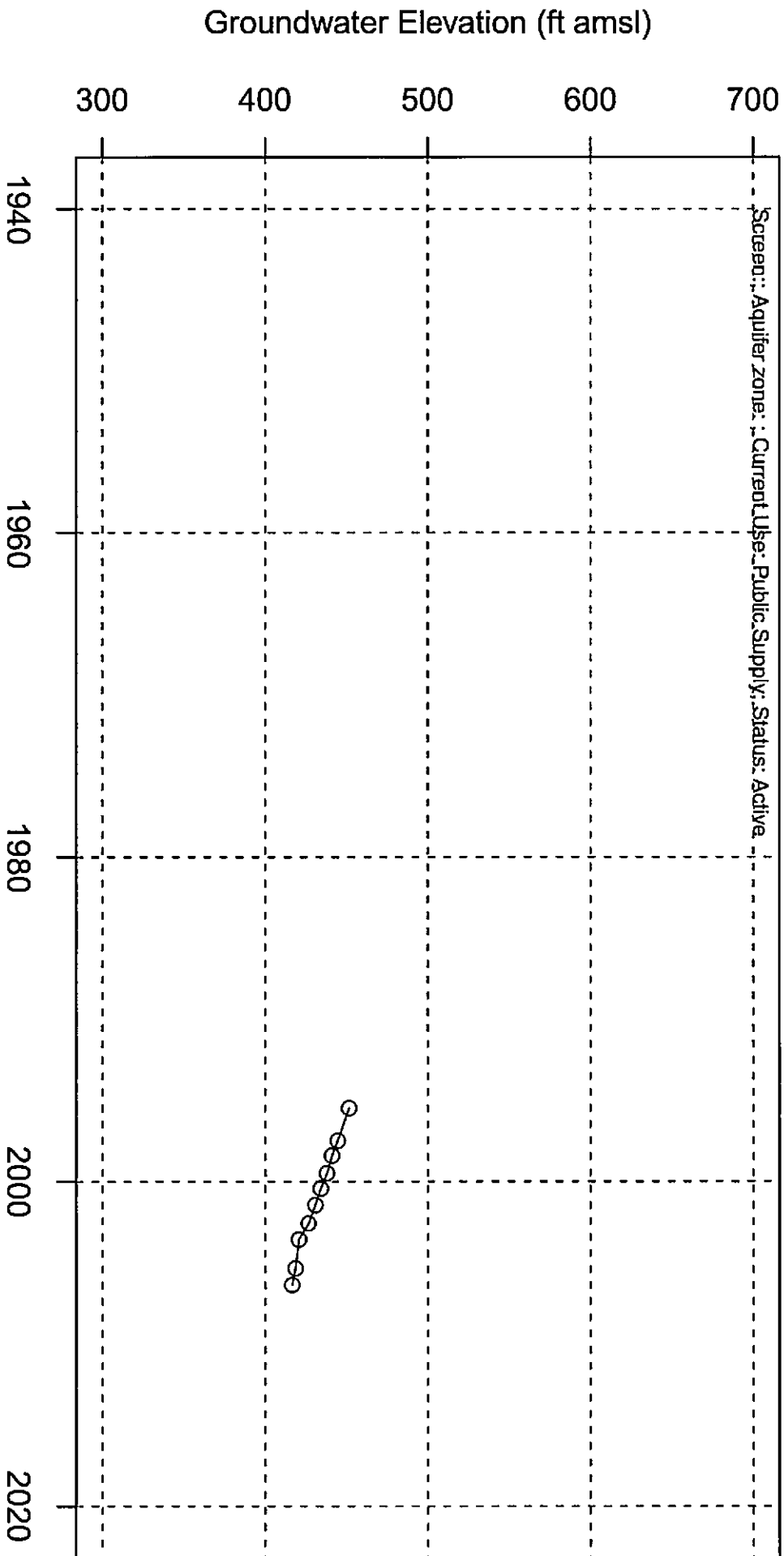
Local ID: N/A ; Number of Measuring Agency(ies): 1

# 010S006E29N002S



Local ID: Pecoff 2 ; Number of Measuring Agency(ies): 1

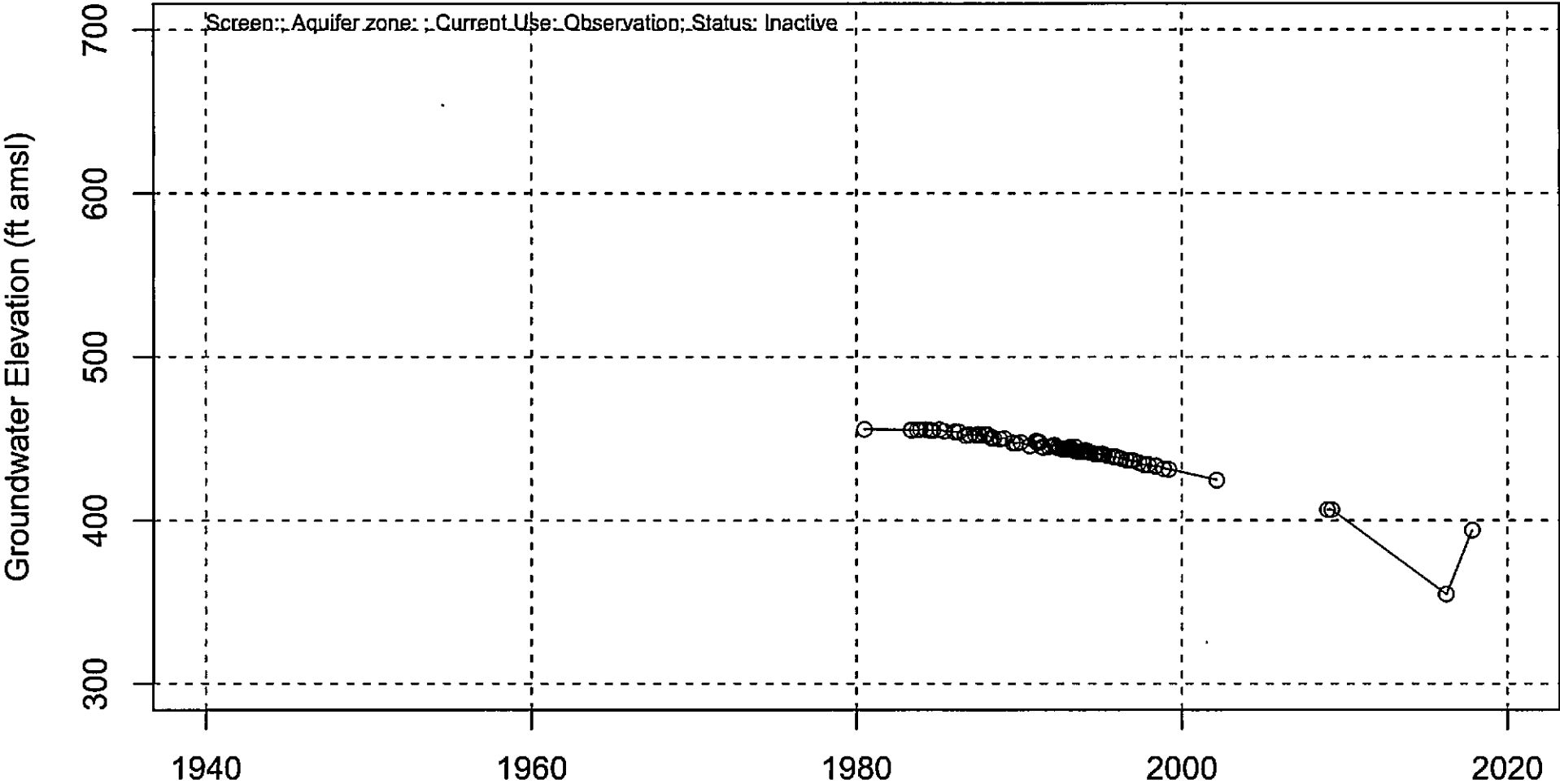
# 010S006E32D001S



Local ID: ID4-11 ; Number of Measuring Agenc(y/ies): 2

January 2020

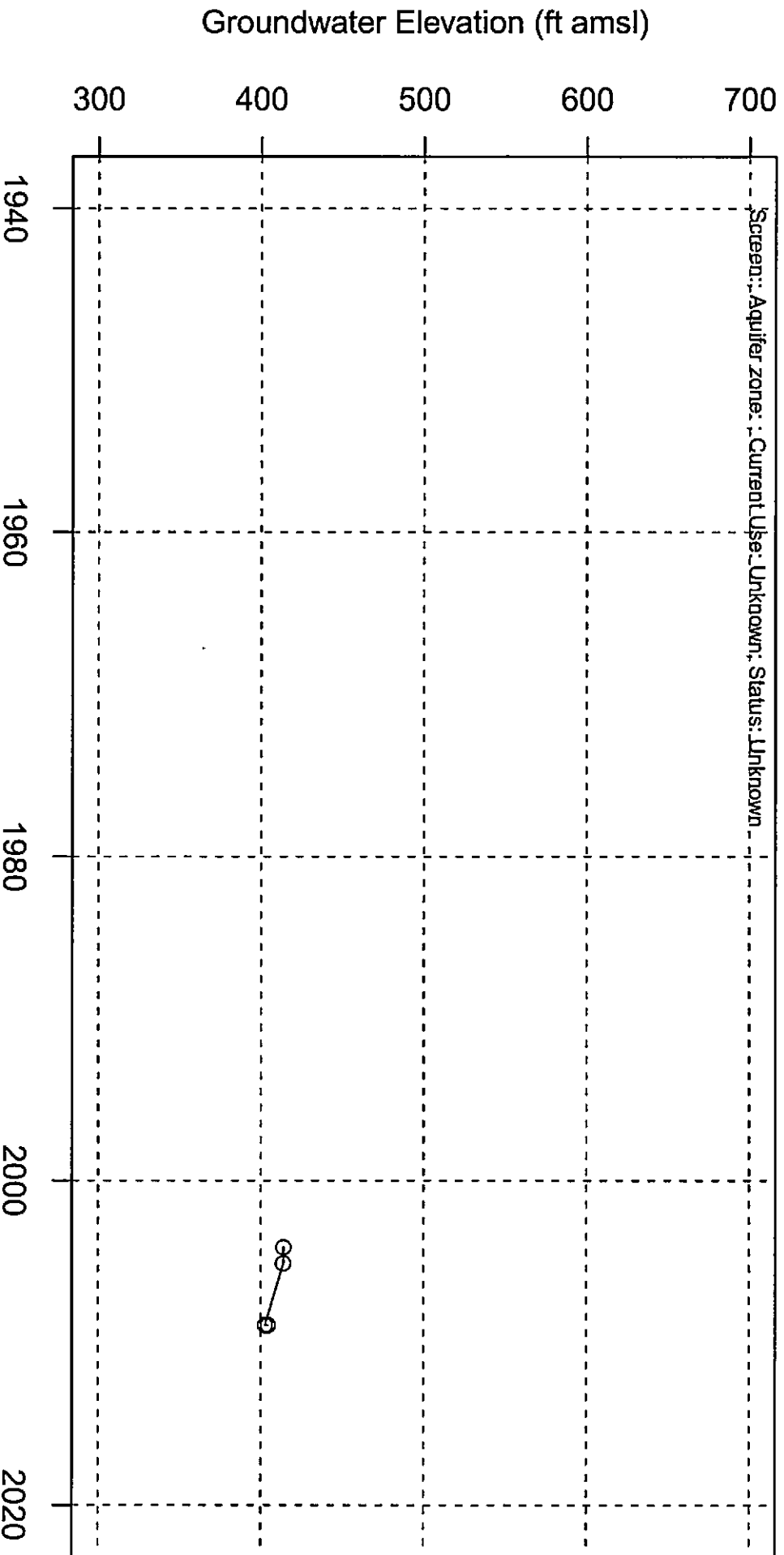
# 010S006E32R001S



Local ID: ID4-1 ; Number of Measuring Agency(ies): 5



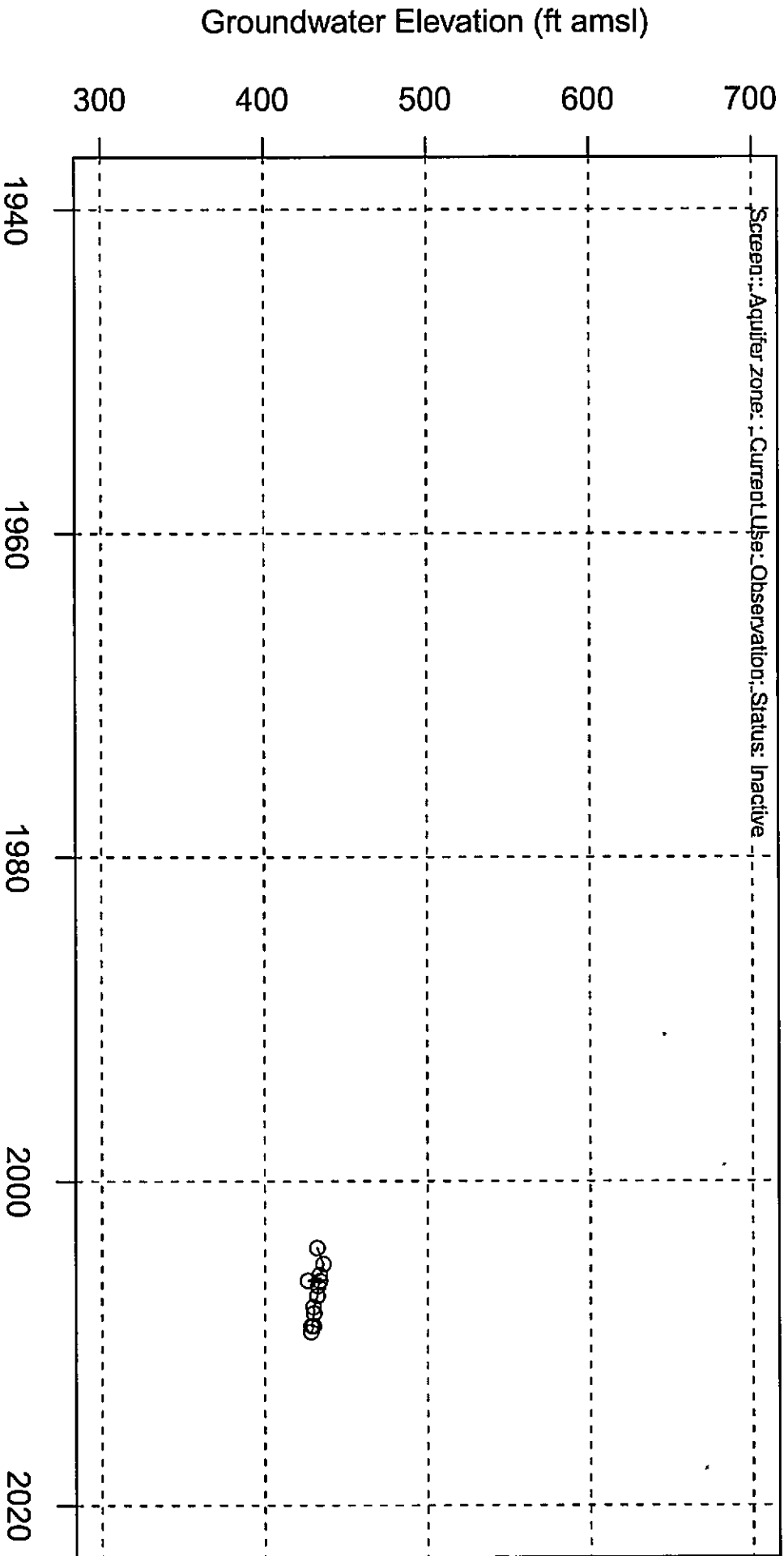
# 010S006E33C002S



Local ID: Springs 2 ; Number of Measuring Agenc(y/ies): 2

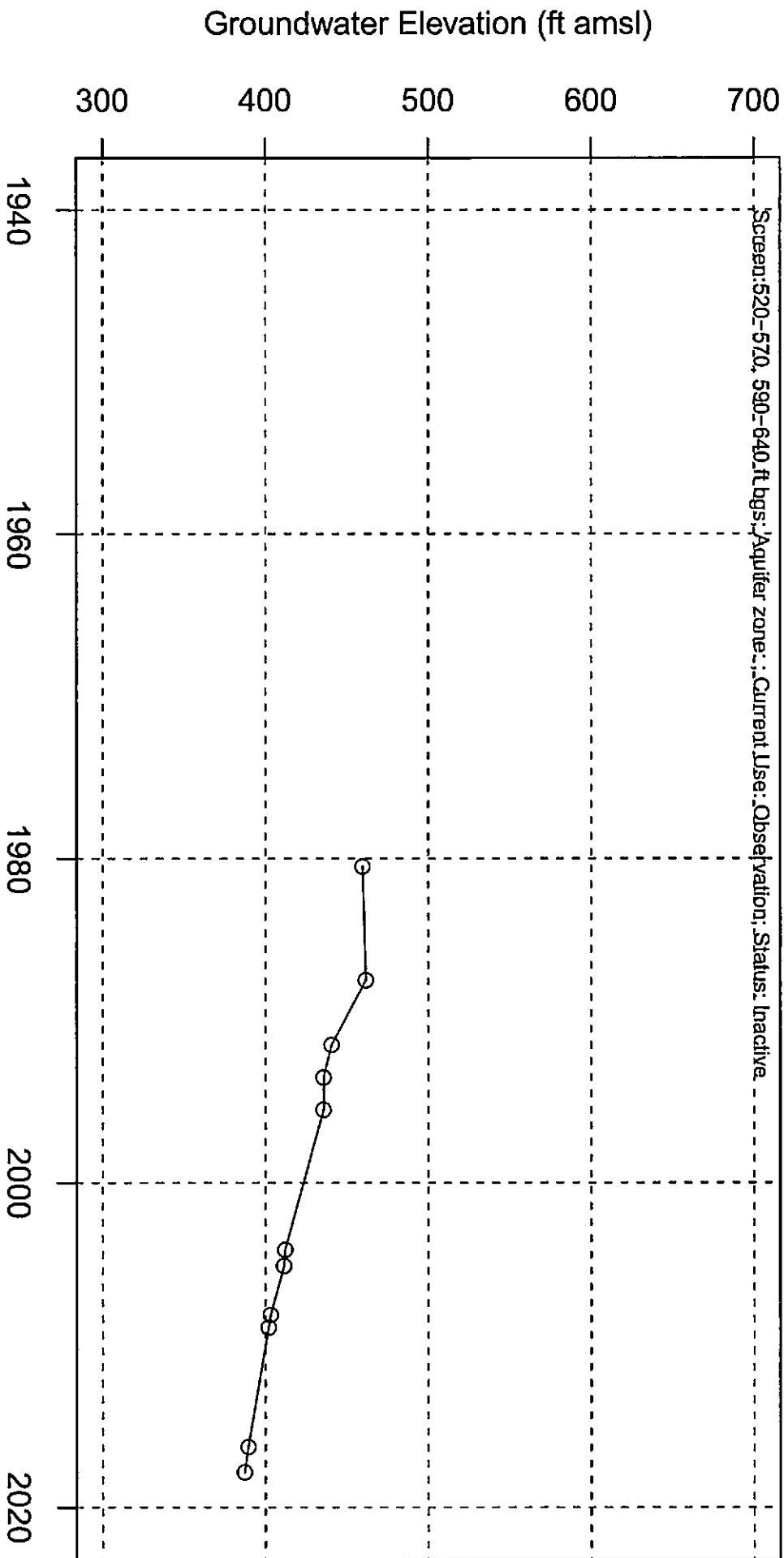
January 2020

# 010S006E33J001S



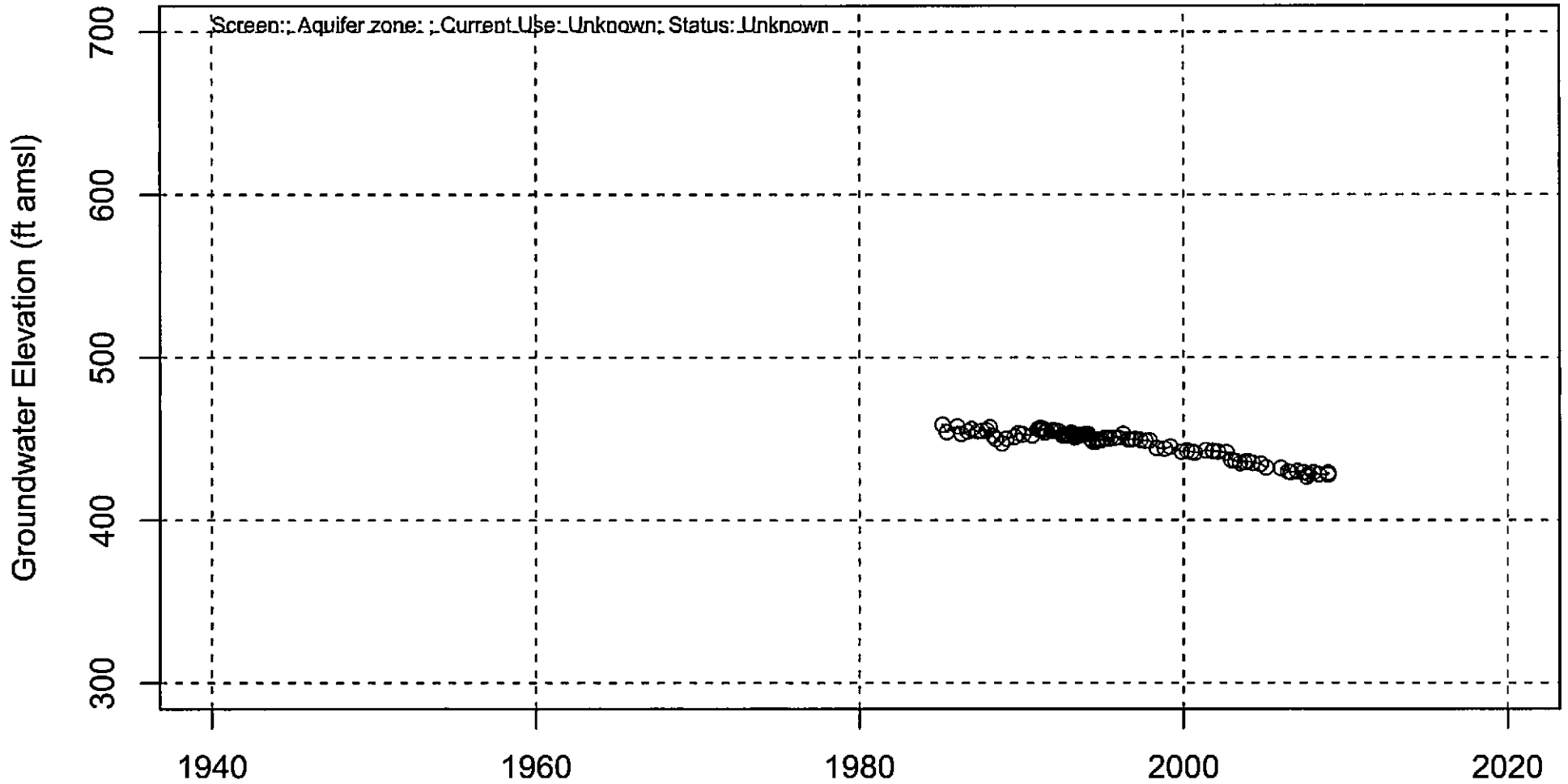
Local ID: Palleason ; Number of Measuring Agenc(y/ies): 3

# 010S006E33Q001S



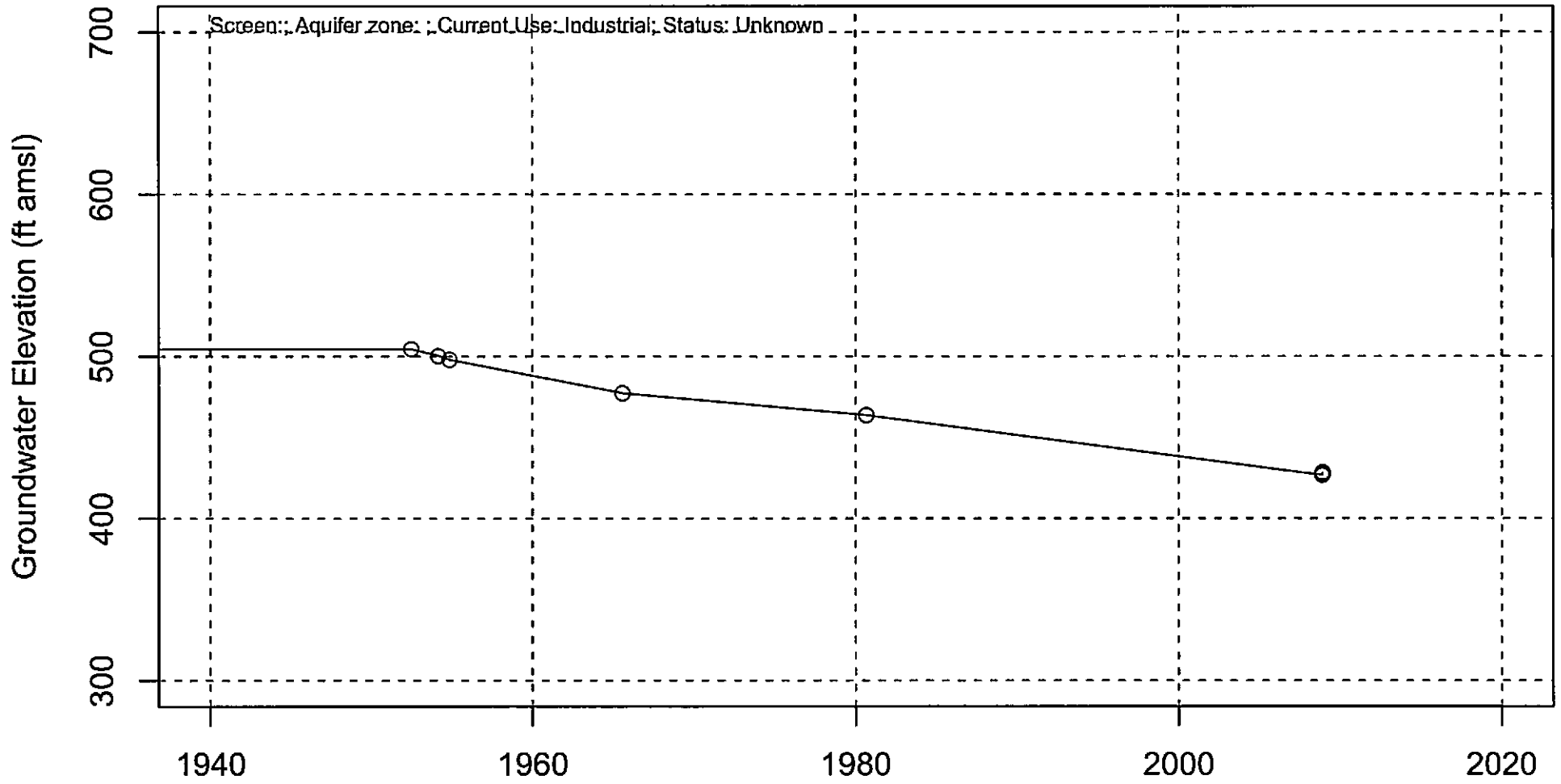
Local ID: ID4-5 ; Number of Measuring Agency(ies): 4

# 010S006E34D001S



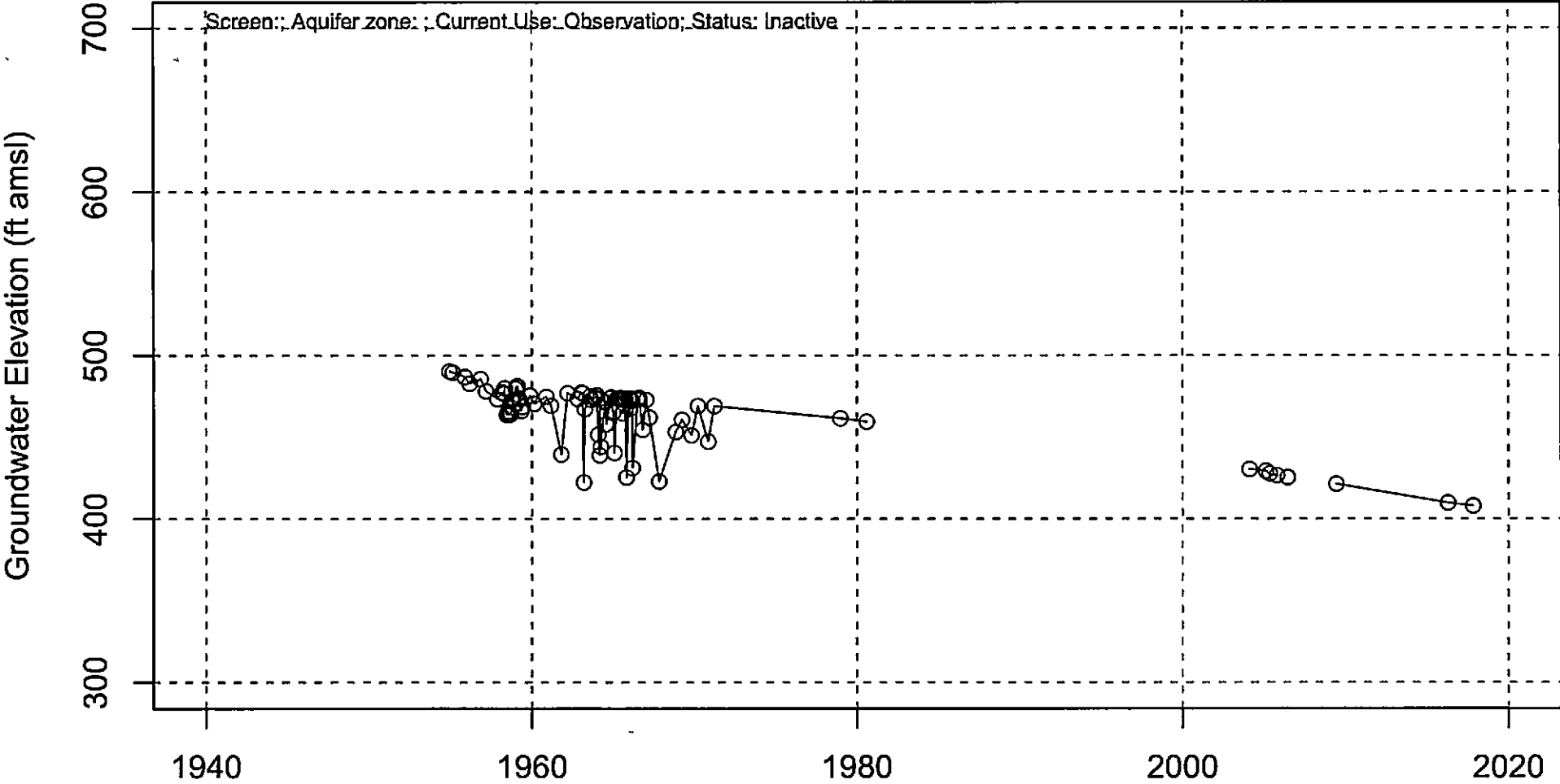
Local ID: UEC North ; Number of Measuring Agency(ies): 2

# 010S006E34K001S



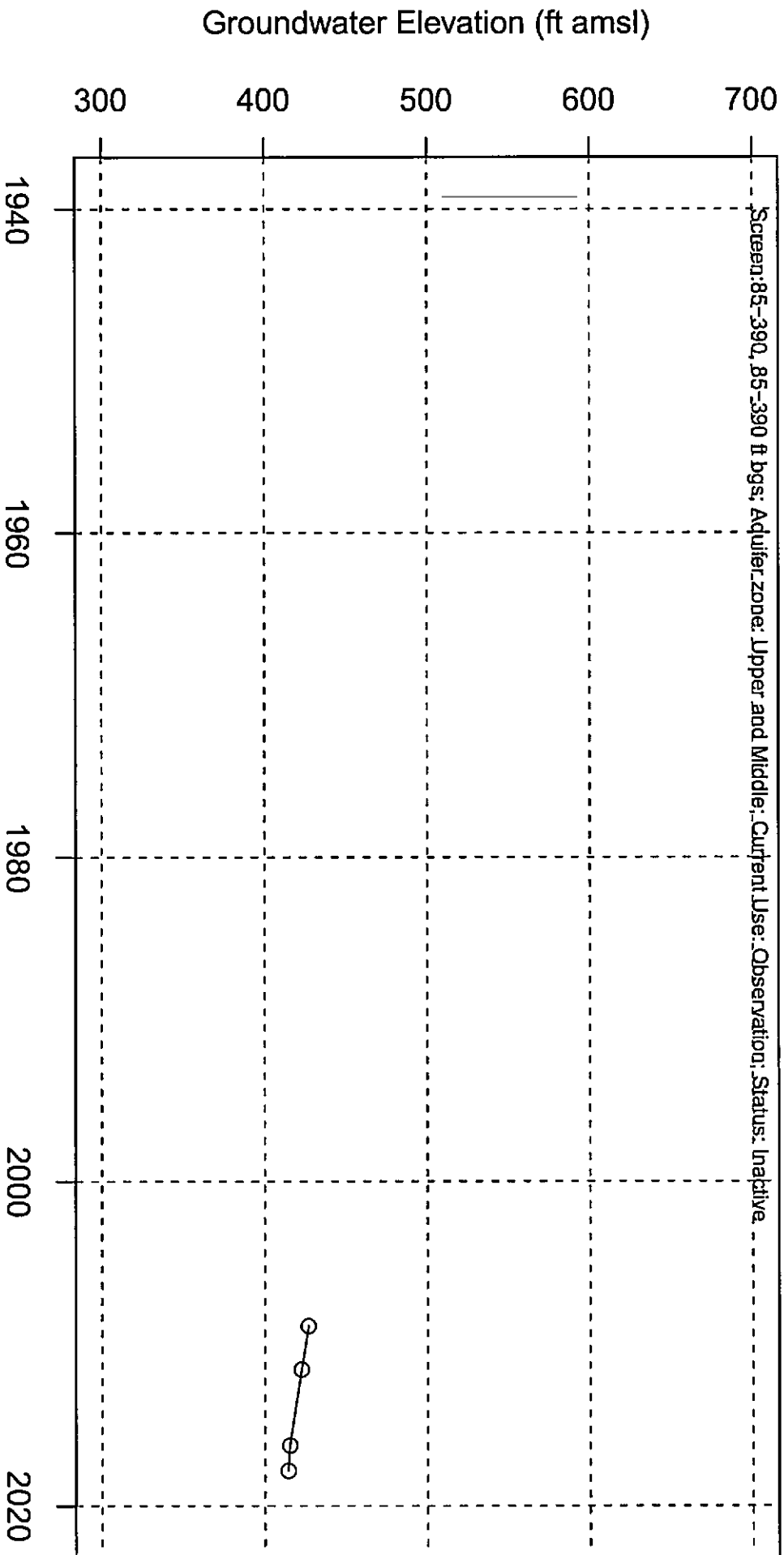
Local ID: Redimix Plant ; Number of Measuring Agency(ies): 3

# 010S006E35N001S



Local ID: Airport 2 ; Number of Measuring Agency(ies): 6

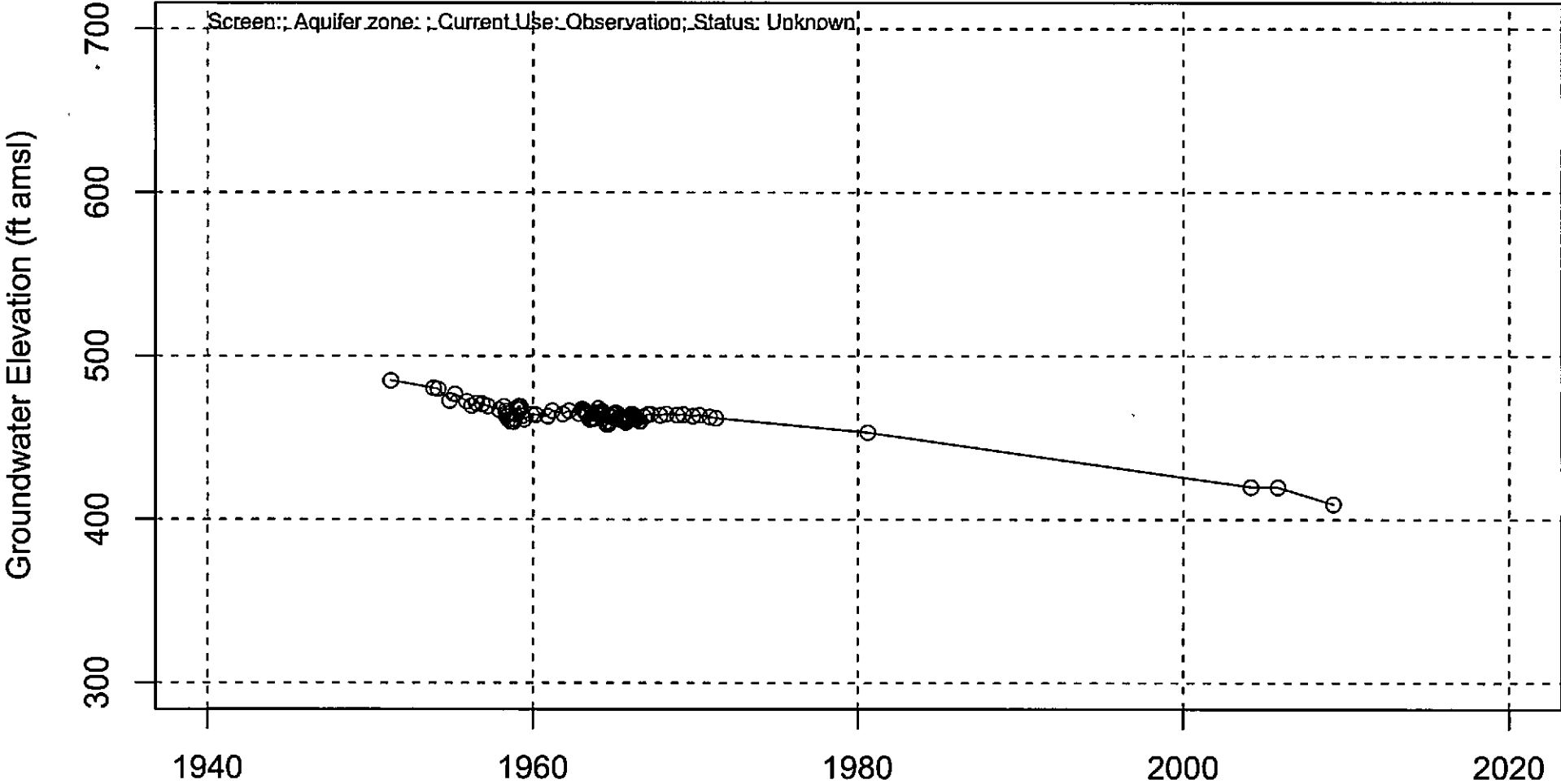
# 010S006E35Q001S



Local ID: MW-4 ; Number of Measuring Agency(y/ies): 3

January 2020

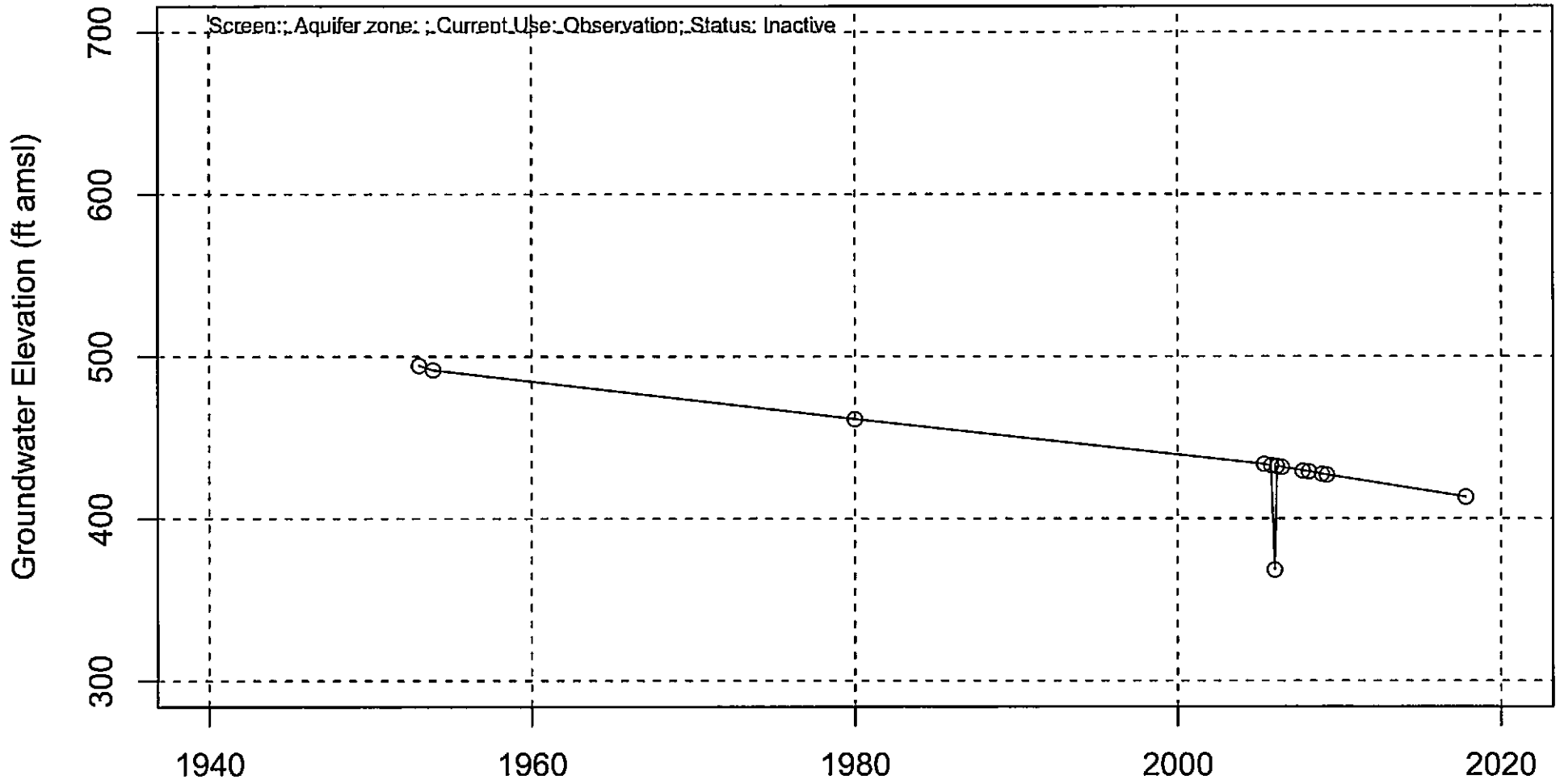
# 010S006E36Q001S



Local ID: Hawkins ; Number of Measuring Agenc(y/ies): 3

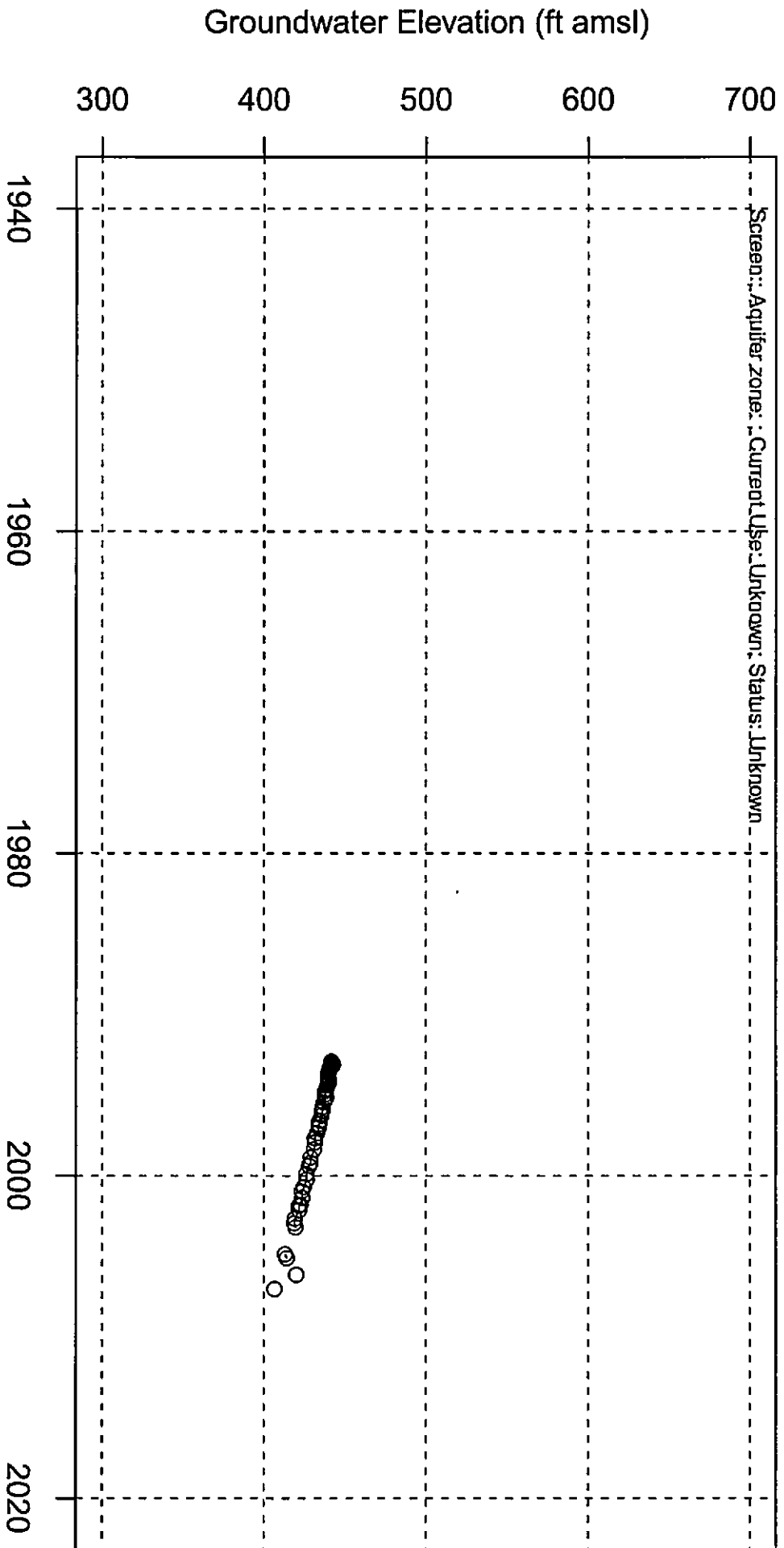


# 011S006E01C001S



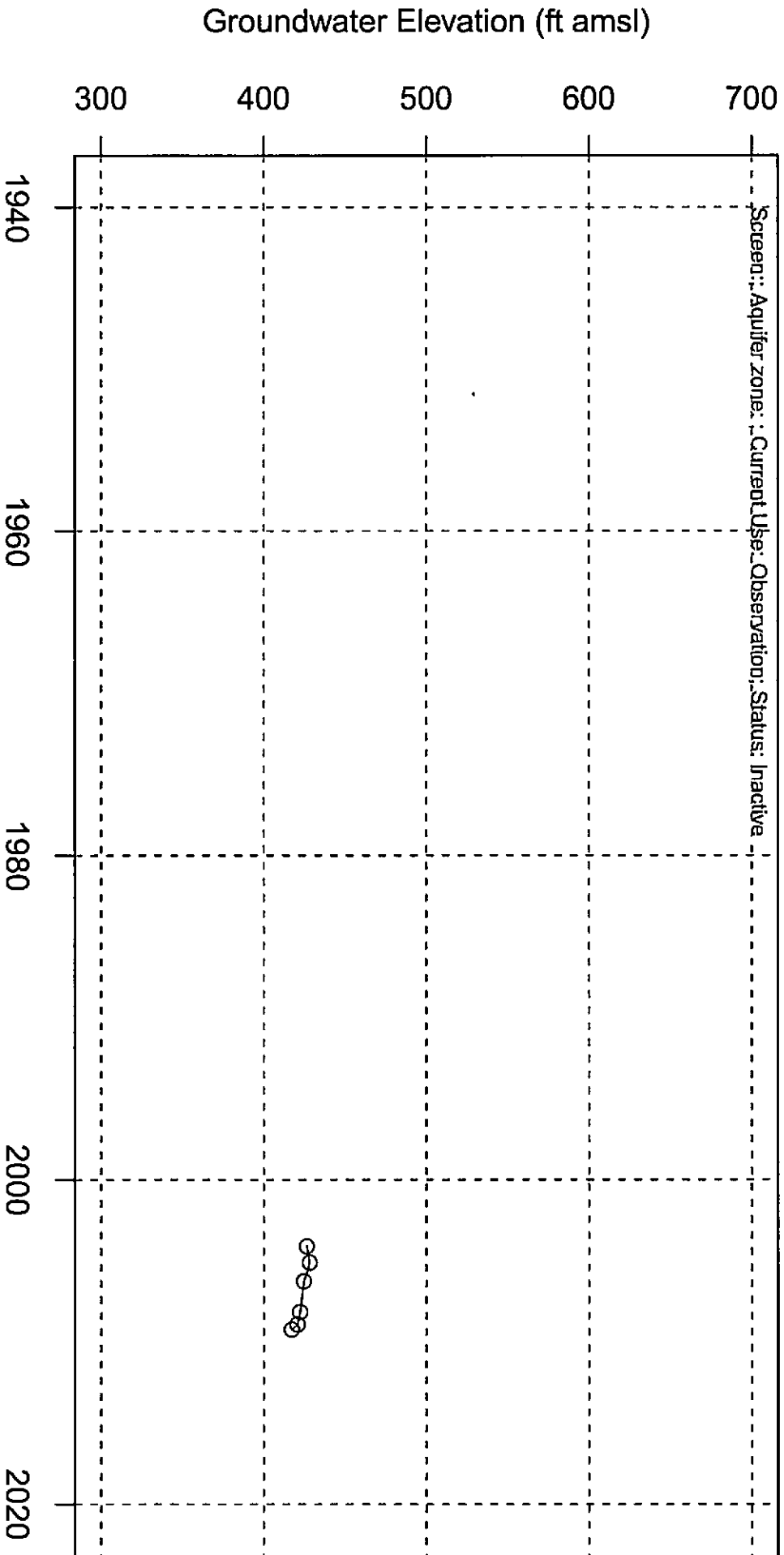
Local ID: Gabrych #2 ; Number of Measuring Agency(ies): 4

# 011S006E02C003S



Local ID: N/A ; Number of Measuring Agenc(y/ies): 3

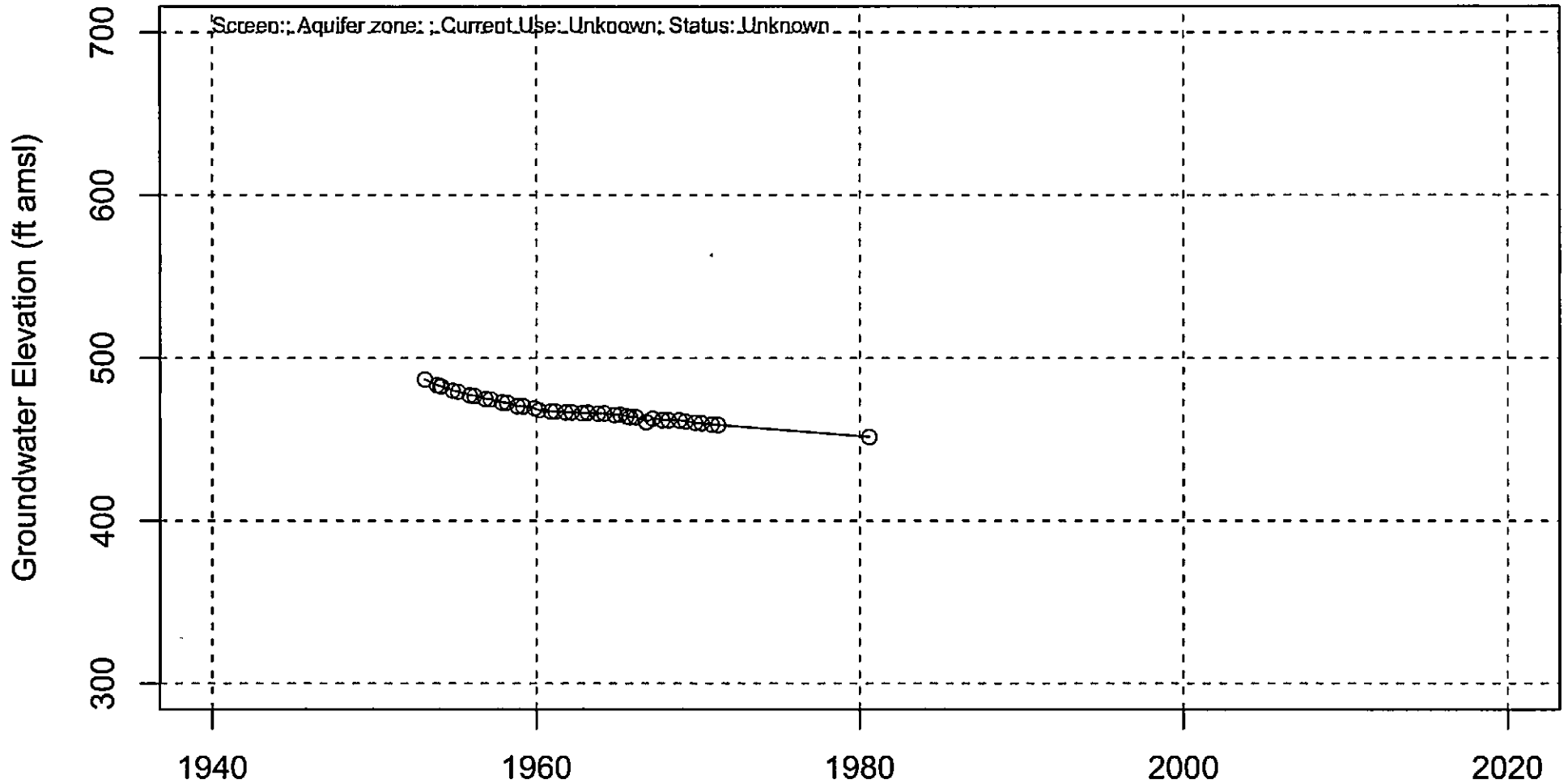
# 011S006E04F001S



Local ID: Cameron 2 ; Number of Measuring Agency(y/ies): 2

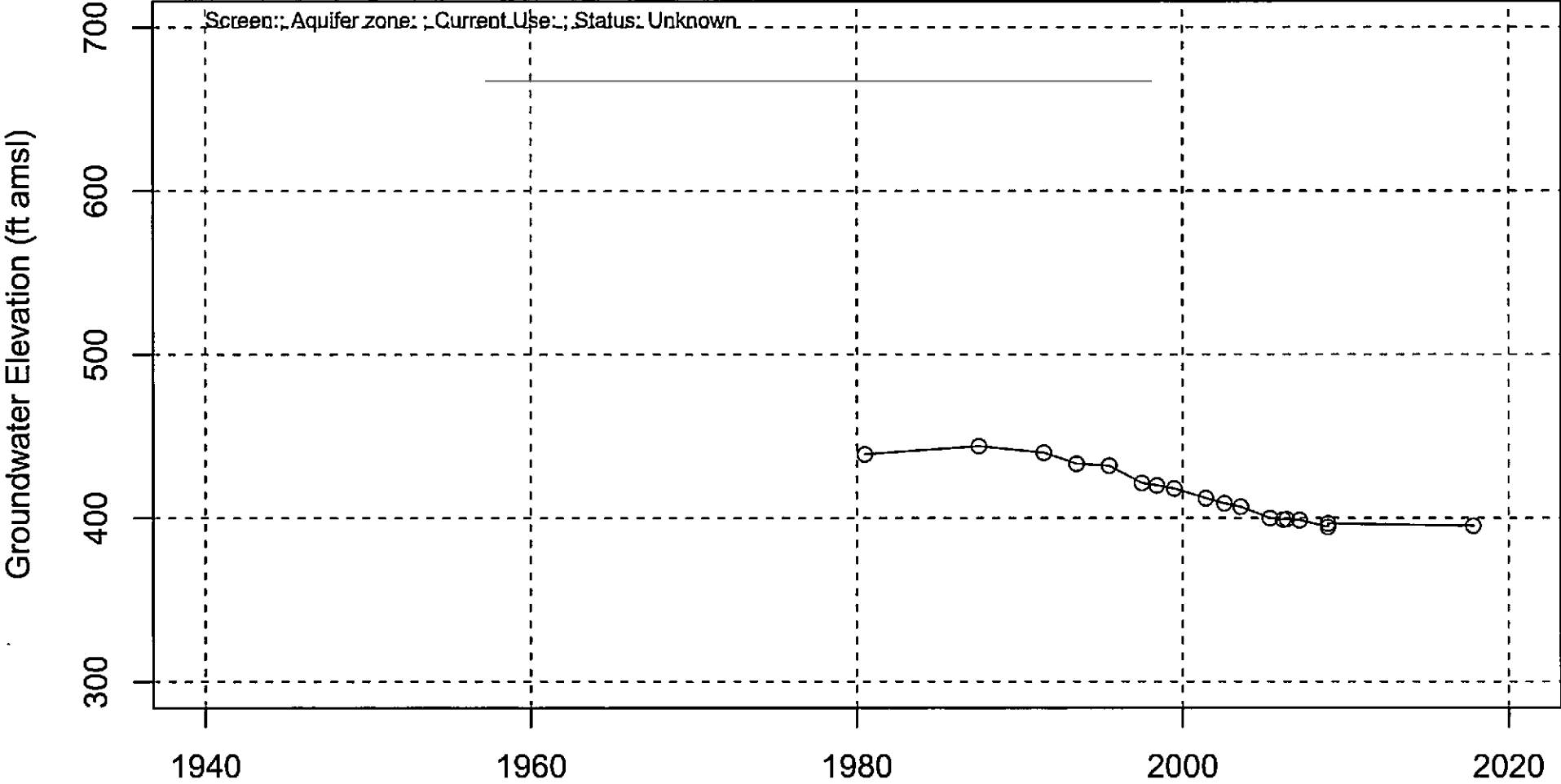
January 2020

# 011S006E05P001S



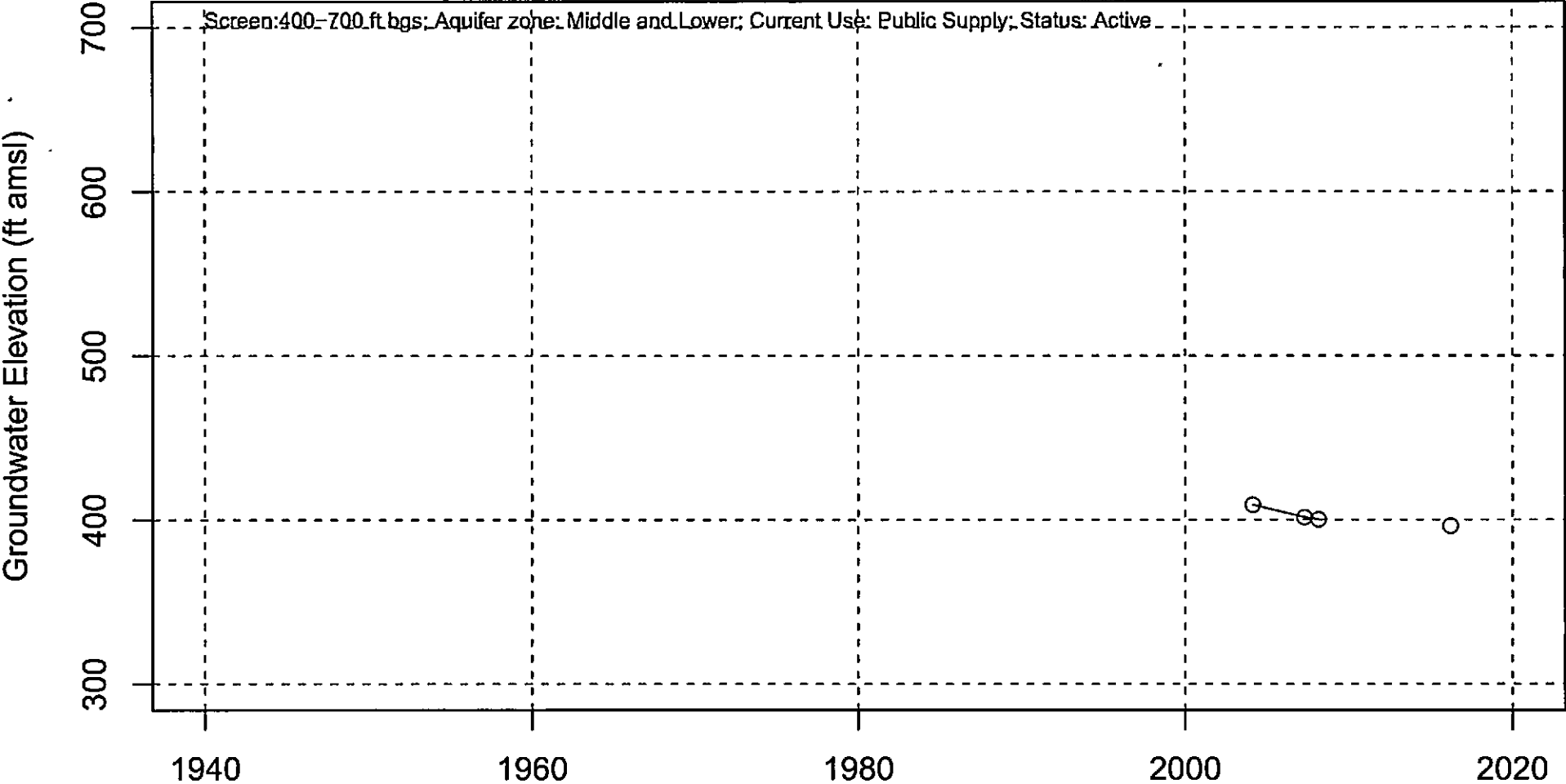
Local ID: Bending Elbow ; Number of Measuring Agency(ies): 3

011S006E07K003S



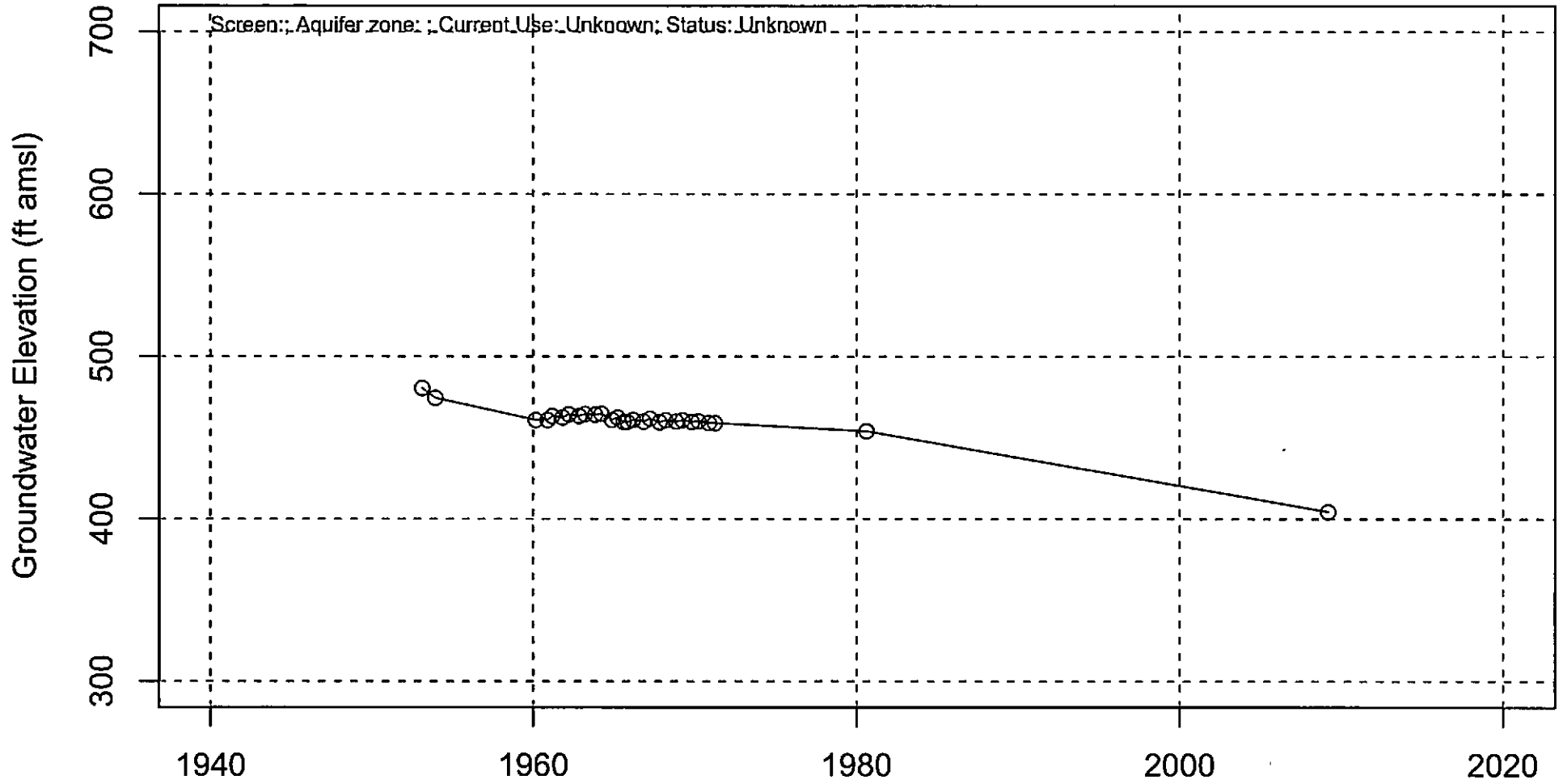
Local ID: N/A ; Number of Measuring Agency(ies): 3

# 011S006E09E001S



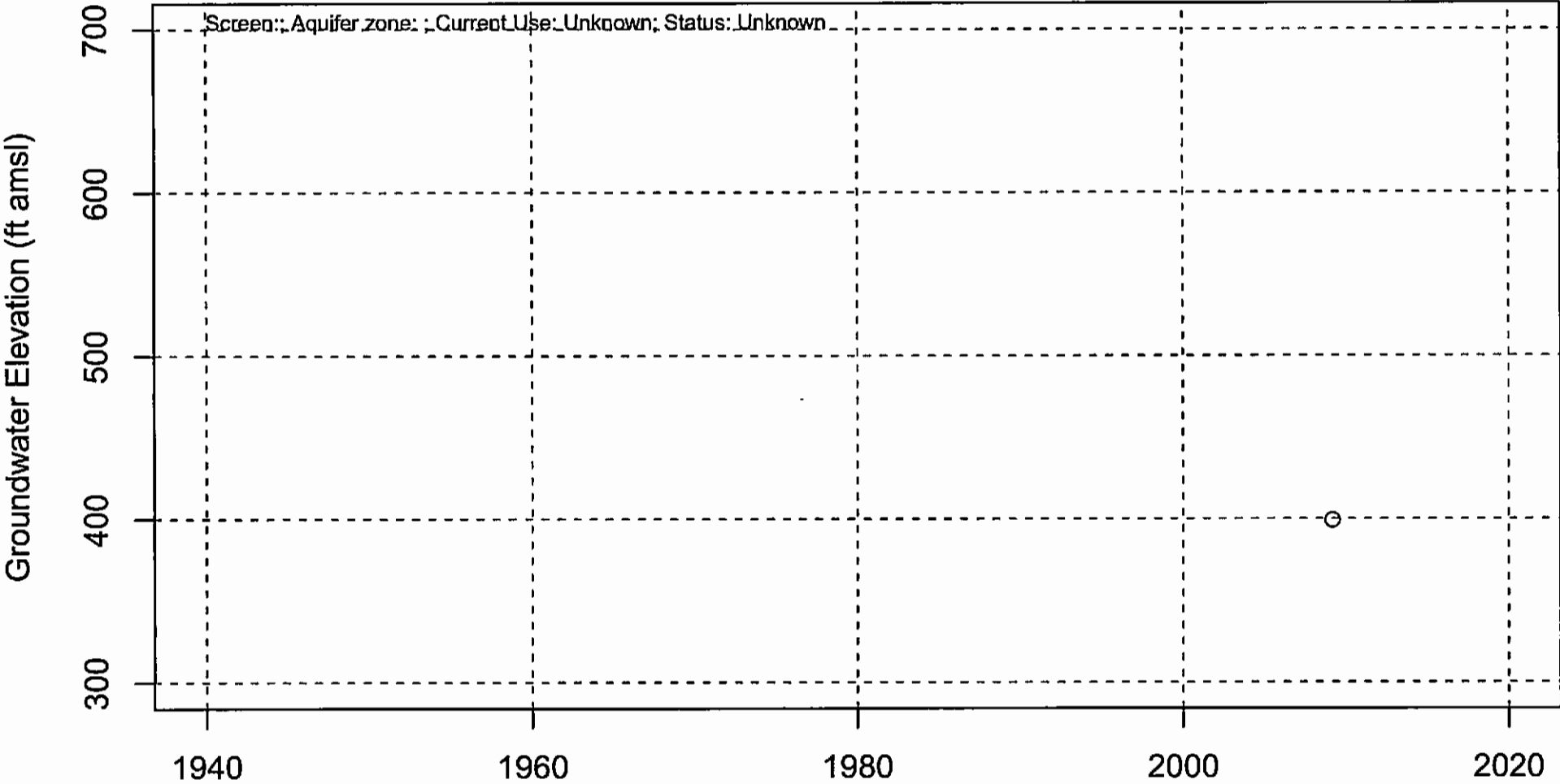
Local ID: ID5-5 ; Number of Measuring Agency(ies): 3

# 011S006E10N001S



Local ID: Abandoned Motel-1 ; Number of Measuring Agency(ies): 2

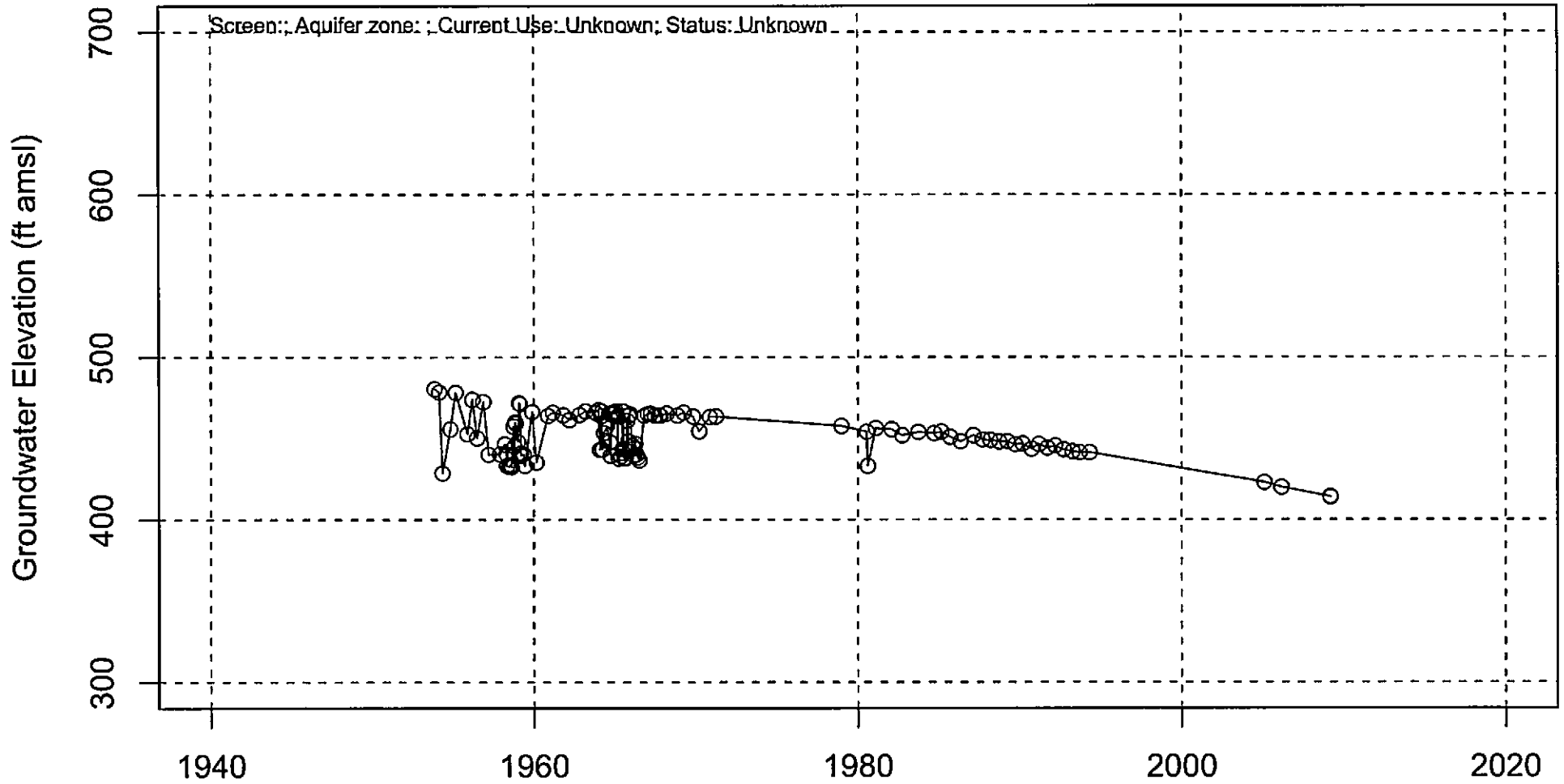
**011S006E10N004S**



Local ID: Abandoned motel-2 ; Number of Measuring Agenc(y/ies): 1

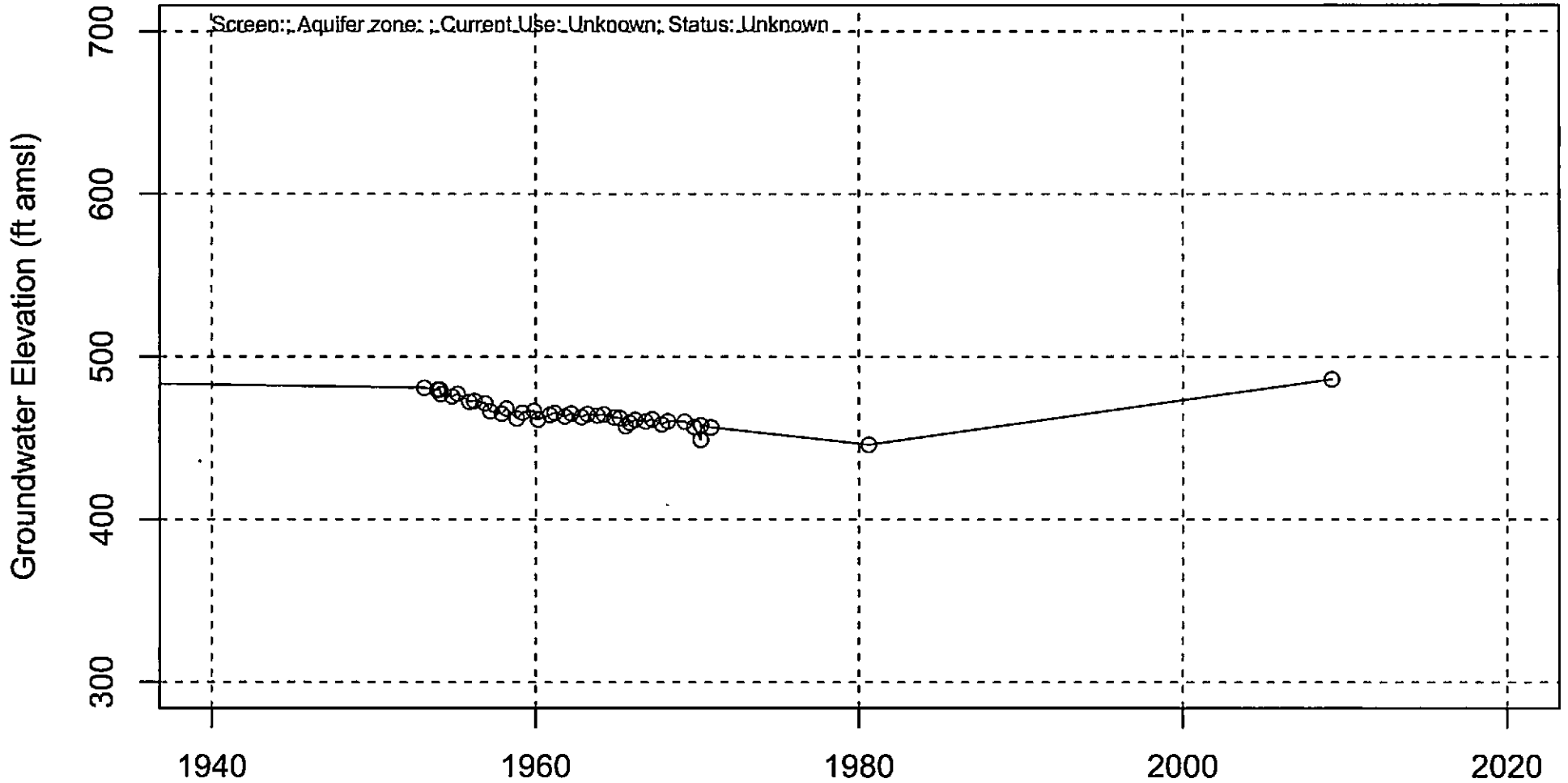


# 011S006E11D002S



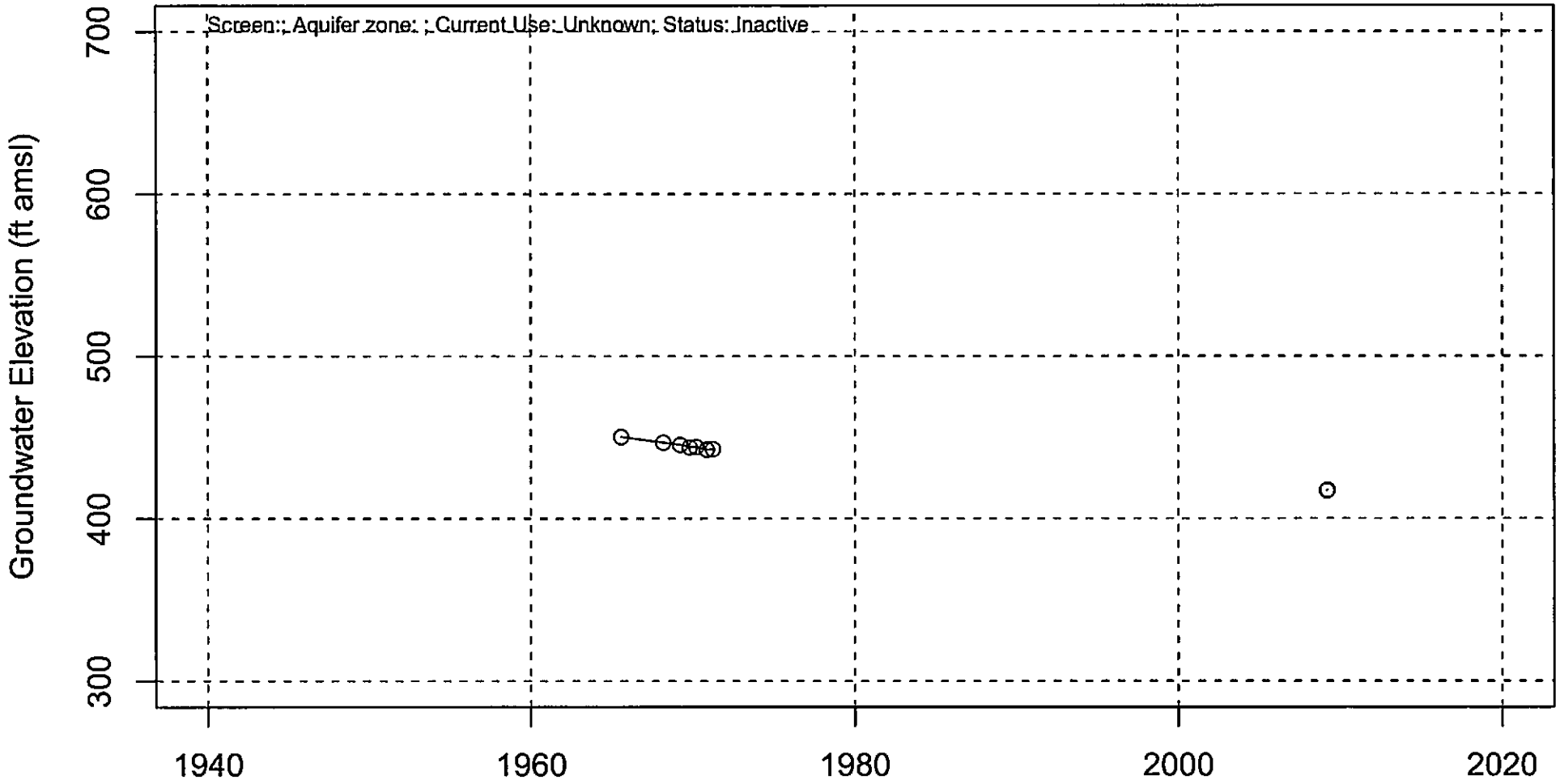
Local ID: Berkovitch ; Number of Measuring Agency(ies): 2

# 011S006E11M001S



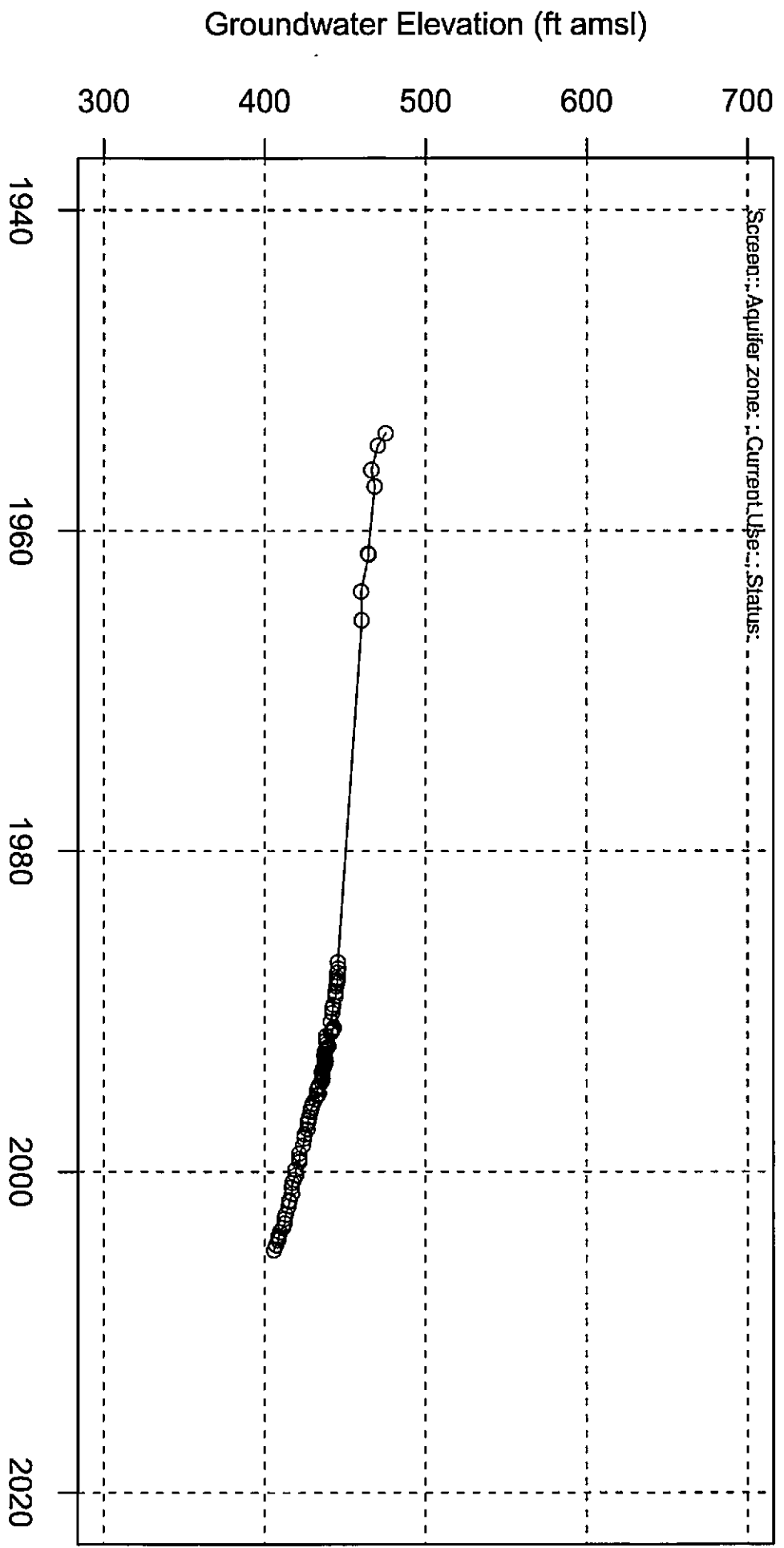
Local ID: Burned House 1 ; Number of Measuring Agenc(y/ies): 2

# 011S006E12G001S



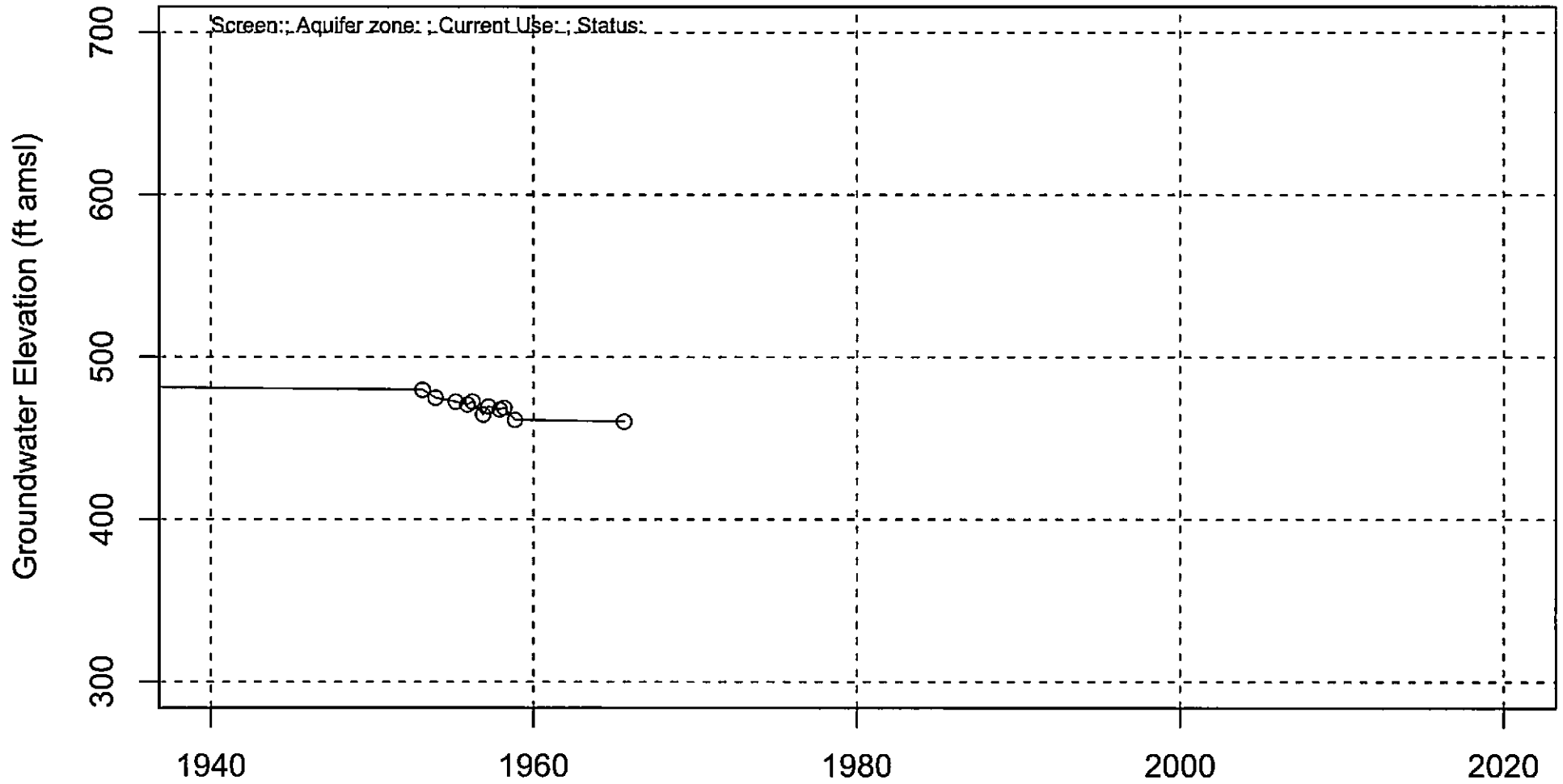
Local ID: Sink - 12G1 ; Number of Measuring Agency(ies): 4

# 011S006E15E002S



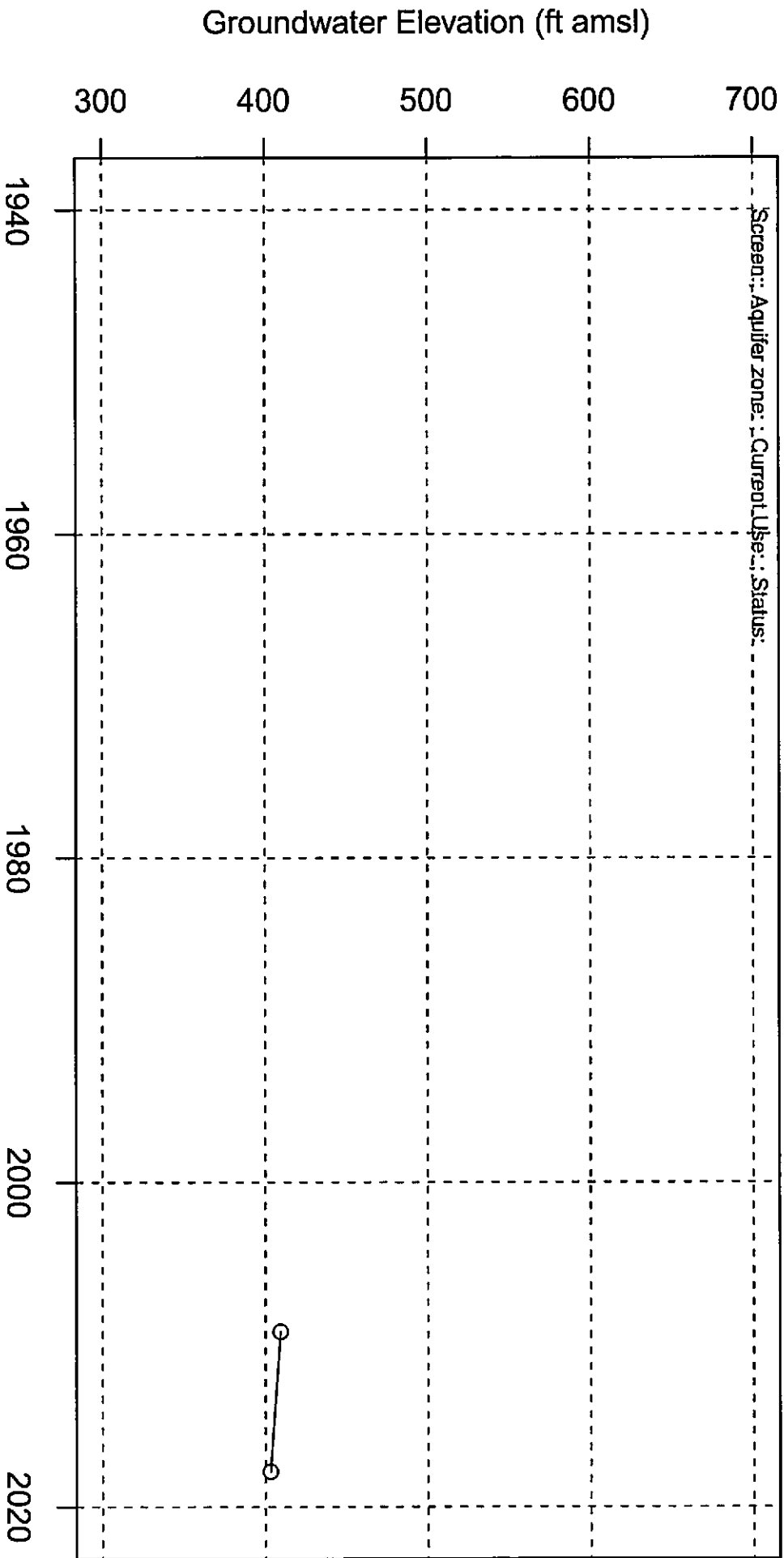
Local ID: Levie Well ; Number of Measuring Agency(y/ies): 2

# 011S006E15F001S



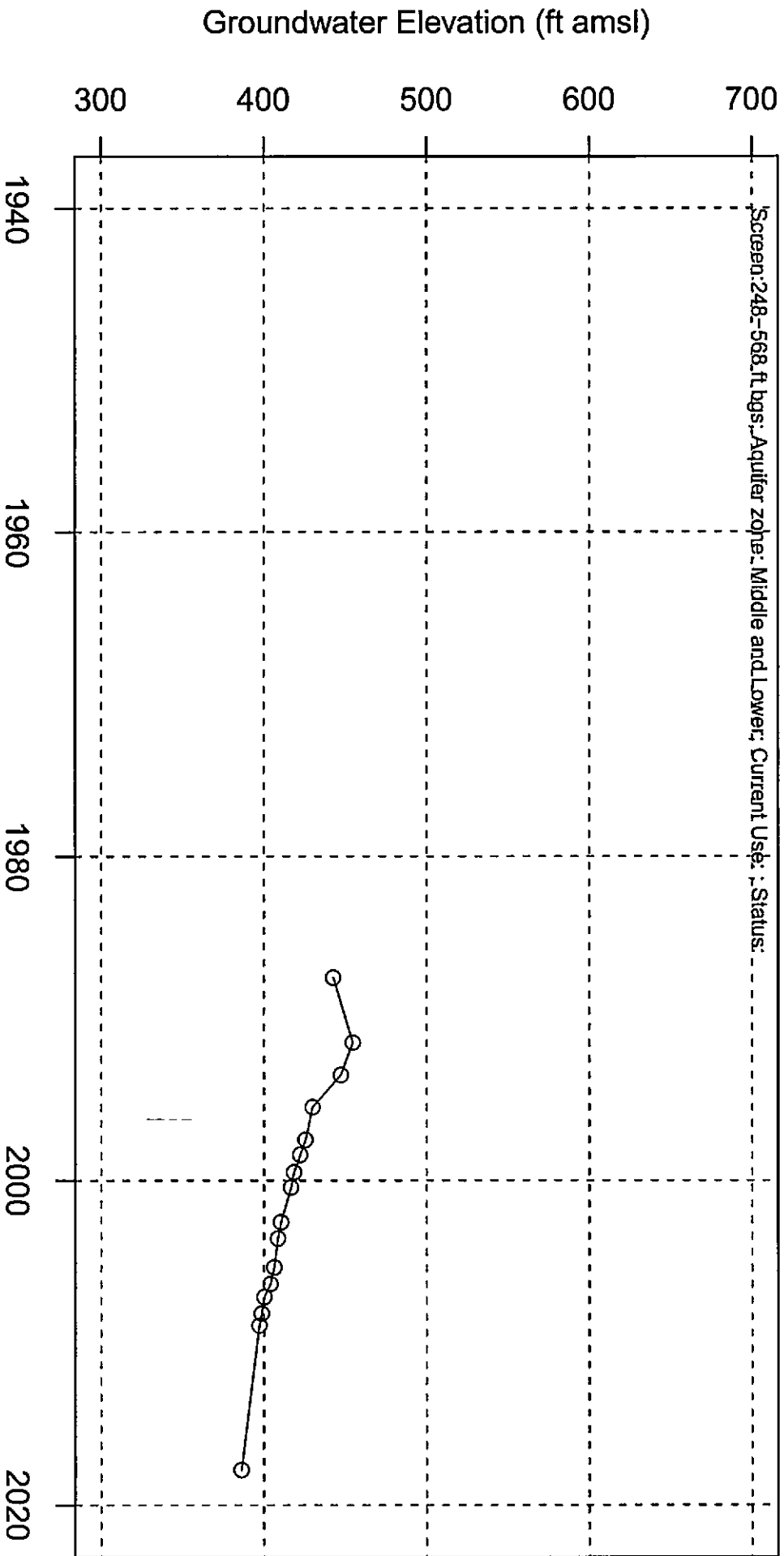
Local ID: N/A ; Number of Measuring Agency(ies): 3

# 011S006E15G001S



Local ID: County Yard (SD DOT) ; Number of Measuring Agenc(y/ies): 2

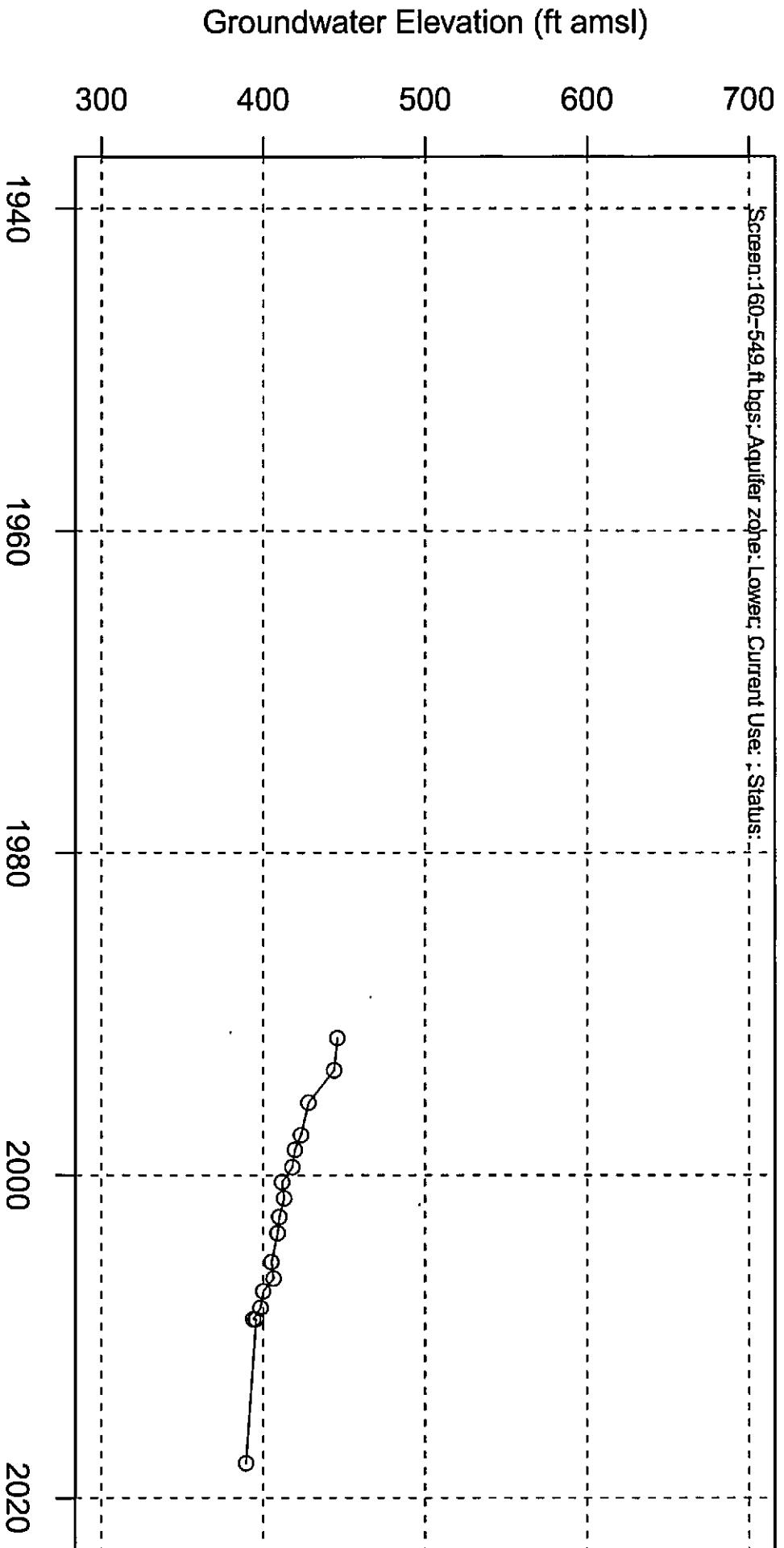
# 011S006E16A002S



Local ID: ID1-12 ; Number of Measuring Agenc(y/ies): 4

January 2020

# 011S006E16N001S

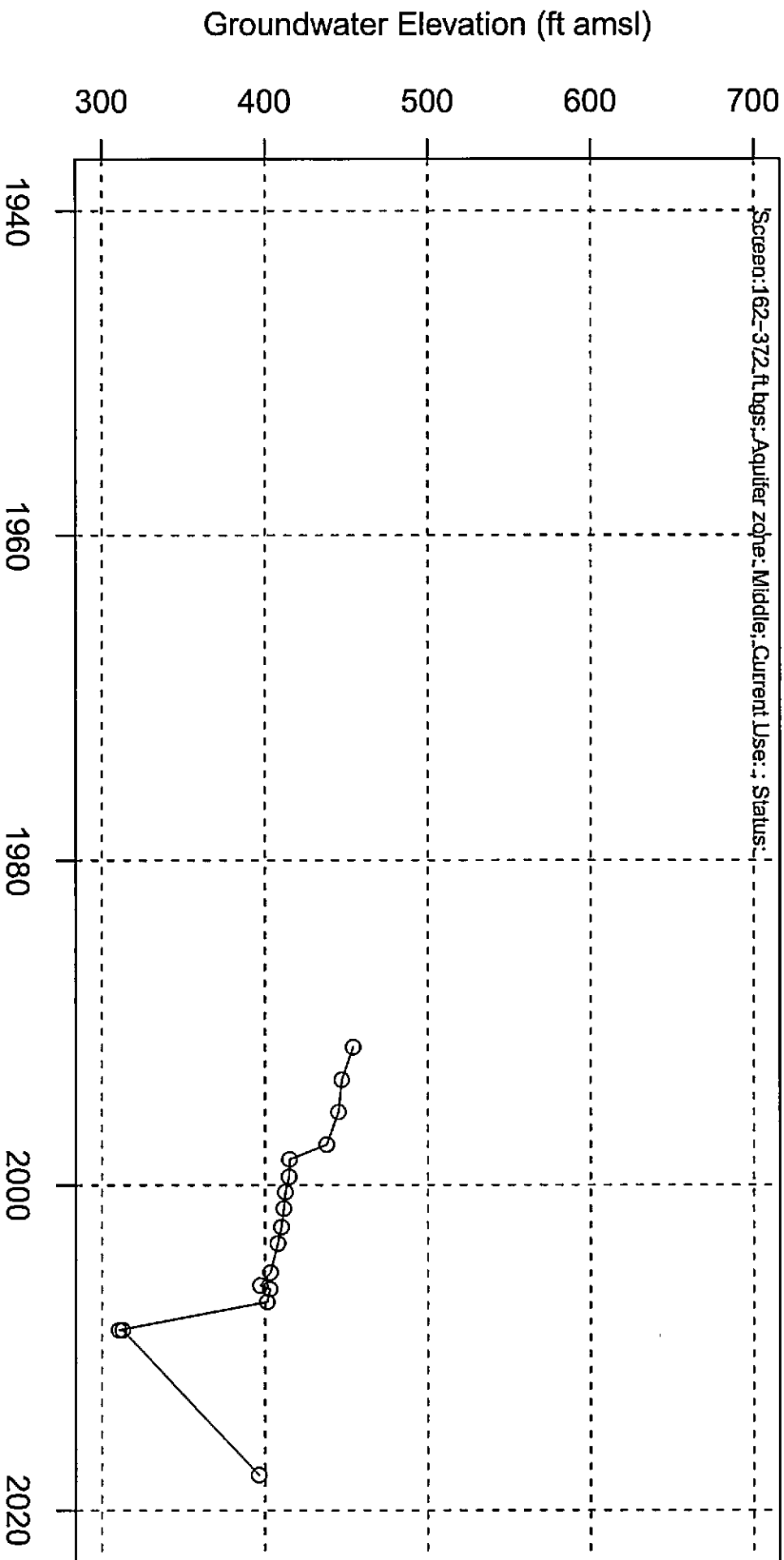


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Local ID: ID1-16 ; Number of Measuring Agency(y/ies): 4



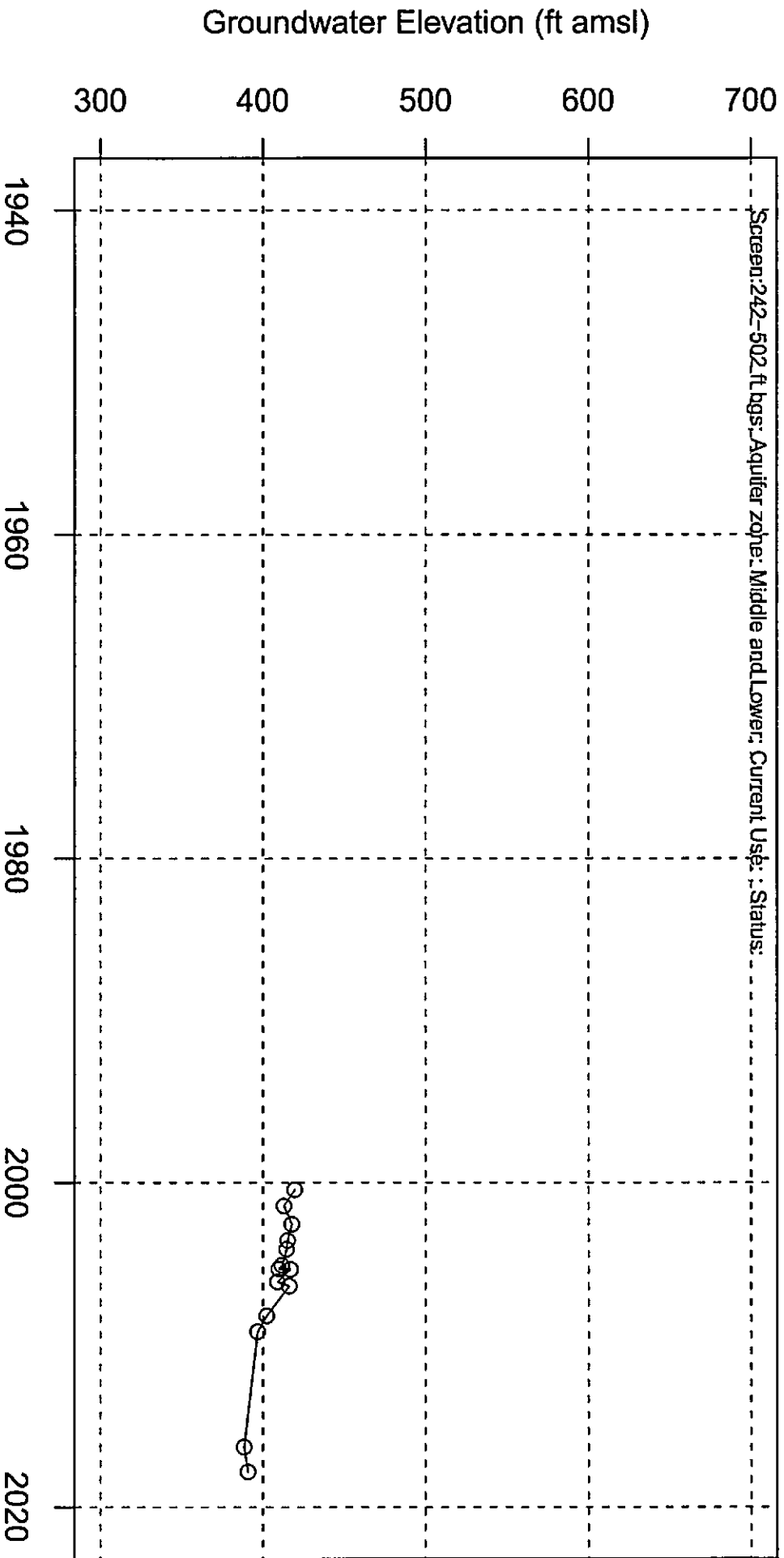
# 011S006E18L001S



Local ID: ID4-10 ; Number of Measuring Agency(y/ies): 3

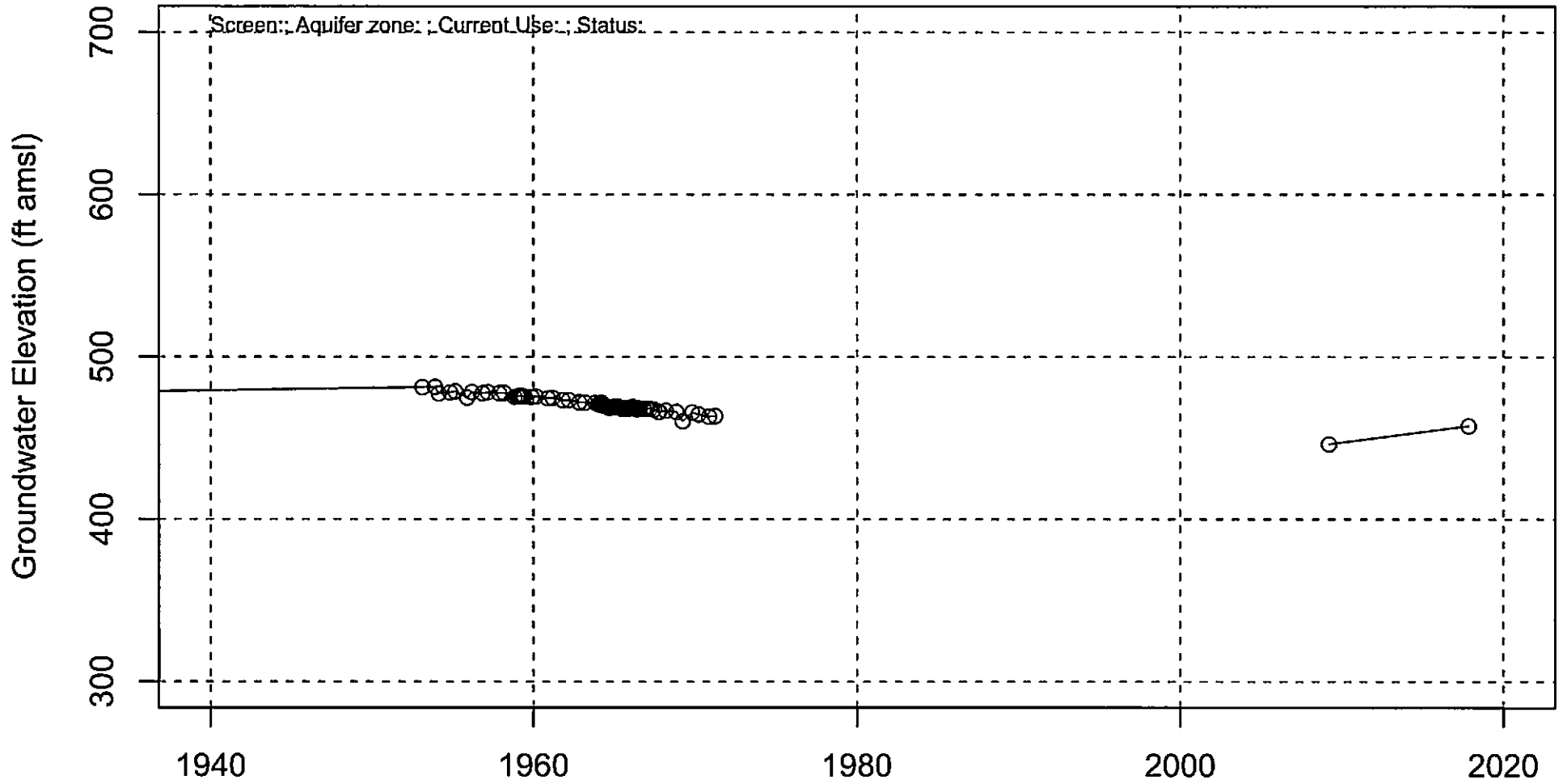
January 2020

# 011S006E20A001S



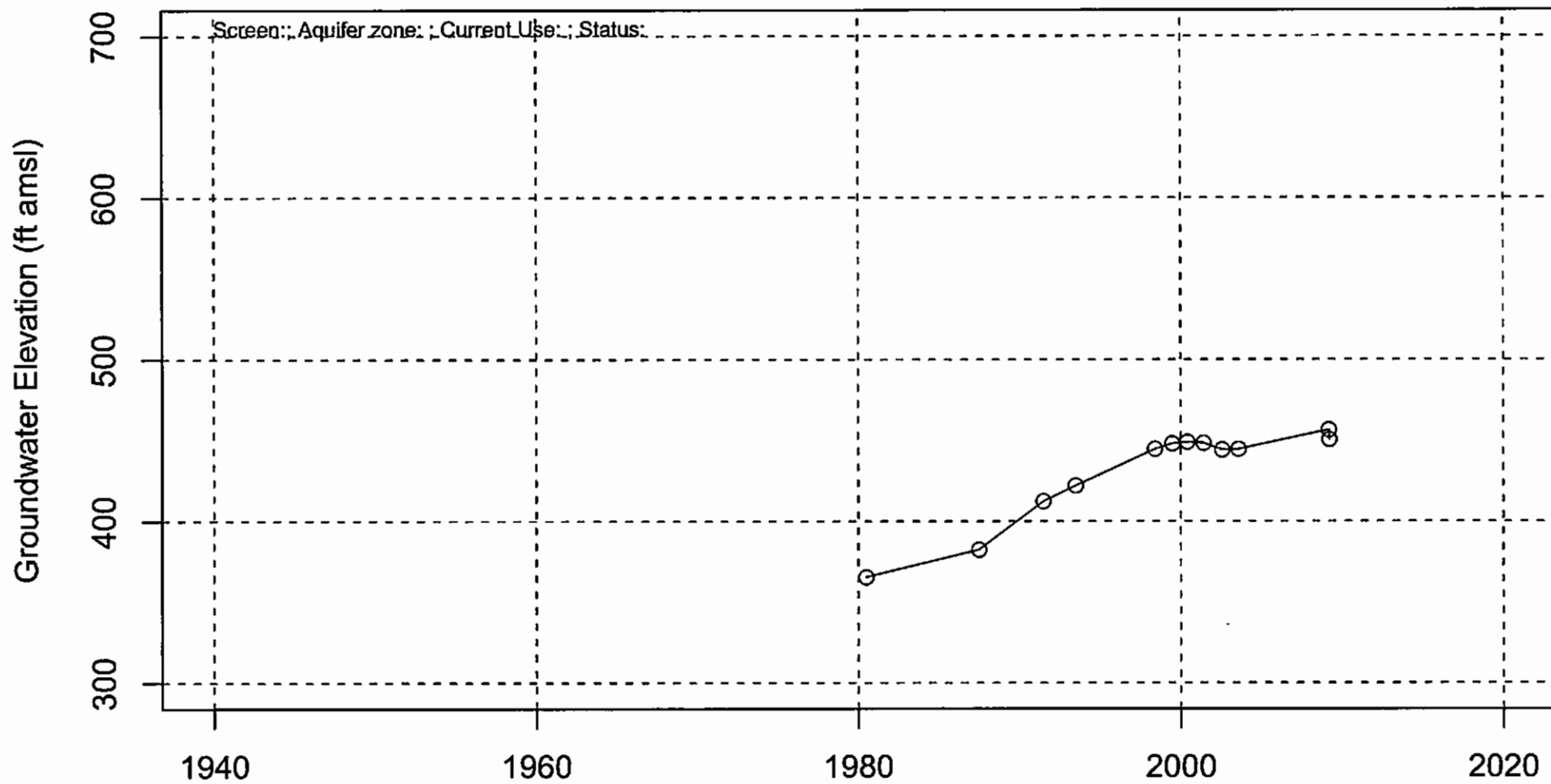
Local ID: Wilcox ; Number of Measuring Agenc(y/ies): 4

# 011S006E22A001S



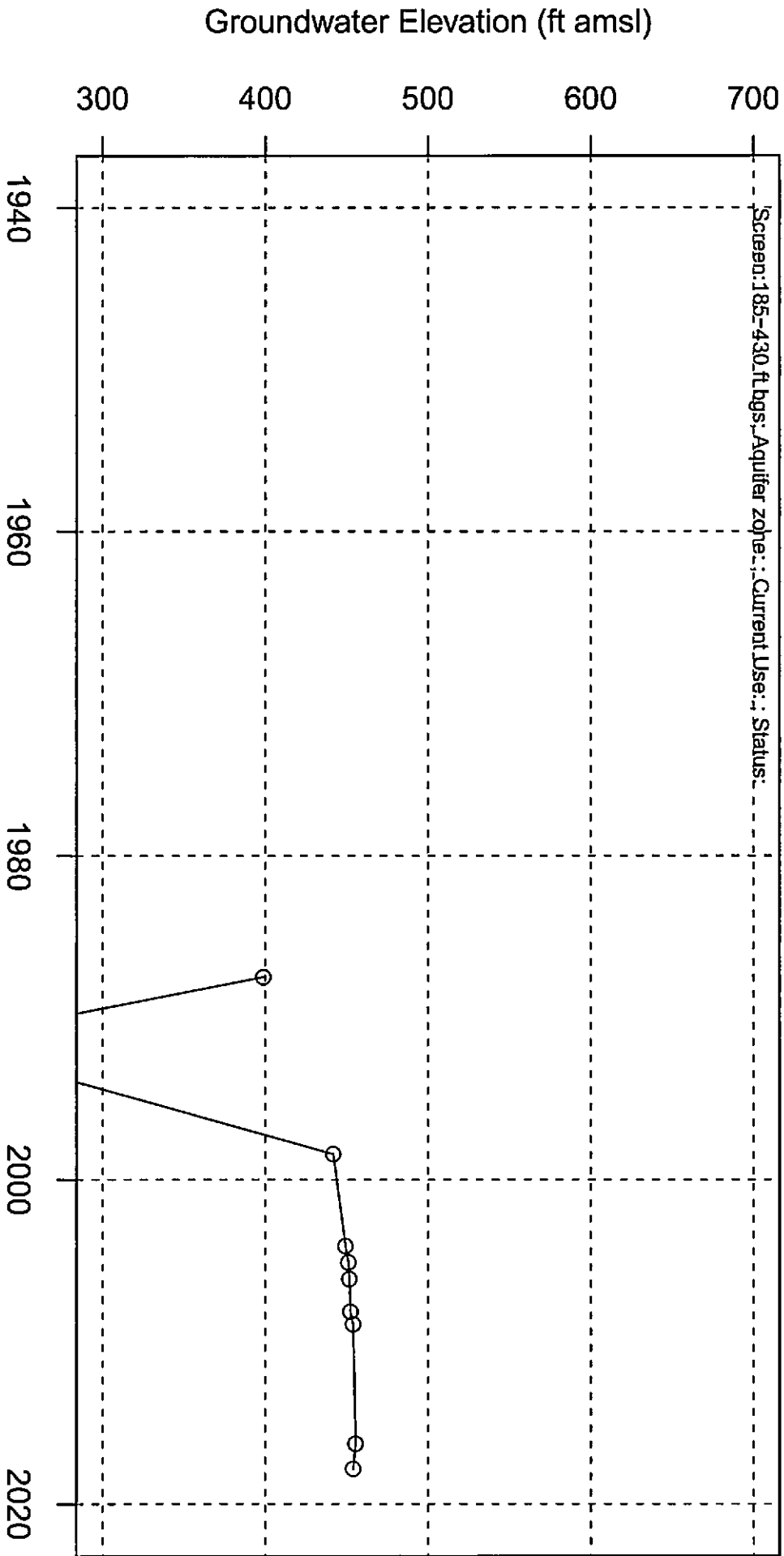
Local ID: Bakko ; Number of Measuring Agency(ies): 4

# 011S006E22A002S



Local ID: Triangle ; Number of Measuring Agency(ies): 2

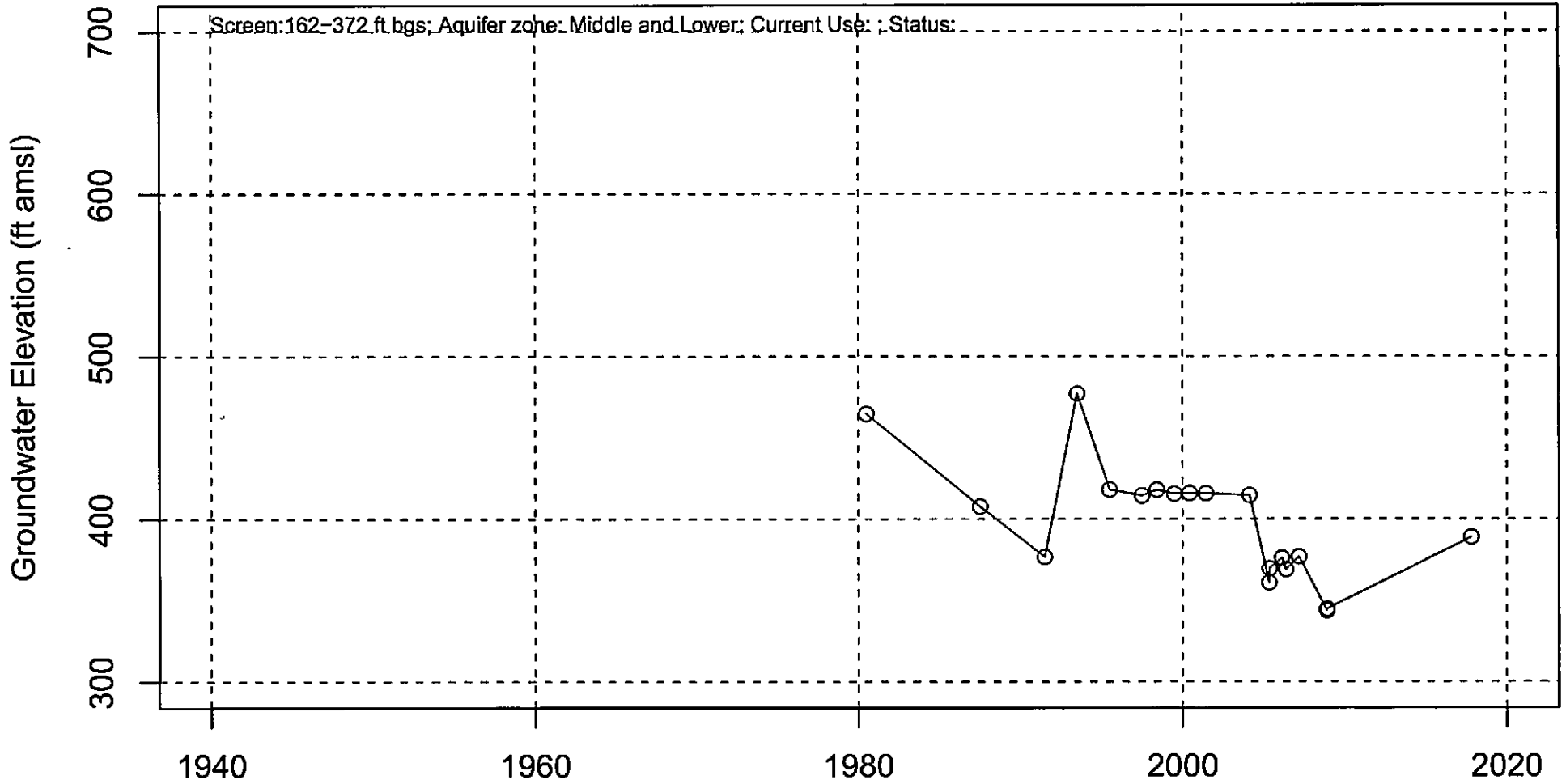
# 011S006E22B001S



Local ID: Paddock ; Number of Measuring Agency(y/ies): 4

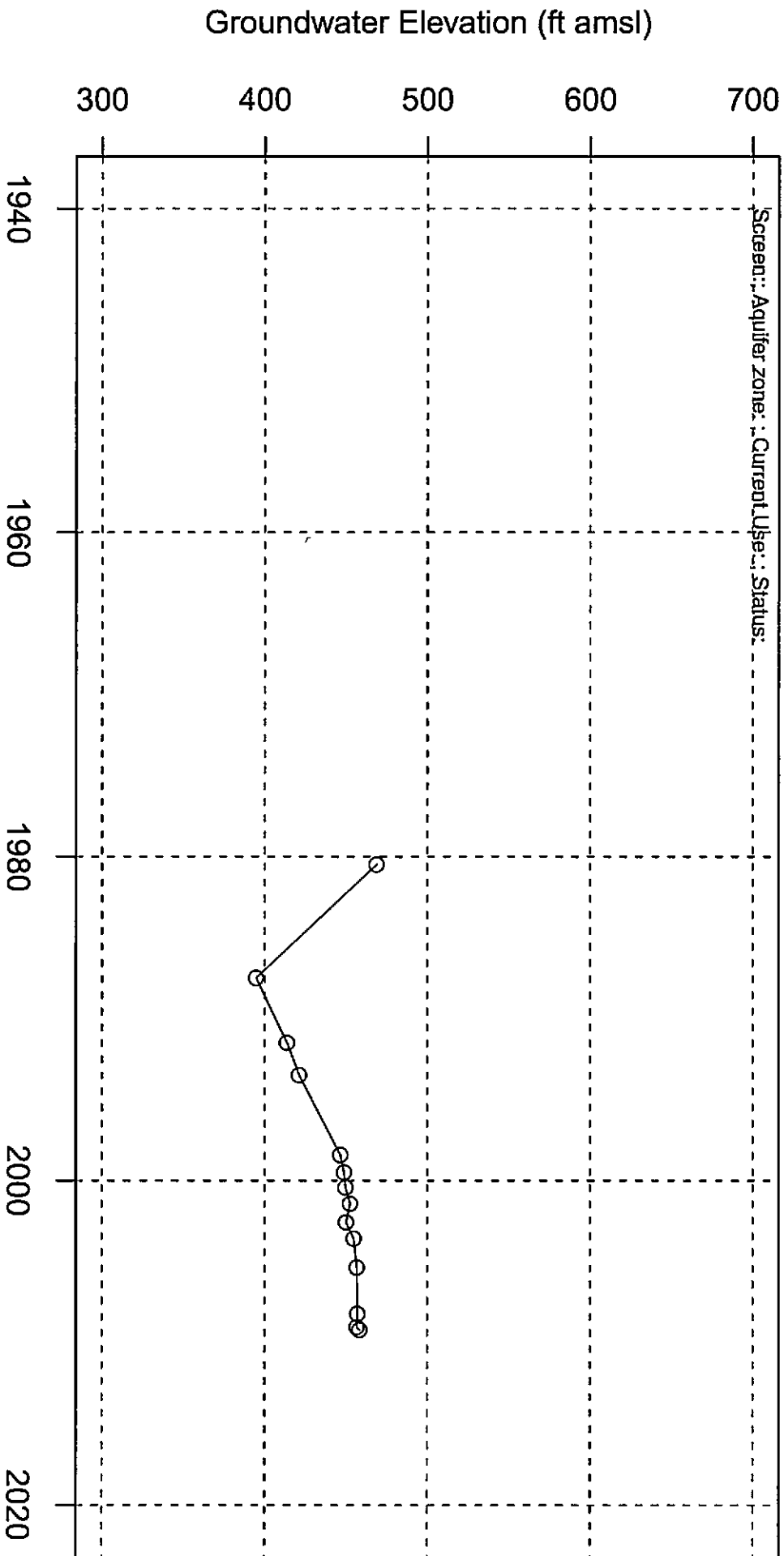
January 2020

# 011S006E22D001S



Local ID: ID1-10 ; Number of Measuring Agency(ies): 4

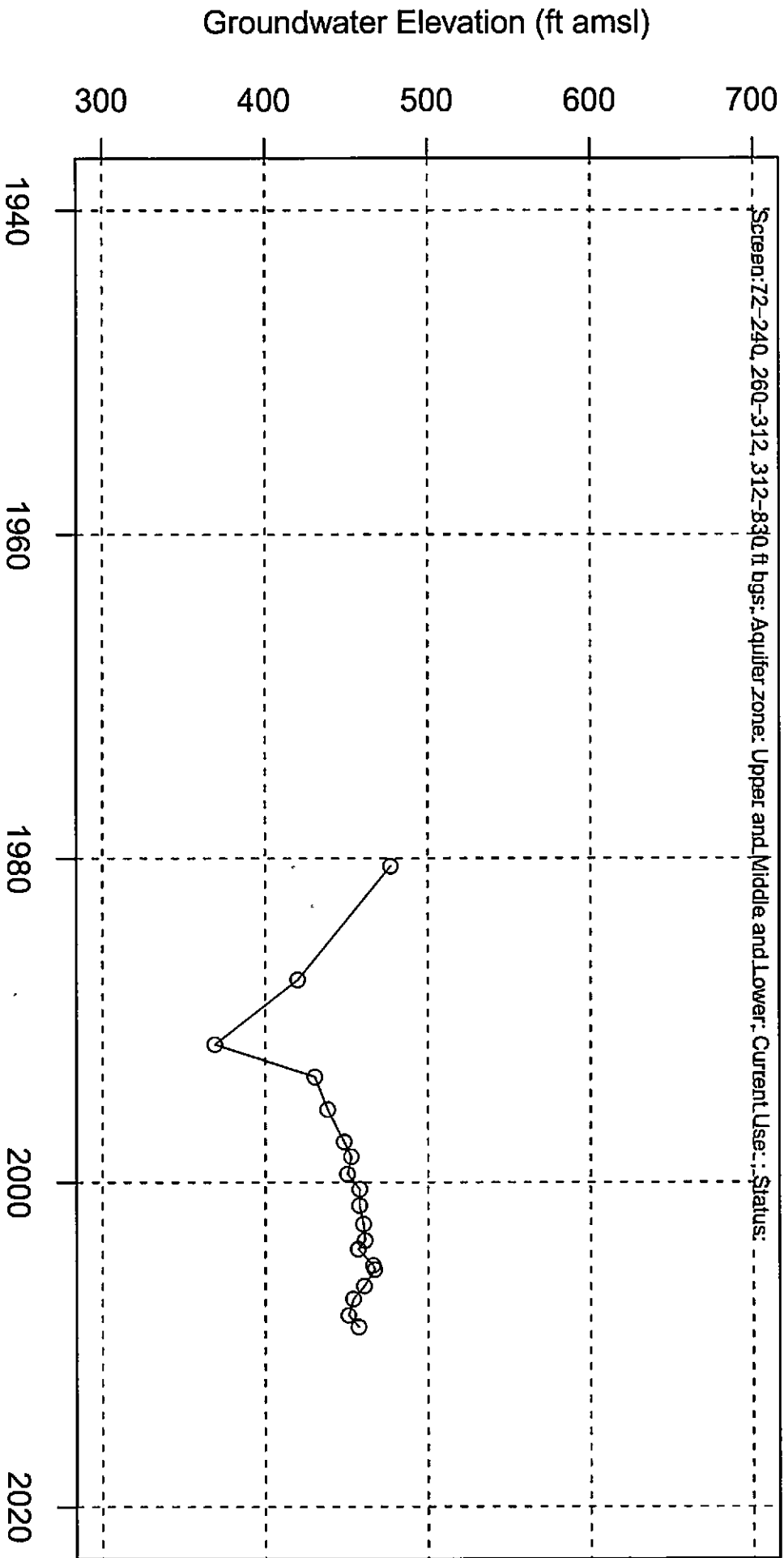
# 011S006E23E001S



Local ID: La Casa ; Number of Measuring Agency(y/ies): 2

January 2020

# 011S006E23J001S

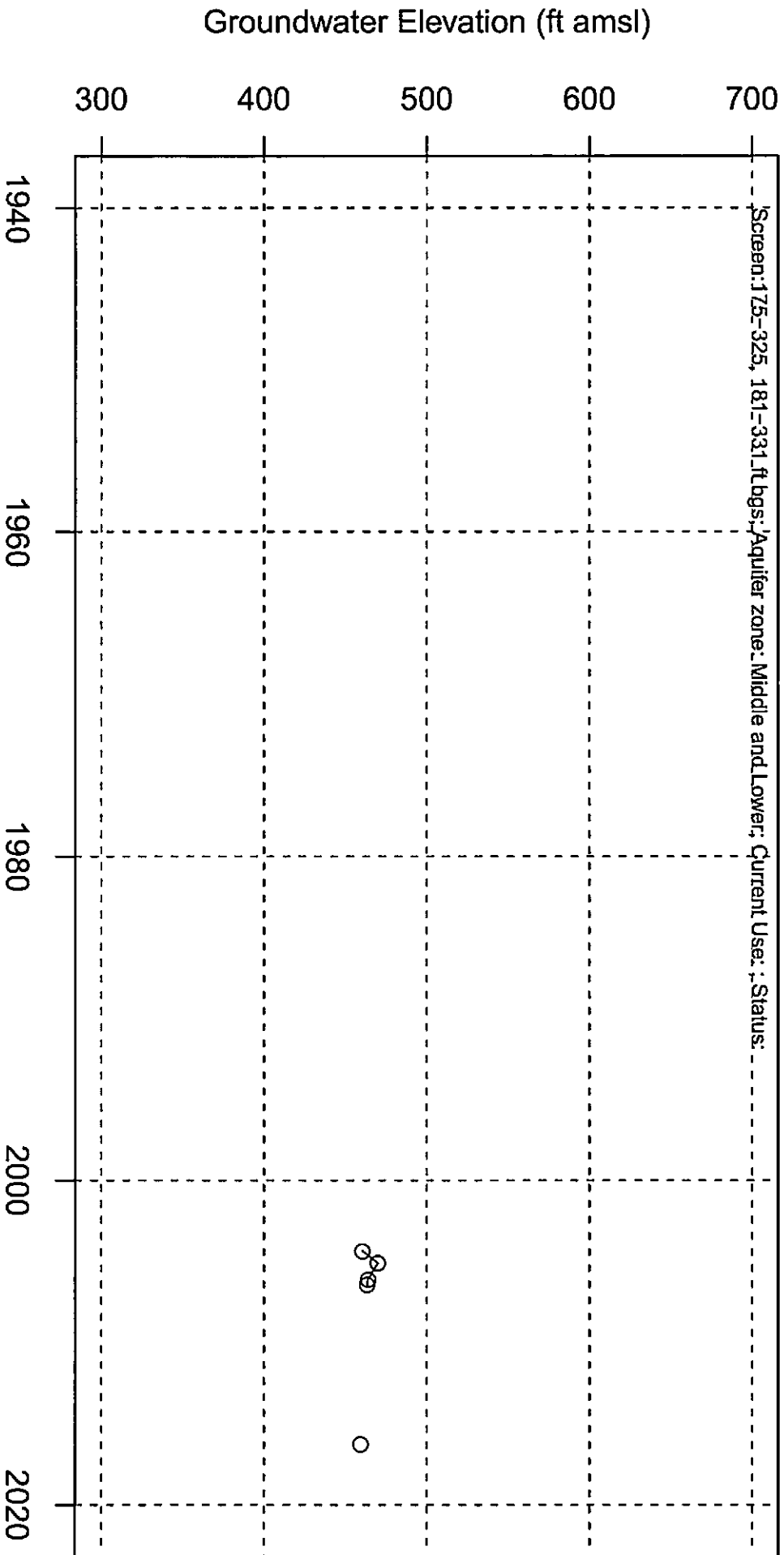


Local ID: ID1-8 ; Number of Measuring Agency(y/ies): 2

January 2020

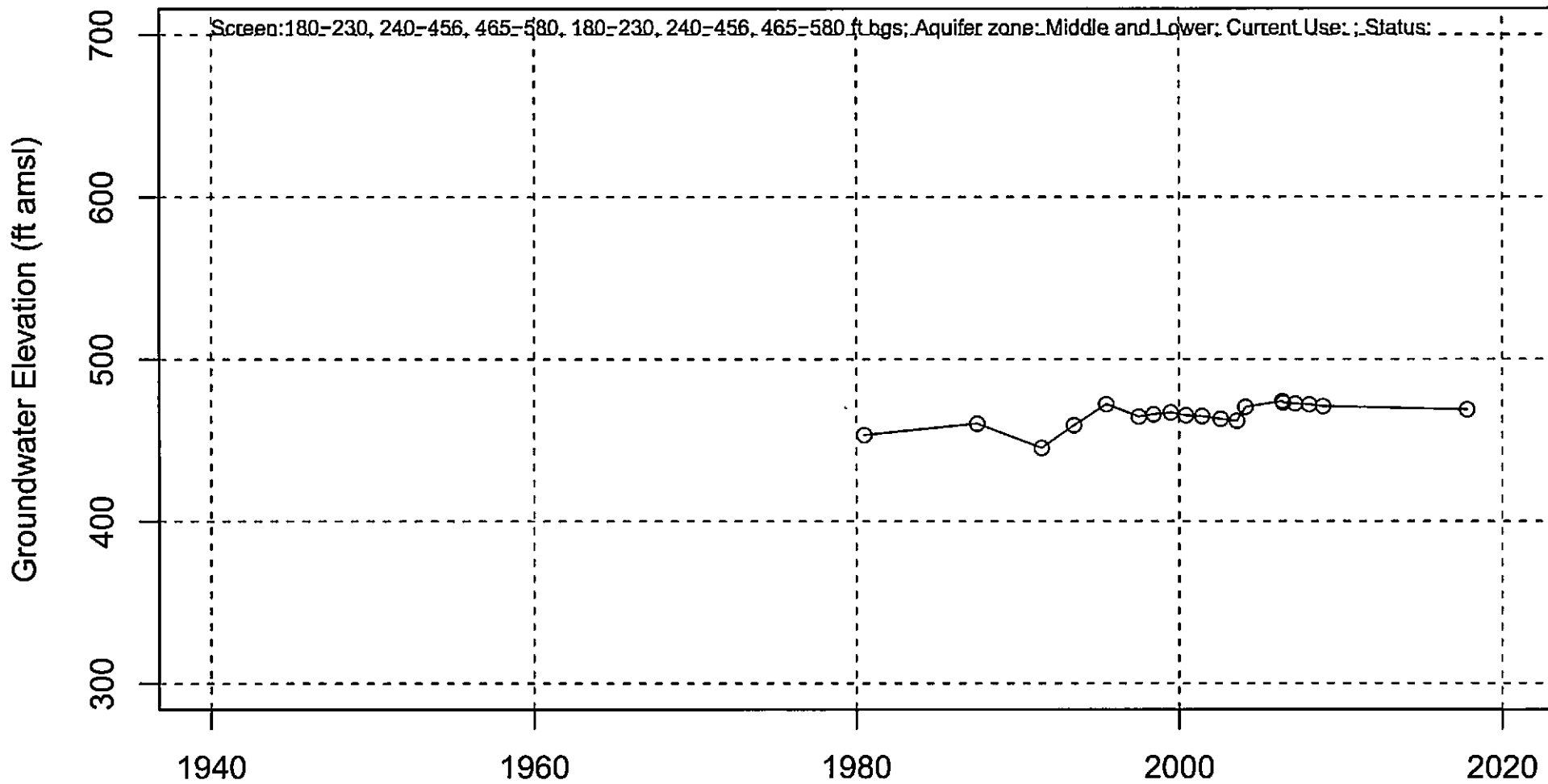


# 011S006E23J002S



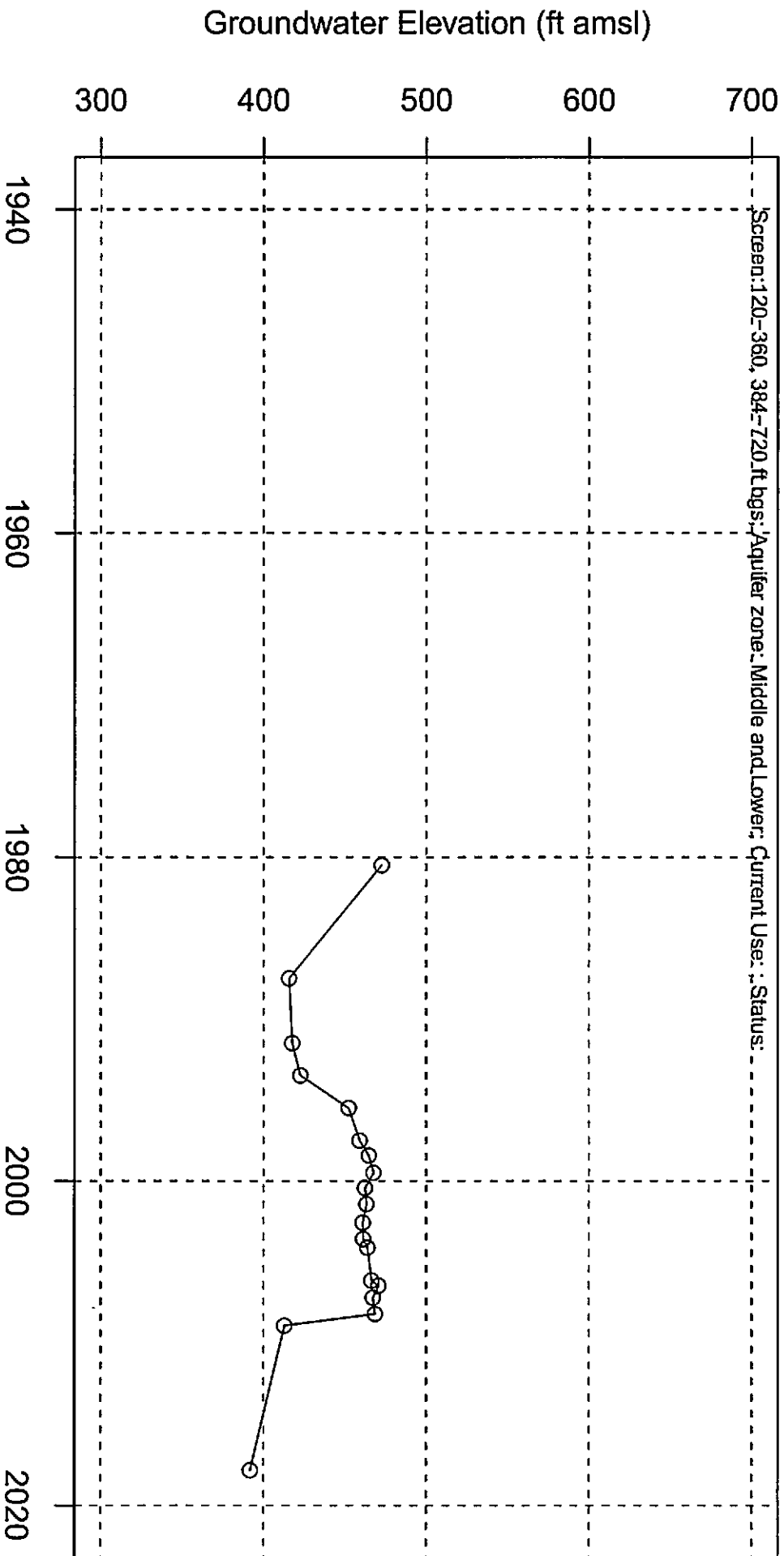
Local ID: MW-3 ; Number of Measuring Agency(ies): 4

# 011S006E25A001S



Local ID: ID1-1 ; Number of Measuring Agency(ies): 3

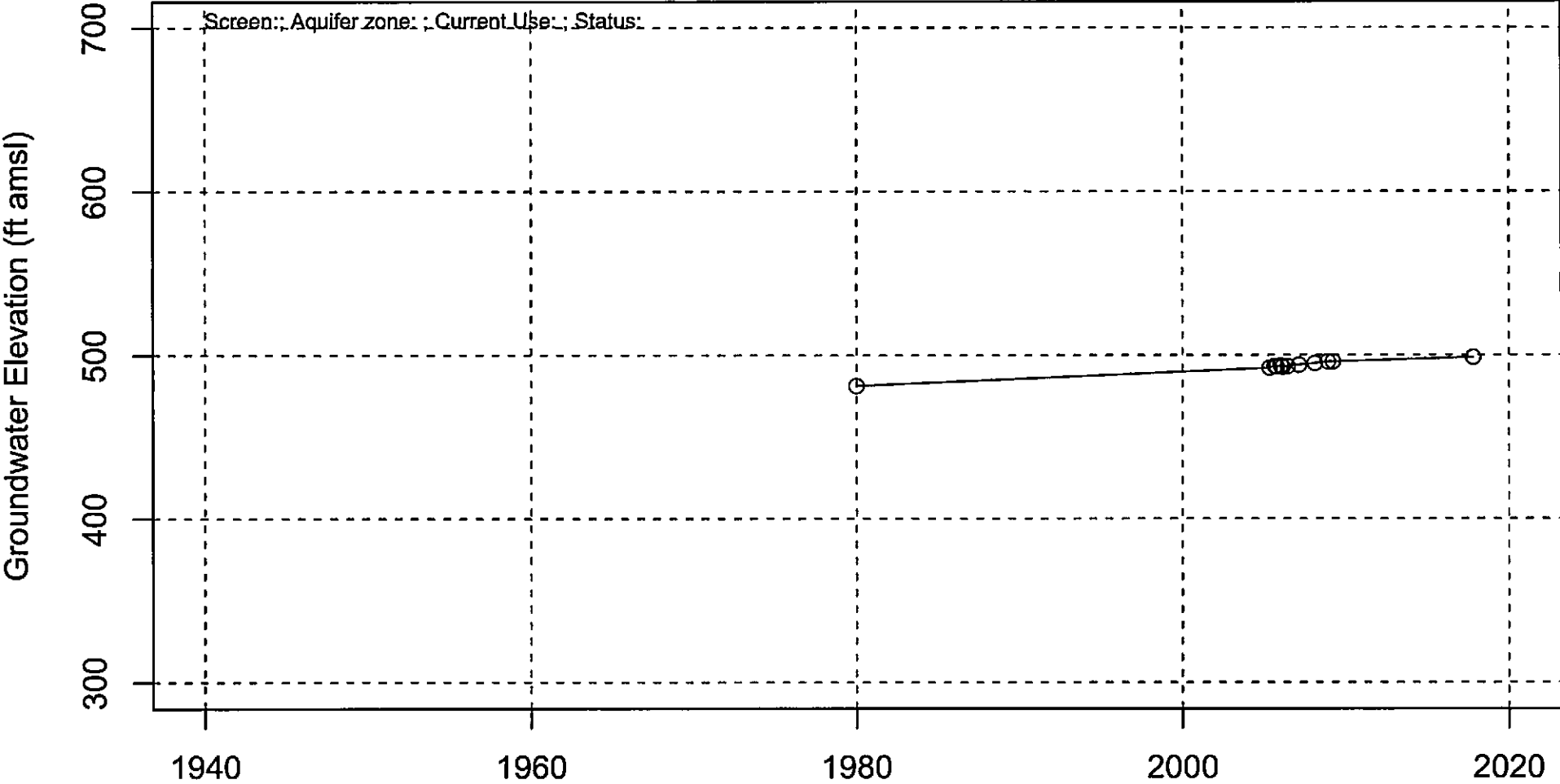
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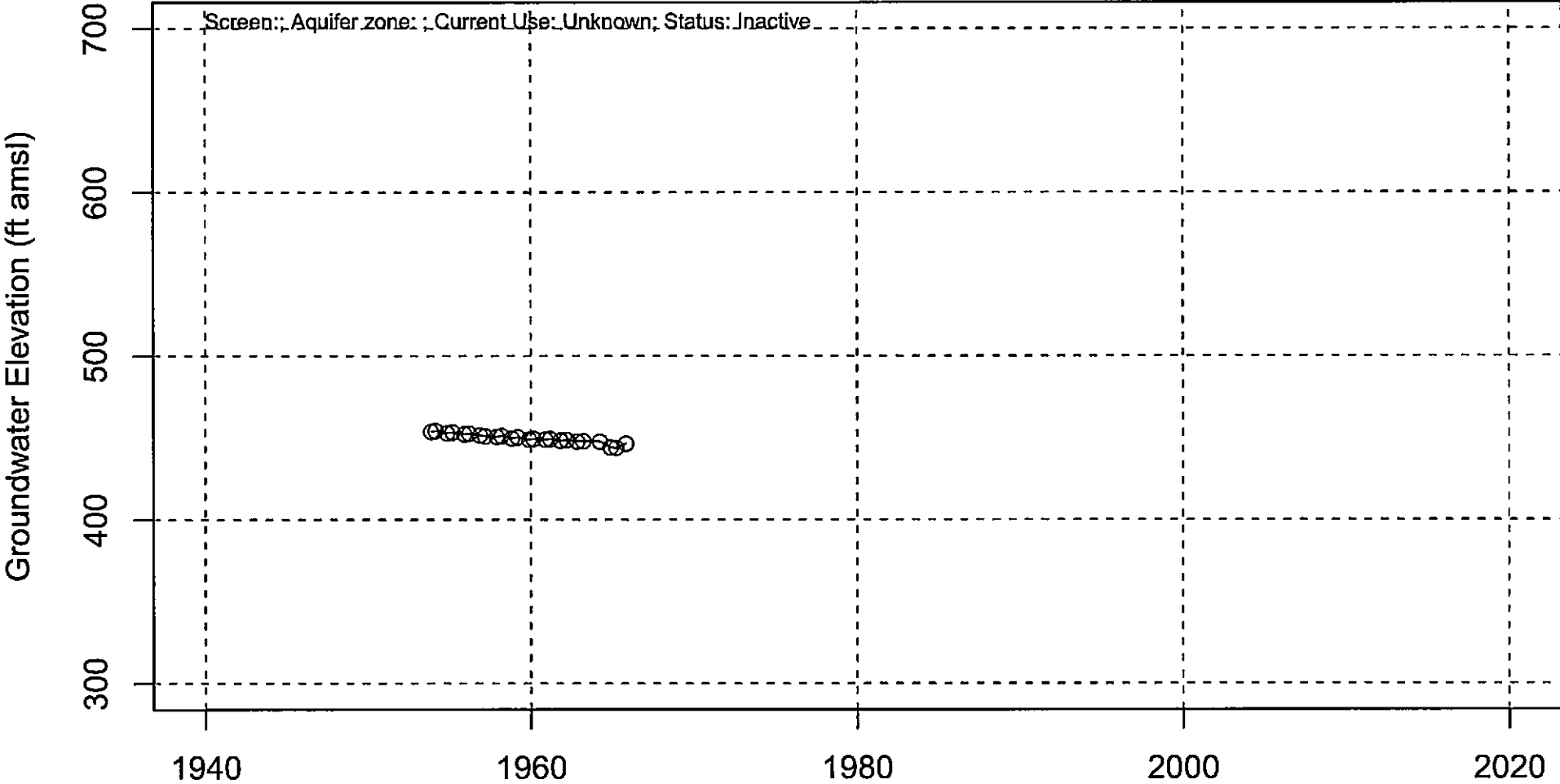
January 2020

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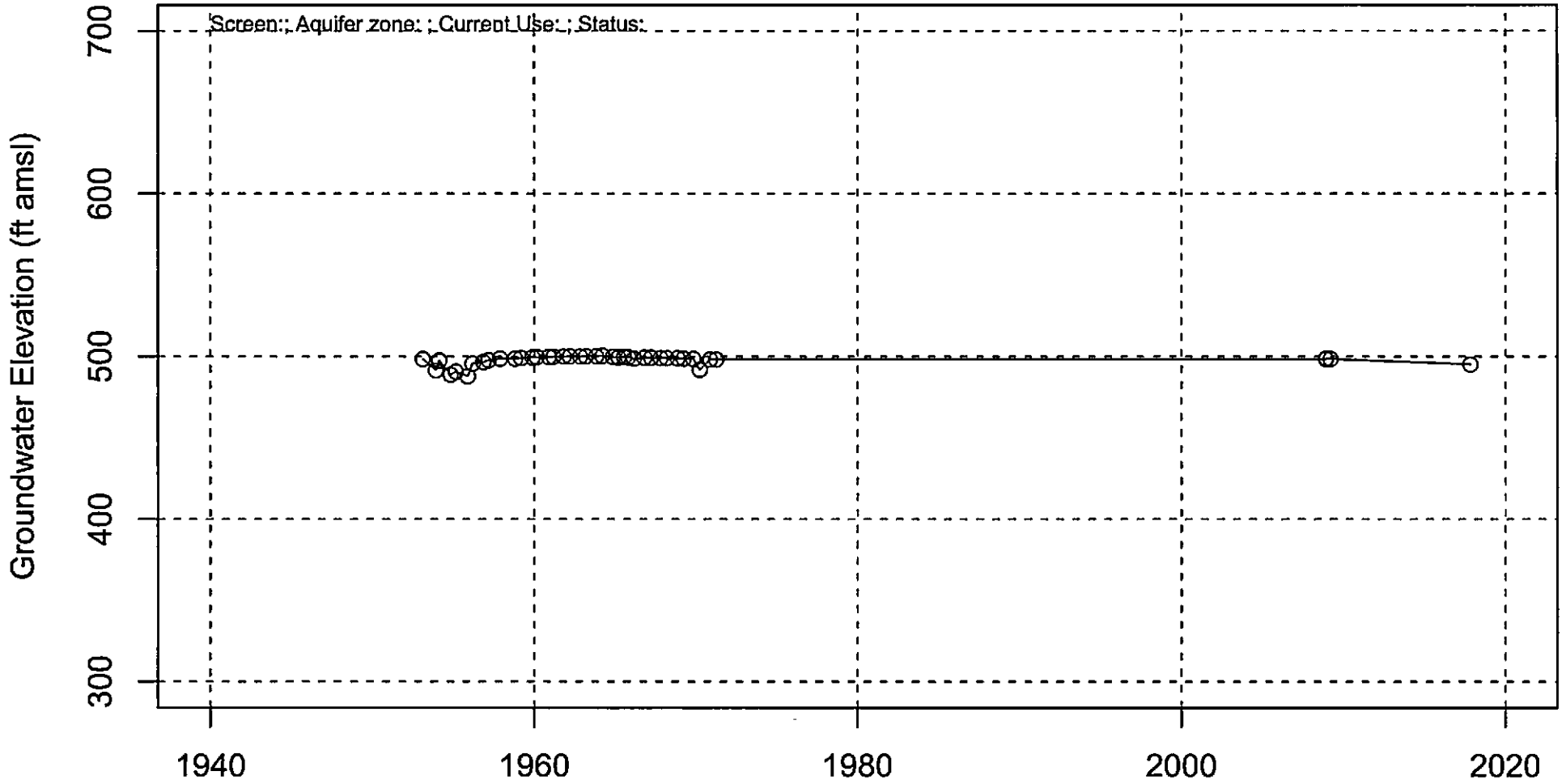
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011S007E07N001S



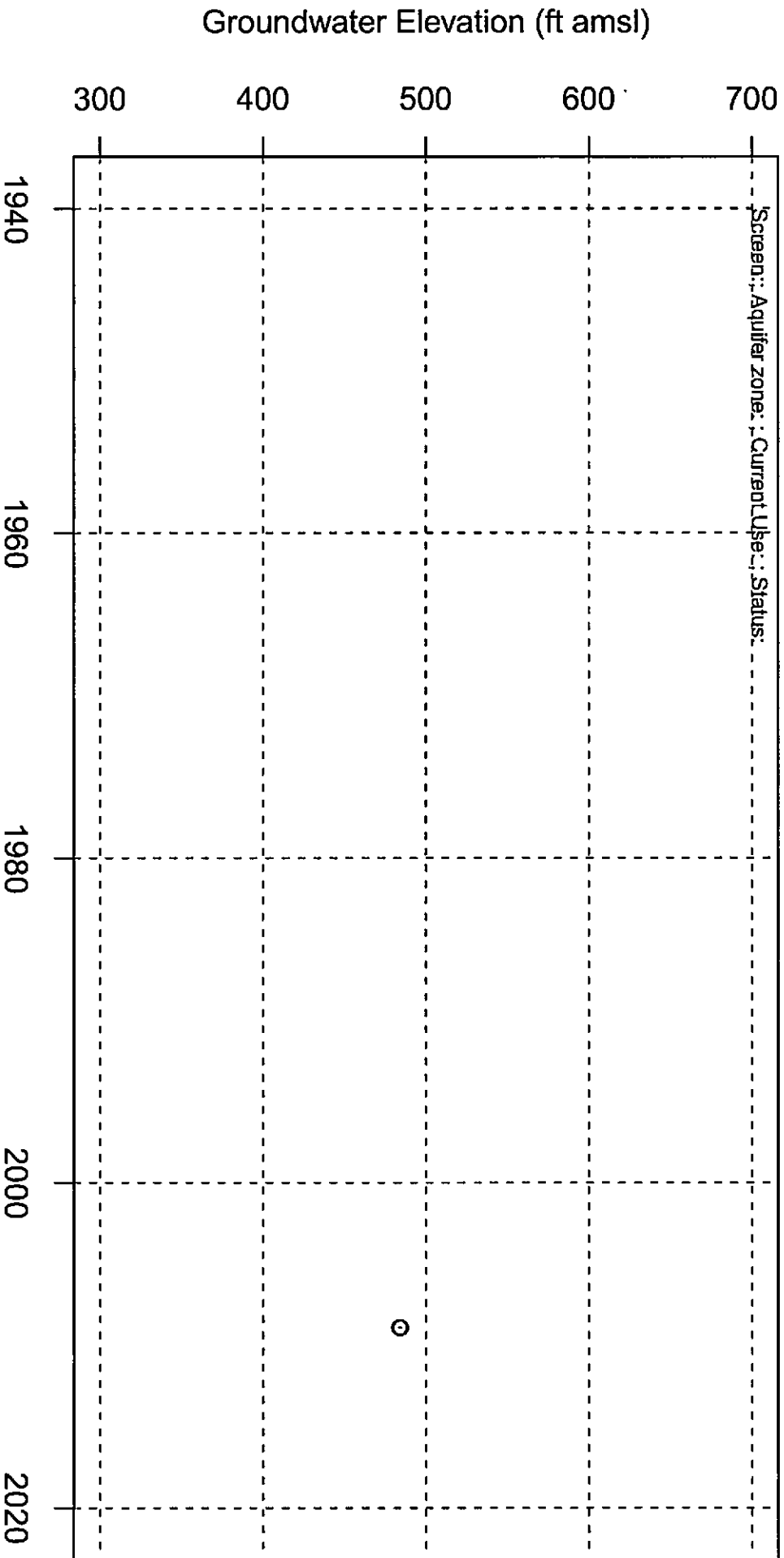
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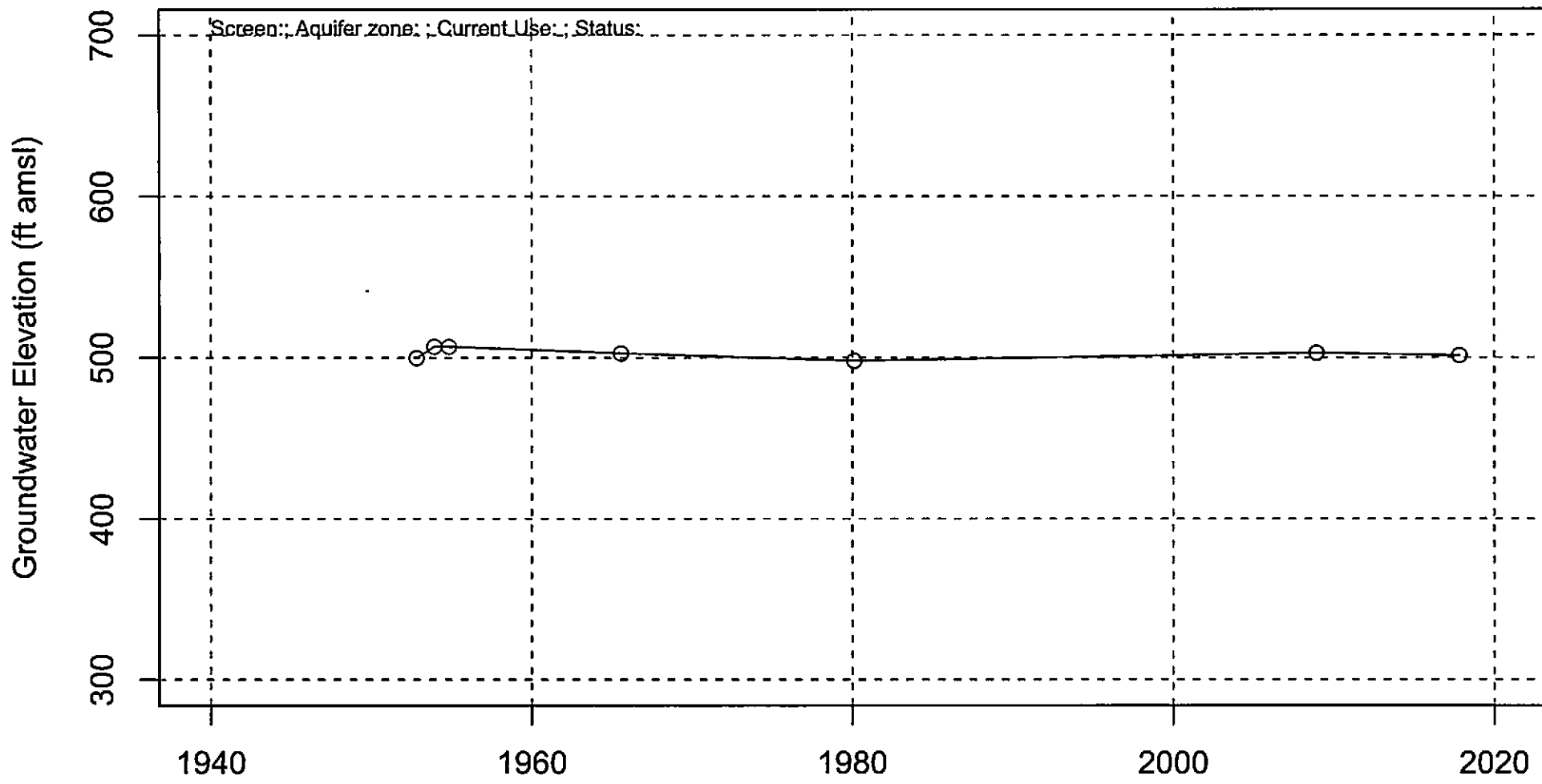
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Local ID: Sky Ranch ; Number of Measuring Agency(y/ies): 2

January 2020

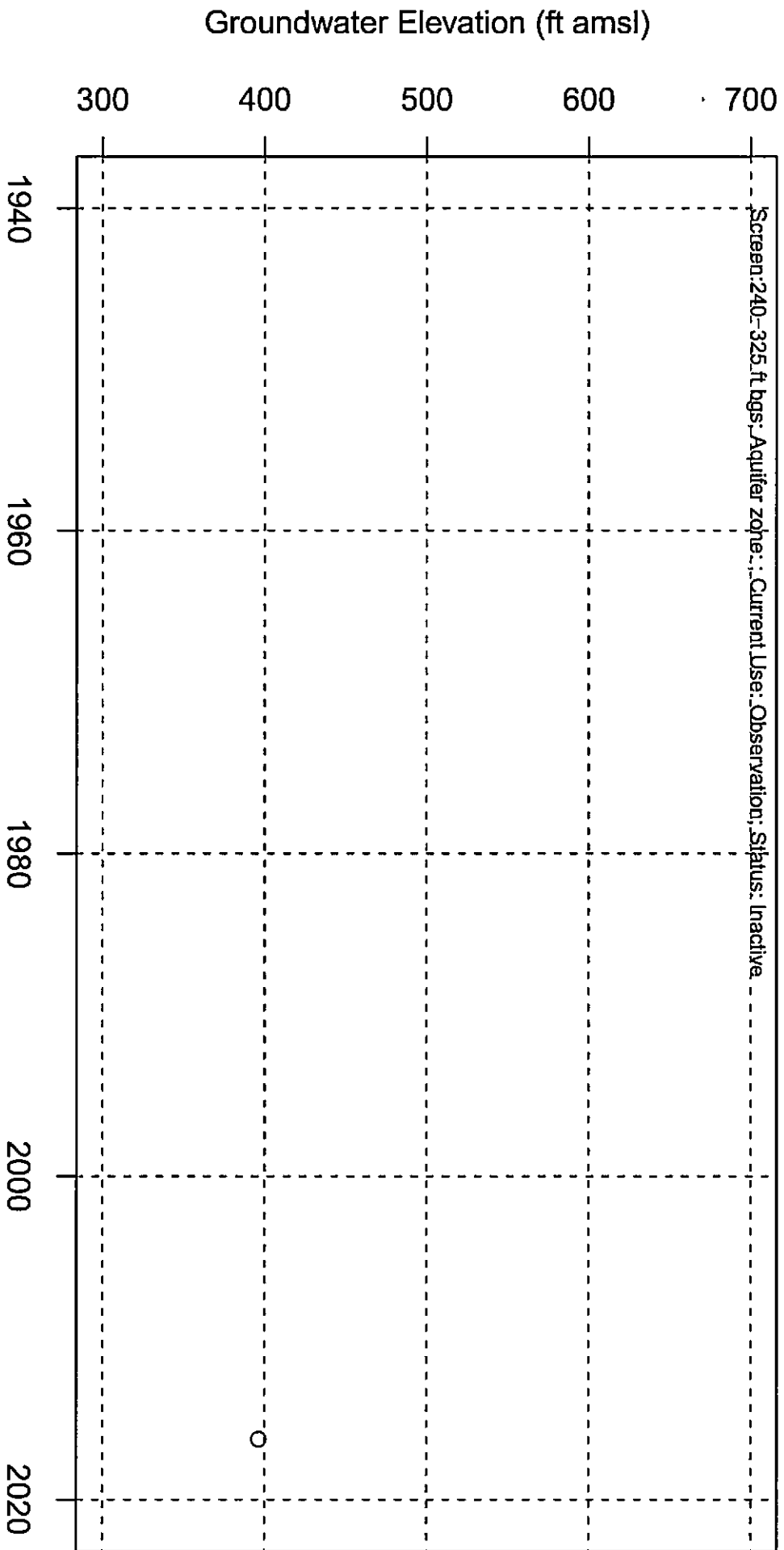
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Local ID: Hayden (32Q1) ; Number of Measuring Agency(ies): 3



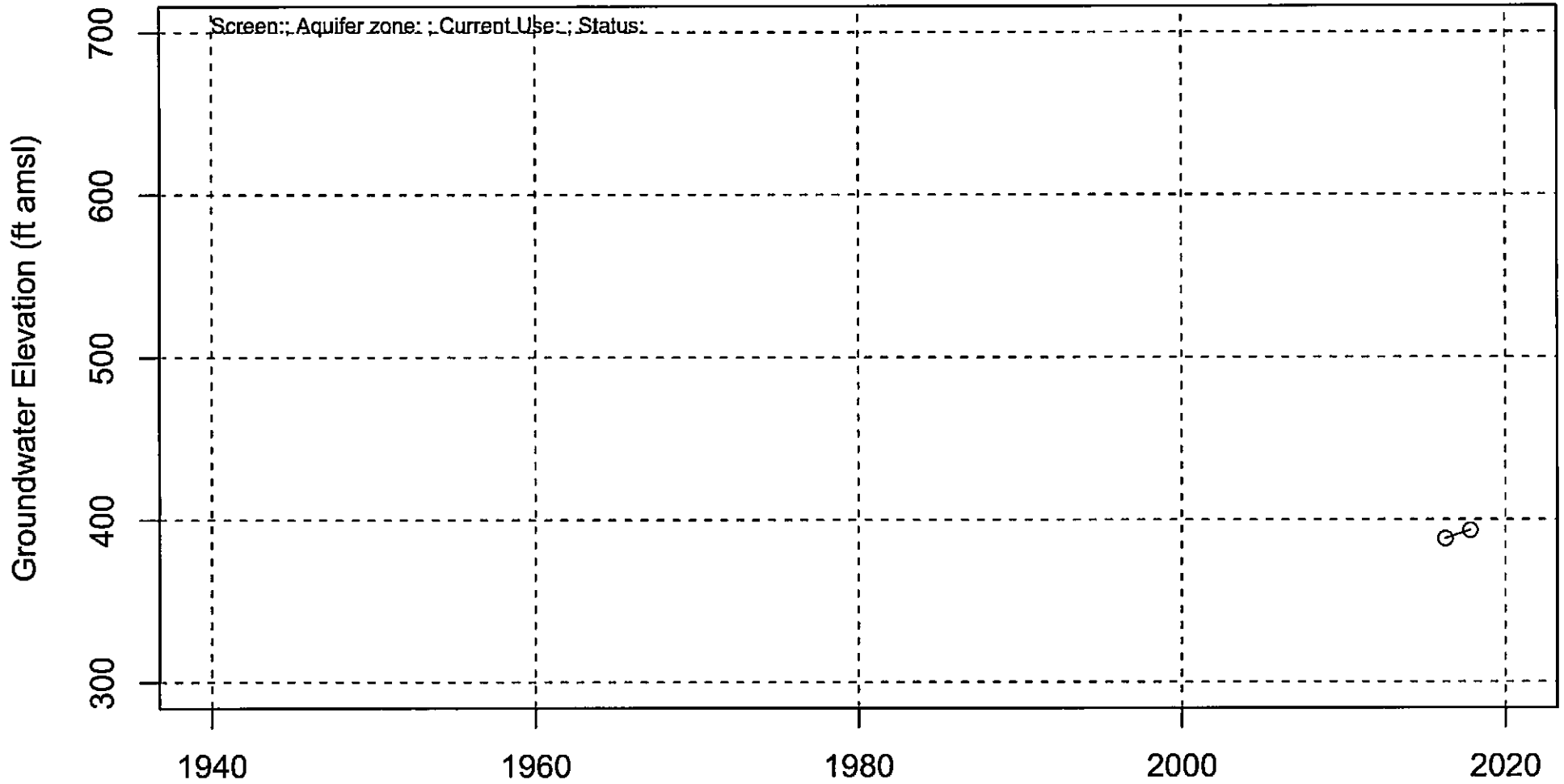
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Local ID: ID4-2 ; Number of Measuring Agency(ies): 1

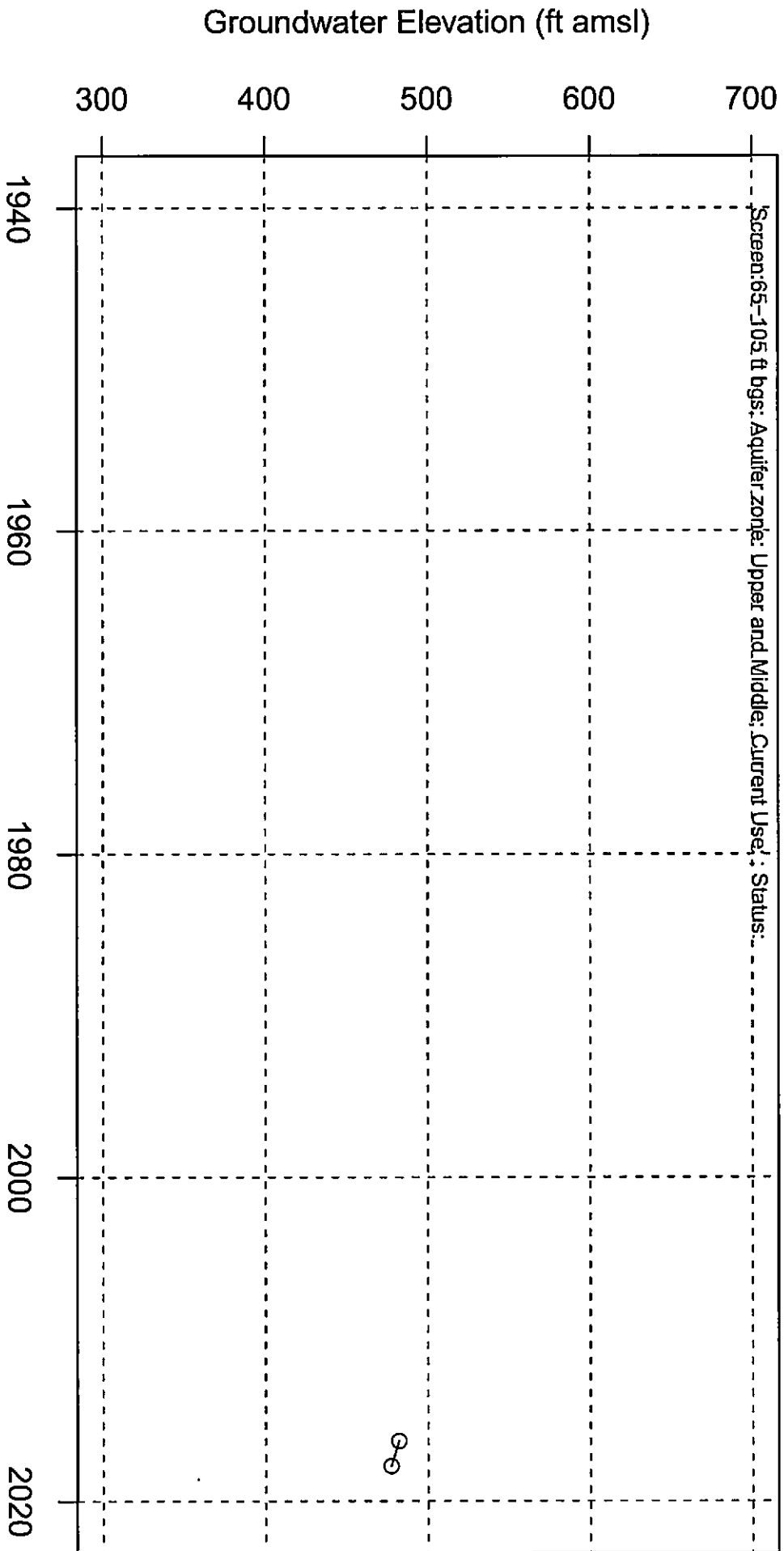
January 2020

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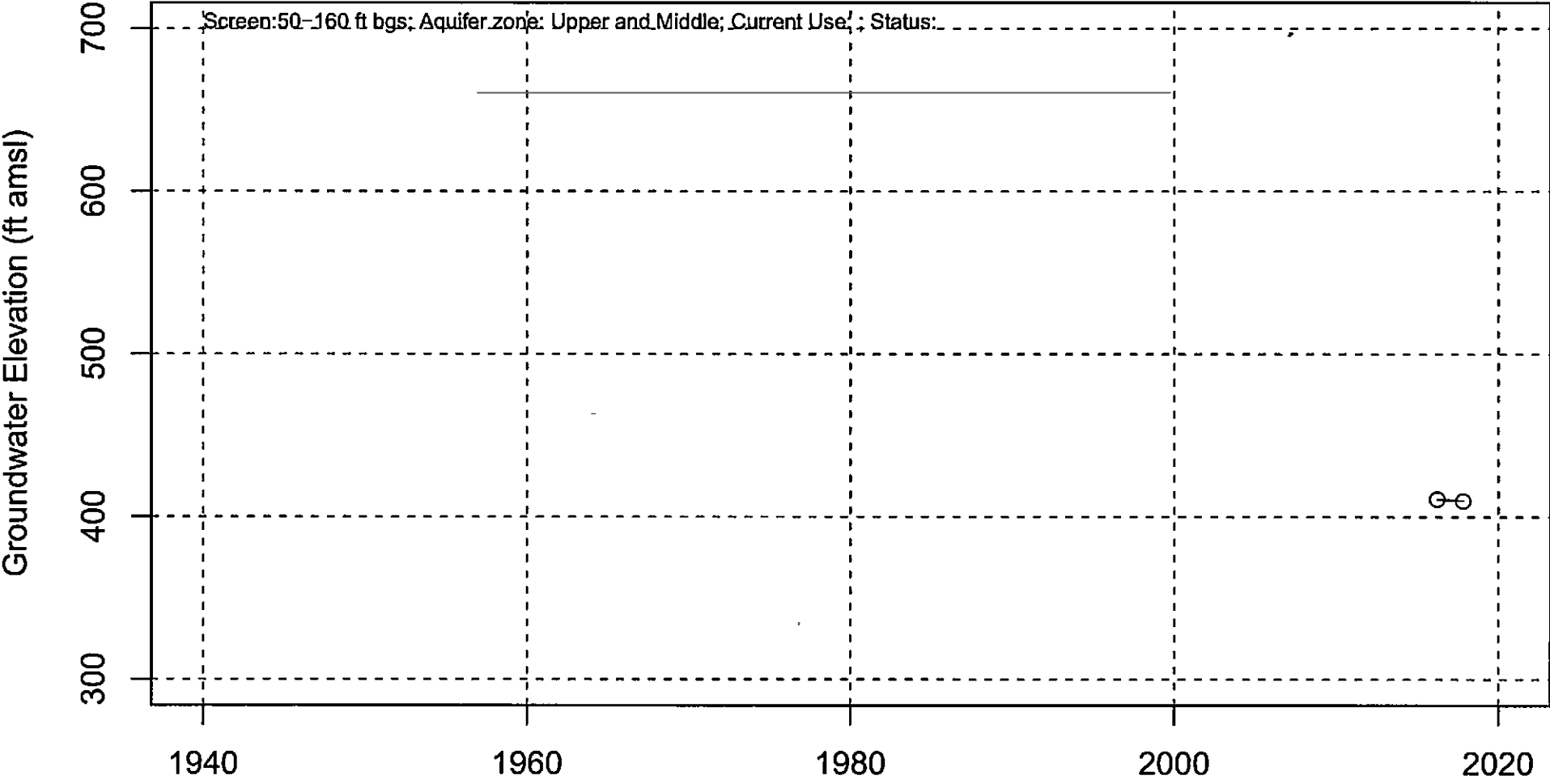
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Local ID: WWTP-1 ; Number of Measuring Agenc(y/ies): 2

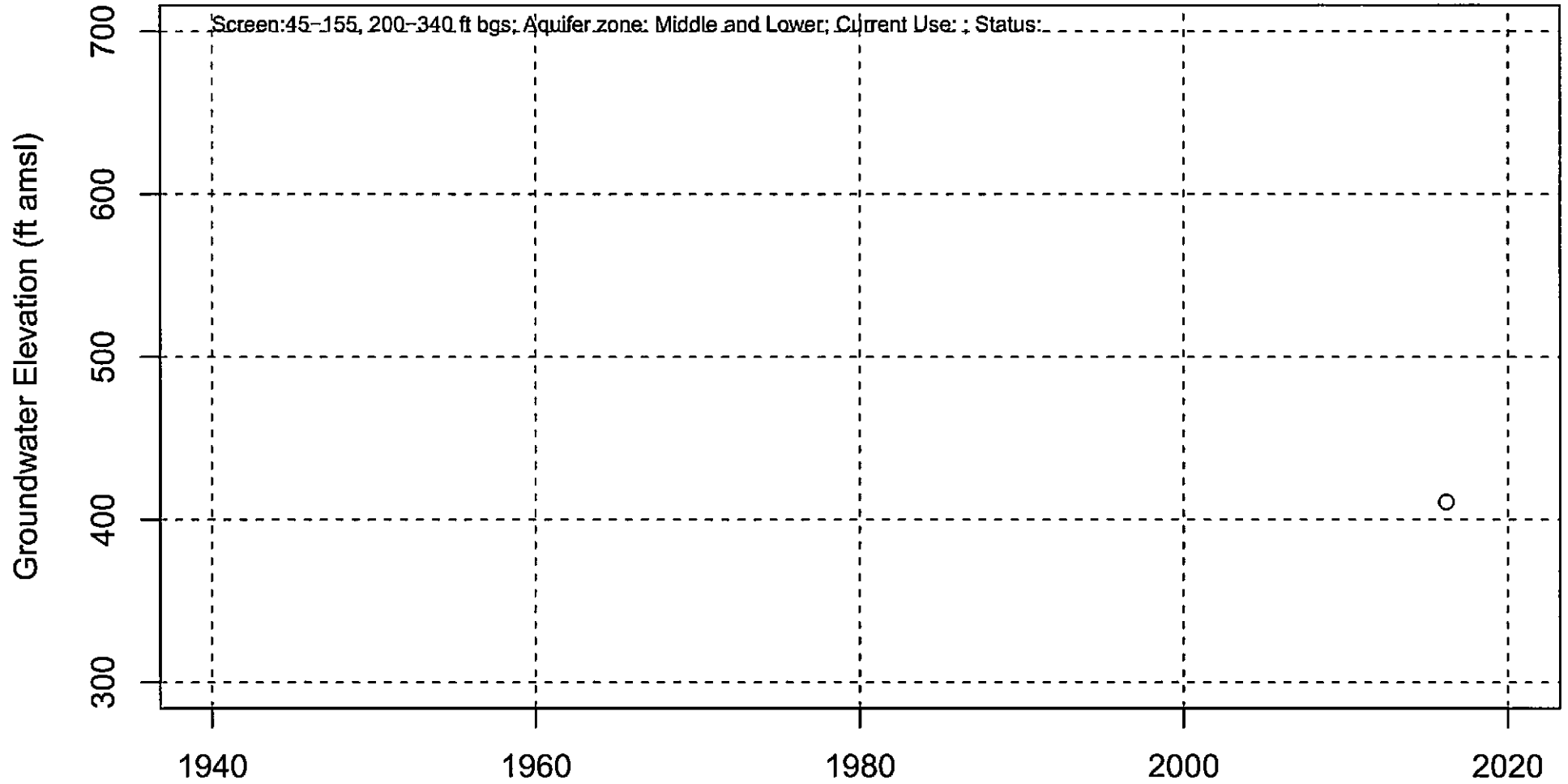
January 2020

**011S007E07R001S**



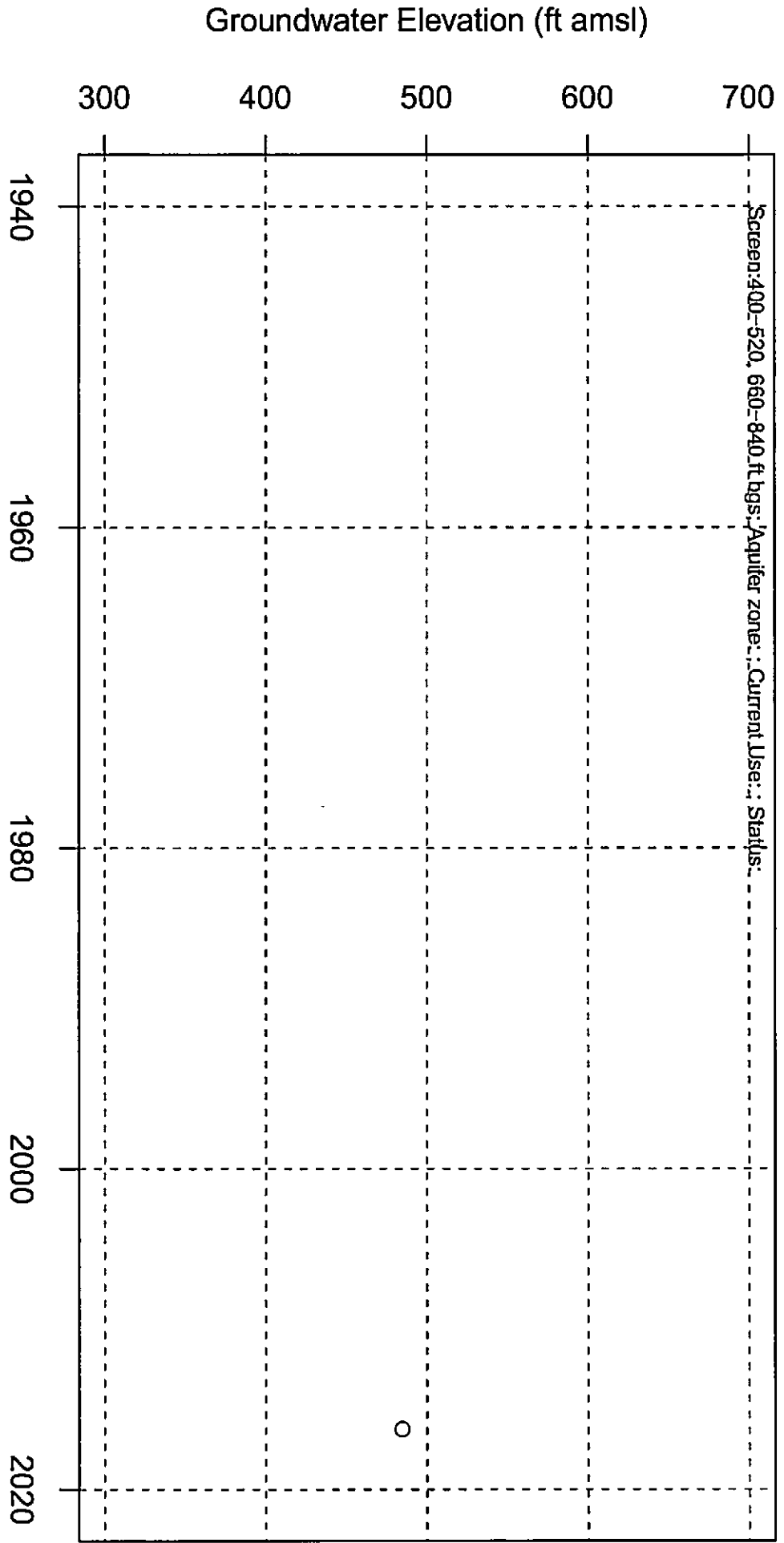
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# 011S007E07R002S



Local ID: MW-5B (West-Upper) ; Number of Measuring Agency(ies): 1

# 012S007E03L001S



January 2020

Local ID: Nel Well (Dr Peter Nels) : Number of Measuring Agenc(y/ies): 1

APPENDIX D4  
*Borrego Springs Subbasin Groundwater  
Dependent Ecosystems*





## DRAFT FINAL TECHNICAL MEMORANDUM

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To: Jim Bennett, Leanne Crow (County of San Diego)  
From: Trey Driscoll, PG, CHG; Dylan Duvergé, PG  
Subject: Borrego Springs Groundwater Subbasin Potential Groundwater Dependent Ecosystems  
Date: February 28, 2019 (Revised July 24, 2019; Finalized August 21, 2019)  
cc: Geoff Poole, Lyle Brecht, David Duncan (Borrego Water District)  
Attachment(s): Figures 1-22, Attachments 1-2

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The Sustainable Groundwater Management Act (SGMA) requires that all beneficial uses and users of groundwater, including environmental users of groundwater (Groundwater Dependent Ecosystems [GDEs]), be considered in Groundwater Sustainability Plans (GSPs) (California Water Code [CWC] Section 10723.2).<sup>1</sup> Each plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes: identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information (Title 23 CCR Section 354.16[g]).<sup>2</sup> This memorandum has been prepared to comprehensively evaluate the status of mapped GDEs within the Borrego Springs Groundwater Subbasin (Subbasin).

### 1 Defining Interconnected Surface Waters and GDEs

The emergency regulations for the evaluation of GSPs adopted by the California Department of Water Resources (DWR) define interconnected surface waters as “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” (Title 23 CCR Section 351[o]). The definition of an interconnected surface water specifies that a surface water need only be hydrologically connected *at any point* to a groundwater source. The perennial portions of mapped creeks in the Subbasin may be considered as interconnected surface waters because at least a portion of their flow is from groundwater springs and/or seepage from the fractured rock aquifer occurring outside the Plan Area. However, changing conditions within the Subbasin, including declining groundwater levels from pumping, does not have a substantial effect on groundwater within the fractured rock aquifer. This is because fractured rock aquifers operate very differently from alluvial aquifers, and because springs/seeps derive their flow from deep percolation of rainfall through bedrock fractures at higher elevations outside the Plan Area. Not only is the Subbasin’s groundwater level elevation hundreds of feet lower than the springs/seeps that contribute to stream flow, but activities within the

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<sup>1</sup> SGMA is codified in California Water Code (CWC), Part 2.75 (Sustainable Groundwater Management), Section 10720-10737.8, et al.

<sup>2</sup> GSP Regulations refers to the emergency regulations adopted by DWR as California Code of Regulations (CCR), Title 23 (Waters), Division 2 (Department of Water Resources), Chapter 1.5 (Groundwater Management), Section 350 et seq. Title 23 CCR Section 353.2(B) states, “The Department [DWR] shall provide information, to the extent available, to assist Agencies in the preparation and implementation of Plans, which shall be posted on the Department’s website.”

Subbasin have no effect on the amount or frequency of recharge received in the mountains. Therefore, aquifer depletion and/or declining groundwater levels within the Subbasin has no effect on the occurrence, volume or frequency of flow within the interconnected portions of Coyote Creek, Borrego Palm Creek, and other creeks that enter the fringes of the Subbasin.

GDEs are defined under SGMA's implementing regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (Title 23 CCR Section 351(m)). GDEs encompass a wide range of natural communities, such as seeps and springs, wetlands and lakes, terrestrial vegetation and, rivers, streams, and estuaries. Within the boundaries of the Plan Area, groundwater does not emerge from the Subbasin's aquifer, and groundwater does not occur near the ground surface:

- **Seeps and Springs:** There are no seeps or springs within the boundaries of the Subbasin. The only springs mapped in public databases that are within the Subbasin are Old Borrego Spring and Pup Fish Pond Spring. Old Borrego Spring dried up sometime before 1963, and the artificial Pup Fish Pond Spring (in addition to the pupfish pond near the Palm Canyon Trailhead in Borrego Palm Canyon Campground) is not a spring, but is a pond sustained by the Anza-Borrego Desert State Park (ABDSP) public water system.
- **Depth to Groundwater:** The shallowest groundwater recorded throughout the Subbasin occurs at the Rams Hill Wastewater Treatment Facility (WWTF) monitoring well (SWID No. 011S006E23H001S) in the northern part of the South Management Area. In this location, the groundwater table was recorded to be 26 feet below ground surface (bgs) in Fall 2018, where discharge of treated effluent into evaporation-percolation ponds causes localized mounding of groundwater. Aside from this location, the shallowest groundwater is recorded at MW-5B, located east-northeast of the Borrego Sink. In this location, the groundwater table was 55 feet bgs in Fall 2018. In locations where creeks, such as Coyote Creek and Borrego Palm Creek, enter the Subbasin on its northern and eastern margins, the shallowest groundwater level recorded from available monitoring wells (State Well ID Nos. 009S006E31E003SI and 010S005E25R002S) is in excess of 285 feet bgs. The depth to groundwater from the available wells closest to Tubb Canyon (ID4-2 and ID4-10) and Henderson Canyon (ID4-3 and ID4-18) is in the range of 315 to 433 feet bgs. In Fall 2018, groundwater levels within the Subbasin were on average 181 feet bgs, with a range between 26 and 433 feet bgs.

Although pumping within the Subbasin has no effect on the interconnected portions of streams outside the Plan Area, and groundwater neither emerges from the Subbasin's aquifer nor occurs near the ground surface, desert phreatophytes<sup>3</sup> (e.g., honey mesquite) have deep taproots specially adapted to access groundwater that does not exist near the ground surface. The Nature Conservancy (TNC) defines a GDE as "plants, animals, and natural communities that rely on groundwater to sustain all or a portion of their water needs" (TNC 2018). This definition of a GDE is broader and more inclusive than the definition under SGMA regulations. For this reason, and because SGMA also requires that stakeholder concerns be addressed and the unique characteristics of each basin be recognized, the GSA has not eliminated from consideration potential GDEs in the Subbasin based solely on lack of groundwater emerging from the aquifer and the high depth to groundwater. The presence of perennial surface waters and the accompanying ecological communities in the arid desert basin is unique, ecologically important, and the source of considerable draw to the region. The economy within the Subbasin relies heavily on recreational opportunities and tourism in the Plan Area, with the ABDSP attracting hundreds of thousands of visitors per year.

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<sup>3</sup> Phreatophytes are long-rooted water loving plants that obtain water supply from groundwater or the capillary fringe just above the water table.

Accordingly, this memorandum evaluates the occurrence and historical trends in potential GDEs, using the best available science, to support development of the GSP.

## 2 Identifying Potential Groundwater Dependent Ecosystems

The Natural Communities Commonly Associated with Groundwater (NCCAG) dataset is provided by the Department of Water Resources (DWR) as a reference dataset and starting point for the identification of GDEs in groundwater basins (DWR 2018). Because the scale of the NCCAG dataset is statewide (i.e., coarse), and consists of a compilation of vegetation and surface hydrology feature (e.g., springs) mapping, it does not incorporate local, basin-specific groundwater conditions such as aquifer characteristics or current data on depth to groundwater. Therefore, the dataset is most appropriately used as an indicator of where GDEs, as defined by SGMA, are more likely to be present. A local, basin-specific analysis is required to verify the degree to which features mapped in the NCCAG dataset depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. Accordingly, features mapped as NCCAG dataset are referred to herein as “potential” GDEs.

The NCCAG dataset and its source data can be reviewed in context of local understanding of surface water hydrology, groundwater conditions, and geology. The NCCAG dataset is comprised of 48 publicly available state and federal agency mapping datasets.<sup>4</sup> After the vegetation, wetland, seeps, and springs data from these 48 datasets were compiled into the NCCAG dataset, data were screened to exclude vegetation and wetland types less likely to be associated with groundwater and retain types commonly associated with groundwater. This initial screening was conducted by DWR, California Department of Fish and Wildlife (CDFW) and the Nature Conservancy (TNC).

Potential GDEs were identified by completing a review of the NCCAG dataset and other pertinent datasets discussed further below. The GSA grouped potential GDEs mapped within the Borrego Springs Groundwater Subbasin (7-024.01; Subbasin) by the NCCAG dataset as follows: 1) GDE Unit 1 – Coyote Creek, 2) GDE Unit 2 – Borrego Palm Creek, and 3) GDE Unit 3 – Honey Mesquite (Borrego Sink) (Figure 1). In addition, the GSA grouped potential GDEs mapped outside of these three zones as “other” potential GDEs, which consist of areas primarily located along the eastern flanks of the mountainous terrain that abuts the Subbasin to the west.

Watersheds contributing to the Subbasin were delineated using the U.S. Geological Survey’s (USGS) StreamStats application (USGS 2017) (Figure 2). The watersheds were delineated from the point of intersection of major drainages with the downstream edge of the Subbasin boundary. A total of 10 watersheds were delineated to complete a detailed review of the NCCAG dataset, along with additional dataset comprised of County of San Diego vegetation communities associated with primarily riparian habitat; USGS’s National Hydrography Dataset flow lines; perennial creeks, streams and springs mapped by the Anza-Borrego Desert State Park (ABDSP); springs identified

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<sup>4</sup> NCCAG dataset includes, but is not limited to, the following: VegCAMP – The Vegetation Classification and Mapping Program, California Department of Fish and Wildlife (CDFW); CALVEG – Classification and Assessment with Landsat Of Visible Ecological Groupings, USDA Forest Service; NWI V 2.0 – National Wetlands Inventory (Version 2.0), United States Fish and Wildlife Service; FVEG – California Department of Forestry and Fire Protection, Fire and Resources Assessment Program (CALFIRE FRAP); United States Geologic Survey (USGS) National Hydrography Dataset (NHD); and Mojave Desert Springs and Waterholes (Mojave Desert Spring Survey). NCCAG dataset viewer is available online at: <https://gis.water.ca.gov/app/NCDatasetViewer/>

on USGS quadrangle maps; land use data; and satellite color-infrared photography (Figure 3 through Figure 12).<sup>5</sup> Potential GDEs mapped within the contributing watersheds include, but are not limited to, Coyote Creek, Henderson Canyon, Borrego Palm Creek, Hellhole Palms Canyon, Culp Canyon, Tubb Canyon, San Felipe Creek, and other minor or unnamed stream segments entering the Subbasin (Figures 3 through Figure 12).

As the GSP is focused on the Subbasin, the potential GDEs should either be located within the Subbasin boundary or be sufficiently approximate to the boundary that there is a reasonable potential for a substantial nexus to exist between the Subbasin’s regional groundwater levels and the potential GDEs.

## 2.1 Primary Potential GDEs

The three primary potential GDEs areas are discussed in the following subsections. These GDE “Units” were identified based on the presence of NCCAG mapped within the Subbasin boundary and their overlap/proximity to perennial segments of major streams that enter the Subbasin, namely Coyote Creek and Borrego Palm Creek.

Other potential GDEs identified in Figure 3 through Figure 12 include Henderson Canyon, Hellhole Canyon, Culp Canyon, Tubb Canyon, and other minor or unnamed stream segments entering the Subbasin. These areas were not selected for detailed evaluation because the potential GDEs mapped in these areas are edge cases confined to the outer fringes of the Subbasin boundary; their geographic confinement to the mountain front at the end of large watersheds indicates that the vegetation communities are supported by surface water flows originating outside the Subbasin (which are storm fed and/or spring-fed). These contributing watershed and fringe areas are described in Section 2.2. Table 1 provides information on the dominant plant species within each GDE unit, global estimates of their maximum rooting depths, and the area in acres mapped for each.

**Table 1. Potential Groundwater Dependent Ecosystems within the Subbasin**

GDE Unit	Dominant Species		Global Estimate of Maximum Rooting Depth (Feet)	Area (Acres)
	Common Name	Scientific Name		
GDE Unit 1 (Coyote Creek)	Catclaw Acacia	<i>Acacia greggii</i>	18.0	3.5
	Desert Willow	<i>Chilopsis linearis</i>	5.2	3.5
	Honey Mesquite	<i>Prosopis glandulosa</i>	6.9–65.6	0.5
	Narrowleaf Willow	<i>Salix exigua</i>	–	1.3
	Tamarisk <sup>1</sup>	<i>Tamarix spp.</i>	32.8–65.6	0.4
<i>Subtotal</i>				9.2
GDE Unit 2 (Borrego Palm Canyon/Creek)	California Fan Palm	<i>Acacia greggii</i>	18.0	0.4
	Catclaw Acacia	<i>Chilopsis linearis</i>	5.2	6.5
	Desert Willow	<i>Washingtonia filifera</i>	–	0.3
<i>Subtotal</i>				7.1

<sup>5</sup> The mapped location of springs was developed from multiple datasets including the ABDSP (2017), Water Quality Control Plan for the Colorado River Basin (Basin Plan) and National Hydrography Dataset.

**Table 1. Potential Groundwater Dependent Ecosystems within the Subbasin**

GDE Unit	Dominant Species		Global Estimate of Maximum Rooting Depth (Feet)	Area (Acres)
	Common Name	Scientific Name		
GDE Unit 3 (Borrego Sink)	Honey Mesquite	<i>Prosopis glandulosa</i>	6.9–65.6	13.2
<i>Subtotal</i>				13.2
Other	Catclaw Acacia	<i>Acacia greggii</i>	18.0	3.2
	Desert Willow	<i>Chilopsis linearis</i>	5.2	1.7
	Tamarisk <sup>1</sup>	<i>Tamarix spp.</i>	32.8–65.6	0.1
<i>Subtotal</i>				5.0
<b>TOTAL</b>				<b>34.6</b>

Source: TNC 2018; Fan et al. 2017.

Notes: GDE = groundwater dependent ecosystem.

<sup>1</sup> The species of tamarisk is not differentiated, so data provided is for the overall genera.

### 2.11 Coyote Creek Mapped GDEs (GDE Unit 1)

The NCCAG dataset has mapped both wetlands and vegetation within GDE Unit 1, Coyote Creek (Figures 1 and 3). These communities are narrowly focused within the riparian corridors associated with Coyote Creek. Potential GDE vegetation types mapped in association with Coyote Creek include: Desert Willow, Narrowleaf Willow, Honey Mesquite (*Prosopis glandulosa*), and Catclaw Acacia (drought deciduous [lacks leaves for most of the year]). The ecological conditions in Coyote Canyon have been evaluated by the ABDSP (Ostermann and Boyce 2002). The following information is excerpted from *Ecological Conditions in Coyote Canyon, Anza-Borrego Desert State Park® An Assessment of the Coyote Canyon Public Use Plan*:

“Riparian vegetation covers approximately 120 acres at Lower Willows, 54 acres at Middle Willows, and 40 acres at Upper Willows” (Figure 3). “The biological importance of Coyote Canyon is largely a function of the perennial surface water and islands of tall-structured wetland vegetation in Lower, Middle and Upper Willows.” “Five sensitive habitat or vegetation types occur in Coyote Canyon, including: Desert Fan Palm Oasis Woodland, Mesquite Bosque, Mojave Riparian Forest, Sonoran Cottonwood Willow Riparian Forest, and Sonoran Riparian Woodland. Several of these riparian vegetation associations have been recognized for their rarity and sensitivity by the state of California. Lower and Middle Willows are identified as Significant Natural Areas (SNA) in the California Department of Fish and Game’s Natural Diversity Data Base because they contain sensitive Desert Fan Palm Oasis Woodland, Sonoran Riparian Forest, and nesting habitat for least Bell’s vireo. Upper Willows contains the same resources but was not designated as an SNA due simply to an oversight (California Department of Parks and Recreation 1995). All riparian habitat in Coyote Canyon is considered wetlands and is protected under the Keene-Nejedly California Wetlands Preservation Act of 1976. There are a variety of vegetation types both within riparian areas, and canyon wide. The tall-statured willow-dominated vegetation in Coyote Canyon is largely dominated by red willow (*Salix laevigata*), accompanied by arroyo

willow (*Salix lasiolepis*), cottonwood (*Populus fremontii*), desert fan palm (*Washingtonia filifera*), and desert grape (*Vitis girdiana*). Perennial shrub species such as mulefat (*Baccharis salicifolia*), narrow-leaved willow (*Salix exigua*), and arrow weed (*Pluchea sericea*) are mixed with willow-dominated vegetation. Wetter portions of the wetlands are dominated by annual and perennial herbs such as cattail (*Typha latifolia*), tule (*Scirpus americanus*), and scratchgrass (*Muhlenbergia asperifolia*) (California Department of Parks and Recreation 2002). The boundary between wetland and upland habitats in Coyote Canyon is typically defined by stands of honey [mesquite] (*Prosopis glandulosa*) and screw-bean (*P. pubescens*) mesquite (California Department of Parks and Recreation 2002). These species have deep rooting systems and are able to better access subsurface moisture. Higher areas within the floodplain support sparse shrublands of low-statured drought-deciduous species such as alkali goldenbush (*Isocoma acradenia*), broom lotus (*Lotus rigidus*), and desert baccharis (*Baccharis sergiloides*) (California Department of Parks and Recreation 2002). It is the diversity and spatial arrangement of vegetation associations (i.e., wetland vegetation, mesquite bosque, dry wash vegetation, creosote bush scrub) in the Canyon, in combination with perennial surface water, that allow for a dense array of habitats and wildlife species. Vegetation is a key component of riparian habitat. It provides structure and cover for animals, shade which influences water temperature, and plays an important role in nutrient cycling and soil stabilization" (Ostermann and Boyce 2002).

Dominant vegetation types identified in the NCCAG dataset include Catclaw Acacia, Desert Willow, Honey Mesquite, Narrowleaf Willow, and Tamarisk over an area of 9.2 acres.

### 2.1.2 Borrego Palm Canyon/Creek Mapped GDEs (GDE Unit 2)

The NCCAG dataset has mapped primarily vegetation within GDE Unit 2, Borrego Palm Canyon/Creek (Figures 1 and 6). These communities are narrowly focused within the riparian corridors associated with Palm Creek. Dominant vegetation types mapped in association with Borrego Palm Canyon/Creek include Desert Willow, California Fan Palm, and Catclaw Acacia, and are collectively mapped in the NCCAG dataset over an area of 7.1 acres.

### 2.1.3 Honey Mesquite (Borrego Sink) Mapped GDEs (GDE Unit 3)

The NCCAG dataset has mapped primarily vegetation within GDE Unit 3, which consists of Mesquite Bosque narrowly focused along the Borrego Sink Wash east of the Borrego Sink (Figures 1 and 13). The dominant vegetation type associated with the Borrego Sink is honey mesquite, which is mapped as having an area of 13.2 acres in the NCCAG dataset. DWR removed a previously large area around and north of the Borrego Sink from the NCCAG dataset because it was determined that the habitat no longer met the criteria for inclusion in the database.

## 2.2 Contributing Watersheds Potential GDEs

Contributing watersheds along the eastern flanks of the mountainous terrain that abuts the Subbasin to the west were evaluated to identify potential GDEs. Watersheds were delineated from the point of intersection of major drainages with the downstream side of the Subbasin boundary. A total of 10 watersheds, including 28 subwatersheds, were delineated as listed in Table 2 and described in the following subsections.

2.2.1 Coyote Creek Watershed

The Coyote Creek watershed is comprised of two subwatersheds referred to as the Coyote Creek and Coyote Creek South subwatersheds. The area of the Coyote Creek watershed contributing to the Subbasin encompasses approximately 94,506 acres (Figures 1 and 3). The watershed is located almost entirely within the boundary of the ABDSP. Upper portions of the watershed are developed with rural residences in the Terwilliger Valley located in Riverside County. The maximum elevation of the watershed is 8,615 feet above mean sea level (amsl) on the flank of Toro Peak in the Santa Rosa Mountains that reaches a maximum 8,716 feet amsl at the peak. The minimum elevation of the watershed is approximately 1,200 feet at the Lower Willows. The Coyote Creek watershed is discussed further in Sections 3 and 6.

**Table 2. Contributing Watersheds Area and Elevation**

Contributing Watershed	Subwatershed	Area (Acres)	Total Area (Acres) <sup>a</sup>	Elevation (Feet, amsl)	
				Maximum	Minimum
Coyote Creek	Coyote Creek	92,722	94,506	8,615	1,200
	Coyote Creek South	1,784			
Horse Camp	North	556	1,931	3,700	940
	Middle North	569			
	Middle South	677			
	South	129			
Henderson Canyon	North 1	1,599	2,984	4,650	1,163
	North 2	123			
	North 3	209			
	South 1	45			
	South 2	582			
	South 3	426			
Borrego Palm Creek	NA	14,994	14,994	6,404	1,300
Hellhole Canyon	Panoramic Overlook Canyon	407	6,667	6,142	962
	North Fork	504			
	Middle Fork	1,535			
	South Fork	4,221			
Dry and Culp Canyons	Dry Canyon	1,009	6,140	4,491	956
	Culp Canyon	5,131			
Tubb Canyon	Tubb Canyon	2,396	3,095	4,520	920
	Road North	265			
	Road Middle	190			
	Road South	244			
Glorietta Canyon	Glorietta Canyon	1,852	2,595	4,589	1,250
	South Fork	743			
Yaqui Ridge	North 1	1,042	2,903	3,864	1,252
	North 2	47			
	North 3	979			
	Yaqui Pass	581			
	Yaqui Ridge	110			
	Cactus Valley	144			

**Table 2. Contributing Watersheds Area and Elevation**

Contributing Watershed	Subwatershed	Area (Acres)	Total Area (Acres) <sup>a</sup>	Elevation (Feet, amsl)	
				Maximum	Minimum
San Felipe Creek	NA	117,339	117,339	5,719	992

Source: Watersheds delineated using StreamStats, USGS 2017.

Notes: amsl = above mean sea level; NA = not applicable.

<sup>a</sup> Total area of the contributing watersheds does not include areas within the Subbasin.

### 2.2.2 Horse Camp Watershed

The Horse Camp watershed is comprised of four subwatersheds referred to as the North, Middle North, Middle South and South subwatersheds (Figure 4). In total, the Horse Camp Watershed area is 1,931 acres. The Horse Camp subwatersheds are characterized by narrow canyons that drain the eastern foothills of the San Ysidro Mountains. The maximum elevation of the watershed is 3,700 feet amsl attained in the Middle South subwatershed and the minimum elevation is about 940 feet amsl in the South subwatershed. The NCCAG dataset indicates no mapped vegetation, wetlands or springs in the watershed. An isolated pocket of mapped vegetation is noted where the Horse Camp drainages converge in a wash on the edge of the valley. These potential GDEs are edge cases mapped in areas confined to the outer fringes of the Subbasin boundary; their geographic confinement to the mountain front indicates that the vegetation communities are supported by surface water flows originating outside the Subbasin and not sustained by the regional groundwater table.

### 2.2.3 Henderson Canyon Watershed

The Henderson Canyon watershed is comprised of six subwatersheds referred to as the North 1, North 2, North 3, South 1, South 2, and South 3 subwatersheds (Figure 5). The total Henderson Canyon watershed area is 2,984 acres. The maximum elevation of the watershed is 4,650 feet amsl attained in the North 1 subwatershed and the minimum elevation is about 1,163 feet amsl in the North Fork subwatershed. No springs are mapped in the watershed. Potential GDEs vegetation is mapped by the NCCAG dataset in the North 2 and South 2 subwatersheds. The mapped vegetation occurs along narrow corridors associated with ephemeral drainages. Mapped vegetation occurs in the Subbasin at the upper portion of the alluvial fans that originate from the watersheds. These potential GDEs are edge cases mapped in areas confined to the outer fringes of the Subbasin boundary; their geographic confinement to the mountain front indicates that the vegetation communities are supported by surface water flows originating outside the Subbasin and not sustained by the regional groundwater table.

### 2.2.4 Borrego Palm Creek Watershed

Borrego Palm Creek watershed encompasses approximately 14,994 acres (Figures 1 and 6). The watershed is located almost entirely within the boundary of the ABDSP. The watershed rises to a maximum elevation of 6,404 feet amsl near Hot Springs Mountain, the highest peak in San Diego County at an elevation of 6,535 feet amsl. The minimum elevation of the watershed is 1,300 feet amsl at the First Palm Grove. The Borrego Palm Creek Watershed is discussed further in Sections 3 and 6.



## 2.2.5 Hellhole Canyon Watershed

The Hellhole Canyon watershed is comprised of four subwatersheds referred to as the Panoramic Overlook Canyon, North Fork, Middle Fork, and South Fork subwatersheds (Figure 7). The total Hellhole Canyon watershed area is 6,667 acres. The maximum elevation of the watershed is 6,142 feet amsl attained in the South Fork subwatershed and the minimum elevation is about 962 feet amsl in the North 3 subwatershed. The Hellhole Canyon subwatersheds discharge through narrow canyons to the Subbasin where the constricted canyons broaden onto an alluvial fan. Vegetation on the alluvial fan is sparse compared to the dense vegetation in the South Fork subwatershed. The County vegetation layer maps a narrow corridor of riparian habitat in the South Fork. Satellite-color infrared photography reveals vegetation along additional drainage segments of the South Fork and lesser vegetation in the Middle Fork. One spring is mapped in the Middle Fork subwatershed. Four springs are mapped in the South Fork. None of the springs or GDEs identified within the watershed occur within the Subbasin.

## 2.2.6 Dry Canyon and Culp Canyon Watersheds

The Dry Canyon and Culp Canyon watersheds are comprised of two watersheds (Figure 8). The total Dry Canyon and Culp Canyon watersheds area is 6,140 acres. Dry Canyon is intersected by Montezuma Valley Road in the middle to lower part of the watershed. Dry Canyon is sparsely vegetated with no mapped potential GDEs or springs. Culp Canyon extends to a much higher elevation reaching 4,591 feet amsl where it abuts the community of Ranchita. Much of the watershed is located above 3,000 feet amsl where 14 springs are mapped. No vegetation is mapped in the area of the springs; however, review of aerial photography reveals narrow corridors of vegetation associated with the spring complexes. Where Culp Canyon enters the valley it joins with several canyons, including Tubb Canyon, to form an alluvial fan. The NCCAG dataset maps vegetation on the alluvial fan. These potential GDEs are edge cases mapped in areas confined to the outer fringes of the Subbasin boundary; their geographic confinement to the mountain front indicates that the vegetation communities are supported by surface water flows originating outside the Subbasin and not sustained by the regional groundwater table.

## 2.2.7 Tubb Canyon Watershed

Tubb Canyon is comprised of four subwatersheds referred to as Tubb Canyon, and Tubb Canyon Road North, Middle and South subwatersheds. The total Tubb Canyon watershed area is 3,095 acres. The maximum elevation of the watershed is 4,520 feet amsl and the minimum elevation (i.e., outlet) is about 920 feet amsl. Tubb Canyon watershed discharges through a narrow canyon to the Subbasin where it broadens into an alluvial fan (Figure 9). Three springs are mapped in the watershed and include Big Spring, Middle Spring, and Tubb Canyon Spring (ABDSP 2017). In the vicinity of Big Spring, seepwillow, catclaw, and mesquite have been identified (San Diego Reader 2010). The satellite color-infrared photography indicates green, healthy vegetation as the color red (high reflection of near-infrared wavelengths). In a desert environment, the green healthy vegetation could represent a potential GDE. A narrow band of habitat appears in the Tubb Canyon Creek channel primarily associated with the mapped springs. A band of vegetation is mapped by the NCCAG dataset where Tubb Canyon opens into the Subbasin near Dry and Culp Canyons. As previously discussed for the Dry and Culp Canyon watersheds, this potential GDE is supported by surface water flows originating outside the Subbasin and not sustained by the regional groundwater table.

## 2.2.8 Glorietta Canyon Watershed

Glorietta Canyon watershed is comprised of two subwatersheds referred to as Glorietta Canyon and South Fork subwatersheds (Figure 10). The total Glorietta Canyon watershed area is approximately 2,595 acres. The maximum elevation of the watershed is 4,589 feet amsl and the minimum elevation (i.e., outlet) is about 1,250 feet amsl. The watershed discharges to the Yaqui Meadows area of the Subbasin. No springs are mapped in the Glorietta Canyon. The satellite color-infrared photography indicates limited vegetation associated with Glorietta Canyon, which agrees with the lack of mapped springs, vegetation, and wetlands. No springs or potential GDEs are mapped in the Subbasin in the vicinity of Glorietta Canyon watershed.

## 2.2.9 Yaqui Ridge Watershed

The Yaqui Ridge watershed is comprised of six subwatersheds scattered along the ridgeline and referred to as the North 1, North 2, North 3, Yaqui Pass, Yaqui Ridge South and Cactus Valley subwatersheds (Figure 11). The total Yaqui Ridge watershed area is 2,903 acres. The maximum elevation of the watershed is 3,864 feet amsl and the minimum elevation (i.e., outlet) is about 1,252 feet amsl. Yaqui Pass Road crosses the Yaqui Ridge South subwatershed. No vegetation or springs are mapped within the Yaqui Ridge Watershed. Sparse vegetation within the drainage channels is shown on aerial photography. No springs or potential GDEs are mapped in the Subbasin in the vicinity of Yaqui Ridge watershed.

## 2.2.10 San Felipe Creek Watershed

The San Felipe Creek watershed is comprised of one large watershed of approximately 117,339 acres (Figure 12). The watershed rises to a maximum elevation of 5,719 feet amsl in the Vulcan Mountains north of the town of Julian, and the minimum elevation (i.e., outlet) is about 992 feet amsl. San Felipe Creek enters the valley through a narrow canyon ("narrows") that cuts through Yaqui Ridge. A deeply incised broad wash extends from the narrows to the valley floor and beyond to the Palo-Verde Wash. Borrego Springs Road crosses the broad San Felipe Creek wash at what is known as the "Texas dip." This wash is often the location of periodic and dramatic flash floods. The San Felipe Creek wash forms the southern boundary of the Subbasin. The NCCAG dataset and County vegetation datasets map extensive vegetation in the upper portion of the watershed and in narrow corridors in the lower portions of the watershed. Limited vegetation is also mapped in the wash near where the San Felipe Creek enters the Subbasin. None of the potential GDE habitat identified occurs within the Subbasin.

# 3 Streamflow

## 3.1 Coyote Creek

Streamflow in the Coyote Creek watershed has been documented by USGS as the number one source of groundwater recharge to the Subbasin via stream flow leakage (i.e., infiltration of surface water runoff primarily during flood events). An estimated 65% of the surface water inflow to the Borrego Valley comes from Coyote Creek (USGS 1982).

Perennial stream flow in Coyote Creek occurs in the northern most section of the Subbasin. Groundwater daylights at lower elevations in the Collins Valley at the Oasis at Santa Catarina Spring and Lower Willows Spring where the

stream is restricted by a narrow hard rock canyon. The restrictive canyon appears to act as a subsurface dam causing groundwater to daylight at the spring and flow into the Subbasin as surface water flow in Coyote Creek. This occurs approximately 1 mile upstream from the Subbasin boundary at an elevation of about 1,300 feet amsl. The spring was first documented in 1774 by members of the Anza Expedition near the site of a large Cahuilla Indian village.<sup>6</sup> “The creek contains three reaches where bedrock forces groundwater to the surface throughout the year, resulting in perennial surface or near-surface water. These areas, referred to as Lower, Middle, and Upper Willows, form three of the most verdant riparian wetlands of the California desert” (Ostermann and Boyce 2002). As the creek flows through the Subbasin, the alluvium becomes deeper and the surface flow either infiltrates into the Subbasin, is consumed by the riparian vegetation through transpiration and/or evaporates. During high rainfall events, flow extends Coyote creek further into the Subbasin for short periods of time.

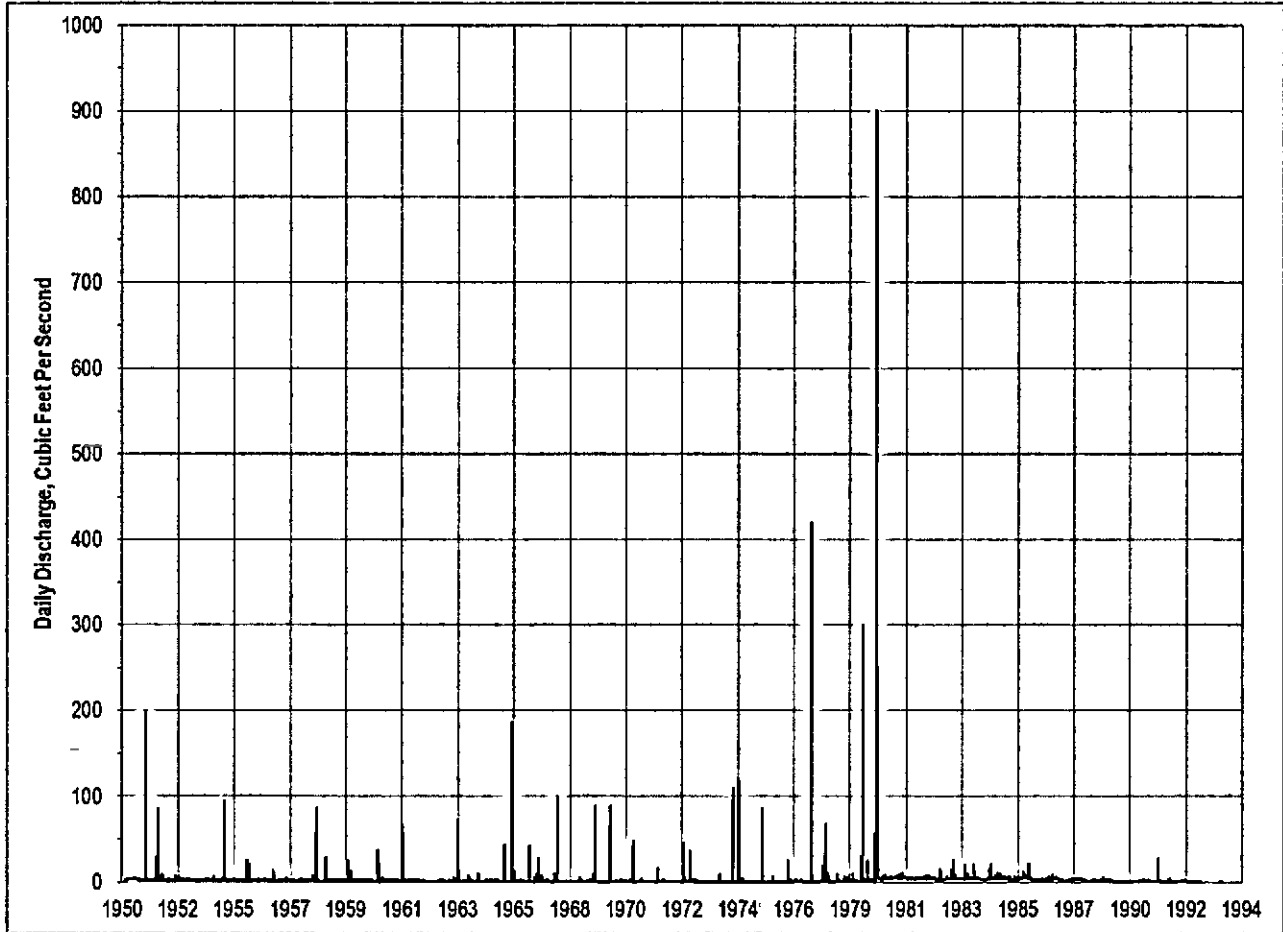
### Historical Stream Flow Measurements

There are two historical streamgages along Coyote Creek located at the northernmost boundary of the Subbasin, one of which stopped recording streamflow in 1983 and the other stopped recording flow in 1993. USGS Station Number 10255800 (Upper-Northern) recorded daily discharge data from 1950–1983; at this station, annual average stream flow was measured to be 1,831 acre-feet per year (USGS 2019). USGS Station Number 10255805 (Lower-Southern) recorded daily discharge data from 1983–1993; at this station, annual average stream flow was measured to be 1,774 acre-feet per year (USGS 2019).

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<sup>6</sup> Over 85 archeological sites have been recorded along the main creek in the Coyote Canyon, including major villages, food processing centers, rock art, and ceremonial and cremation sites (Ostermann and Boyce 2002).

### Exhibit 1. U.S. Geological Survey 10255800 and 10255805 Coyote Creek Stream Flow 1950 to 1993



Source: USGS 2019.

**Notes:**

Discharge data from 1950 to 1983 was recorded at the upper-northern Coyote Creek USGS gage (10255800), while data from 1983 to 1993 was recorded at the lower-southern gage (10255805).

Annual variability of stream flow over the period measured ranges from 326 acre-feet to 10,715 acre-feet. This large annual variability is a function of large annual variability of precipitation falling on the Coyote Creek watershed. Coyote Creek stream flow is generally correlated with precipitation and spring discharge from Clark Valley. Exhibit 1 shows the combined daily discharge from Coyote Creek USGS streamgages 10255800 and 10255805 for the period from 1950 to 1993.

#### Manual Stream Flow Measurements

To evaluate the potential GDEs associated with Coyote Creek, the GSA has investigated whether the perennial and ephemeral creek segments are gaining water or losing water to the underlying aquifer system. To complete this analysis, the GSA has commenced mapping the perennial extent of flow in to the Subbasin on a semi-annual basis (spring and fall). The upper historical streamgage is the GSA's manual monitoring point for Coyote Creek. At this

location, the GSA manually measured an instantaneous stream flow of 0.46 cubic feet per second (CFS) in Spring 2018, which converts to 206.5 gallons per minute. At that time, the former lower historical USGS streamgage station was observed to be dry.

In Spring 2018, the perennial extent of flow in Coyote Creek was documented to cease downstream of the third-crossing and upstream of the second crossing. No flow was observed in Spring 2018 at the lower inactive USGS streamgage, which is one of the permanent locations for manual flow readings. In Fall 2017, stream flow extended almost half-way from the second crossing to the first crossing. The crossings refer to where an unimproved trail crosses the creek bed, and are shown in Figure 1. In Fall 2017, there was a precipitation event in the Coyote Creek watershed that produced runoff in Coyote Creek; however, no stream flow measurements are available for this event. Flow in the stream was observed to decrease incrementally from the upper inactive USGS streamgage to two locations measured downstream.

“From 1951 to 1992, average daily streamflow in the creek measured at Lower Willows [USGS gages 10255800 and 10255805] was relatively stable and ranged from 0.5 cubic feet per second (cfs) to 4.9 cfs, with the exception of 1980, when the average was 14.8 cfs” (Ostermann and Boyce 2002). The streamflow measurements taken by the GSA at approximately the same location are within the range of historical measurements. The evidence gathered thus far indicates that the reach of Coyote Creek that was mapped as potential GDE by DWR is a “losing” stream, and that this habitat, where it occurs, is supported by intermittent storm events and/or flows emanating from the upland watersheds and basins. The evidence points to a losing stream because despite having a watershed size of 94,506 acres, Coyote Creek loses flow with distance downstream (i.e., within 1–2 miles of its crossing into the Subbasin). Stream flow, or lack thereof, has a clear and immediate relationship with runoff events from precipitation. If groundwater emanating from the Borrego Springs Subbasin were contributing to base flow within Coyote Creek, there would be a less rapid and obvious response to precipitation, and rather than going dry upon entering the Subbasin, flow would be expected to be maintained (or even increase) with distance downstream. Additionally, the depth to the regional groundwater table in the Subbasin in the vicinity of Coyote Creek is hundreds of feet below ground surface (288 feet at State Well ID No. 009S006E31E003SI) and disconnected from surface flows.

## 3.2 Borrego Palm Creek

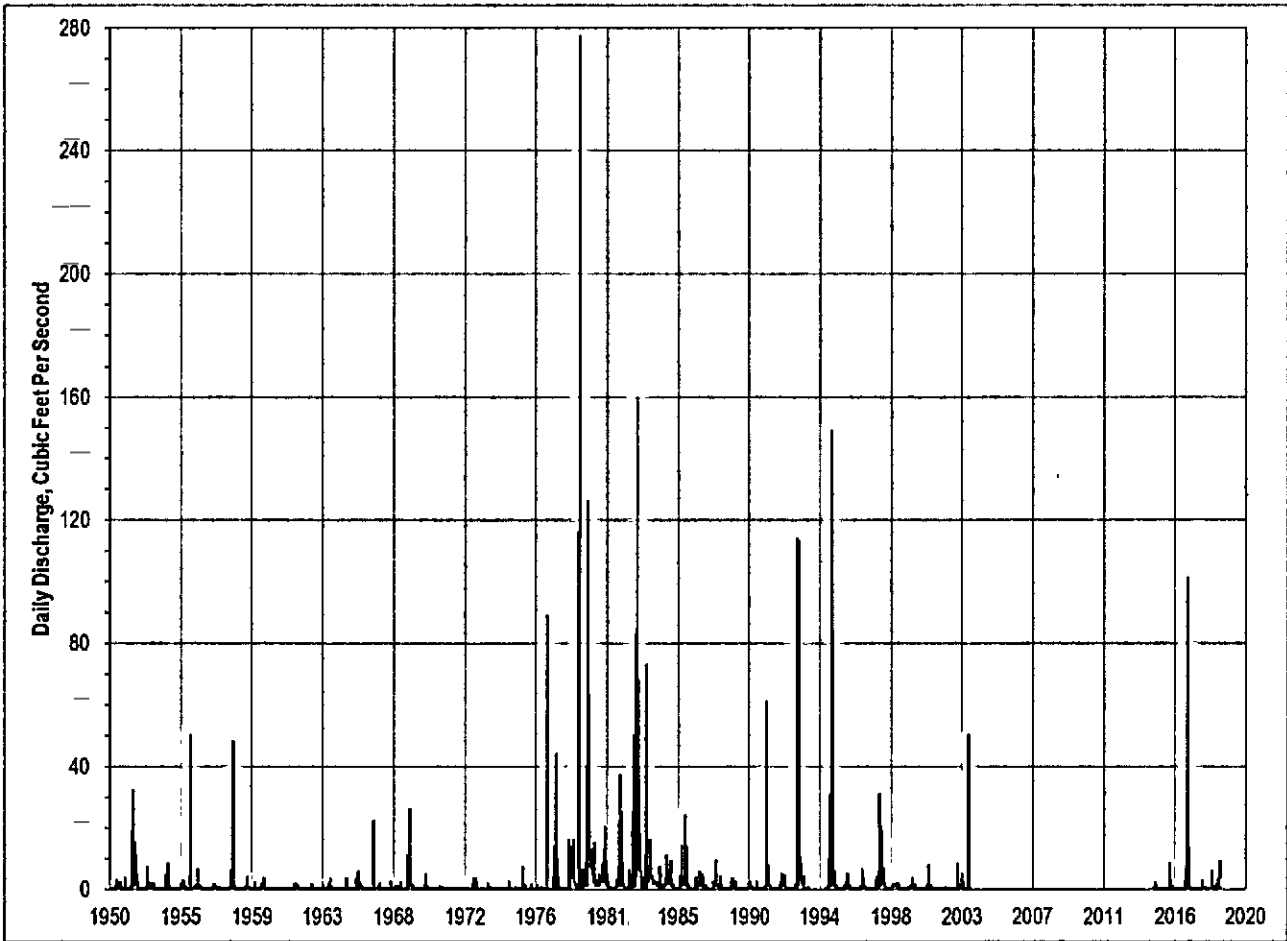
Intermittent stream flow from the Borrego Palm Creek watershed is an important source of recharge to the Subbasin. Perennial flow occurs in Borrego Palm Creek upstream of the palm oasis but apart from wetter periods, the perennial flow infiltrates into the ground along the steep alluvial fan that emerges into the Subbasin.

### Historical/Active Stream Flow Measurements

An active streamgage, USGS Station Number 10255810, is located on Borrego Palm Canyon downstream on the palm oasis. This streamgage has a 55-year period of record with sub-daily data (15 minute) from 2015 to 2019, and daily data from 1950 to 2003 (USGS 2019). The data indicate little to no flow over most of the period of record punctuated by higher flows associated with individual precipitation events. During wet years, prolonged stream flow after individual precipitation events is often recorded, but in most years little to no base flow is recorded in the summer months. Brief runoff events occur during occasional thunderstorms. Exhibit 2 shows the daily discharge from Borrego Palm Canyon USGS streamgage 10255810 for the period from 1950 to 2003, and 2015 to 2019. Similar to Coyote Creek, Borrego Palm Creek shows a high annual variability in stream flow, but with a smaller watershed, base flows rarely persist throughout the year, and peak flows are lower. As shown in Exhibit 2, peak flows above 80 cfs have occurred in 1977,

1979, 1980, 1983, 1993, 1995, and 2017. In most years, peak flow remains under 10 cfs. The highest peak flows on have occurred in the summer and winter, while average baseflow peaks in the winter. Total average flow at Borrego Palm Creek streamgage over the period of record is just shy of 1 cfs.

### Exhibit 2. U.S. Geological Survey 10255810 Borrego Palm Canyon Stream Flow 1950 to 2019



Source: USGS 2019.

Notes: Streamgage was inactive September 30, 2003, to January 6, 2015.

#### Manual Stream Flow Measurements

The USGS regularly performs manual streamflow monitoring of its active gages including the Borrego Palm Canyon streamgage. A total of 19 manual measurements were taken by USGS staff in 2018 and 2019 with recorded stream flow of no flow to 7.26 cubic feet per second (449 gpm) (USGS 2019). The clear and consistent relationship between seasonal and episodic precipitation and the patterns of recorded stream flow indicates that the reach of Borrego Palm Creek that was mapped as potential GDE by DWR is a “losing” stream, and that this habitat, where it occurs, is supported by intermittent storm events and/or flows emanating from the upland watersheds and basins.

## 4 Honey Mesquite (Borrego Sink)

According to the USGS (2015), the Borrego Sink, a topographic low where the water table prior to development was within 10 feet of land surface, was the site of about 450 acres of honey mesquite and other native phreatophytes, indicating that shallow groundwater and occasional accumulations of surface water was historically sufficient to support a healthy groundwater dependent ecosystem. The chronic decline in groundwater levels that has occurred in the Subbasin since the 1940s caused a rapid decline in both the health and extent of the historical honey mesquite habitat early on in this period. As stated in General Plan Update Groundwater Study completed by the County of San Diego (2010): “The mesquite bosque, a rare and sensitive groundwater-dependent habitat, is believed by many experts to be desiccating in portions of Borrego Valley, even though their taproots can reach down to 150 feet for water.” The green area in Figure 1 depicts the pre-pumping mapped historical extent of phreatophytes in the Subbasin by USGS (USGS 2015). The pink area depicts the mapped pre-January 1, 2015, extent of potential GDEs (SANGIS 2017); and the orange area depicts the extent of mapped GDEs by the NCCAG dataset (DWR 2018).

### 4.1 Historical Accounts (Old Borrego Spring)

Prior to development, mesquite trees, salt grass, willow and rushes were reported to be abundant in the valley (USGS 1909). The habitat is thought to have covered an approximate four-square mile area. Its extent and health benefitted greatly from the presence of a flowing spring (Old Borrego Spring) and groundwater levels estimated to be 10 feet bgs. A shallow groundwater table and Old Borrego Spring is likely to have provided significant support for the recruitment of seedlings, asexual regeneration, and the early stages of maturity.

In 1963, Lester Reed wrote in *Old Time Cattlemen and Other Pioneers of the Anza-Borrego Area*,

Since so much recent pumping of water in the Borrego Valley, the old spring no longer flows. This spring was one of the watering places upon which the Indians, and the old-timers could depend, although the water was of poor quality. The first time I visited Old Borrego Spring was just two or three days before Christmas 1913 when my brother Gilbert (Gib), and I were riding though on horseback from Imperial Valley to spend the holidays with our parents at the Mud Spring Ranch about fifteen miles southeast of Hemet. Since early boyhood, I heard old-timers talk about Borrego Springs water; so I thought I would try it. As I have said many times before, I found it to taste but very little better than the treated water we are expected to drink today. (Reed 2004)

The Old Borrego Spring was located in the vicinity of the Desert Lodge anticline, fold axes running perpendicular to the Veggie Line fault (notice uplifted sediments located south of the Old Borrego Spring and mapped NCCAG vegetation), Coyote Creek fault and Yaqui Ridge/San Felipe anticline associated with the San Jacinto fault zone (Steely 2009) (Figures 1 and 13). The faulting and folding effectively compartmentalize the deep sediments of the Subbasin from the adjacent Ocotillo Wells Groundwater Subbasin. When groundwater levels were closer to the surface in the Subbasin this resulted in ‘daylighting’ of groundwater at the Old Borrego Spring.

## 4.2 Ecology and Rooting Depth

Honey mesquite are an adaptable species characterized by a dimorphic root system capable of utilizing both surface water and groundwater resources opportunistically. Honey mesquite exhibit mechanisms of drought tolerance, including seasonally changing stomatal sensitivity and osmotic adjustment. Sharifi et al. (1982) stated: “Desert phreatophytes are a complex group of species with varied adaptive mechanisms to tolerate or avoid drought and should not be considered simply as a group of species that avoid desert water stress by utilizing deep ground water unavailable to other desert species of drought tolerance and avoidance.” Similarly, Ansley et al. (1991) stated: “in regions where accessible groundwater is minimal, honey mesquite often appear to be less than fully phreatophytic. [...] These plants have developed an extensive system of lateral roots and respond rapidly to precipitation.” Thus, with a sufficiently rapid and large decline in groundwater levels, Honey Mesquite can transition to a less than phreatophytic state, retaining the ability to utilize surface water and/or localized pockets of soil moisture perched above the groundwater table.

Within the Borrego Subbasin, this transition has manifested itself through a reduction in the extent, abundance, and health of the honey mesquite community. Figure 1 shows the historical extent of the honey mesquite habitat north and west of the Borrego Sink in pink and blue (as mapped by USGS and the County), and the current extent of the honey mesquite GDE in orange (from the NCCAG dataset). Since pre-development times, the honey mesquite's habitat has shrunk considerably, from about 450 acres in pre-development times to 13.2 acres today, as mapped in the NCCAG dataset. A significant decline in the health of the honey mesquite GDE is confirmed by a preliminary comparison of vegetation transects—one in Clark Valley and the other near the Borrego Sink—provided to the GSA by Mark Jorgenson (former ABDSP superintendent) (Jorgenson 2019). The percentage Honey Mesquite trees counted as dead was 11% in the Clark Valley, which overlies an undeveloped aquifer untapped by pumpers, compared with 53.8% in the Borrego Sink area. Though the methods and criteria used in the population count is not known by the GSA at this time, this further supports the information provided by USGS (2015), indicating that the Honey Mesquite community experienced significant stress and has desiccated, likely as a result of loss of access to groundwater.

Estimates of maximum rooting depths for honey mesquite vary considerably. According to the Fire Effects Information System compiled by the U.S. Forest Service, honey mesquite, in the absence of available subsurface water, can have taproots of up to 190 feet (Sosebee and Wan 1989, as cited in Steinberg 2001). For the genera as a whole (not limited to the *Prosopis glandulosa* species), *Prosopis* roots have been found at a depths of 52 meters (170 feet) in soils (Phillips 1963 as cited in Nilsen et al. 1983), and stands of *Prosopis* survive in regions with little to no recorded rainfall by tapping underground water resources (Mooney et al. 1980 as cited in Nilsen et al. 1983). The Nature Conservancy published a database of maximum rooting depths for GDE species from published scientific literature and expert opinion through a crowd sourcing campaign, including local and international studies. A compilation of 23 studies of *Prosopis* found their mean root depths to be 20 feet, with a standard deviation of 34 feet (Fan et al. 2017). As shown on Table 1, estimates for maximum rooting depth of honey mesquite species throughout the American southwest range from 6.9–65.6 feet, with the higher values in this range occurring in Texas (Fan et al. 2017).

While honey mesquite has been broadly reported to have extremely deep taproots, the best available information does not support the occurrence of extremely deep taproots. The USGS (2015) notes that the maximum rooting depth for phreatophytes found locally in around the Borrego Sink and areas to the north was 15.3 feet. This is within the range of the closest study of honey mesquite in TNC's database compiled in response to SGMA, which reports



the maximum rooting depths to be between 13.12 and 19.69 feet at Harper's Well, California (Nilsen et al. 1983). Given Harper's Well is located approximately 20 miles southeast of the Subbasin, this is considered the best available information on the maximum honey mesquite rooting depth in the Plan Area. With the lack of site-specific information on the root depth of the honey mesquite community, there is very high uncertainty associated with these values. Given the characteristics of honey mesquite as a drought tolerant species with a dimorphic root system able to transition to a less than phreatophytic state, simple comparisons between known groundwater levels and maximum root depths likely oversimplifies the evaluation of impacts to GDEs. The degree to which honey mesquite relies upon surface water must be considered, along with an evaluation of trends over time. This analysis is provided in Section 6.3.

### 4.3 Groundwater Level Trends and Plant Water Use

Recent groundwater levels from wells adjacent to the current and historical honey mesquite habitat range shown in Figure 1 occur at depths from approximately 55 to 134 feet below the ground surface. Since 1955, pumping in the Subbasin has resulted in a groundwater level decline in the vicinity of the Borrego Sink (MW-5A/B) of about 44 feet. The average rate of decline over this period is approximately 0.67 feet per year. The 1955 groundwater level (as measured at Well No. "Sink-7N1") was about 11 feet below ground surface and the most recent groundwater level measured in Fall 2018 (MW-5A/B) was 55 feet below ground surface. As indicated above, this area is thought to have had groundwater levels nearly to the ground surface, based on the presence of a flowing Old Borrego Spring. The "Sink" wells shown in Figure 1 (i.e., 12G1 and 7N1) have become dry based on measurements performed by DWR. Groundwater level measurements collected in 2009 of Sink Well 12G1 and well MW-5B indicated similar groundwater level elevations, which suggests that well MW-5B is sufficiently representative of depth to the groundwater table in the area of the Borrego Sink.

Groundwater levels have long since declined below a level that can support the estimated rooting depth of the habitat, as evidenced by the lack of significant change in habitat health since 1985 (see Section 6.3). Natural discharge determined from the Borrego Valley Hydrologic Model (BVHM) attributable to evapotranspiration was approximately 6,500 acre-feet per year prior to development, but has been virtually zero in the last several decades (1990–2010) (USGS 2015). The BVHM includes a component of evapotranspiration in the water budget, and estimates close to 400 acre-feet of percolating surface water throughout the Subbasin is lost to evapotranspiration under existing conditions. Based on the land uses and mapped vegetation incorporated into the BVHM, this is dominated by losses from non-native tamarisk, and other land uses.

## 5 Potential GDEs Ecological Condition

To assess the ecological condition of potential GDEs, several additional datasets were reviewed.

### 5.1 Threatened and Endangered Species

The Environmental Conservation Online System (ECOS) contains spatial data of critical habitat for threatened and endangered species. Critical habitat for Peninsular bighorn sheep is identified in the Subbasin (Figure 14). Critical habitat for Least Bell's vireo is also identified in the vicinity of the Subbasin near where Coyote Creek enters the Subbasin. Potential effects to these critical habitats must be analyzed along with the endangered species themselves during the California Environmental Quality Act (CEQA) review of the GSP Projects and Management

Actions. The U.S. Fish and Wildlife Information for Planning and Consultation (IPaC) lists the other endangered species in the larger contributing watershed to the Subbasin: 2 mammals, 24 migratory birds, 1 reptile, 2 amphibians, 2 fishes, 2 insects, and flowering plants (USFWS 2018). An official consultation based on the CEQA project description is required with the resource agencies in order to evaluate potential impacts, get an official species list, and make species determinations. TNC has generated a list of freshwater species located within each groundwater basin in California. This list, included as Attachment 1, is provided as a reference to describe the environmental beneficial users of surface water in the Subbasin. Adoption of the GSP is not anticipated to have any adverse impact on this list of species because, as discussed in Section 1, there is no hydrologic connection between the Subbasin's groundwater aquifer and the overlying surface waters.

## 5.2 Areas of Conservation Emphasis

The Areas of Conservation Emphasis (ACE) is a California Department of Fish and Wildlife non-regulatory tool that brings together the best available map-based data in California to depict biodiversity, significant habitats, connectivity, climate change resilience, and other datasets for use in conservation planning. ACE project contains spatial data on native species richness, rarity, endemism, and sensitive habitats for six taxonomic groups: birds, fish, amphibians, plants, mammals, and reptiles. Information on the location of four sensitive habitat types (i.e., wetlands, riparian habitat, rare upland natural communities, and high-value salmonid habitat) are also summarized. The ACE dataset is available statewide based on watersheds using hydrologic units at the 12-digit code level (HUC12) for aquatic habitat. The Borrego Valley HUC12 subwatershed has a low Significant Aquatic Habitat Rank (Figure 15).

The ACE dataset is available statewide at a 2.5-square-mile hexagon grid for terrestrial habitat. The color ramp has been coded at the USDA Ecoregion level with each color approximate to the 20th percentile of land area in the Colorado Desert Ecoregion. The developed areas of Borrego Springs have a terrestrial habitat rank of 0 (Figure 16). Moving outward from the developed area of Borrego Springs the rank increases to higher terrestrial habitat values.

Species Biodiversity Summaries combine the three measures of biodiversity developed for ACE into a single metric. These three measures include: (1) native species richness, (2) rare species richness, and (3) irreplaceability. Much of western flank of the Subbasin is ranked as high species biodiversity [grey hexagons] depicted in Figure 17. Interestingly, the Species Biodiversity Rank seems to conflict with the previous Significant Terrestrial Habitat Rank for the hexagons located in the central portion of the Subbasin.

The California National Diversity Database (CNDDDB) or California Special Status Species contains text and spatial information on California's special status species (rare plants and animals). It is a positive detection database. Records in the database exist only where species were detected. This means there is a bias in the database towards locations that have more survey work. Also, the database is proprietary and shall be displayed at such a scale (no larger than a scale of 1:350,000), or in such a way that the viewers/users cannot determine exact location information of the elements mapped in the system. Several positive detections are noted in the CNDDDB within the Subbasin (Figure 18).

The California Protected Areas Database (CPAD) contains GIS data about lands that are owned in fee and protected for open space purposes by over 1,000 public agencies or non-profit organizations. This dataset shows that the majority of lands surrounding Borrego Springs are protected areas managed by the Anza Borrego Desert State Park (Figure 19). Additional parcels are managed within the Subbasin by the Anza Borrego Foundation, Borrego Water District (BWD) and County.

## 6 Potential GDEs Hydrogeologic Conceptual Model

A Hydrogeologic conceptual model has been developed for the entire Subbasin to provide the framework for the development of water budgets, analytical and numerical models, and monitoring networks. A HCM differs from a mathematical (analytical or numerical) model in that it does not compute specific quantities of water flowing through or moving into or out of a basin, but rather provides a general understanding of the physical setting, characteristics, and processes that govern groundwater occurrence and movement within the basin. Figure 20 presents the parameters of the HCM developed for the Subbasin, which conceptually depicts basin boundaries, stratigraphy, water table, land use, and the components of inflow and outflow from the Subbasin. In order to better evaluate potential GDEs, it was necessary to refine the Subbasin-wide HCM to address specific areas of the Subbasin representative of the GDE Units. As such, large scale HCMs have been developed for the ephemeral and perennial creeks and drainages (Contributing Watersheds) and the Borrego Sink (honey mesquite) to provide a better understanding of the physical setting, characteristics and processes that govern groundwater occurrence and movement in these unique settings within the larger HCM. The location-specific HCMs are described in the following subsections and shown where they occur in the context of the Subbasin-wide HCM in Figure 20.

### 6.1 Ephemeral and Perennial Creeks and Drainages (Contributing Watersheds)

A HCM was developed for the potential GDEs identified in the Subbasin and at the Subbasin margins. Figure 21 depicts a HCM applicable to GDE Unit 1 – Coyote Creek, GDE Unit 2 – Borrego Palm Creek and other similar canyons that drain mountainous terrain adjacent to the Subbasin. This HCM illustrates that the source of water for potential GDE Units 1 and 2, and other similar canyons is stream flow that originates from outside of the Subbasin. Ephemeral and perennial streams transition to disconnected streams as they flow across the numerous alluvial fans that descend on the Subbasin. Stream flow percolates into a thick unsaturated zone. The regional groundwater table is often hundreds of feet below the streams. At Coyote Creek, the nearest well, State Well ID No. 009S006E31E003SI, has a depth to groundwater of 288 feet below land surface. At Borrego Palm Canyon Creek, the nearest well, State Well ID No. 010S005E25R002S, has a depth to groundwater of 348 feet below land surface. Other wells located adjacent to the Subbasin margins all have depths to groundwater several hundred feet below land surface.

The hydrogeological conceptual model (HCM) of the Subbasin indicates that the groundwater table may shallow within the narrow “fingers” of alluvium that extend into the canyons on the northern and western margins of the Subbasin (fringe areas), because the subsurface boundary between the alluvium and bedrock steeply rises in these locations. The groundwater monitoring network does not extend into these fringe areas; however, the deepest groundwater levels in the Subbasin are consistently recorded in monitoring wells located less than one mile away (i.e., State Well ID Nos. 009S006E31E003SI and 010S005E25R002S, ID4-2, ID4-3, ID4-10, and ID4-18). Desert alluvial fans such as those abutting the mountain front are natural recharge zones, meaning that groundwater declines in the Subbasin do not affect surface water conditions underlying the mouths of the canyons or at the head of these alluvial fans. Alluvium extending into these canyons can be conceptualized as containing groundwater that is perched on bedrock shelves hundreds of feet above the Subbasin’s aquifer. Both field observations and aerial photography show that stream flows that emerge from the canyons, when present, rapidly diminish with distance from the canyons as flow is lost to recharge. The Subbasin as a whole is therefore a system whose surface waters are disconnected from the underlying groundwater table (i.e., losing streams), which exists at considerable depths.

Groundwater extraction from water wells in the Subbasin does not effect GDEs associated with ephemeral and perennial creeks and drainages because the groundwater accessed by the wells is not water that is accessible or available to the potential GDEs.

## 6.2 Borrego Sink (Mesquite Bosque)

A HCM was developed for the Borrego Sink (Mesquite Bosque) to evaluate potential GDEs. Figure 22 depicts a HCM for potential GDE Unit 3 - Borrego Sink (Mesquite Bosque). The Borrego Sink is a topographic low in the Subbasin. The sink in all but the most exceptional wet years acts as closed or terminal basin where flood waters pool and fine sediment settles. After flood events, most of the water that reaches the sink evaporates leaving a white crust of salt that is often visible on the surface of the sink. Some of the flood waters that reach the sink percolate into the fine sediment and may locally support perched groundwater zones. As previously discussed in Section 4, Old Borrego Spring no longer discharges to the Borrego Sink.

Driller's logs for wells located in the vicinity of the Borrego Sink were reviewed to characterize the subsurface lithology. In particular, the log for MW-5A and 5B and Rams Hill test borehole No. 12 were reviewed.

MW-5 is a multicompletion well constructed in 2006 drilled to a depth of 480 feet bgs under the oversight of the BWD and DWR. MW-5 is located about 1.2 miles northeast of the Borrego Sink.

In general, the boring encountered variably thick interbedded materials (silt and clay). Based on the borehole cuttings and the geophysical logs, the geologic materials encountered can be separated into three main zones or sequences divided at prominent clay layers: an upper zone dominated by poorly consolidated coarse grained materials from the surface to about 165 feet bgs; a middle zone of moderately consolidated interbedded fine- and coarse-grained materials between 165 feet and 355 feet bgs; and a lower zone of consolidated or lithified beds for fine-grained and coarse-grained material between 355 to 480 feet bgs. (DWR 2007)

MW-5B is screened from 45 to 155 feet below ground surface and appears to sufficiently represent the depth of the groundwater table in the vicinity of the Borrego Sink though it is possible that it represents a semi-confined potentiometric surface rather than the unconfined water table. MW-5A is screened from 200 to 340 feet and has a similar groundwater level to the shallower MW-5B suggesting potentially unconfined conditions in this part of the Subbasin; however, it is uncertain whether a good well seal was obtained during installation of the multicompletion monitoring well.

Test borehole No. 12 was drilled in 2014 about 0.5 mile south of the Borrego Sink, immediately south of the Rams Hill Wastewater Treatment Facility. Interbedded sand, silt and clay was encountered to a total borehole depth of 764 bgs. Coarser material was only encountered at the surface to a depth of about 30 feet, and in one zone from 490 to 610 feet bgs. Thick clay zones with thin interbedded silty sands were encountered from 30 to 490 feet and from 610 feet to 764 feet (Dudek 2014). The depositional environment indicated by log is often one of low energy as evidenced by thick fine grain deposits. The depositional environment of the upper portion of the log is consistent with that of a desert playa (current depositional environment) and lacustrine setting (lake setting that occurred in desert basins during the last ice age [Pleistocene Epoch]). Deeper sections of the borehole may have encountered the Palm Springs Formation. The Borrego Sink HCM illustrates the predominantly fine sediment characterized in the subsurface in the vicinity of the Borrego Sink with coarser sediment shown proximal to mountainous terrain from which the sediments are derived (Figure 22).

Groundwater levels in the vicinity of the Borrego Sink have been measured at “Sink” wells 7N1 and 12G1 since 1953 and 1965, respectively, and MW-5A and MW-5B since 2006. The “Sink” wells have since become dry based on measurements performed by DWR in 2009. It is not known exactly when the Sink wells went dry; however, the groundwater level in well 7N1 was last measured by the USGS in 1965 at a depth of 36.0 feet bgs and well 12G1 was measured by the DWR in 2009 at a depth of 64.0 feet bgs. The total well depth of 7N1 is 30.0 feet and 12G1 is 65.2 feet as measured by DWR.<sup>7</sup> The overlap of a groundwater level measurement in 2009 of Sink Well 12G1 with MW-5B has a similar groundwater level elevation suggesting that well MW-5B is sufficiently representative of depth to the unconfined groundwater table in the area of the Borrego Sink. The depth to groundwater at MW-5B in Spring 2018 was 55 feet bgs. The groundwater table in the vicinity of the Borrego Sink has declined approximately 44 feet over the period from 1953 to 2019. The decline in the groundwater table in the vicinity of the Borrego Sink has resulted in the drying of Old Borrego Spring and desiccation of the honey mesquite as previously discussed in Section 4. Given that groundwater levels likely will not substantially recover under current climate conditions and pumping volumes, the impacts to the Borrego Sink are considered permanent and irreversible.

### 6.3 Evaluation of Remote Sensing Data

Comparison of aerial photography shows GDE Units 1 and 2, and other GDEs mapped around the western margins of the Subbasin have remained in place since the early 1950s, despite a long term and persistent trend of declining groundwater levels in the Subbasin. This suggests that these communities are being supported by surface water entering the Basin from perennial and ephemeral waters originating outside its boundaries, rather than the regional water table within the Subbasin. See Attachment 2 for aerial photograph comparison.

As discussed in Section 4.2, the estimate of rooting depth for honey mesquite is based on the best available data, but has a high degree of uncertainty. Based on the GDEs HCM discussed above (Section 6.2), water levels are believed to have dropped below the root depth of the honey mesquite early in the Subbasin’s history of pumping (i.e., prior to 1985). TNC’s GDE Pulse tool was used to evaluate if declining groundwater levels since 1985 have had any effect on the honey mesquite community (GDE Unit 3) mapped in the NCCAG dataset. The GDE pulse dataset provides annual data averaged for each NCCAG-mapped polygon that assess plant greenness and moisture indices (Klausmeyer et al. 2019):

- The Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. The average NDVI for each GDE polygon from Landsat data during the driest part of the year (July 9-Sept 7) was calculated to estimate vegetation health when the plants are most likely dependent on groundwater.
- The Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels. The average NDVI for each GDE polygon from Landsat data during the driest part of the year (July 9-Sept 7) was calculated to estimate vegetation health when the plants are most likely dependent on groundwater.

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<sup>7</sup> The total well depth of Sink well 7N1 measured by DWR at 30 feet is less than the last groundwater level measured by USGS in 1965 of 36.0 feet. Sink well 7N1 likely either collapsed at 30.0 or is filled with sediment in the bottom of the well.

Using the annual dry-month medoids, Klausmeyer et al. (2019) calculated the NDVI and NDMI vegetation metrics (VMs) as a useful means to provide a proxy for vegetation growth and water stress, which are helpful variables for inferring ecosystem health. Klausmeyer et al. (2019) states the following:

Living vegetation absorbs radiation in portions of the visible spectrum and reflects in the near-infrared (NIR), whereas radiation in the red as well as shortwave-infrared (SWIR) is absorbed by water present in the vegetation. Therefore, NIR and red wavelengths are sensitive to variations in photosynthetic chlorophyll, and SWIR wavelengths are sensitive to variations in moisture. Numerous spectral vegetation indices have been used to study vegetation health, drought impacts on vegetation, and deforestation. NDVI is the most widely used VM in the literature and is a reliable measure of the photosynthetic chlorophyll content in leaves and vegetation cover (Figure 1) (Rouse et al. 1974; Jiang et al. 2006). NDVI has been used in several studies to identify terrestrial ecosystems and wetlands that depend on groundwater based on the principle that ecosystems that are able to maintain consistent greenness during a prolonged dry period, are defined as potentially groundwater-dependent (Gou, Gonzales, and Miller 2015; Barron et al. 2014; Doody et al. 2017). NDMI is based on the NIR and SWIR bands and is also widely used in the literature as a metric of vegetation moisture stress. (Wilson and Sader 2002; Jinand Sader 2005)

Because of the highly arid environment in Borrego Springs, NDVI is selected as the most useful metric to document plant health. Klausmeyer et. al (2019) provides an example that characterizes “healthy” vegetation as having a NDVI of 0.72 and an “unhealthy” vegetation as having an NDVI of 0.14. It should be noted that such qualifications are species specific, and that at the time that Landsat images are taken (summer), honey mesquite is in its dormant phase.

Tables 3a and 3b present yearly average NDVI by dominant species for NDVI and NDMI, respectively. For all species other than Tamarisk, the long term trend has been one of “little to no change” as categorized in TNC’s GDE Pulse mapper. Furthermore, When the data is summarized by GDE Unit, the picture is similar. NDVI changes very little in the period between 1985 and 2018. Exhibit 3 relates the average NDVI and NDMI in the NCCAG-mapped polygons to groundwater levels and annual precipitation. A statistical correlation analysis between the VMs, groundwater levels and precipitation found the following:

- There is no correlation between the NDVI index and groundwater levels between 1985 and 2018. During this time frame, groundwater levels are estimated to have declined by 21 feet, based on groundwater level monitoring in Well MW-5A/B and in Sink Wells 12G1 and 7N1.
- There is a moderately positive correlation between the NDVI index and precipitation.
- Changes in NCCAG plant health indices after 1985—throughout the Subbasin, and regardless of the time interval chosen—are on average flat, slightly increasing, or slightly decreasing.

Evaluation of plant health indices derived from Landsat data have shown that there have been minimal changes in vegetation moisture and/or greenness since 1985 within any of the potential GDEs mapped within the Subbasin. Changes observed by year between 1985 and 2015 have been minor, and have tracked consistently with changes in annual precipitation occurring over the same time frame, rather than the steady decline in groundwater levels.

If potential GDEs were relying primarily on the regional groundwater table, one would expect to see a steady decline in community health over the 20 year period.

**Table 3a. Yearly Average Normalized Difference Vegetation Index Statistics by Dominant Species (1985–2018 )**

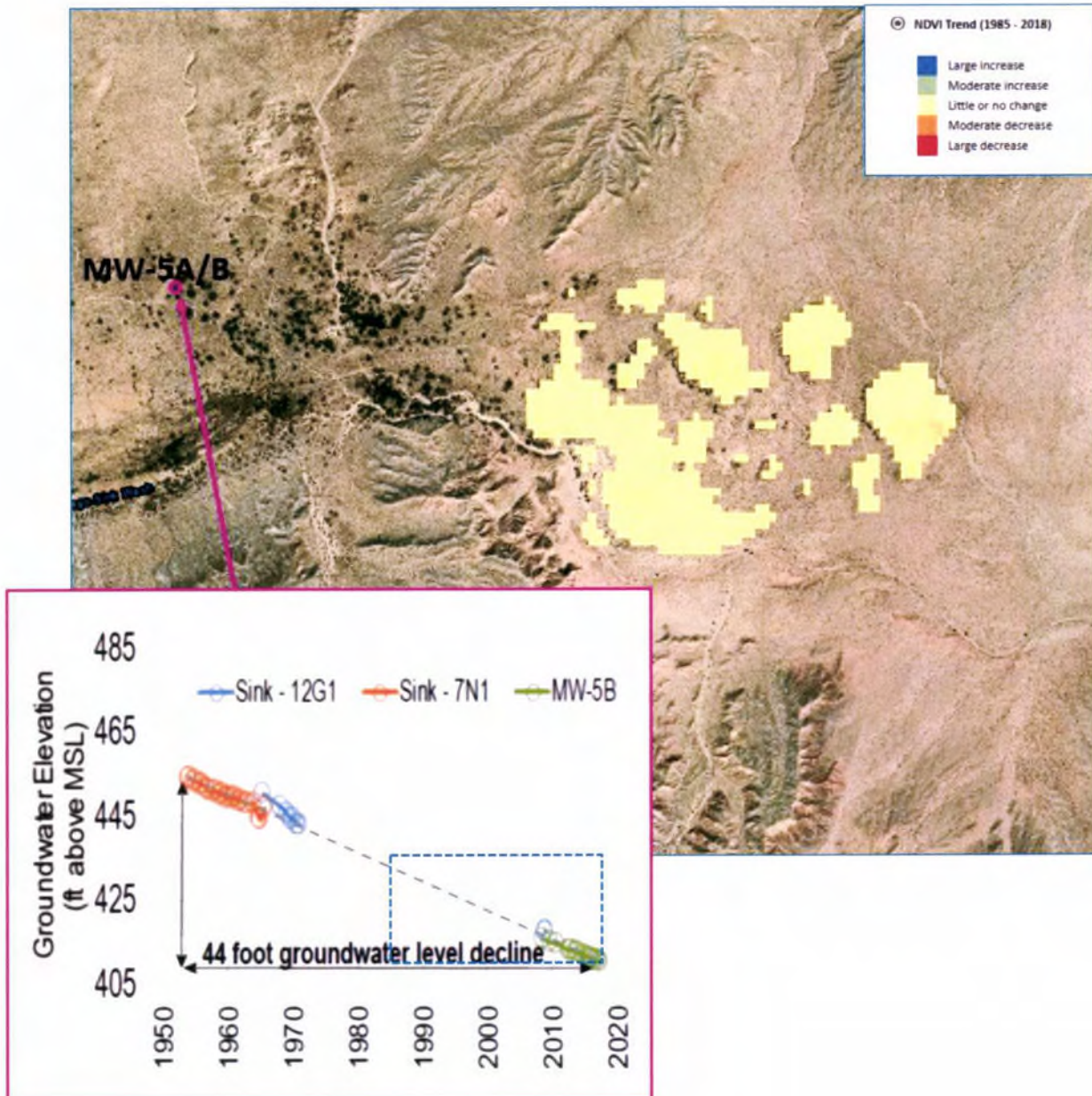
	Catclaw Acacia	Desert Willow	Honey Mesquite	Narrowleaf Willow	Tamarisk	California Fan Palm
Average	0.1211	0.1085	0.1161	0.1162	0.2621	0.2512
Minimum	0.0928	0.0783	0.0887	0.0889	0.2660	0.2501
Maximum	0.1458	0.1363	0.1379	0.1449	0.2702	0.2489
Change (1985 to 2018)	0.0075	0.0074	-0.0006	-0.0006	-0.1540	0.0092

**Table 3b. Yearly Average Normalized Difference Vegetation Index Statistics by Groundwater Dependent Ecosystem Unit (1985–2018 )**

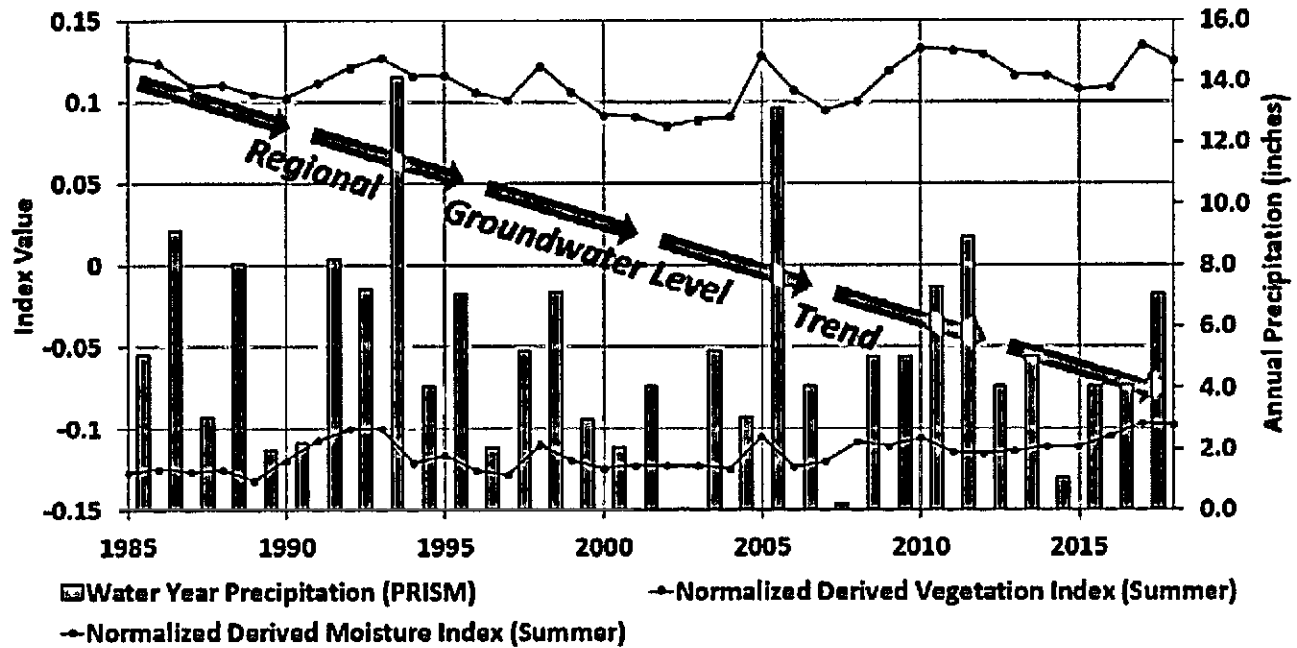
	GDE Unit 1	GDE Unit 2	GDE Unit 3	Other
Average	0.1481	0.1719	0.1002	0.1224
Minimum	0.1148	0.1138	0.0756	0.0986
Maximum	0.1783	0.2057	0.1271	0.1639
Change (1985 to 2018)	0.0348	-0.0143	-0.0150	-0.0015



### Exhibit 3. Relationship between Groundwater Dependent Ecosystem Health Indicators, Groundwater Levels, and Precipitation







## 7 Evaluation of Nexus of GDEs with Subbasin Groundwater

The SGMA definition of GDEs was applied to evaluate reliance of ecological communities and species on Subbasin groundwater. The evaluation revealed that Subbasin creeks can be characterized as losing streams in that they primarily act as groundwater recharge areas rather than local discharge of groundwater from the Subbasin to the stream reach. Potential GDEs that exist within Subbasin creek drainages rely on both periodic surface flows and soil moisture, and not directly on the regional groundwater table, which based on groundwater levels recently measured adjacent to the creek drainages indicate groundwater levels are beyond the rooting depth zone of existing vegetation mapped as potential GDEs.

The impact of rapidly declining groundwater levels on GDE vegetation is most apparent in the Borrego Sink. The honey mesquite that previously flourished in the Borrego Sink has desiccated and its areal extent has decreased significantly as groundwater levels have dropped in response to increased groundwater extraction. Pumping in the Subbasin has resulted in a groundwater level decline of about 44 feet over the last 65 years in the vicinity of the Borrego Sink. Recent groundwater levels from wells adjacent to the main mapped habitat range from approximately 55 to 134 feet below the ground surface. Because of the long-term imbalance of pumping with available natural recharge, an irreversible impact has occurred to the honey mesquite, which is mostly desiccated prior to January 1, 2015.

Vegetation that occurs in the Borrego Sink has access to soil moisture in the unsaturated zone and potentially perched groundwater where present. Perched groundwater consists of local pockets (or lenses) of low permeability sediment (e.g., clay and silt) that “pinch out,” meaning they are not laterally extensive enough to be considered a regionally significant aquitard. These zones are considered “perched” because they occur above the regional groundwater table, and thus are disconnected from changes experienced within regional aquifer (including outflows such as pumping). With these types of subsurface conditions, surface water may be slower to percolate into the

underlying regional groundwater table, possibly providing conditions necessary to sustain remnant stands of honey mesquite and/or support ongoing recruitment in combination with periodic storm flow events. The percolating groundwater used by this vegetation removes water that would otherwise constitute recharge. In other words, rather than the regional aquifer being a water source for the vegetation, the vegetation subtracts from the water available for deep infiltration.

## 8 Conclusion and Recommendations

A review of available pertinent spatial datasets, historical data including stream flow and groundwater levels, satellite-derived vegetation metrics, and geology was completed to develop a robust HCM to evaluate nexus of GDEs with Subbasin regional groundwater levels. Because of the long-term imbalance of pumping with available natural recharge, an irreversible impact has likely occurred on the honey mesquite community from a decline in groundwater levels, an impact which, based on the best available science, was completed and became permanent sometime prior to 1985. The comprehensive assessment revealed potential GDEs identified within the Subbasin no longer have direct reliance on groundwater emerging from aquifers or on groundwater occurring near the ground surface, and instead are sustained by periodic stormwater flows, soil moisture, and potentially perched groundwater where present. These findings indicate that based on best available data there is no need for the GSP to address minimum groundwater level thresholds with respect to potential GDEs.

Detailed mapping of vegetation is lacking for the area in the vicinity of the Borrego Sink. Groundwater level monitoring of wells located in the vicinity of the Borrego Sink should continue.

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## 10 Advisory Committee Meeting GDEs Presentations

GDE presentations by DUDEK at SGMA Borrego Valley GSP Advisory Committee meetings in chronological are as follows:

ACM 2017.11.27	Coyote Creek
ACM 2018.05.31	Groundwater Dependent Ecosystems
ACM 2018.07.26	Groundwater Dependent Ecosystems
ACM 2019.01.31	Groundwater Dependent Ecosystems (GDEs) Approach in GSP
ACM 2019.07.25	Groundwater Dependent Ecosystems Response to Public Comments

Presentations are available from the County of San Diego’s Borrego Valley Groundwater Basin website: <https://www.sandiegocounty.gov/content/sdc/pds/SGMA/borrego-valley.html>

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*draft Final Technical Memorandum*

*Subject: Borrego Springs Groundwater Subbasin Potential Groundwater Dependent Ecosystems*

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**Attachments**

Attachment 1 California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Attachment 2 Aerial Photography Comparison

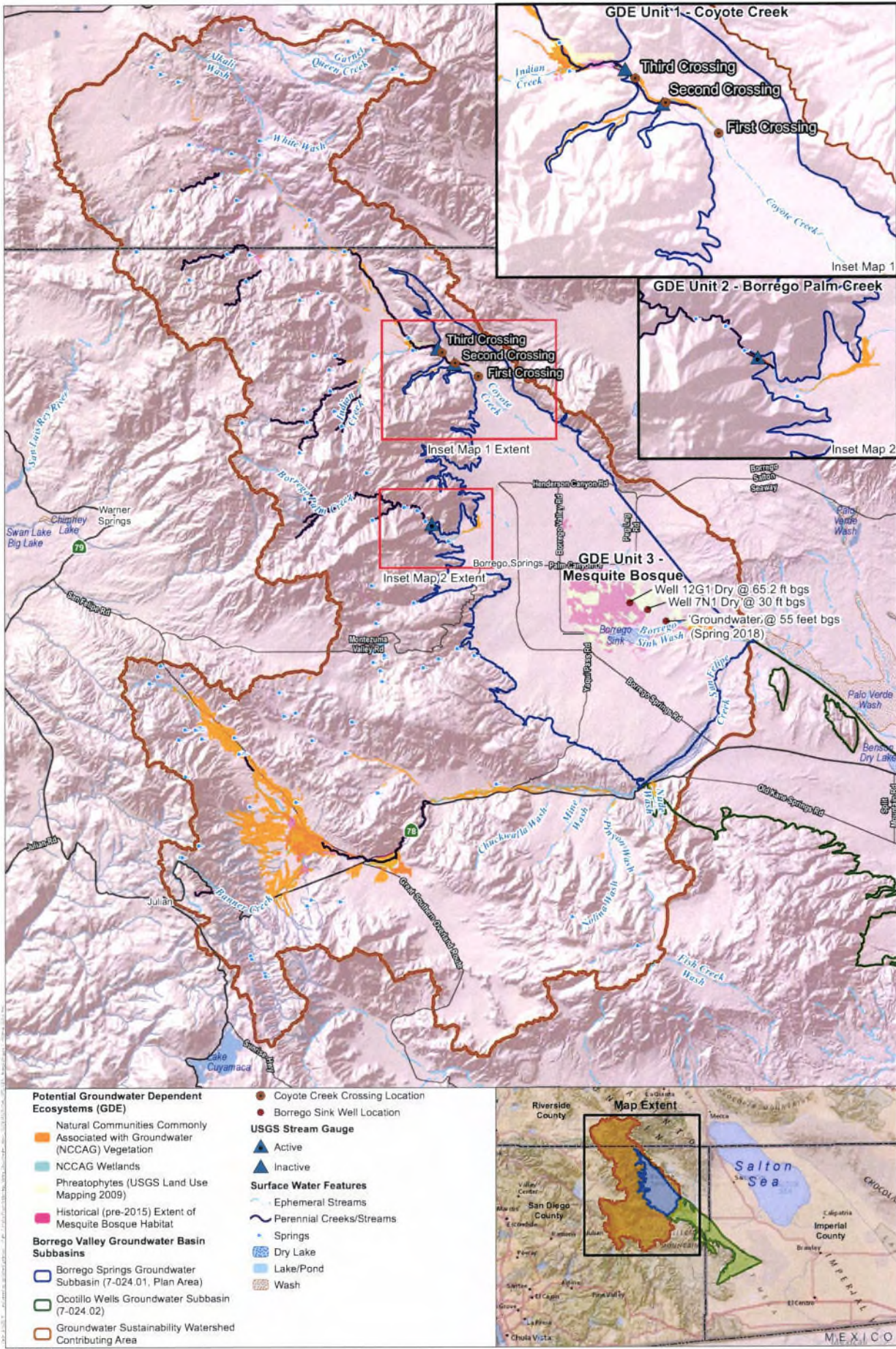


# Figures 1–22

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DRAFT March 2019

DATUM: NAD 1983. DATA SOURCE: DWR 2018, USGS NHD 2017, State Parks 2017, SanGIS 2017

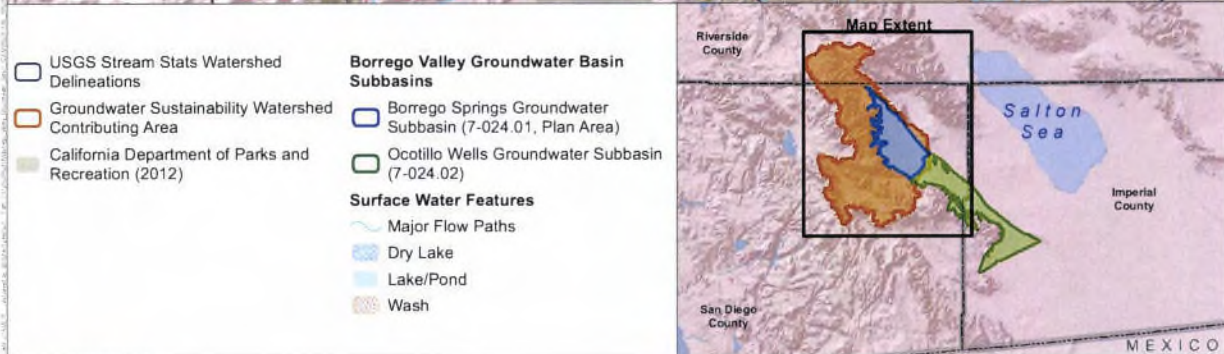
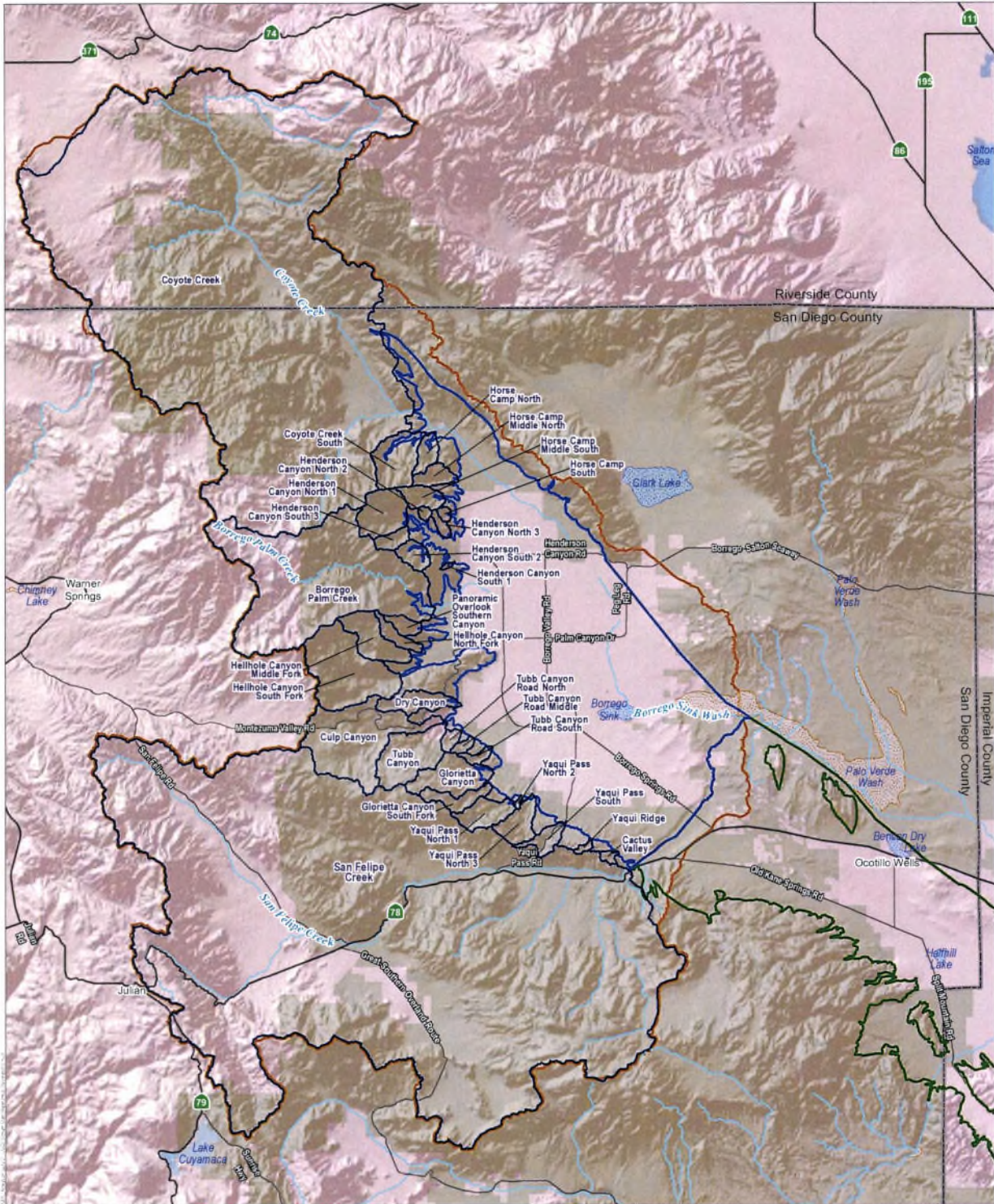
**DUDEK**



Figure 1  
Borrego Springs Subbasin and Potential Groundwater Dependent Ecosystems

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems



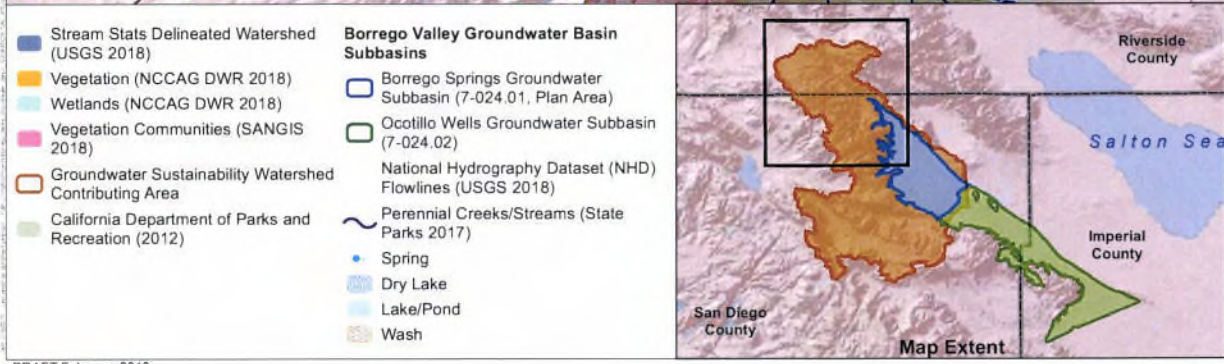
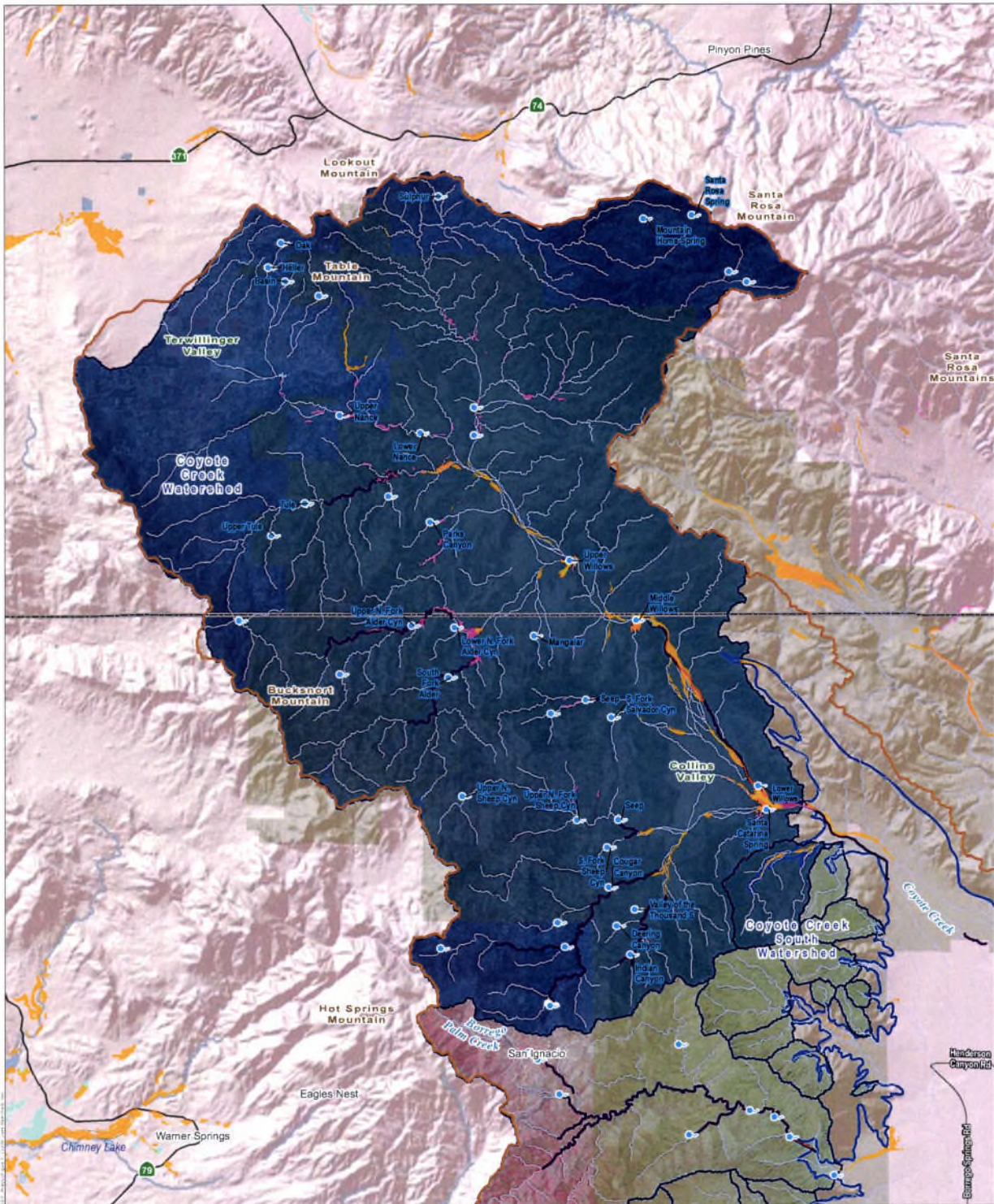


DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: USGS Stream Stats 2016



Figure 2  
 USGS Stream Stats Watershed Delineations  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





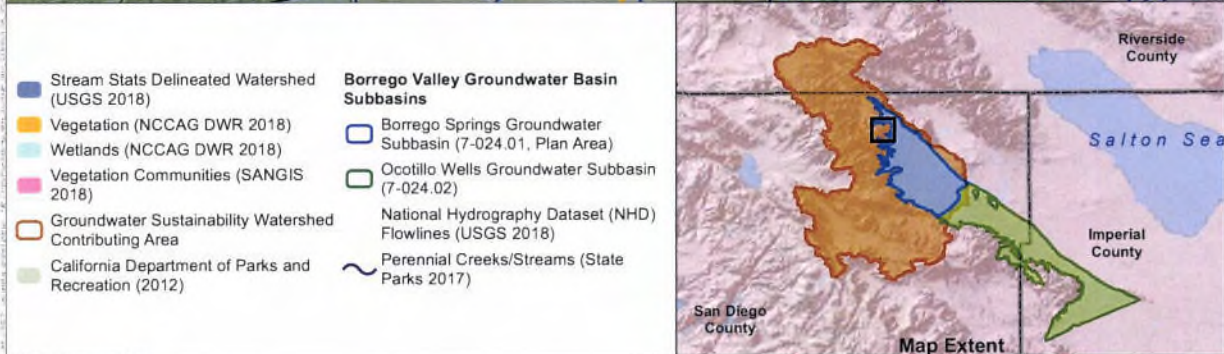
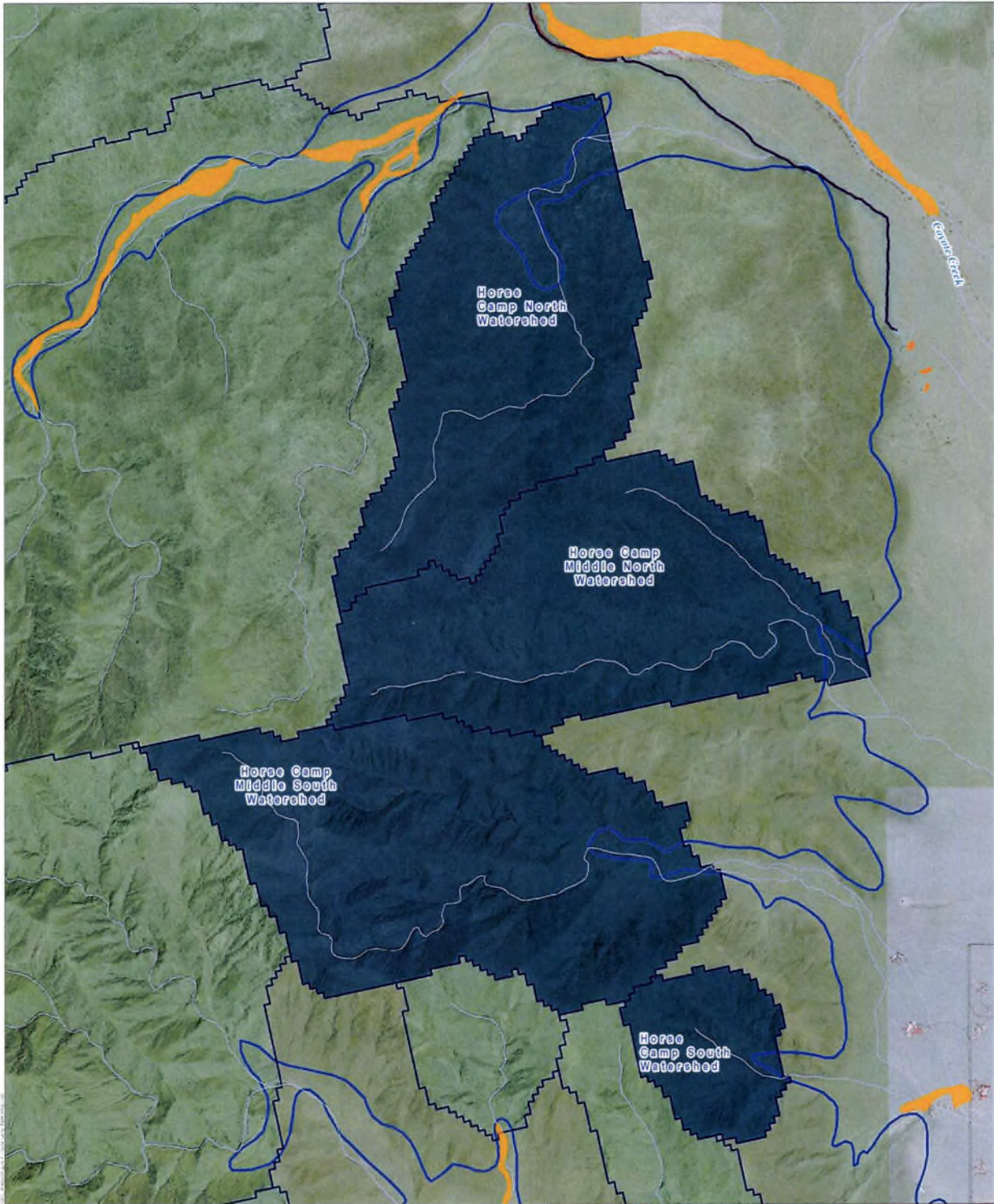
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Figure 3  
 Coyote Creek Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





DRAFT February 2019

DATUM: NAD 1983 DATA SOURCE: USGS NHD 2018, USGS Stream Stats 2018, California State Parks 2017, USDA 2016, DWR 2018

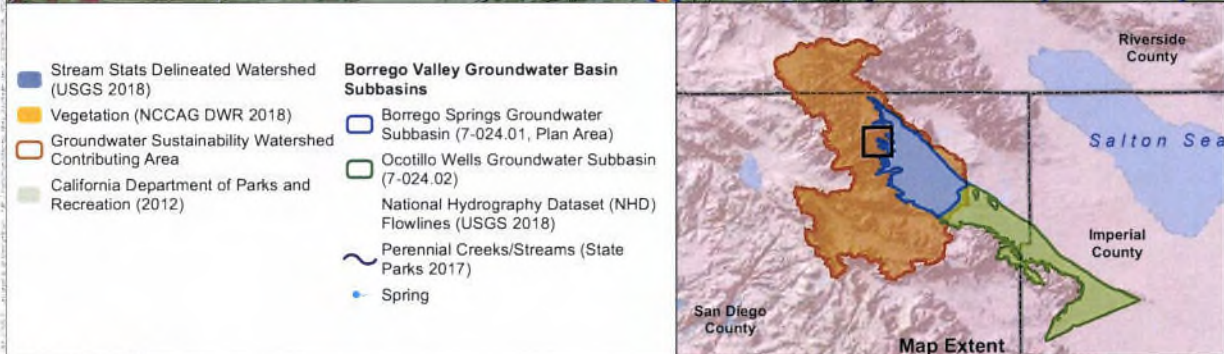
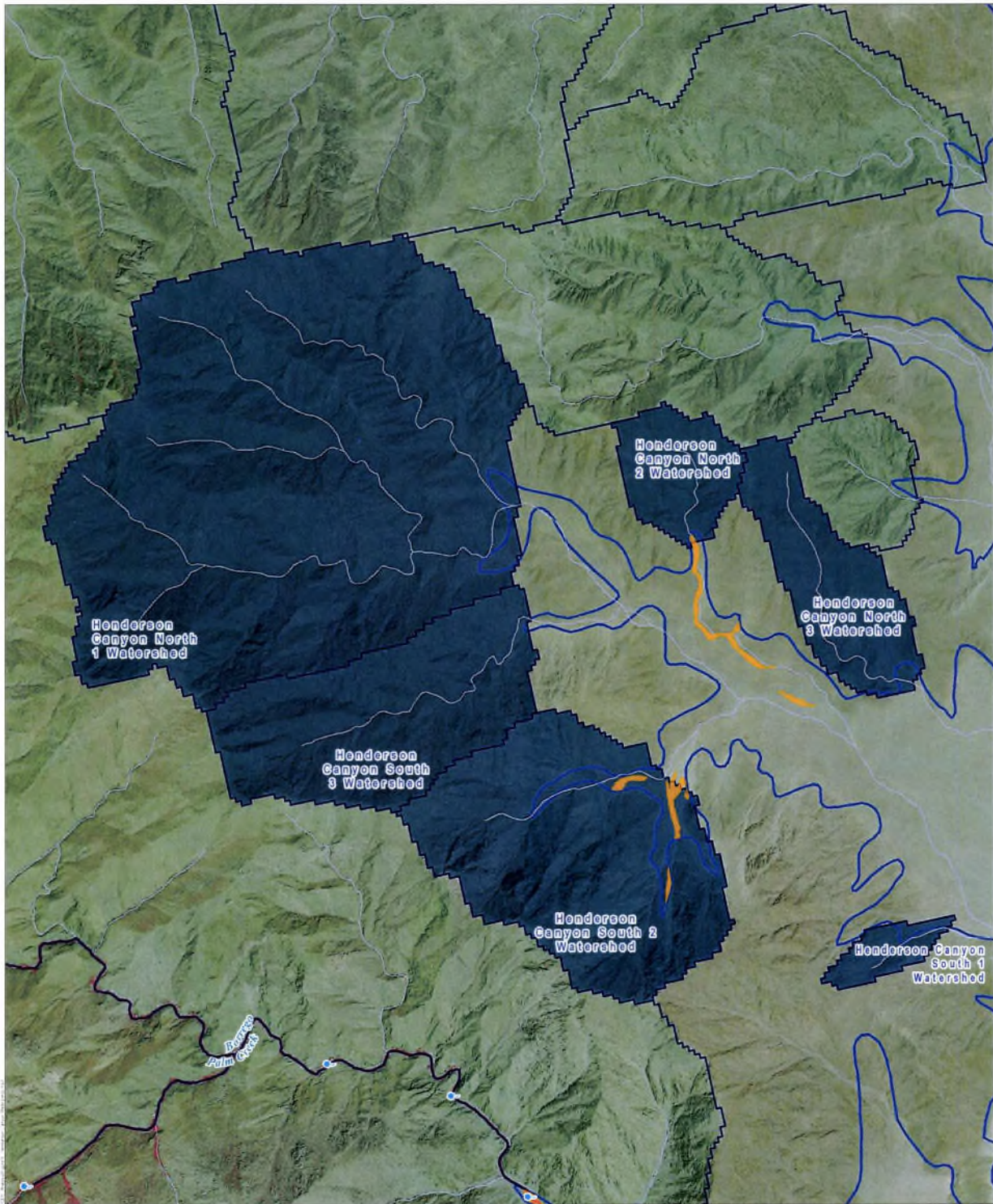


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Figure 4  
Horse Camp Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





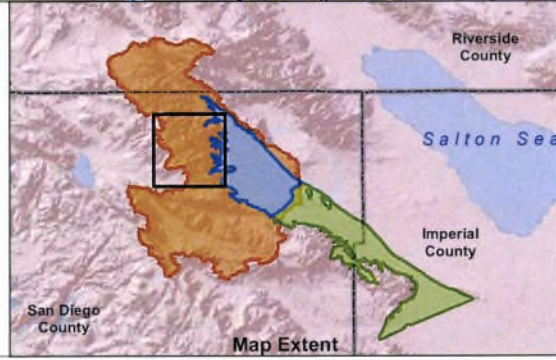
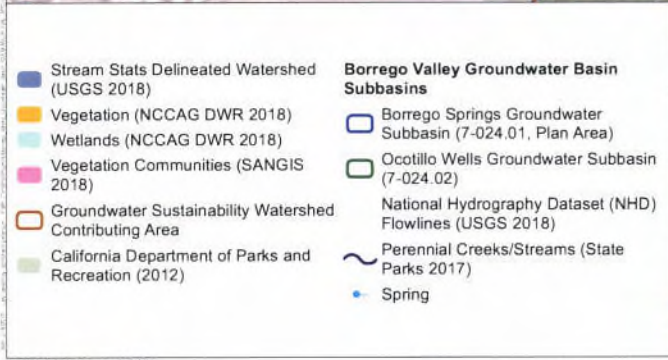
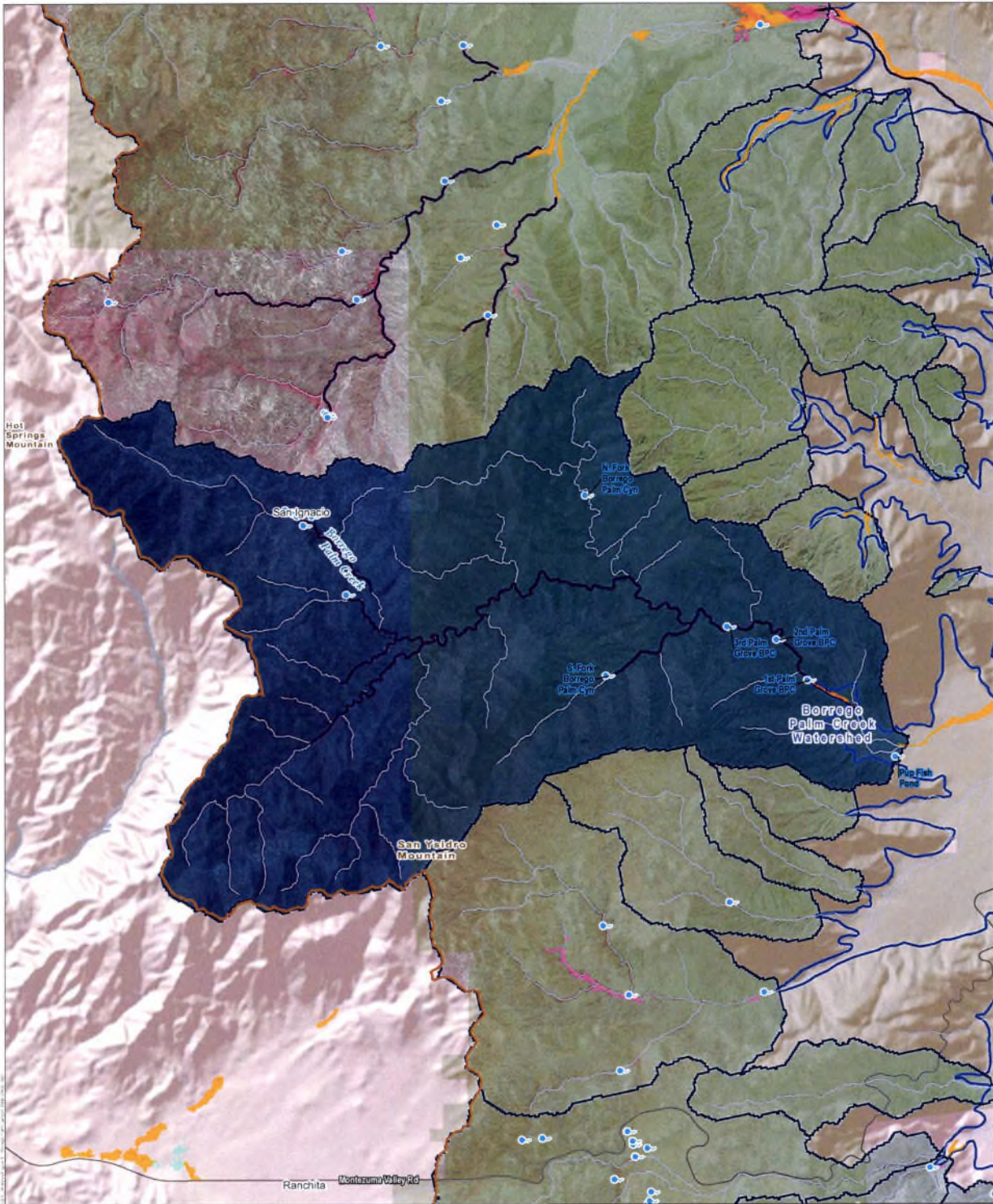
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DATUM NAD 1983 DATA SOURCE USGS NHD 2018, USGS Stream Stats 2018, California State Parks 2017, USDA 2016, DWR 2018



Figure 5  
Henderson Canyon Watersheds  
Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





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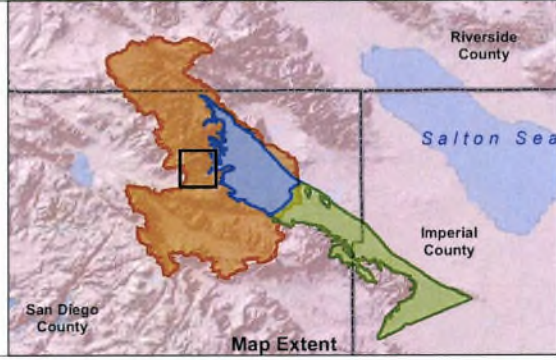
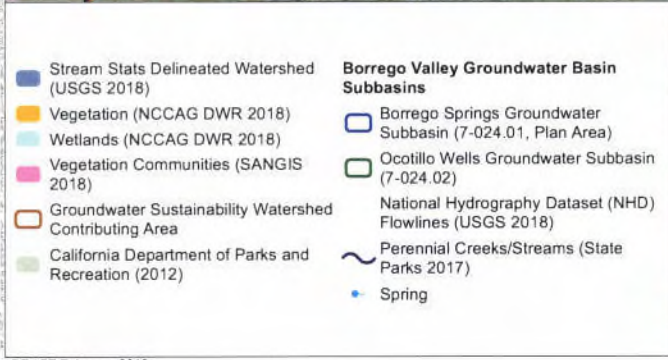
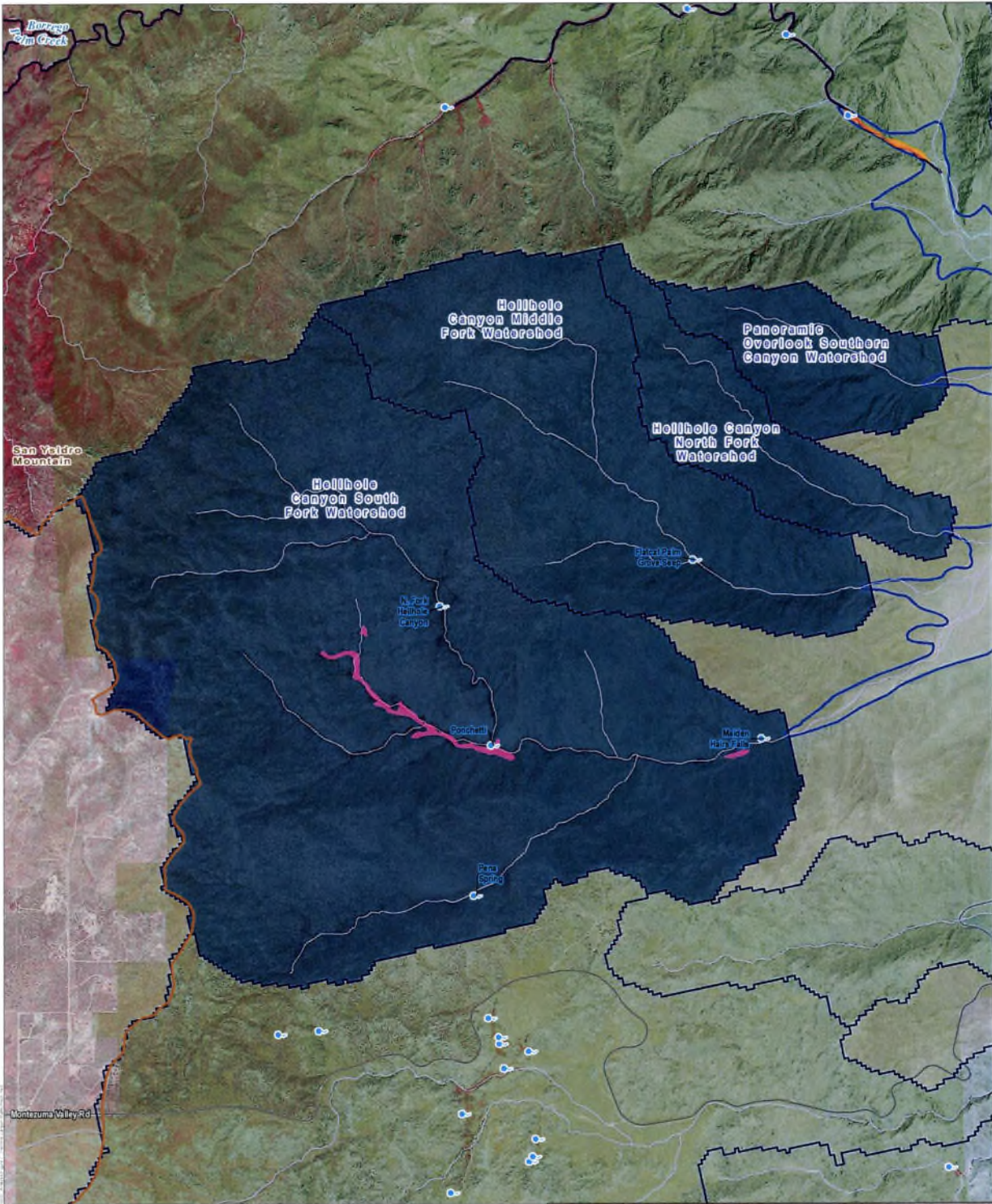
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Figure 6  
Borrego Palm Canyon Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





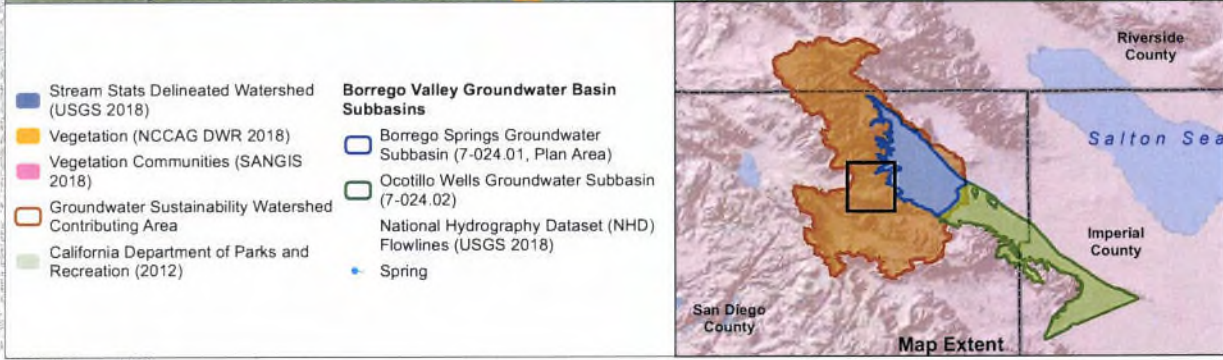
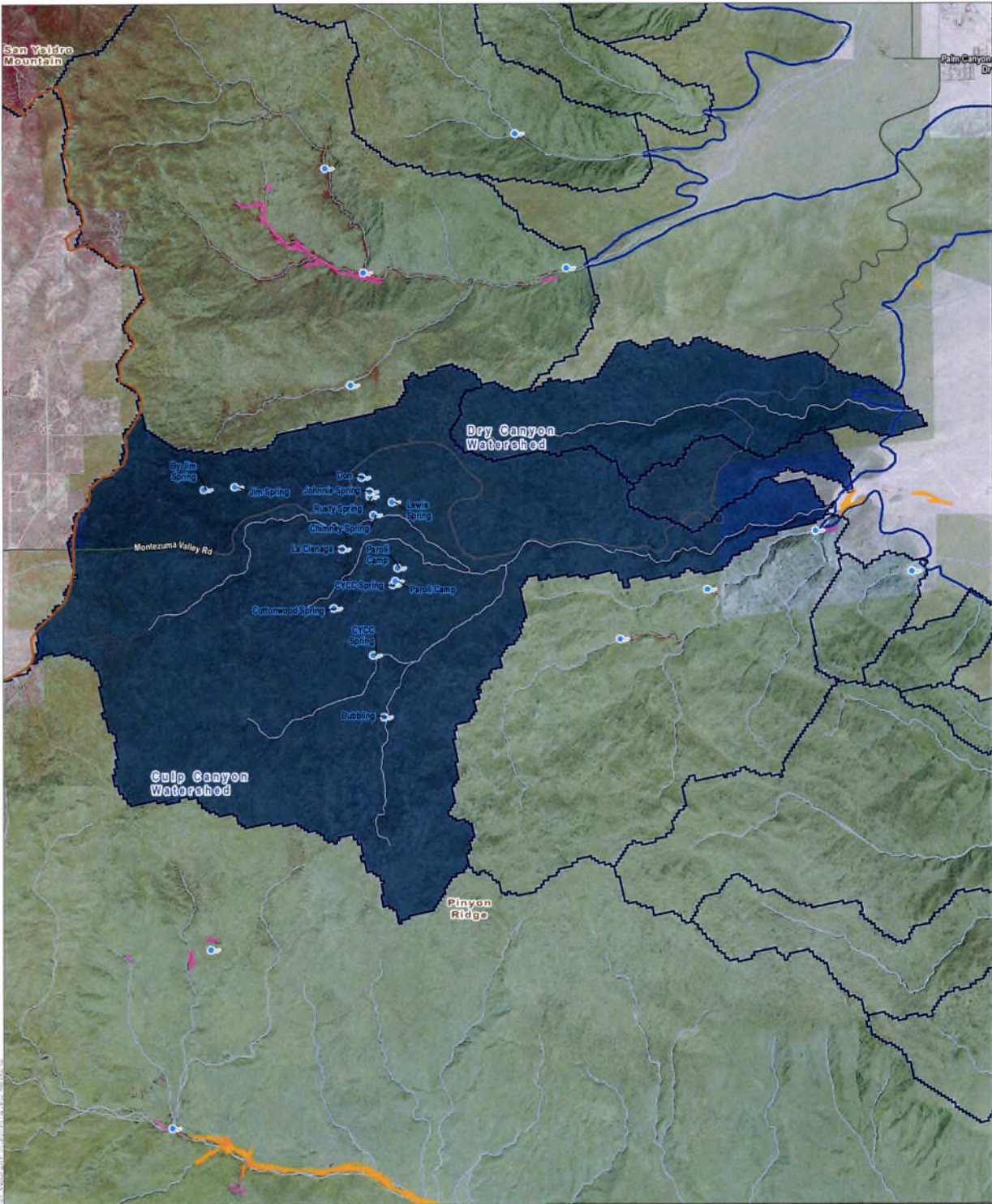
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Figure 7  
 Hellhole Canyon Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems



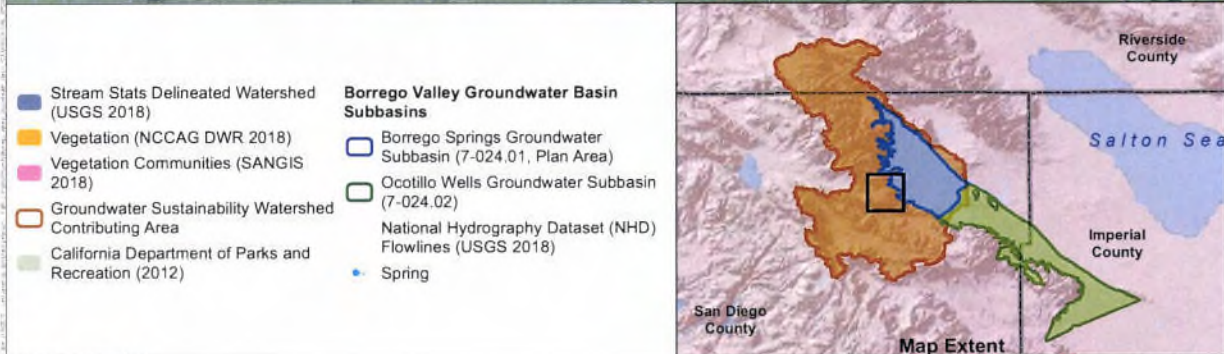
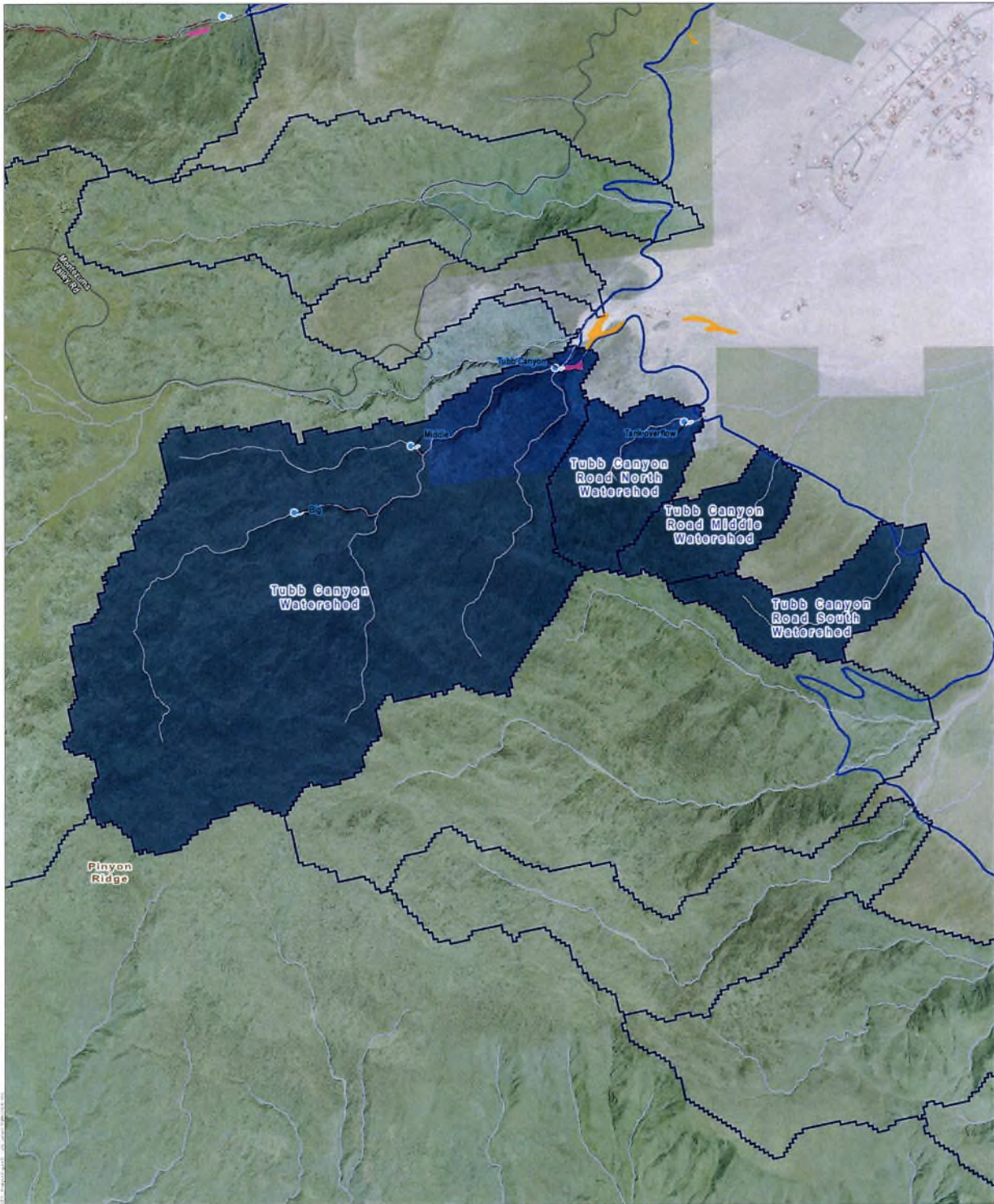


DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: USGS NHD 2016, USGS Stream Stats 2016, California State Parks 2017, USDA 2016, DWR 2018



Figure 8  
 Dry Canyon and Culp Canyon Watersheds  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





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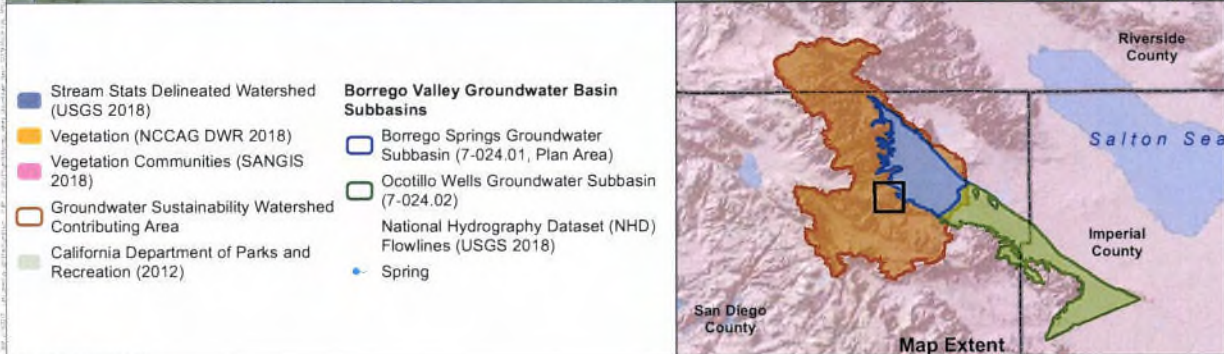
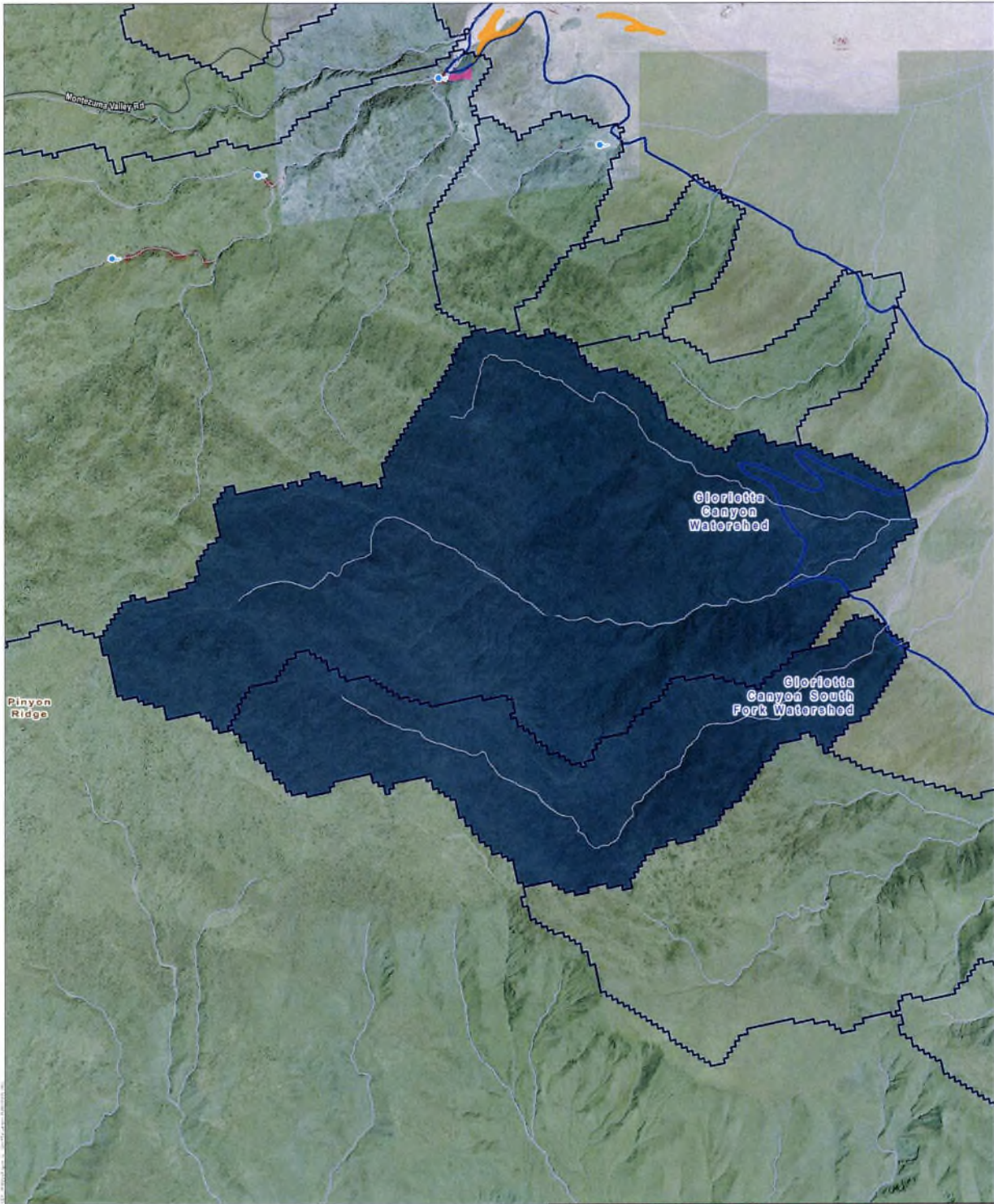
DATUM: NAD 1983. DATA SOURCE: USGS NHD 2018; USGS Stream Stats 2018; California State Parks 2017; USDA 2016; DWR 2018



Figure 9  
Tubb Canyon Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





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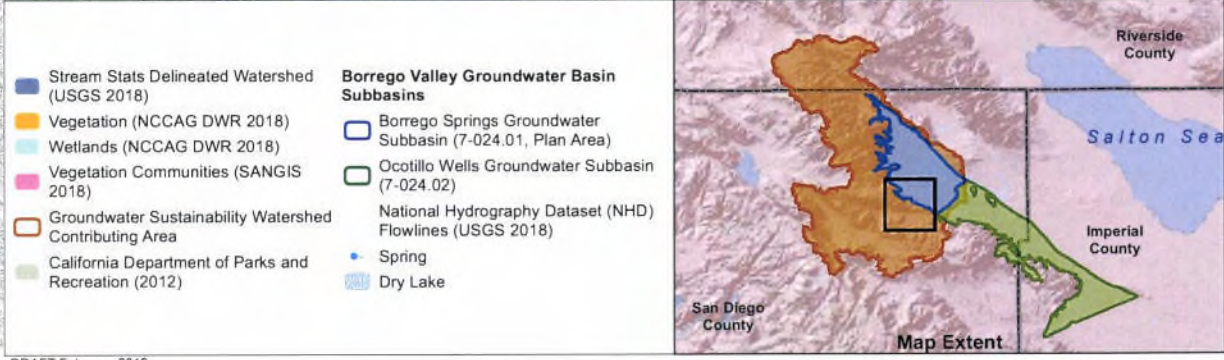
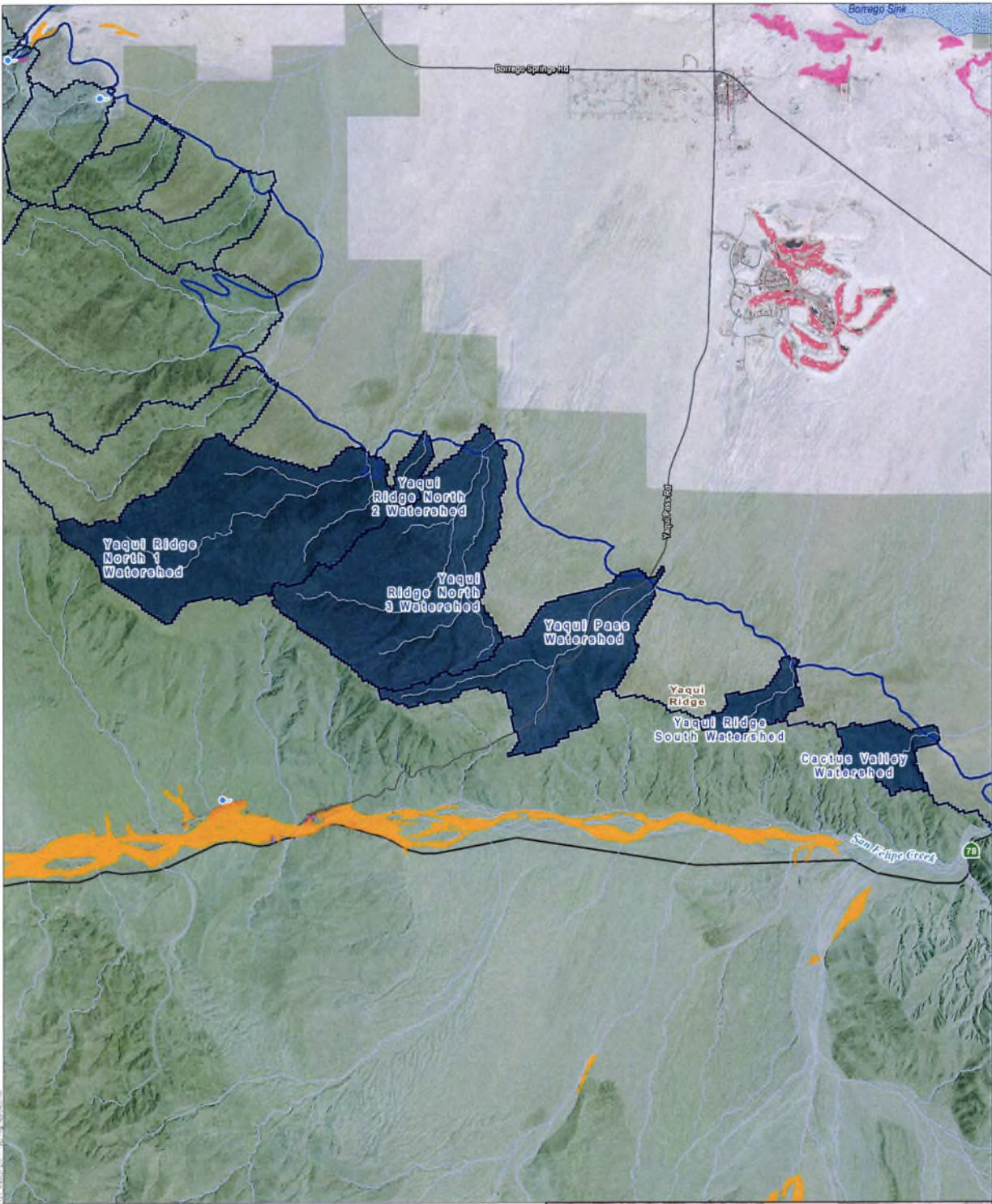
DATUM: NAD 1983 DATA SOURCE: USGS NHD 2018, USGS Stream Stats 2018, California State Parks 2017, USDA 2016, DWR 2018



Figure 10  
Glorietta Canyon Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: USGS NHD 2018; USGS Stream Stats 2018; California State Parks 2017; USDA 2016; DWR 2018

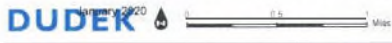
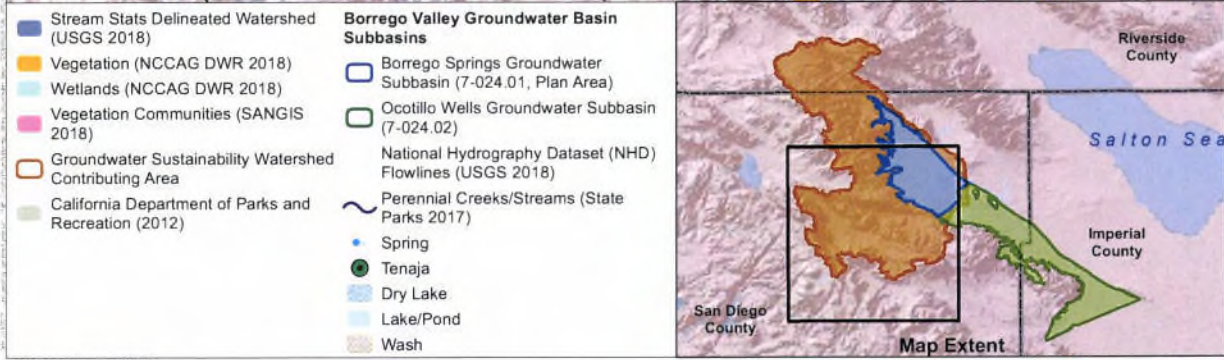
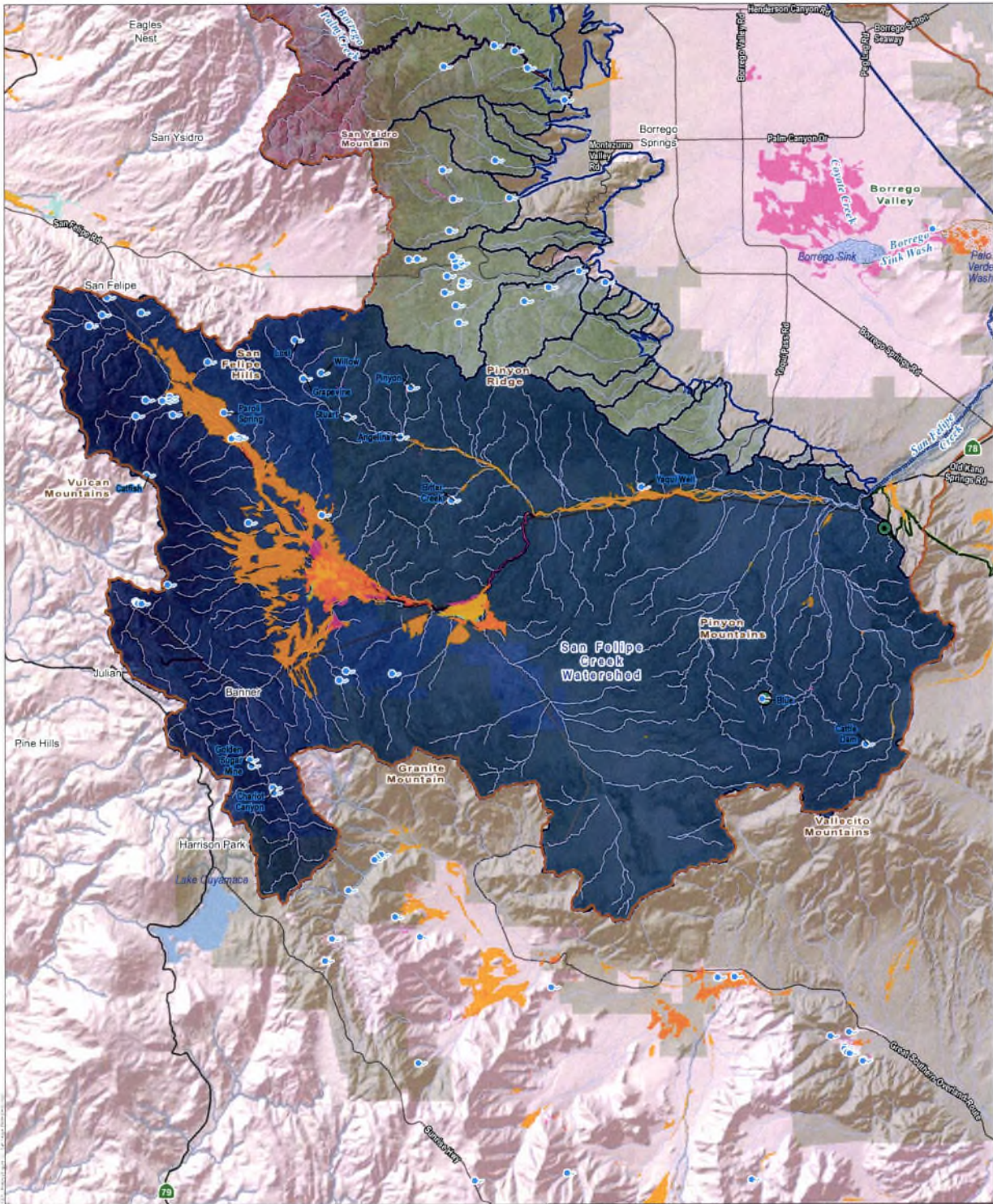


Figure 11  
 Yaqui Ridge Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





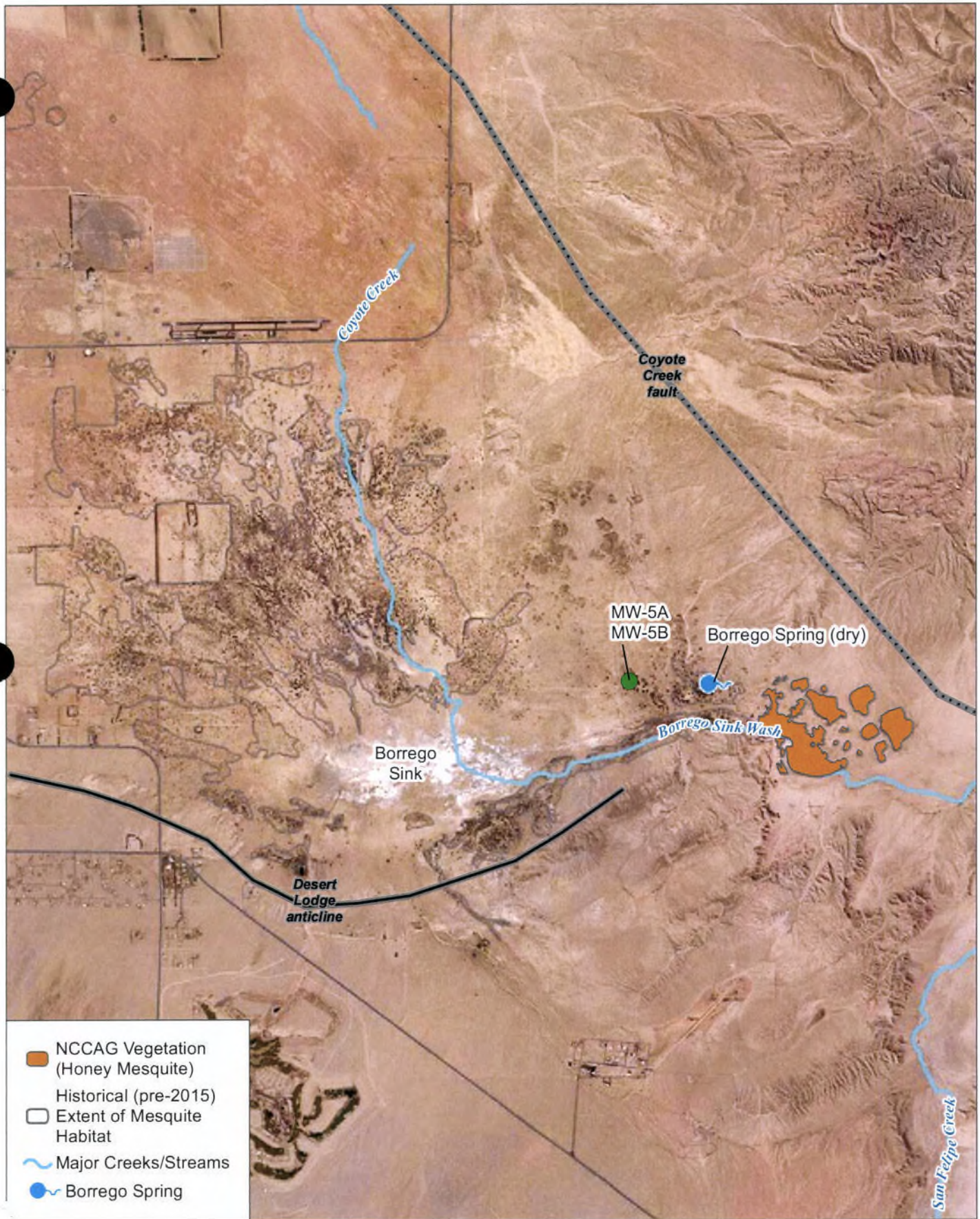
DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: USGS NHD 2018; USGS Stream Stats 2018; California State Parks 2017; USDA 2016; DWR 2018



Figure 12  
 San Felipe Watersheds

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems



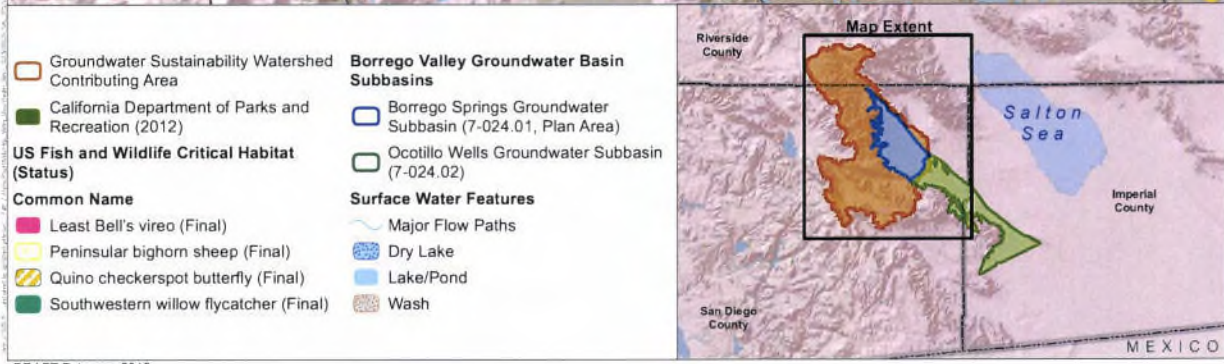
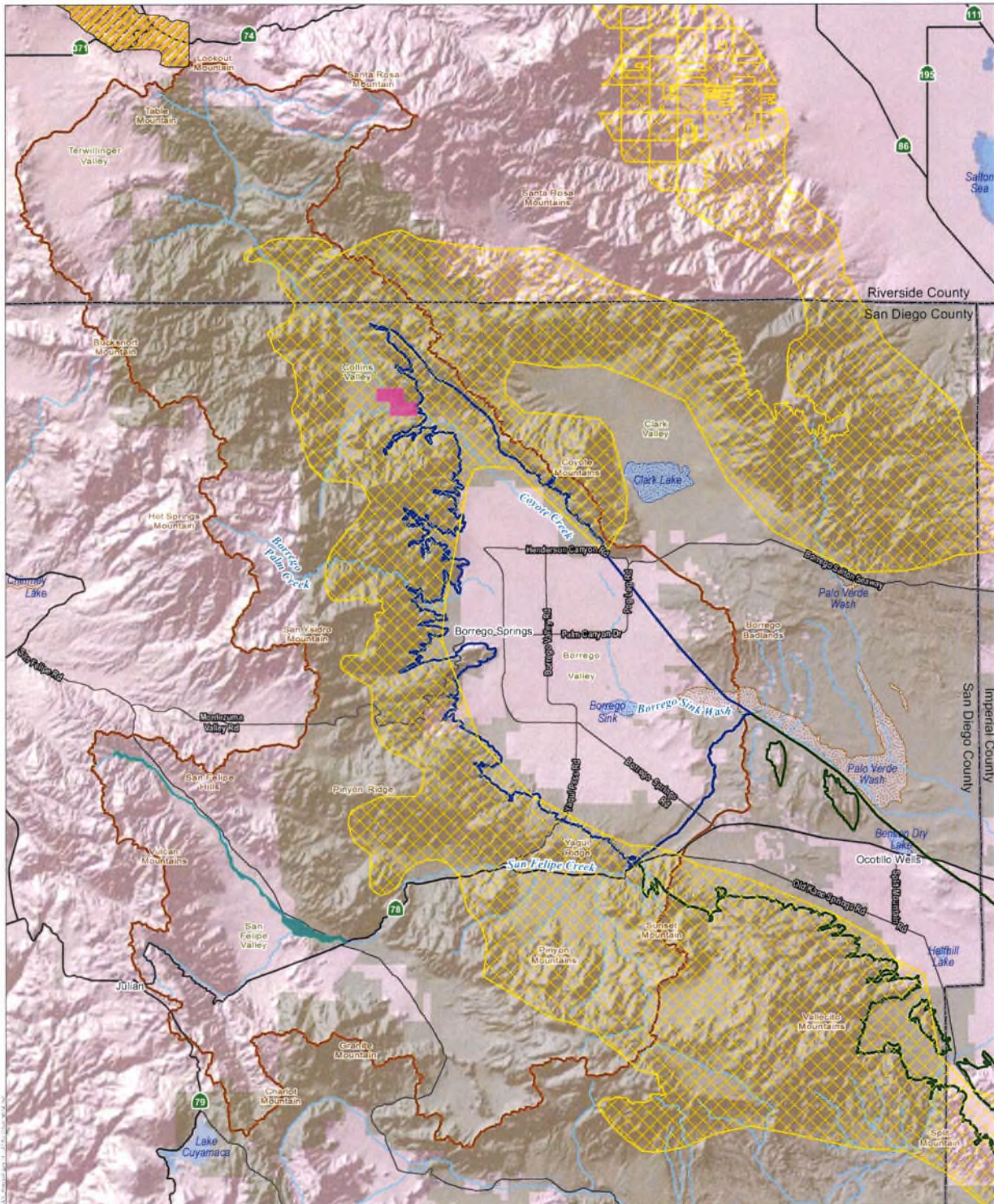


SOURCE: DWR, USGS NHD, SanGIS

Figure 13  
Borrego Sink Potential GDEs

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





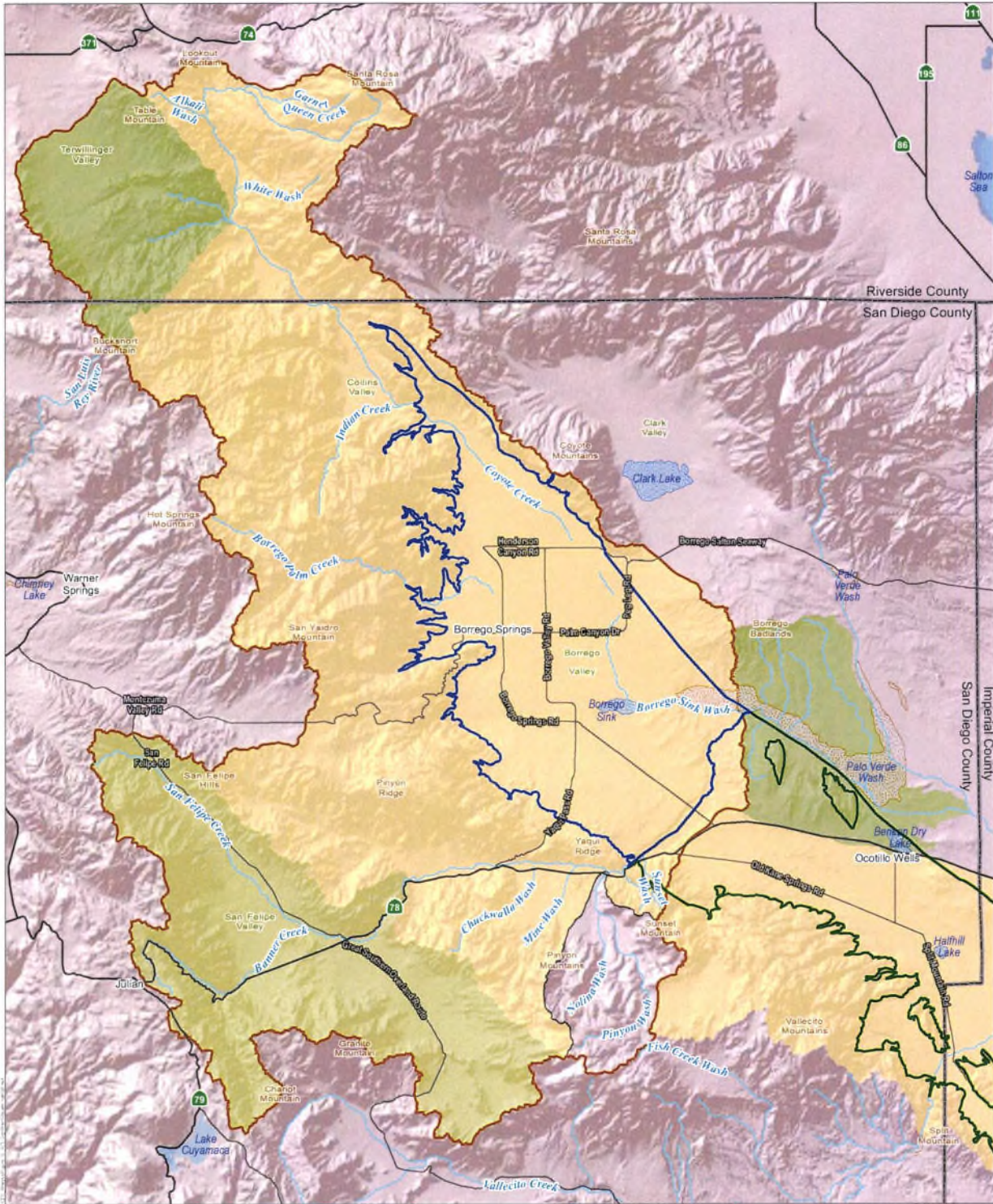
DRAFT February 2019  
 DATUM NAD 1983 DATA SOURCE USFWS 2018



Figure 14  
 US Fish and Wildlife Critical Habitat

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





**Areas of Conservation Emphasis Significant Aquatic Habitat Rank**

- 3 - medium
- 2
- 1 - low
- 0

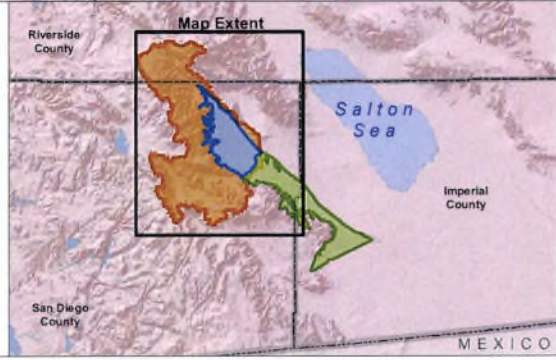
**Borrego Valley Groundwater Basin Subbasins**

- Borrego Springs Groundwater Subbasin (7-024.01, Plan Area)
- Ocotillo Wells Groundwater Subbasin (7-024.02)

**Surface Water Features**

- Major Flow Paths
- Dry Lake
- Lake/Pond
- Wash

**Groundwater Sustainability Watershed Contributing Area**



DRAFT February 2019  
 DATUM NAD 1983 DATA SOURCE CDFW 2018

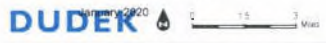
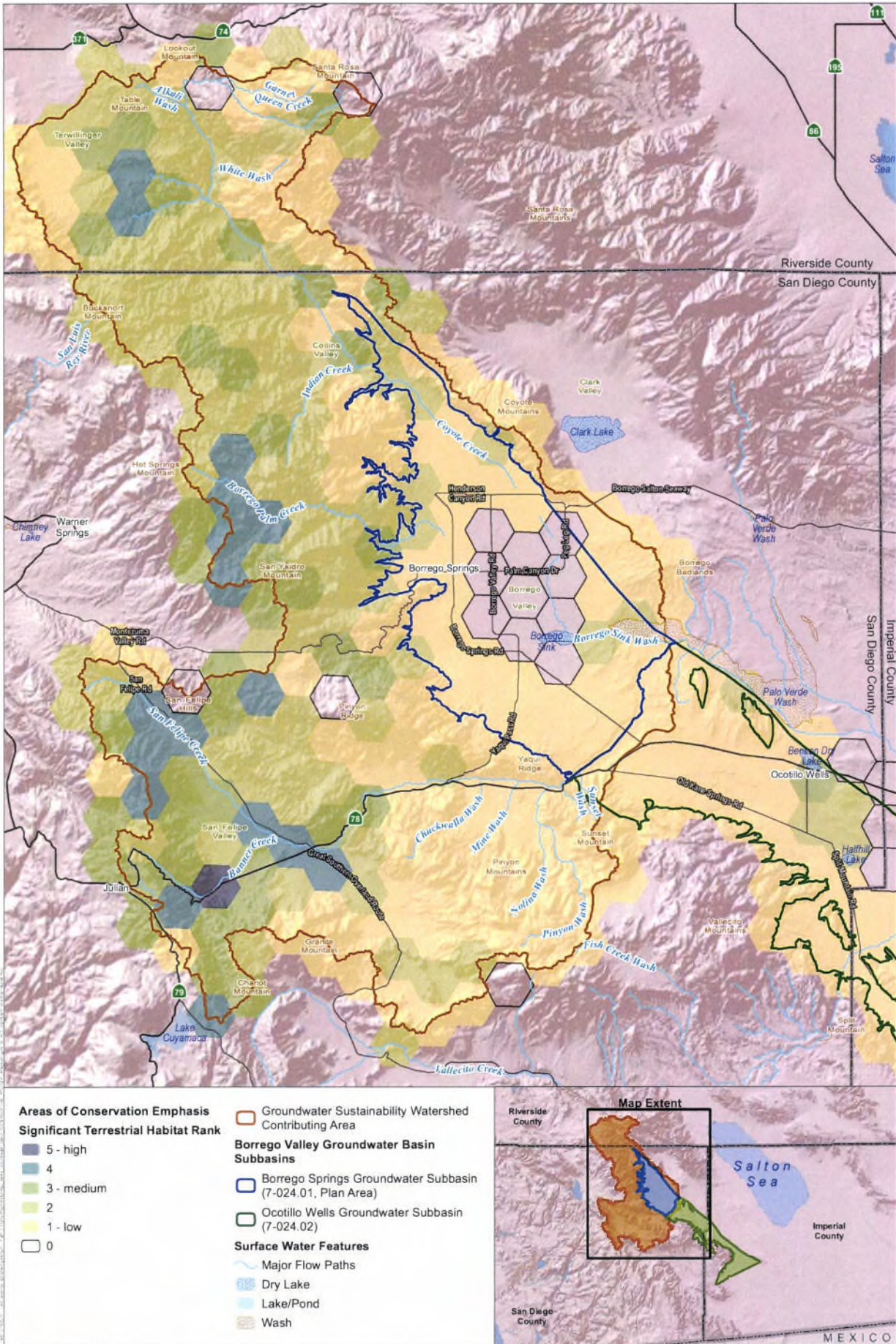


Figure 15  
 Areas of Conservation Emphasis (ACE) - Significant Aquatic Habitat  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





**Areas of Conservation Emphasis  
Significant Terrestrial Habitat Rank**

- 5 - high
- 4
- 3 - medium
- 2
- 1 - low
- 0

**Groundwater Sustainability Watershed  
Contributing Area**

**Borrego Valley Groundwater Basin  
Subbasins**

- Borrego Springs Groundwater Subbasin (7-024.01, Plan Area)
- Ocotillo Wells Groundwater Subbasin (7-024.02)

**Surface Water Features**

- Major Flow Paths
- Dry Lake
- Lake/Pond
- Wash

**Map Extent**

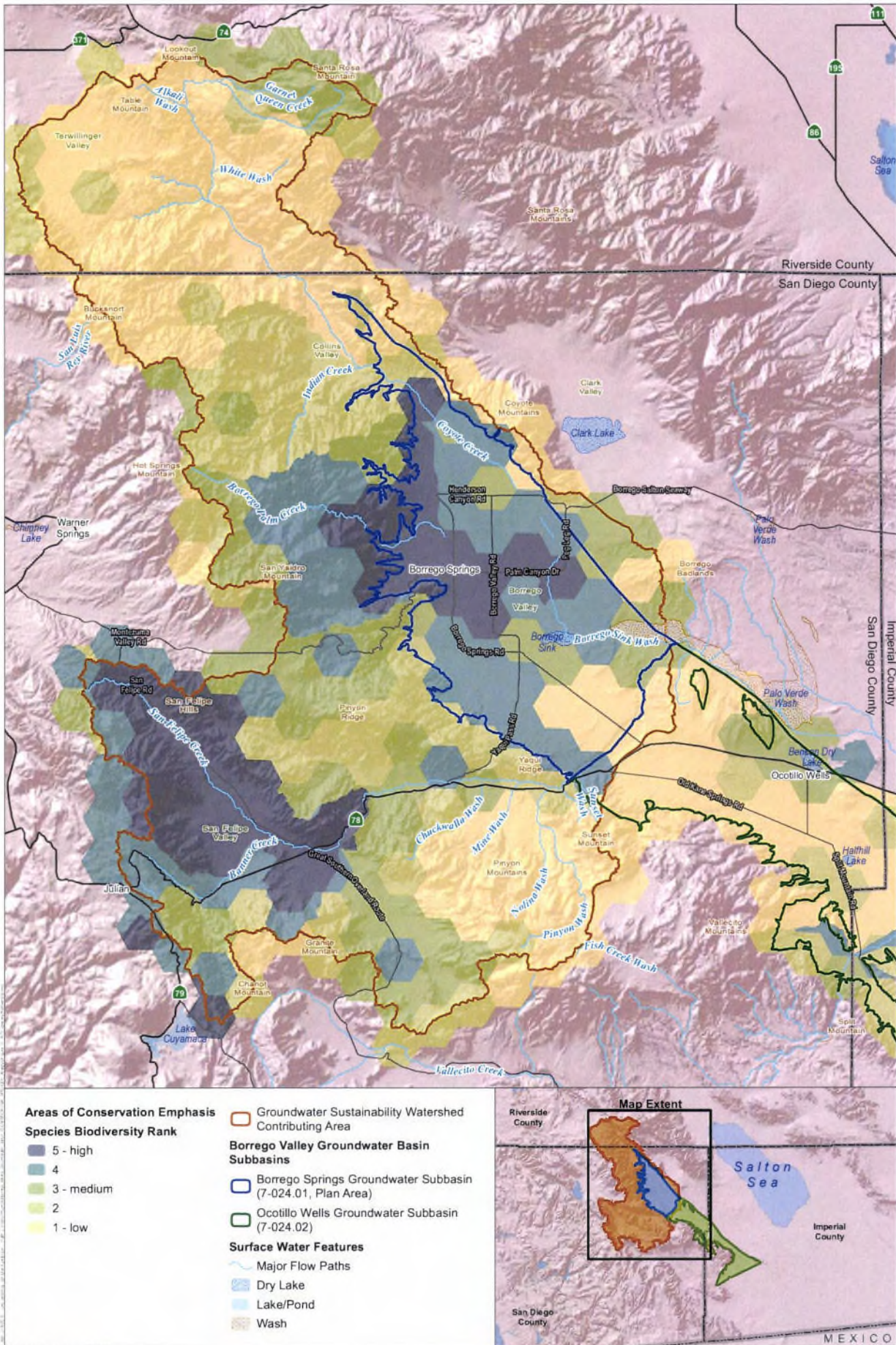


DRAFT February 2019  
DATUM NAD 1983 DATA SOURCE CDFW 2018



Figure 16  
Areas of Conservation Emphasis (ACE) - Significant Terrestrial Habitat  
Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





DRAFT February 2019  
 DATUM NAD 1983 DATA SOURCE CDFW 2018

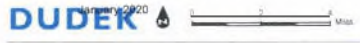
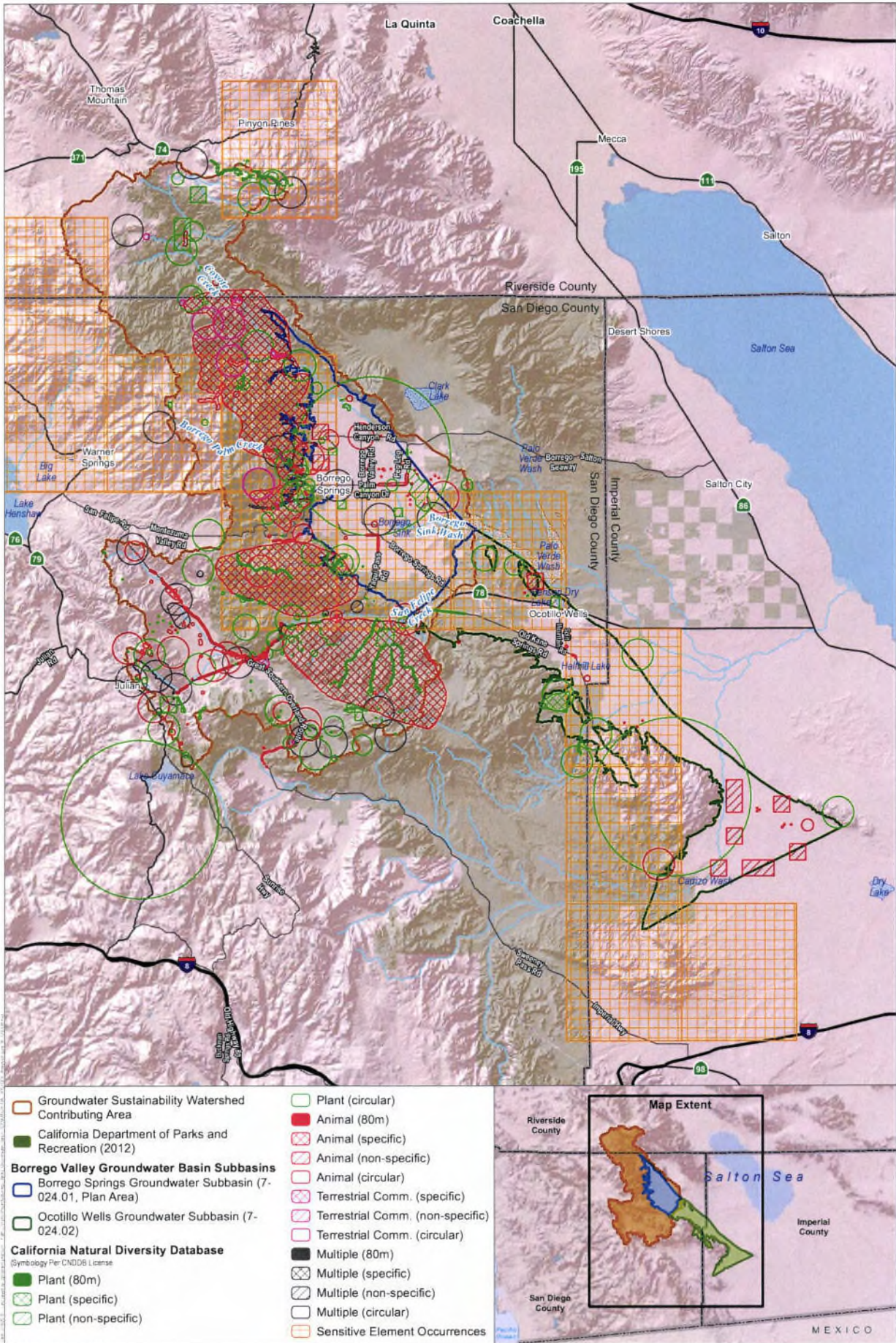


Figure 17  
 Areas of Conservation Emphasis (ACE) - Species Biodiversity  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





- Groundwater Sustainability Watershed Contributing Area
- California Department of Parks and Recreation (2012)
- Borrego Valley Groundwater Basin Subbasins**
- Borrego Springs Groundwater Subbasin (7-024.01, Plan Area)
- Ocotillo Wells Groundwater Subbasin (7-024.02)
- California Natural Diversity Database**  
(Symbology Per CNDDB License)
- Plant (80m)
- Plant (specific)
- Plant (non-specific)
- Animal (80m)
- Animal (specific)
- Animal (non-specific)
- Animal (circular)
- Terrestrial Comm. (specific)
- Terrestrial Comm. (non-specific)
- Terrestrial Comm. (circular)
- Multiple (80m)
- Multiple (specific)
- Multiple (non-specific)
- Multiple (circular)
- Sensitive Element Occurrences

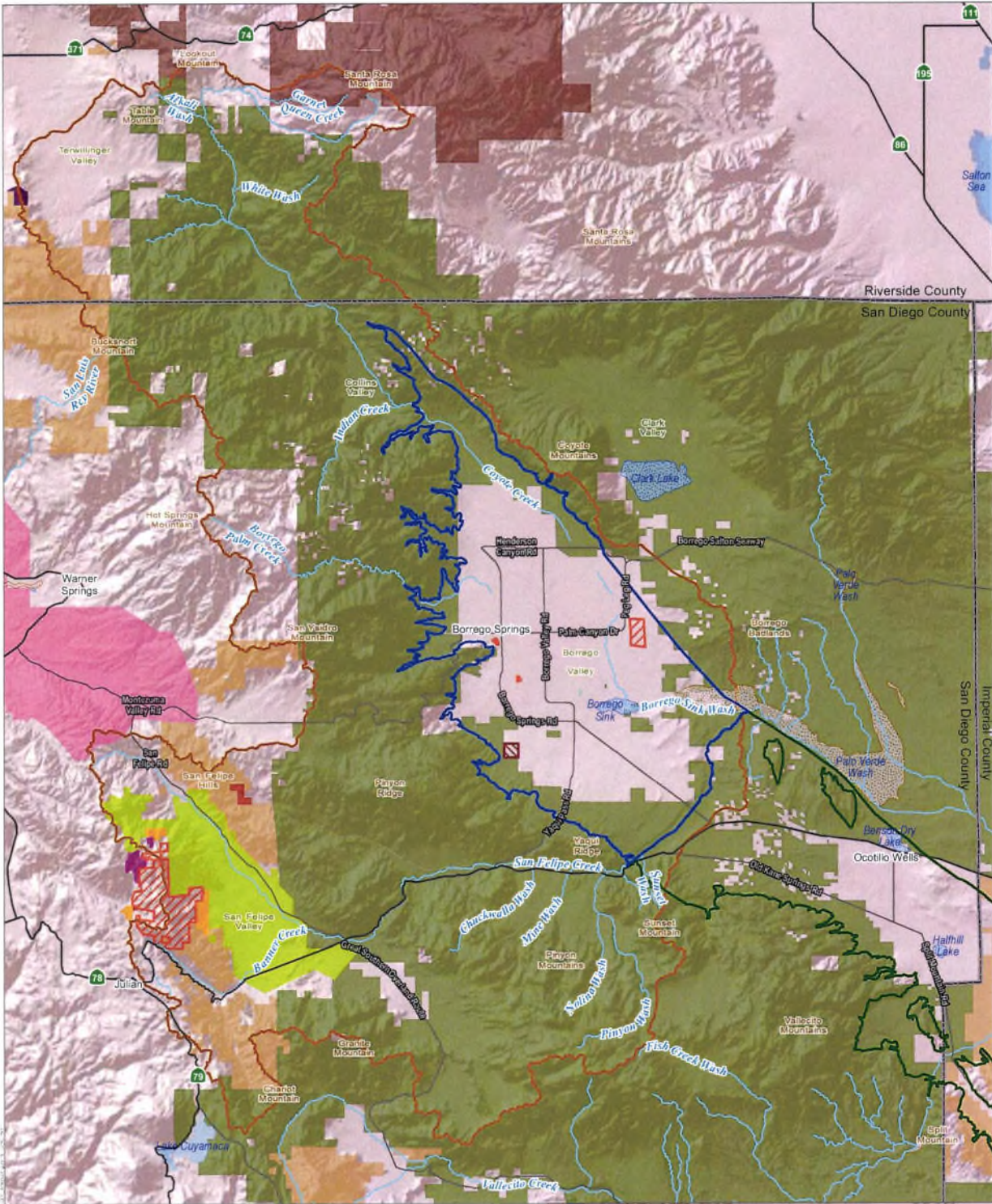


DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: CDFW 2016

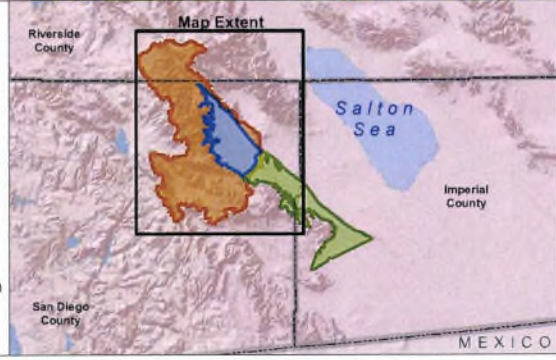


Figure 18  
 California Natural Diversity Database (CNDDB)  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems





- Groundwater Sustainability Watershed Contributing Area
- Borrego Springs Groundwater Subbasin (7-024.01, Plan Area)
- Ocotillo Wells Groundwater Subbasin (7-024.02)
- California Protected Areas**
- Managing Agency Super Units**
- Anza-Borrego Foundation
- Borrego Water District
- California Department of Fish and Wildlife
- California Department of Parks and Recreation
- San Diego County
- San Dieguito River Park Joint Powers Authority
- San Dieguito River Valley Land Conservancy
- United States Bureau of Land Management
- United States Forest Service
- Vista Irrigation District
- Volcan Mountain Preserve Foundation
- Western Riverside County Regional Conservation Authority



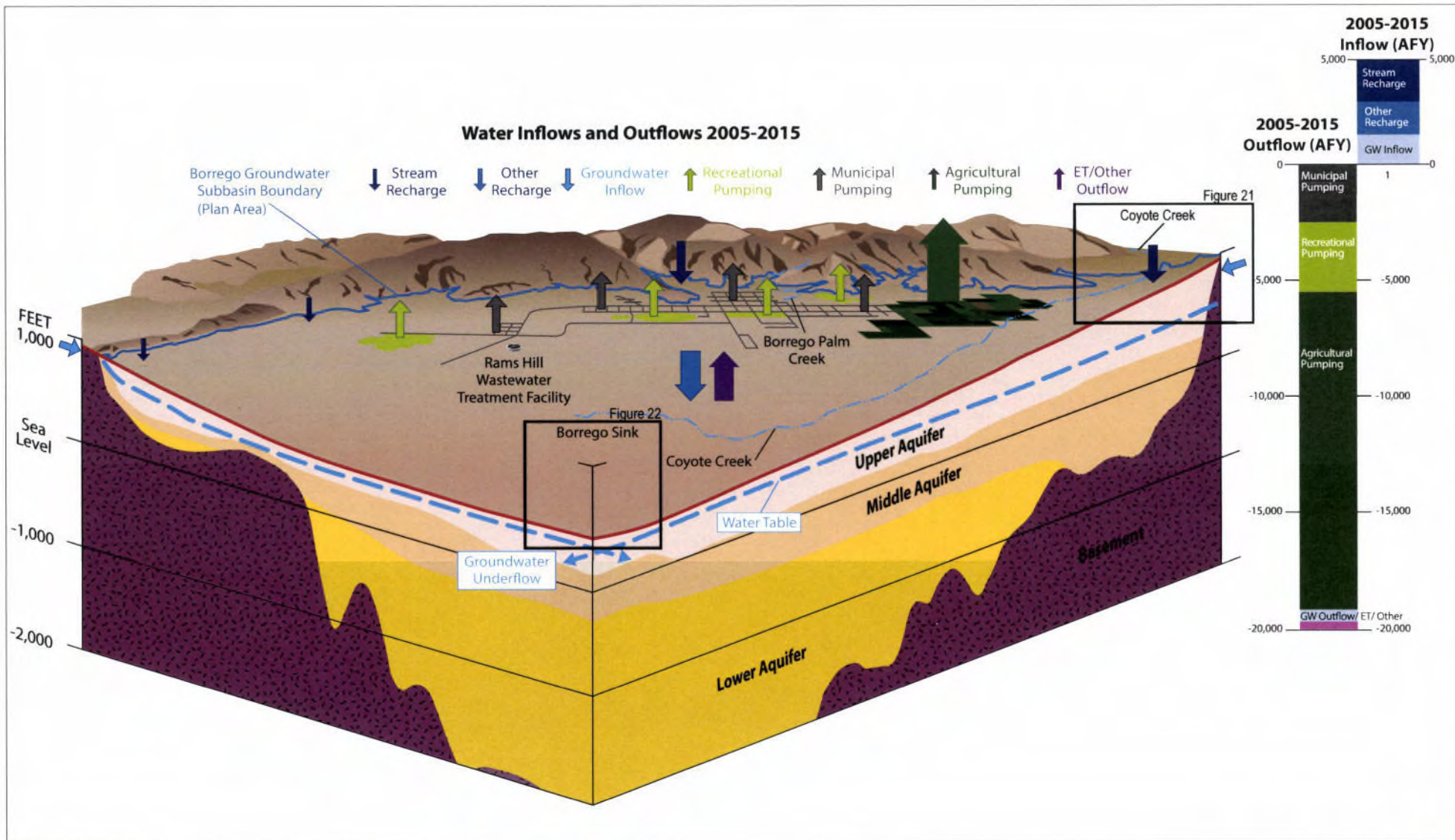
DRAFT February 2019  
 DATUM: NAD 1983 DATA SOURCE: CPAD 2017a



Figure 19  
 California Protected Areas Database (CPAD)  
 Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems



### Water Inflows and Outflows 2005-2015



SOURCE: USGS 1982 and USGS 2015

FIGURE 20





- 1 Source of water for perennial streams and NCCAGs is outside the basin boundary
- 2 Perennial streams transition to disconnected streams
- 3 Ephemeral streams lose water through a thick unsaturated zone
- 4 Cone of depression for pumping wells do not intersect GDEs

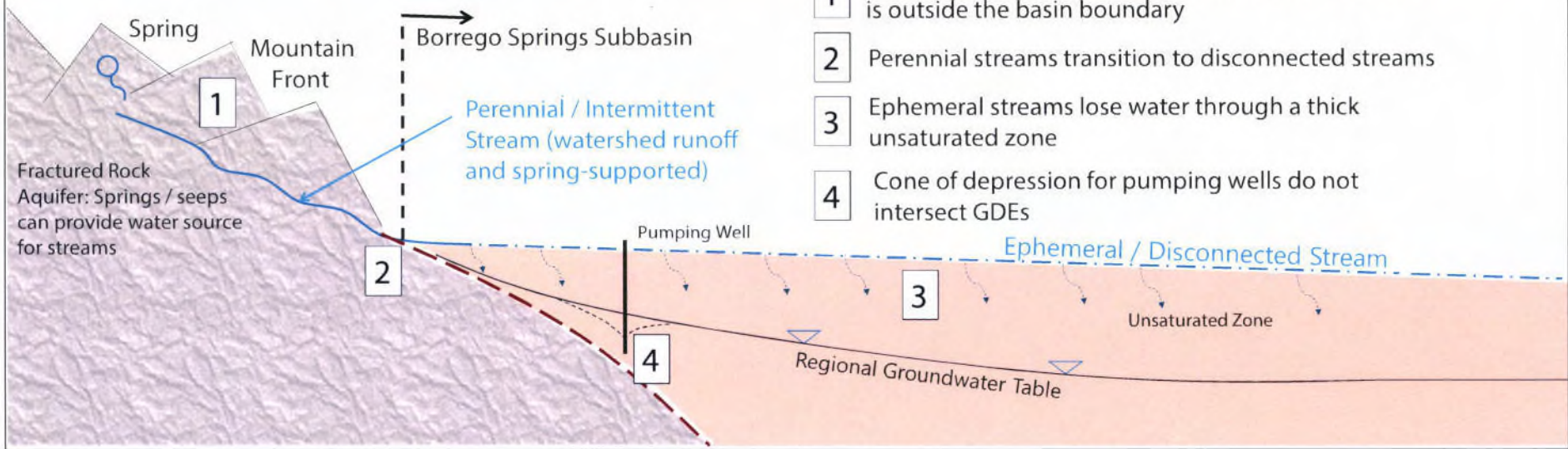
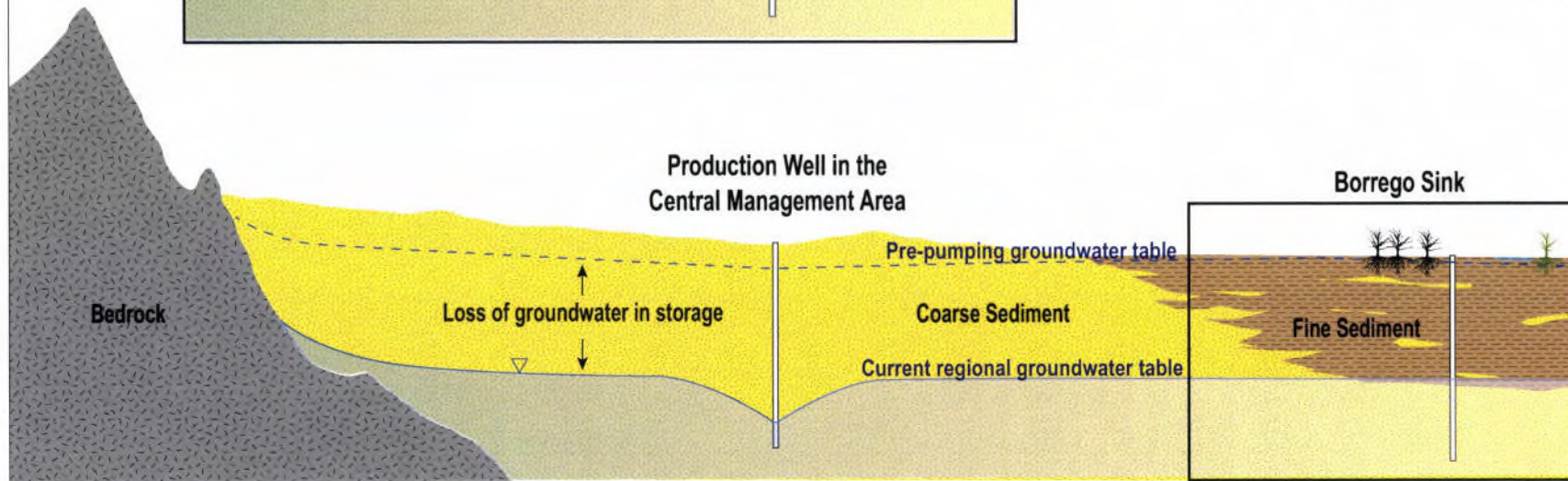
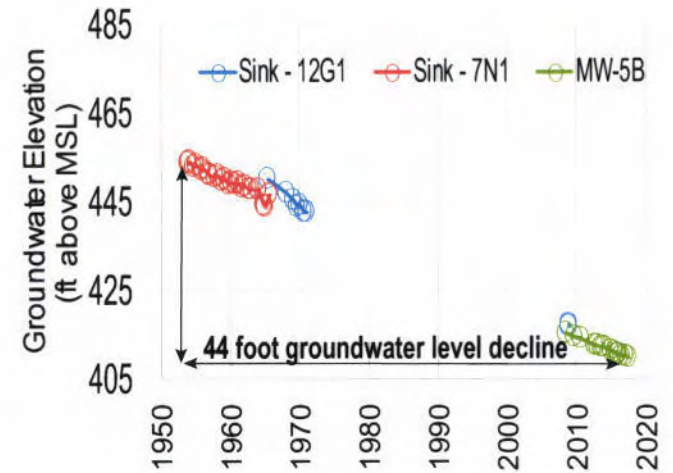
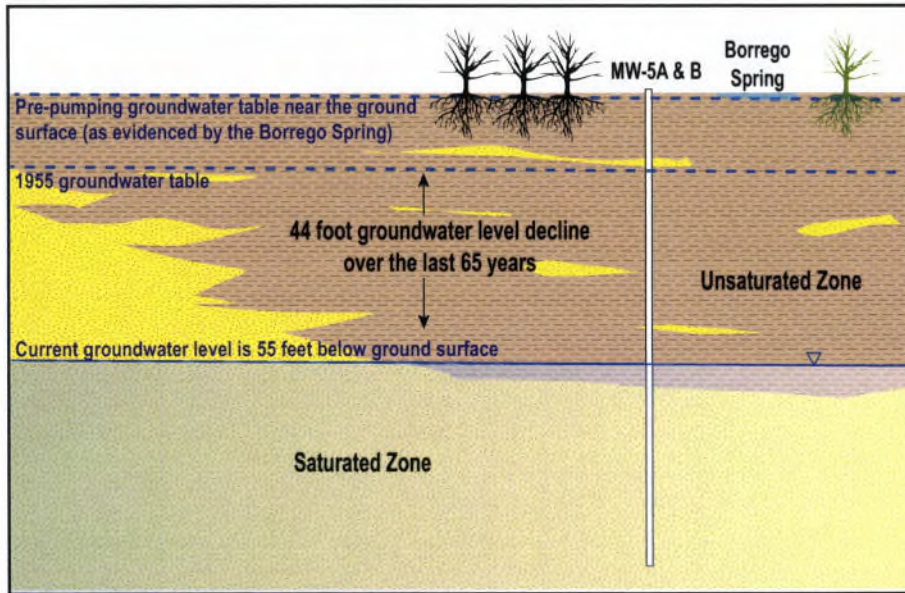


FIGURE 21

Contributing Watersheds Hydrogeologic Conceptual Model

Borrego Springs Subbasin Potential Groundwater Dependent Ecosystems







# Attachment 1

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California Freshwater Species Database (Borrego Springs  
Groundwater Subbasin)





California Freshwater Species Database (Porrego Springs Groundwater Subbasin)

Group	Scientific Name	Common Name	Federal List	State List	Other List	Agency	Type of Observation	Specificity	Source
Birds	<i>Vireo bellii pusillus</i>	Least Bell's Vireo	Endangered	Endangered		BLM	Current observations (post 1980)	Polygon	California Natural Diversity Database (4/2016)
Herps	<i>Actinemys marmorata marmorata</i>	Western Pond Turtle		Special Concern	ARSSC	BLM, USFS	Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Herps	<i>Anaxyrus boreas boreas</i>	Boreal Toad					Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Herps	<i>Anaxyrus californicus</i>	Arroyo Toad	Endangered	Special Concern	ARSSC		Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Herps	<i>Anaxyrus punctatus</i>	Red-spotted Toad					Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Herps	<i>Pseudacris cadaverina</i>	California Treefrog			ARSSC		Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Herps	<i>Thamnophis hammondi hammondi</i>	Two-striped Gartersnake		Special Concern	ARSSC	BLM, USFS	Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Mammals	<i>Castor canadensis</i>	American Beaver			Not on any status lists		Modeled habitat/generalized observation	Polygon	California Wildlife Habitat Relationships
Birds	<i>Actitis macularius</i>	Spotted Sandpiper					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Aechmophorus occidentalis</i>	Western Grebe					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Agelaius tricolor</i>	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority	BLM	Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Aix sponsa</i>	Wood Duck					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Anas acuta</i>	Northern Pintail					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Anas americana</i>	American Wigeon					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Anas americana</i>	American Wigeon					Current observations (post 1980)	Point	CLO EBIRD_CA

## California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Birds	Anas americana	American Wigeon					Current observations (post 1980)	Point	CLO GBBC
Birds	Anas americana	American Wigeon					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Anas clypeata	Northern Shoveler					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas crecca	Green-winged Teal					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas crecca	Green-winged Teal					Current observations (post 1980)	Point	CLO GBBC
Birds	Anas cyanoptera	Cinnamon Teal					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas cyanoptera	Cinnamon Teal					Current observations (post 1980)	Point	CLO GBBC
Birds	Anas discors	Blue-winged Teal					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	CLO EBIRD_CAN
Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	CLO GBBC
Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Anas strepera	Gadwall					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anas strepera	Gadwall					Current observations (post 1980)	Point	CLO GBBC
Birds	Anser albifrons	Greater White-fronted Goose					Current observations (post 1980)	Point	CLO EBIRD
Birds	Anser albifrons	Greater White-fronted Goose					Current observations (post 1980)	Point	CLO EBIRD_CA
Birds	Anser albifrons	Greater White-fronted Goose					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Ardea alba	Great Egret					Current observations (post 1980)	Point	CLO EBIRD
Birds	Ardea alba	Great Egret					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Ardea herodias	Great Blue Heron					Current observations (post 1980)	Point	CLO EBIRD
Birds	Aythya affinis	Lesser Scaup					Current observations (post 1980)	Point	CLO EBIRD

California Freshwater Species Database (Porrego Springs Groundwater Subbasin)

Birds	<i>Aythya americana</i>	Redhead		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Aythya collaris</i>	Ring-necked Duck					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Aythya collaris</i>	Ring-necked Duck					Current observations (post 1980)	Point	CLO GBBC
Birds	<i>Aythya valisineria</i>	Canvasback		Special			Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Aythya valisineria</i>	Canvasback		Special			Current observations (post 1980)	Point	CLO GBBC
Birds	<i>Botaurus lentiginosus</i>	American Bittern					Current observations (post 1980)	Point	SDNHM Birds
Birds	<i>Bucephala albeola</i>	Bufflehead					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Butorides virescens</i>	Green Heron					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Calidris mauri</i>	Western Sandpiper					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Calidris minutilla</i>	Least Sandpiper					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Calidris minutilla</i>	Least Sandpiper					Current observations (post 1980)	Point	SDNHM Birds
Birds	<i>Chen caerulescens</i>	Snow Goose					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Chen rossii</i>	Ross's Goose					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Chroicocephalus philadelphia</i>	Bonaparte's Gull					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Chroicocephalus philadelphia</i>	Bonaparte's Gull					Unknown	Point	SDNHM Birds
Birds	<i>Cistothorus palustris palustris</i>	Marsh Wren					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Egretta thula</i>	Snowy Egret					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Egretta thula</i>	Snowy Egret					Current observations (post 1980)	Point	CLO EBIRD_CA
Birds	<i>Empidonax traillii</i>	Willow Flycatcher	Bird of Conservation Concern	Endangered		USFS	Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Empidonax traillii brewsteri</i>	Willow Flycatcher	Bird of Conservation Concern	Endangered			Current observations (post 1980)	Point	SDNHM Birds

## California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Birds	<i>Fulica americana</i>	American Coot					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Fulica americana</i>	American Coot					Current observations (post 1980)	Point	CLO GBBC
Birds	<i>Fulica americana</i>	American Coot					Current observations (post 1980)	Point	iNaturalist Observations
Birds	<i>Gallinago delicata</i>	Wilson's Snipe					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Himantopus mexicanus</i>	Black-necked Stilt					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Icteria virens</i>	Yellow-breasted Chat		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Lophodytes cucullatus</i>	Hooded Merganser					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Megaceryle alcyon</i>	Belted Kingfisher					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Megaceryle alcyon</i>	Belted Kingfisher					Current observations (post 1980)	Point	CLO GBBC
Birds	<i>Mergus serrator</i>	Red-breasted Merganser					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron					Current observations (post 1980)	Point	iNaturalist Observations
Birds	<i>Oreothlypis luciae</i>	Lucy's Warbler		Special Concern	BSSC - Third priority	BLM	Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Oreothlypis luciae</i>	Lucy's Warbler		Special Concern	BSSC - Third priority	BLM	Current observations (post 1980)	Point	iNaturalist Observations
Birds	<i>Oxyura jamaicensis</i>	Ruddy Duck					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Oxyura jamaicensis</i>	Ruddy Duck					Current observations (post 1980)	Point	CLO GBBC
Birds	<i>Oxyura jamaicensis</i>	Ruddy Duck					Current observations (post 1980)	Point	iNaturalist Observations
Birds	<i>Pelecanus erythrorhynchos</i>	American White Pelican		Special Concern	BSSC - First priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Phalacrocorax auritus</i>	Double-crested Cormorant					Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Phalacrocorax auritus</i>	Double-crested Cormorant					Current observations (post 1980)	Point	CLO EBIRD_CAN

California Freshwater Species Database /Porrego Springs Groundwater Subbasin)

Birds	Phalacrocorax auritus	Double-crested Cormorant					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Piranga rubra	Summer Tanager		Special Concern	BSSC - First priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	Plegadis chihi	White-faced Ibis		Watch list			Current observations (post 1980)	Point	CLO EBIRD
Birds	Plegadis chihi	White-faced Ibis		Watch list			Current observations (post 1980)	Point	iNaturalist Observations
Birds	Podiceps nigricollis	Eared Grebe					Current observations (post 1980)	Point	CLO EBIRD
Birds	Podiceps nigricollis	Eared Grebe					Current observations (post 1980)	Point	iNaturalist Observations
Birds	Podilymbus podiceps	Pied-billed Grebe					Current observations (post 1980)	Point	CLO EBIRD
Birds	Porzana carolina	Sora					Current observations (post 1980)	Point	CLO EBIRD
Birds	Rallus limicola	Virginia Rail					Current observations (post 1980)	Point	CLO EBIRD
Birds	Rallus limicola	Virginia Rail					Unknown	Point	SDNHM Birds
Birds	Setophaga petechia	Yellow Warbler			BSSC - Second priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	Setophaga petechia	Yellow Warbler			BSSC - Second priority		Current observations (post 1980)	Point	iNaturalist Observations
Birds	Setophaga petechia	Yellow Warbler			BSSC - Second priority		Current observations (post 1980)	Point	SDNHM Birds
Birds	Tachycineta bicolor	Tree Swallow					Current observations (post 1980)	Point	CLO EBIRD
Birds	Tachycineta bicolor	Tree Swallow					Current observations (post 1980)	Point	CLO EBIRD_CA
Birds	Tachycineta bicolor	Tree Swallow					Current observations (post 1980)	Point	CLO GBBC
Birds	Tringa melanoleuca	Greater Yellowlegs					Current observations (post 1980)	Point	CLO EBIRD
Birds	Tringa semipalmata	Willet					Current observations (post 1980)	Point	CLO EBIRD
Birds	Tringa solitaria	Solitary Sandpiper					Current observations (post 1980)	Point	CLO EBIRD
Birds	Vireo bellii	Bell's Vireo					Current observations (post 1980)	Point	CLO EBIRD

California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Birds	<i>Vireo bellii arizonae</i>	Arizona Bell's Vireo	Bird of Conservation Concern	Endangered		BLM	Current observations (post 1980)	Point	SDNHM Birds
Birds	<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	CLO EBIRD
Birds	<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	SDNHM Birds
Fishes	<i>Cyprinodon macularius</i>	Desert pupfish	Endangered	Endangered	Endangered - Moyle 2013		Current observations (post 1980)	Point	California Natural Diversity Database (4/2016)
Herps	<i>Anaxyrus boreas boreas</i>	Boreal Toad					Current observations (post 1980)	Point	CAS HERP
Herps	<i>Anaxyrus boreas boreas</i>	Boreal Toad					Current observations (post 1980)	Point	iNaturalist Observations
Herps	<i>Anaxyrus boreas boreas</i>	Boreal Toad					Current observations (post 1980)	Point	SDNHM Herps
Herps	<i>Anaxyrus boreas halophilus</i>	California Toad			ARSSC		Current observations (post 1980)	Point	CAS HERP
Herps	<i>Anaxyrus punctatus</i>	Red-spotted Toad					Current observations (post 1980)	Point	iNaturalist Observations
Herps	<i>Pseudacris cadaverina</i>	California Treefrog			ARSSC		Current observations (post 1980)	Point	CAS HERP
Herps	<i>Pseudacris cadaverina</i>	California Treefrog			ARSSC		Current observations (post 1980)	Point	iNaturalist Observations
Herps	<i>Pseudacris cadaverina</i>	California Treefrog			ARSSC		Current observations (post 1980)	Point	SDNHM Herps
Herps	<i>Pseudacris regilla</i>	Northern Pacific Chorus Frog					Current observations (post 1980)	Point	CAS HERP
Insects & other inverts	<i>Abedus</i> spp.	<i>Abedus</i> spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	<i>Anax junius</i>	Common Green Darner					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	<i>Argia nahuana</i>	Aztec Dancer					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	<i>Argia</i> spp.	<i>Argia</i> spp					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012

Insects & other inverts	<i>Argia vivida</i>	Vivid Dancer					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	<i>Argia vivida</i>	Vivid Dancer					Unknown	Point	CASENT Arthropods
Insects & other inverts	<i>Argia vivida</i>	Vivid Dancer					Unknown	Point	LACMENT
Insects & other inverts	<i>Baetis adonis</i>	A Mayfly					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	<i>Baetis</i> spp.	<i>Baetis</i> spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Belostomatidae fam.	Belostomatidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	<i>Callibaetis</i> spp.	<i>Callibaetis</i> spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	<i>Chaetarthria pallida</i>					Not on any status lists	Unknown	Point	SBMNH SBMNH-ENT
Insects & other inverts	Chironomidae fam.	Chironomidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Coenagrionidae fam.	Coenagrionidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	<i>Cricotopus</i> spp.	<i>Cricotopus</i> spp					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012

## California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Insects & other inverts	Cryptochironomus spp.	Cryptochironomus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Enallagma civile	Familiar Bluet					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Erpetogomphus compositus	White-belted Ringtail					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Erpetogomphus spp	Erpetogomphus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Erythemis collocata	Western Pondhawk					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Eucorethra underwoodi					Not on any status lists	Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Eukiefferiella spp.	Eukiefferiella spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Fallceon quilleri	A Mayfly					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Fallceon spp.	Fallceon spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Gomphidae fam.	Gomphidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Helichus spp.	Helichus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012



Insects & other inverts	Helicopsyche spp.	Helicopsyche spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Hetaerina americana	American Rubyspot					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Hetaerina americana	American Rubyspot					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Heterelmis obesa					Not on any status lists	Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Heterotrissocladius spp.	Heterotrissocladius spp					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Hydropsyche spp.	Hydropsyche spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Hydropsychidae fam.	Hydropsychidae fam					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Hydroptila spp.	Hydroptila spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Hydroptilidae fam.	Hydroptilidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Laccobius spp.	Laccobius spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012

## California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Insects & other inverts	Larsia spp.	Larsia spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Lauterborniella spp.	Lauterborniella spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Lethocerus americanus					Not on any status lists	Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Libellula croceipennis	Neon Skimmer					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Libellula saturata	Flame Skimmer					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Libellula saturata	Flame Skimmer					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Libellulidae fam.	Libellulidae fam.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Macrodiplax balleata	Marl Pennant					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Meropelopia spp.	Meropelopia spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Nilotanypus spp.	Nilotanypus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Ochrotrichia spp.	Ochrotrichia spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012

Insects & other inverts	Ophiogomphus spp.	Ophiogomphus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Orthemis ferruginea	Roseate Skimmer					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Pachydiplax longipennis	Blue Dasher					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Palaethemis lineatipes	Red Rock Skimmer					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Pantala flavescens	Wandering Glider					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Paracladopelma spp.	Paracladopelma spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Parametricnemus spp.	Parametricnemus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Paratendipes spp.	Paratendipes spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Peltodytes spp.	Peltodytes spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Pentaneura spp.	Pentaneura spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Perithemis intensa	Mexican Amberwing					Current observations (post 1980)	Point	iNaturalist Observations

California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Insects & other inverts	Phaenopsectra spp.	Phaenopsectra spp					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Polypedilum spp.	Polypedilum spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Postelichus spp.	Postelichus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Pseudochironomus spp.	Pseudochironomus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Radotanypus spp.	Radotanypus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Rhagovelia spp.	Rhagovelia spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Rheotanytarsus spp.	Rheotanytarsus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Rhionaeschna multicolor	Blue-eyed Darner					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Sanfilippodytes spp.	Sanfilippodytes spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Simulium spp.	Simulium spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012

Insects & other inverts	Sperchon spp.	Sperchon spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Stictotarsus striatellus				Not on any status lists		Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Stictotarsus striatellus				Not on any status lists		Unknown	Point	SBMNH SBMNH-ENT
Insects & other inverts	Sympetrum corruptum	Variegated Meadowhawk					Current observations (post 1980)	Point	California dragonfly and damselfly database
Insects & other inverts	Sympetrum corruptum	Variegated Meadowhawk					Current observations (post 1980)	Point	iNaturalist Observations
Insects & other inverts	Sympetrum spp.	Sympetrum spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Tanytarsus spp.	Tanytarsus spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Insects & other inverts	Tinodes spp.	Tinodes spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Mollusks	Physa spp.	Physa spp.					Current observations (post 1980)	Point	SWAMP via CEDEN. Download 10 April 2014, Obs before 13 July 2012
Plants	Baccharis salicina				Not on any status lists		Current observations (post 1980)	Point	SD SD
Plants	Castilleja minor minor	Alkali Indian-paintbrush					Current observations (post 1980)	Point	SD SD
Plants	Castilleja minor spiralis	Large-flower Annual Indian-paintbrush					Current observations (post 1980)	Point	Calflora
Plants	Castilleja minor spiralis	Large-flower Annual Indian-paintbrush					Current observations (post 1980)	Point	SD

California Freshwater Species Database (Borrego Springs Groundwater Subbasin)

Plants	Datisca glomerata	Durango Root					Current observations (post 1980)	Point	SD
Plants	Datisca glomerata	Durango Root					Current observations (post 1980)	Point	SD SD
Plants	Juncus dubius	Manposa Rush					Current observations (post 1980)	Point	SD SD
Plants	Juncus rugulosus	Wrinkled Rush					Current observations (post 1980)	Point	SD
Plants	Juncus xiphioides	Iris-leaf Rush					Current observations (post 1980)	Point	SD
Plants	Juncus xiphioides	Iris-leaf Rush					Current observations (post 1980)	Point	SD SD
Plants	Lythrum californicum	California Loosestrife					Current observations (post 1980)	Point	Herbarium ARIZ
Plants	Lythrum californicum	California Loosestrife					Current observations (post 1980)	Point	SD
Plants	Lythrum californicum	California Loosestrife					Current observations (post 1980)	Point	SD SD
Plants	Lythrum californicum	California Loosestrife					Current observations (post 1980)	Point	SEINET
Plants	Mimulus guttatus	Common Large Monkeyflower					Current observations (post 1980)	Point	Calflora
Plants	Mimulus guttatus	Common Large Monkeyflower					Current observations (post 1980)	Point	SD
Plants	Phacelia distans	NA					Current observations (post 1980)	Point	Calflora
Plants	Phacelia distans	NA					Current observations (post 1980)	Point	SD
Plants	Phacelia distans	NA					Current observations (post 1980)	Point	SD SD
Plants	Phacelia distans	NA					Unknown	Point	UC UC
Plants	Platanus racemosa	California Sycamore					Current observations (post 1980)	Point	Calflora
Plants	Platanus racemosa	California Sycamore					Current observations (post 1980)	Point	SD
Plants	Platanus racemosa	California Sycamore					Current observations (post 1980)	Point	SD SD
Plants	Pluchea sericea	Arrow-weed					Current observations (post 1980)	Point	Calflora
Plants	Pluchea sericea	Arrow-weed					Current observations (post 1980)	Point	SD

California Freshwater Species Database (Porrego Springs Groundwater Subbasin)

Plants	<i>Pluchea sericea</i>	Arrow-weed					Current observations (post 1980)	Point	SD SD
Plants	<i>Salix exigua exigua</i>	Narrowleaf Willow					Current observations (post 1980)	Point	Calflora
Plants	<i>Salix exigua exigua</i>	Narrowleaf Willow					Current observations (post 1980)	Point	RSA RSA
Plants	<i>Salix exigua exigua</i>	Narrowleaf Willow					Current observations (post 1980)	Point	SD SD
Plants	<i>Salix gooddingii</i>	Goodding's Willow					Current observations (post 1980)	Point	SD
Plants	<i>Salix gooddingii</i>	Goodding's Willow					Current observations (post 1980)	Point	SD SD
Plants	<i>Salix laevigata</i>	Polished Willow					Current observations (post 1980)	Point	SD
Plants	<i>Salix laevigata</i>	Polished Willow					Current observations (post 1980)	Point	SD SD
Plants	<i>Schoenoplectus americanus</i>	Three-square Bulrush					Current observations (post 1980)	Point	SD
Plants	<i>Schoenoplectus americanus</i>	Three-square Bulrush					Current observations (post 1980)	Point	SD SD
Plants	<i>Typha domingensis</i>	Southern Cattail					Current observations (post 1980)	Point	RSA
Plants	<i>Typha domingensis</i>	Southern Cattail					Current observations (post 1980)	Point	RSA RSA
Plants	<i>Typha domingensis</i>	Southern Cattail					Current observations (post 1980)	Point	SD
Plants	<i>Typha domingensis</i>	Southern Cattail					Current observations (post 1980)	Point	SD SD
Plants	<i>Veronica anagallis-aquatica</i>	NA					Current observations (post 1980)	Point	Calflora
Plants	<i>Veronica anagallis-aquatica</i>	NA					Current observations (post 1980)	Point	SD
Plants	<i>Veronica anagallis-aquatica</i>	NA					Current observations (post 1980)	Point	SD SD





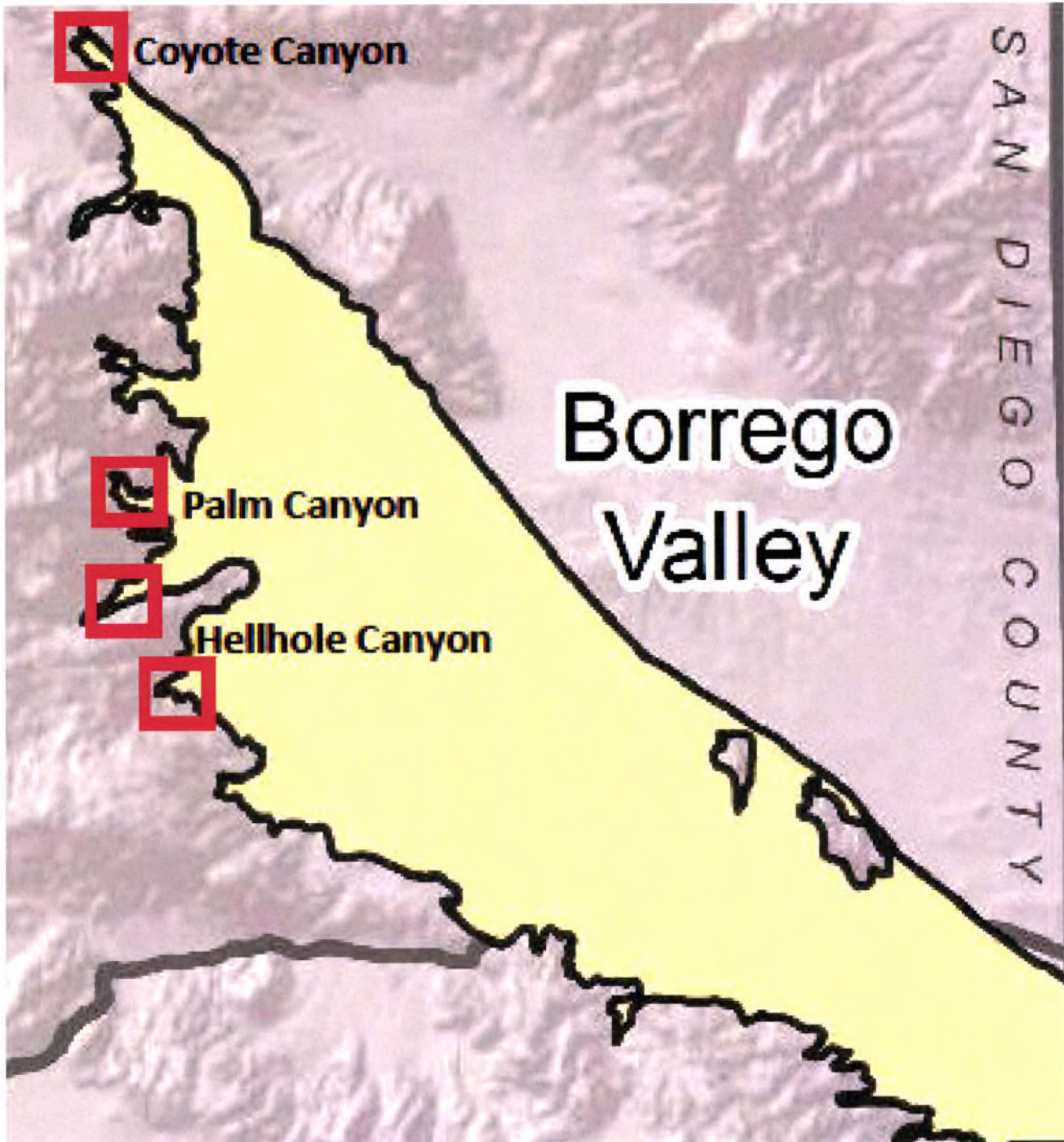


# Attachment 2

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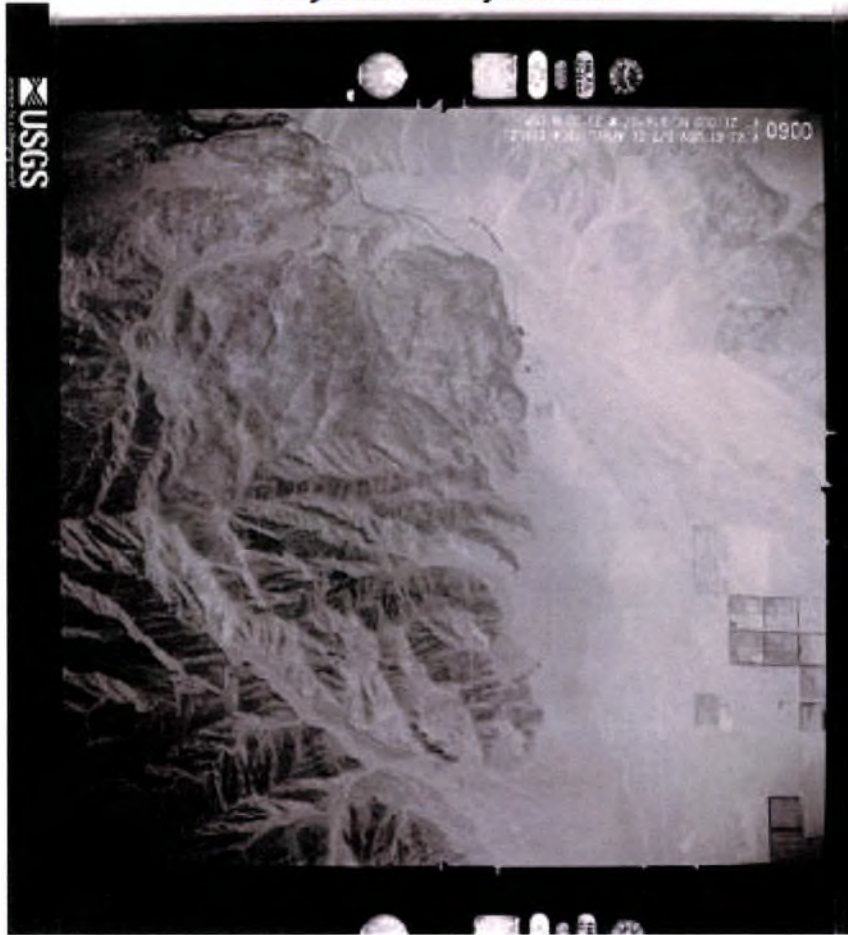
## Aerial Photography Comparison







**Coyote Canyon 1954**



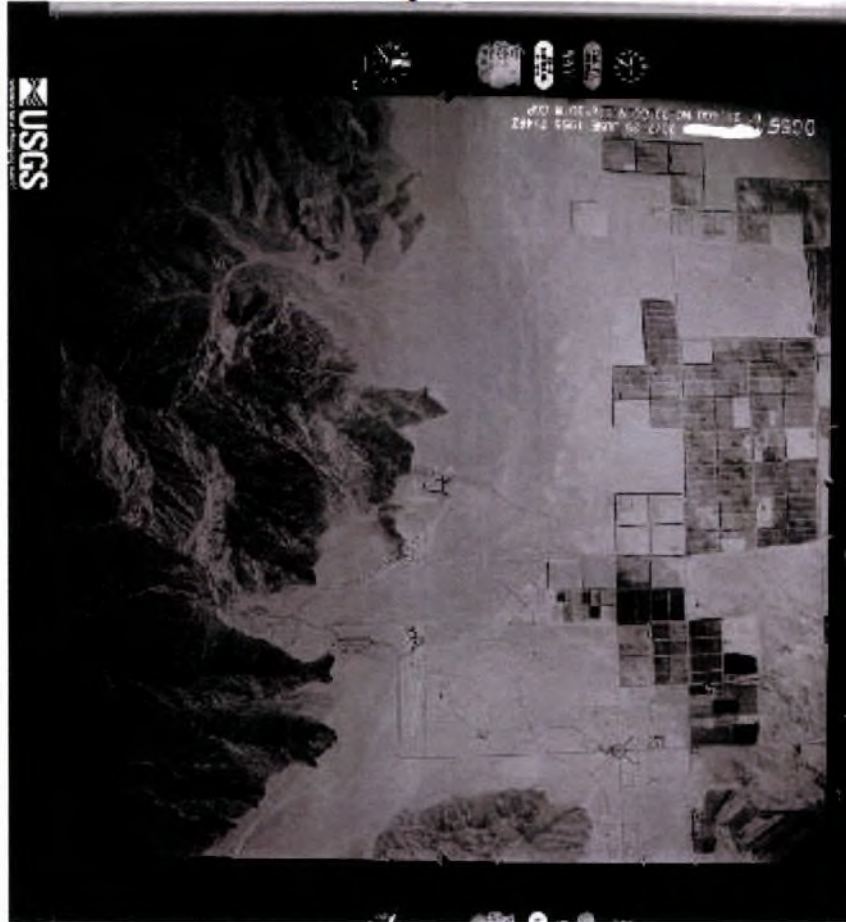
**Coyote Canyon 2017**



SOURCE: USGS



**Palm Canyon 1954**



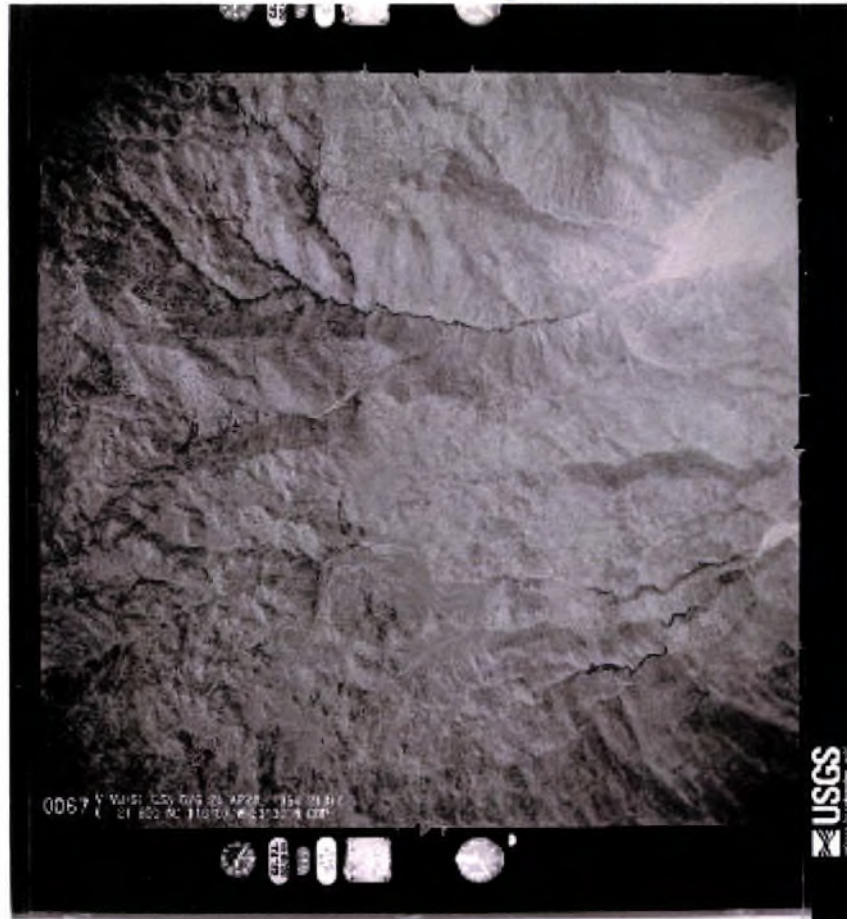
**Palm Canyon 2017**



SOURCE: USGS



### Hellhole Canyon 1954



### Hellhole Canyon 2017



SOURCE: USGS



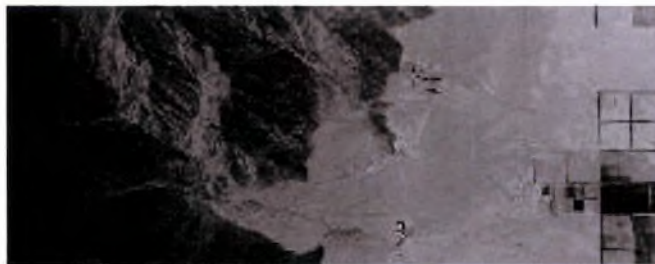
**1954**

**2017**

**Coyote Canyon:**



**Hellhole Canyon:**



**Palm Canyon:**



SOURCE: USGS

# **APPENDIX E**

## *Monitoring Protocols and Metering Plan*

- E1:** Borrego Sampling and Analysis Plan and Quality Assurance Plan
- E2:** Borrego Metering Plan

# **APPENDIX E1**

## ***Borrego Sampling and Analysis Plan and Quality Assurance Plan***

The Sampling and Analysis Plan and Quality Assurance Plan has been modified and superseded by Section 4.3 of the Settlement Agreement and Section VI.B. of the Judgment, whereby the interim Watermaster will continue the County-initiated program of water quality monitoring in the Basin that was conducted through March 2019 as part of GSP development on an interim basis until the Court approves the permanent Watermaster and the Watermaster adopts its own Plan.

**SAMPLING AND ANALYSIS PLAN AND QUALITY  
ASSURANCE PROJECT PLAN  
Borrego Springs Subbasin**

*Prepared for*

**Borrego Valley Groundwater Sustainability Agency**

*Prepared by*

**Geosyntec**   
consultants

engineers | scientists | innovators

2355 Northside Drive, Suite 250  
San Diego, California 92108

**OCTOBER 2017**



# Sampling and Analysis Plan and Quality Assurance Project Plan

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- A Example Groundwater Elevation Monitoring Field Form
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# Sampling and Analysis Plan and Quality Assurance Project Plan

## ACRONYMS AND ABBREVIATIONS

COPC	constituent of potential concern
DMS	data management system
DQO	data quality objective
DWR	California Department of Water Resources
EPA	United States Environmental Protection Agency
GSP	Groundwater Sustainability Plan
HDPE	high-density polyethylene
LCS	laboratory control sample
LIMS	laboratory information management system
mL	milliliter
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
QAPP	Quality Assurance Project Plan
QA	quality assurance
QC	quality control
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
Subbasin	Borrego Springs Subbasin

# Sampling and Analysis Plan and Quality Assurance Project Plan

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# **Sampling and Analysis Plan and Quality Assurance Project Plan**

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## **1 INTRODUCTION**

The Borrego Springs Subbasin (Subbasin) of the Borrego Valley Groundwater Basin has been identified by the California Department of Water Resources (DWR) as subject to critical conditions of overdraft (DWR 2016a). As such, in accordance with California's Sustainable Groundwater Management Act, a Groundwater Sustainability Agency has been formed to develop and implement a basin-specific Groundwater Sustainability Plan (GSP). The general purpose of the GSP is to facilitate a long-term groundwater withdrawal rate less than or equal to the sustainable yield of the Subbasin within the 20-year implementation period mandated by the Sustainable Groundwater Management Act.

The objective of this Sampling and Analysis Plan (SAP) is to establish consistent field data collection and laboratory analytical procedures, including protocols for measuring groundwater levels and protocols for sampling groundwater quality. The SAP incorporates pertinent protocols presented in DWR's Best Management Practices for the Sustainable Groundwater Management of Groundwater Monitoring Protocols, Standards, and Sites (DWR 2016b).

### **1.1 Project Overview and Applicability of the SAP/QAPP**

The GSP is currently being developed for the Subbasin. An interim Monitoring Plan was prepared in support of the GSP that outlines the types of monitoring necessary to address the six DWR-designated sustainability indicators in the Subbasin (Dudek 2017). This SAP serves to supplement the Monitoring Plan by establishing consistent monitoring procedures associated with the two primary sustainability indicators for the Subbasin: (1) chronic lowering of groundwater levels and (2) degraded water quality. The Monitoring Plan identifies these two sustainability indicators as the primary drivers of the anticipated undesirable effects from overdraft in the Subbasin. Although the data collected to address the above-referenced sustainability indicators will also be used to evaluate reduction in groundwater storage, other DWR-designated sustainability indicators (i.e., seawater intrusion, depletion of interconnected surface water, and land subsidence) are not considered significant in the Subbasin at this time (Dudek 2017). Therefore, this SAP does not provide protocols for monitoring seawater intrusion, measuring streamflow, or measuring subsidence.

Included within this SAP is a Quality Assurance Project Plan (QAPP). The QAPP provides a framework for implementing procedures for field sampling, chain-of-custody, sample transportation, laboratory analysis, and reporting that will yield defensible data of known quality. Together, the SAP and QAPP are designed to facilitate data collection such that data are of acceptable quality to meet project requirements.

# Sampling and Analysis Plan and Quality Assurance Project Plan

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# **Sampling and Analysis Plan and Quality Assurance Project Plan**

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## **2 SAMPLING AND ANALYSIS PLAN**

The following section describes the sampling methodology, analytical parameters, and sample handling procedures to be followed for routine groundwater monitoring activities in the Subbasin. Specific sampling locations and pertinent well specifications are identified in the Monitoring Plan (Dudek 2017).

### **2.1 Health and Safety**

A project-specific Health and Safety Plan will be prepared and implemented to address potential hazards that may be encountered in the field. Safety meetings will be held at the commencement of the project and each day before work begins to discuss safe work practices during field activities.

### **2.2 Sampling Objectives**

The objectives of monitoring activities are to collect accurate and defensible groundwater elevation data, and to collect representative groundwater samples to evaluate concentrations of constituents of potential concern (COPCs) in groundwater. The purpose of monitoring activities is to track groundwater conditions in the Subbasin throughout implementation of the GSP to evaluate progress toward achieving measurable objectives and sustainable management of the Subbasin, as defined in the Monitoring Plan (Dudek 2017).

### **2.3 Constituents of Potential Concern**

Groundwater samples collected from the site will be analyzed for the site-specific COPCs defined in the Monitoring Plan, including the following:

#### **Routine Constituents**

- Arsenic
- Fluoride
- Nitrate
- Sulfate
- Radionuclides (gross alpha particle activity)
- Total dissolved solids

#### **Baseline Constituents**

- Anions (bicarbonate, carbonate, chloride, fluoride, hydroxide, nitrate, sulfate, total alkalinity)



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- Cations (calcium, magnesium, potassium, sodium, and total hardness)

Additional detail regarding COPCs is presented in Section 3.5, Analytical Methods, of this SAP.

## **2.4 Groundwater Monitoring Frequency**

Groundwater elevation measurements and water quality sampling will be performed on a semi-annual schedule. The initial water quality sampling event will include sampling and analysis for cations and anions to establish baseline chemistry; analysis for cations and anions in subsequent sampling events is not currently planned.

## **2.5 Groundwater Monitoring Methods**

Groundwater monitoring procedures described herein were compiled in consideration of the DWR's best management practices (DWR 2016b), the County of San Diego's Site Assessment and Mitigation Manual (County of San Diego 2012), and professional judgment. See Appendix A for an example groundwater elevation monitoring field form.

### **2.5.1 Groundwater Elevation Monitoring**

Groundwater elevation monitoring will be conducted using the following procedures:

- Groundwater elevation data should approximate conditions at a discrete period in time; therefore, groundwater levels will be collected within as short a time interval as possible, preferably within a 1- to 2-week period.
- The sampler will have the previous depth to water measurements available in the field.
- The water level indicator will be decontaminated after each well.
- An electronic water level that employs a battery-powered probe assembly attached to a cable marked in 0.01-foot increments will be used. When the probe makes contact with the water surface, an electrical impulse is transmitted in the cable to activate an audible alarm. The equipment will be equipped with a sensitivity adjustment switch that enables the operator to distinguish between actual and false readings caused by the presence of conductive, immiscible components on top of groundwater. The manufacturer's operating manual should be consulted for instructions on use of the sensitivity adjustment.
- The well cap or cap covering the access port will be unlocked and removed.
- The sampler will listen for pressure release while removing the lid. If a release is observed, the measurement will wait to allow the water level to equilibrate. Additionally, multiple measurements will be collected to ensure that the well has reached equilibrium such that no significant changes in water level are observed.

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- All parts of the water level indicator that may come into contact with liquids in the well will be thoroughly rinsed or sprayed with deionized water immediately prior to lowering the probe into the well.
- The probe will be lowered through the access port or well casing to the anticipated depth of water.
- When the water level probe signals contact with water, the depth will be read on the tape from a datum point permanently marked on the well casing. Continue until two consecutive readings are within 0.01 foot of each other. The depth will be recorded on the Water Level Measurement Log.
- Measurements will be taken at an established reference point, generally at the top of the casing at the surveyor's mark. The mark should be permanent (e.g., a notch or mark at the top of casing). If the surveyor's point is not marked at the time of the water level, the north side of the casing will be used and marked.
- If water is not encountered in the well, the depth to water will be recorded as "dry" on the Water Level Measurement Log.
- If the water level in the well has dropped below the top of the dedicated pump, the probe will not be lowered past the pump. If feasible, remove the dedicated pump. Once the pump has been removed, allow the water level to equilibrate and measure the water level according to the method described above.
- Rewind the probe, replace the well cap, and relock the well.
- The sampler will calculate the groundwater elevation by subtracting the depth to water from the reference point elevation. The sampler must ensure that all measurements are consistent units of feet, tenths of feet, and hundredths of feet. Measurements at reference point elevations should not be recorded in feet and inches.
- The sampler will record the well identifier, date, time (24-hour format), reference point elevation, height of reference point above the ground surface (stick-up), depth to water, groundwater elevation, and comments regarding any factors that may affect the depth to water readings such as weather, recent well pumping or nearby irrigation cascading water, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it will be noted.
- All relevant data will be entered into the Groundwater Sustainability Agency's data management system (DMS) as soon as possible. Care will be taken to avoid data entry mistakes, and the entries will be checked by a second person for compliance with data quality objectives (DQOs).

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## **Pressure Transducers**

Groundwater levels and/or calculated groundwater elevations may be recorded using pressure transducers equipped with data loggers installed in monitoring wells. When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

The following general protocols will be followed when installing a pressure transducer in a monitoring well:

- The sampler will use an electronic sounder and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in each well to properly program and reference the installation. It is recommended that samplers use transducers to record measured groundwater levels to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.
- The sampler will note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.
- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. The installer of the transducer will consider battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers at the time of installation.
- The sampler will note whether the pressure transducer uses a vented or non-vented cable for barometric pressure compensation; appropriate corrections for natural barometric pressure changes will be implemented.
- Manufacturer specifications will be followed for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.
- The cable will be secured to the well head with a well dock or another reliable method. The cable will be marked at the elevation of the reference point with tape or an indelible marker to allow for estimate of potential future cable slippage.
- The transducer data will be regularly checked against hand-measured groundwater levels to monitor electronic drift or cable movement. This will happen during routine site visits, at least semi-annually, or as necessary to maintain data integrity.
- Data will be downloaded as necessary to ensure no data is lost and will be entered into the Groundwater Sustainability Agency's DMS following the established quality assurance/quality control (QA/QC) program. Data collected with non-vented data logger cables will be corrected for atmospheric barometric pressure changes, as appropriate. After

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the sampler is confident that the data have been safely downloaded and stored, the data will be deleted from the data logger to ensure that adequate data logger memory remains.

### **2.5.2 Groundwater Quality Monitoring**

Groundwater quality monitoring and sampling will be conducted using the following procedures. See Appendix B for an example groundwater quality monitoring field form.

- Prior to sampling, the sampler must contact the selected California-certified environmental laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.
- Groundwater elevation will be measured in the well following appropriate protocols, as described above.
- General well specifications for the wells to be sampled should be available in the field, most notably the screened interval and total well depth.
- Sample containers will be labeled prior to sample collection. The sample label must include sample ID, sample date and time, sample personnel, sample location, preservative used, and analyses and analytical method.
- Samples will be collected under laminar flow conditions. Laminar flow occurs when fluid flows in parallel layers, with limited lateral disruption or mixing of the layers. This may require reducing pumping rates prior to sample collection to minimize turbulent flow of groundwater entering the well screen.
- All field instruments will be calibrated daily and evaluated for drift throughout the day. Calibration will be documented in field logs.
- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Samples will be appropriately filtered, as recommended for the specific analyte. Samples to be analyzed for metals (i.e., arsenic) will be field-filtered prior to preservation; unfiltered samples will not be collected in a preserved container.
- If pumping during sampling or purging causes a well to go dry, the condition will be documented and the well will be allowed to recovery to within 90% of the original level measured prior to pumping. Professional judgement should be used about to whether the sample will meet the DQOs, and will be adjusted as necessary.

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- The following will occur for groundwater wells equipped with a functioning dedicated pump:
  1. Samples will be collected at or near the wellhead. Samples will not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.
  2. After cleaning the sampling port, a new, clean length of flexible clear plastic tubing will be connected to the sample access port. The tubing will be inserted into the sample bottle. The sample access port will be opened slowly. It will be verified that the liquid stream is not flowing greater than 100 milliliters (mL) per minute.
  3. The sample bottle will be filled so that no air space remains. The bottle will be capped and then wiped clean after capping. The completed label will then be adhered to the sample bottle.
  4. Field measurements for depth to water, pH, specific conductance, temperature, turbidity, dissolved oxygen, oxygen-reduction potential, and color will be collected and documented after the samples are collected.
- The following will occur for groundwater wells requiring sample collection using a temporary pump:
  1. The pump will be lowered slowly down the well, positioning the well intake at the middle of the well screen or at the predetermined selected sampling depth.
  2. Disturbance of the water column in the well will be minimized by initiating pumping at a low rate (see below). Dedicated tubing (left in place between sampling events) is recommended to minimize disturbance to the water column before and during sampling.
  3. Pumping will begin at a steady rate of 100 mL per minute and the depth to water will be measured frequently (e.g., every 1 minute for the first few minutes) to ensure that less than 0.1 feet of drawdown occurs. The pumping rate may be increased if drawdown is less than 0.1 feet, but the pumping rate will not exceed 500 mL per minute.
  4. Field parameters and depth to water will be recorded on field data sheets a minimum of every 5 minutes while purging. Purging will continue until pH, temperature, specific conductance, oxidation reduction potential, dissolved oxygen, and turbidity stabilize (three consecutive readings), which is defined as follows:
    - a.  $\pm 0.2$  units for pH
    - b.  $\pm 3\%$ – $5\%$  for specific conductance
    - c.  $\pm 20$  millivolts (mV) for oxidation reduction potential
    - d.  $\pm 10\%$  for temperature
    - e.  $\pm 10\%$  for turbidity

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- f.  $\pm 0.2$  milligrams per liter for dissolved oxygen
- 5. Dissolved oxygen and turbidity tend to stabilize last and are better measures of sufficient purging. Drawdown will be minimized during purging and/or sampling, not exceeding 0.1 feet, if possible.
- 6. In the case that the above criteria for stabilization are not met before three well volumes have been pumped, then a maximum of five well volumes will be pumped before samples are taken. Also, if stabilization has not occurred after 2 hours of purging regardless of well volume status, samples will be collected at this point. In the spirit of water conservation, this method will be avoided if possible.
- 7. For protocol regarding variances, consult the Site Assessment and Mitigation Manual (County of San Diego 2012).
  - If pumping during sampling or purging causes a well to go dry, the condition will be documented and the well will be allowed to recovery to within 90% of the original level measured prior to pumping. Professional judgement will be used as to whether the sample will meet the DQOs and adjusted as necessary.
  - After sample collection, the sealed sample bottle will be placed in a “zip-lock” style bag and placed inside an ice chest filled with ice to maintain a sample temperature of 4°C to prevent degradation of the sample. At the completion of sampling, the completed chain-of-custody will be placed in the ice chest, which will be sealed and labeled. The samples will be transported from the site to the laboratory by courier service or other means. The samples will be delivered to the laboratory within 24 hours after the sample has been collected.

### **2.6 Sample Handling**

The following section details methods that are to be used for sample labeling, identification, containerizing, preservation, transportation, and maintaining proper chain-of-custody. Samples will be handled in accordance with San Diego County’s Site Assessment and Mitigation Manual (County of San Diego 2012) and the United States Geological Survey’s National Field Manual for the Collection Water Quality Data sampling protocols (USGS 2014).

#### **2.6.1 Sample Handling and Identification**

Each groundwater sample collected for analysis will be designated with a unique identification (ID) number. The sample identification number will include information to identify the sample location, date, and field QC classification, if applicable.



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The following identifying factors will be used:

- Local well ID (e.g., ID4-18)
- Date (i.e., year, month, day)
- Field QC classification, if applicable (e.g., “D” for field duplicate)

For example:

- Sample identification number “ID4-18-20170704” would represent a groundwater sample collected from well ID4-18 on July 4, 2017.

### **2.6.2 Sample Containers and Transportation**

Groundwater samples will be collected in the following containers:

- Arsenic by United States Environmental Protection Agency (EPA) Method 6010B: 250 mL high-density polyethylene (HDPE) bottle preserved with hydrochloric acid
- Cations and anions: 1 liter unpreserved HDPE
- Fluoride by SM 4500-F C: 250 mL unpreserved HDPE
- Nitrate by EPA 300.0: 250 mL unpreserved HDPE
- Radionuclides (gross alpha particle activity) by EPA 900.0: 1 liter unpreserved HDPE
- Sulfate by EPA 300.0: 250 mL unpreserved HDPE
- Total dissolved solids by SM 2540 C: 1 liter unpreserved HDPE

Analyte-specific laboratory holding times as described in Section 3.5.3 will be reviewed to plan for samples to be received by the laboratory within the appropriate timeframe.

### **2.6.3 Chain-of-Custody Procedures**

A chain-of-custody form will be used to record possession of the samples from the time of collection to the time of arrival at the laboratory. The individual who collects the samples will prepare them for shipment, complete the chain-of-custody form, and sign the form when transferring the samples to the laboratory courier. The samples will be released to the laboratory by the courier signature on the chain-of-custody form and signed as received by laboratory receiving personnel. The laboratory receiving personnel will verify that all samples listed on the chain-of-custody form are present, sample integrity, and that proper sample preservation procedures were used.

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### **2.6.4 Equipment Decontamination**

Prior to sampling, re-usable sampling equipment (e.g., submersible pumps) will be decontaminated using an Alconox wash, a potable water rinse, then a distilled water final rinse (i.e., the three-bucket wash method).

### **2.6.5 Investigative-Derived Waste**

Evidence of hazardous concentrations of COPCs has not been identified in Subbasin wells. If purge water is generated from a groundwater well it will be discharged to the ground away from the wellhead. Additionally, investigative-derived wastes (e.g., sampling gloves, disposable sampling devices, tubing) will be disposed of off site as municipal solid waste.

### **2.6.6 Field Documentation**

Field logbooks will be maintained during confirmation sampling field activities. The field logbooks will serve to document observations, personnel on site, equipment activity, field procedures, and other vital information. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. The following information for each sampling area will be documented on field forms:

- Field crew names
- Date of sampling
- Wells names
- Names and times of samples collected
- Chain-of-custody number
- General observations

### **2.6.7 Photographs**

Photographs will be taken at sample locations and other relevant areas on site. The photographs will serve to verify information entered in the field logbooks.

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## **3 QUALITY ASSURANCE PROJECT PLAN**

### **3.1 Roles and Responsibilities**

Brief descriptions of key personnel responsibilities are provided below.

The sampling project manager is a member of the project team who will provide oversight and serve as the point of contact for the responsible parties. The sampling project manager will have responsibility for the overall project performance.

The QA manager will be responsible for ensuring the integrity of the SAP/QAPP and will coordinate all QA-specific activities. The QA manager will do the following:

- Ensure that the appropriate analytical methods and sampling equipment are selected.
- Be responsible for data validation and advise the sampling project manager with respect to data management and statistical evaluation of the data.
- Be responsible for performance and/or systems audits of the laboratory, should they be required.

The field manager or designated representative will be located at the site during field activities and will coordinate the technical field activities in accordance with approved plans, including the Monitoring Plan (Dudek 2017), QAPP, and Health and Safety Plan. The field manager will be responsible for verifying that the field work (to include sampling operations and sampling QC) is performed within the approved guidelines. The field manager will be responsible for implementing and maintaining overall operating standards and field QA responsibilities. Such responsibilities will include the following:

- Appropriate calibration and maintenance of field instruments
- Appropriate equipment decontamination
- Compliance with QA/QC sampling requirements (e.g., field duplicate collection)

In addition, the field manager will coordinate safety and technical activities occurring at the site, and conduct daily briefing sessions prior to work on the site. Although various field functions will be performed by individuals, the field manager will bear field responsibilities.

The laboratory project manager will be responsible for the day-to-day management of the laboratory work, to include data processing and data processing QA, verification that laboratory QA/QC procedures are being maintained, and verification that technical review of reports has been performed. Although various laboratory functions will be performed by different

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individuals, the laboratory project manager will provide signature approvals to laboratory-generated information and bear laboratory responsibilities.

### **3.2 Quality Objectives and Criteria**

The DQO process is used to derive qualitative and quantitative statements in relation to a particular data collection event (or group of events). Performing the DQO process is generally one of the prerequisite steps to data collection. The DQO process is described in EPA Guidance (EPA 2006). The steps of the DQO process are as follows:

- State the problem
- Identify the goals of the study
- Identify information inputs
- Define the boundaries of the study
- Develop the analytic approach
- Specify performance or acceptance criteria
- Develop the plan for obtaining data

The steps of the DQO process for the project are summarized below:

- **The problem:** Groundwater quality in the Subbasin, as observed through groundwater samples collected from monitoring and production wells, is potentially degrading. Overdraft conditions are potentially exacerbating impacts from naturally occurring COPCs, which may result in undesirable effects such as degraded water quality that is unsuitable for irrigation and/or drinking.
- **The goals:** Evaluate baseline and long-term trends in COPC concentrations for comparison to measurable objectives to be established in the GSP.
- **Information inputs:** Obtain analytical data for groundwater samples using the tests outlined in Section 3.5.1 of this SAP.
- **The boundaries of the study:** Samples will be collected from groundwater wells within the Subbasin, as designated in the Monitoring Plan (Dudek 2017).
- **The analytic approach:** Concentrations of COPCs will be tracked and studied throughout implementation of the GSP, as described in the Monitoring Plan.
- **Performance or acceptance criteria:** The usability of the data collected for this phase of work will be based on measurement activities, consistent with accepted guidance

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documents such as SW846 Test Methods. Testing results will be evaluated against performance-based acceptance criteria.

- The plan for obtaining data: The overall plan is outlined within the Monitoring Plan (Dudek 2017), and sampling details are presented in Section 2 of this SAP.

### **3.3 Special Training/Certification**

No specialized training is required. Standard training specifications will be outlined in the project-specific Health and Safety Plan.

### **3.4 Documentation and Records**

Documentation will involve generating, maintaining, and controlling field data, laboratory analytical data, field logs, reports, and any other data relevant to the project. Bound field log books, loose-leaf drilling logs, or automated field data entry records generated with personal data assistants are examples of documents. This project will have dedicated field log books, forms, and a DMS that will not be used for other projects. Entries will be dated and the time of entry will be recorded. Sample collection data and visual observations will be documented on forms or personal data assistants, or, when forms are not available or applicable, in the field log book. Any sample collection equipment, field analytical equipment, and equipment used to make physical measurements will be identified in the field documentation. Calculations, results, equipment usage, maintenance, and repair and calibration data for field sampling, and analytical and physical measurement equipment will also be recorded in field documentation. Once completed, the field forms, field databases, and field log book will become part of the project file.

Office data management will involve establishing and maintaining a project file. The project file will include the following:

- Planning documents, such as the QAPP
- Plans and schedules
- Standard operating procedures (SOPs) (for both the field and laboratory)
- Field sampling logs
- Field screening data
- QA auditing and inspection reports
- Laboratory analytical data
- Calculations
- Drawings and figures

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- Reports
- External and internal correspondence
- Notes/minutes of meetings and phone conversations
- Contract/purchase orders
- Change orders
- Bid evaluations

All project-related information will be routed to the sampling project manager who will be responsible for distributing the information to appropriate personnel. Project documentation will be archived for a minimum of 15 years. Pertinent documentation will be uploaded to the project's online DMS.

### **3.5 Analytical Methods**

#### **3.5.1 Laboratory Methods**

The following laboratory methods will be used during groundwater sample analysis activities:

- Arsenic by EPA Method 6010B
- Cations and anions by Methods 300.0, SM 2340C, and SM 2320B
- Fluoride by SM 4500 F C
- Nitrate by EPA 300.0
- Radionuclides by EPA 900.0
- Sulfate by EPA 300.0
- Total dissolved solids by SM 2540 C

#### **3.5.2 Required Reporting Limits and Method Detection Limits**

Reporting limits represent the lowest normally obtainable measurement level achieved and reported by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. The method detection limit (MDL) is the minimum concentration that can be measured with 99% confidence that the analyte concentration is greater than zero by an analytical procedure in a given matrix containing the analyte. Sample-specific reporting limits may vary as a result of sample matrix and compound concentration. Samples with no positive results (down to the MDL) are typically reported as "ND" (indicating "not detected") by the laboratory. Positive results below the reporting limit but above the MDL are reported as



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estimated values by the laboratory. Reporting limits and MDLs are adjusted for dilutions, as necessary, by the laboratory. A summary of the MDLs and reporting limits for the COPCs is presented in Table 1.

**Table 1**  
**Summary of Method Detection Limits and Reporting Limits**

COPC	Method	Reporting Limit (mg/kg)
Fluoride	SM 4500-F C	0.10
Arsenic	6010B	0.0100
Calcium	6010B	0.100
Magnesium	6010B	0.100
Potassium	6010B	0.500
Sodium	6010B	0.500
Total Dissolved Solids	SM 2540 C	1.0
Chloride	300.0	1.0
Nitrate (as N)	300.0	0.10
Sulfate	300.0	1.0
Hardness (as CaCO <sub>3</sub> )	SM 2340 C	2.0
Alkalinity	SM 2320B	1.0
Bicarbonate	SM 2320B	1.0
Carbonate	SM 2320B	1.0
Hydroxide	SM 2320B	1.0
Radionuclides (Gross Alpha Particle Activity)	900.0	Variable

COPC = constituent of potential concern; mg/kg = milligrams per kilogram

Laboratory analytical methods specified in Section 3.5.1 are generally consistent with those used during previous sampling performed in the Subbasin.

### 3.5.3 Holding Times

Knowledge of required holding times will have a direct impact on scheduling of sample collecting, packing, and shipping activities. To ensure proper sample handling, the sample container, volume, preservation, and holding times applicable to each analytical method are shown in Table 2.

**Table 2**  
**Borrego Springs Subbasin – Groundwater Sample Analytical Suite**

Constituent	Method	Sample Container	Preservative	Holding Time (days)
Fluoride	SM 4500-F C	250 mL HDPE	Ice 4°C	28
Arsenic	6010B	250 mL HDPE	Ice 4°C	28
Calcium	6010B	250 mL HDPE	Ice 4°C	28

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**Table 2**  
**Borrego Springs Subbasin – Groundwater Sample Analytical Suite**

Constituent	Method	Sample Container	Preservative	Holding Time (days)
Magnesium	6010B	250 mL HDPE	Ice 4°C	28
Potassium	6010B	250 mL HDPE	Ice 4°C	28
Sodium	6010B	250 mL HDPE	Ice 4°C	28
Total Dissolved Solids	SM 2540 C	1 L HDPE	Ice 4°C	7
Chloride	300.0	125 mL HDPE	Ice 4°C	28
Nitrate (as N)	300.0	125 mL HDPE	Ice 4°C	2
Sulfate	300.0	125 mL HDPE	Ice 4°C	28
Hardness (as CaCO <sub>3</sub> )	SM 2340 C	250 mL HDPE	Ice 4°C	180
Alkalinity	SM 2320B	250 mL HDPE	Ice 4°C	14
Bicarbonate	SM 2320B	250 mL HDPE	Ice 4°C	14
Carbonate	SM 2320B	250 mL HDPE	Ice 4°C	14
Hydroxide	SM 2320B	250 mL HDPE	Ice 4°C	14
Radionuclides	900.0	1 L HDPE	Ice 4°C	5

mL = milliliters; L = liters; HDPE = high-density polyethylene bottle

### 3.5.4 Field Methods

Procedures for using field measurement devices are presented in Section 3.6.4.

## 3.6 Quality Control

### 3.6.1 Introduction

This section addresses QC procedures associated with field sampling and analytical efforts. Included are general QC considerations, as well as specific QC checks that provide ongoing control and assessment of data quality in terms of precision and accuracy.

### 3.6.2 Field Quality Assurance/Quality Control

QA/QC for fieldwork refers to methods of measuring the quality of the field sampling techniques. Drilling, sampling, and field record keeping will be conducted in accordance with current sampling protocols for groundwater sampling, as applicable. Field instrumentation will be calibrated in accordance with the manufacturer's instructions at the beginning of each field day.

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In addition to the primary samples, the following QA/QC samples will be collected:

- **Field Duplicate.** One field duplicate sample will be collected for every 20 samples collected. The field duplicates will be analyzed for the same COPCs as the primary samples, and will be used to evaluate field sample collection reproducibility. The location where the field duplicate is collected will be noted on the sampling logs. The duplicate sample name will be different than the original sample name.
- **Matrix Spike/Matrix Spike Duplicate (MS/MSD).** One MS/MSD sample will be selected as applicable, and noted on the chain-of-custody. The MS/MSD samples will be analyzed for the same COPCs as the primary samples, and will be used by the laboratory to check for the ability to accurately and precisely recover compounds of interest from the site-specific matrix.

Field blanks will not be collected for this scope of work because easily transferable constituents such as volatile organic compounds are not anticipated to be encountered. The results of the analyses of these QC sample types are used as independent, external checks on field sample collection techniques.

### **3.6.3 Laboratory Quality Control**

To obtain data on precision and accuracy, the analytical laboratory will analyze the QC samples described below. The control limits and corrective actions for each parameter are specified in the pertinent laboratory analytical method SOPs. The analytical methods require analyses of the following QC samples:

- Calibration verification following instrument calibration and continuing calibration verification.
- Laboratory blank verification at instrument calibration and at the method required frequency thereafter for continuing blank verification.
- Method blank analysis at a rate of once per batch of samples or one per 20 samples of a single matrix, whichever is more frequent, to determine contamination levels during sample preparation.
- Laboratory control sample (LCS) analyses at a rate of one per batch. The LCS is used to verify that the analytical system is in control based on the percent recovery of the analyte(s).
- MS/MSD or MS/Laboratory Duplicate analyses will be conducted as applicable. The MS/MSDs and/or MS/Laboratory Duplicate are used to check for the ability to accurately and precisely recover compounds of interest from the matrix.

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### **3.6.4 Field Procedures**

Field monitoring and analytical equipment will be maintained in accordance with the manufacturers' recommended schedules and procedures. Maintenance activities will be documented by either field or laboratory personnel. Calibration will be performed on a routine basis and as otherwise required. Calibrating equipment or calibration standards will also be routinely recalibrated or replaced and documented. Routine inspection of equipment is intended to identify problems requiring maintenance before they cause a major disruption in field monitoring or analytical activities, or adversely affect the validity and precision of the data being measured.

### **3.6.5 Laboratory Procedures**

The laboratory is responsible for maintaining laboratory equipment in accordance with manufacturers' recommended maintenance and procedures in order to minimize downtime of the analytical systems. Each analyst is responsible for conducting a daily inspection of critical systems on instruments under their charge. Inspections will include vacuum lines and pumps for the gas chromatograph/mass spectrometer, automatic injection systems, controlled reagent-feed motors, temperature-controlled ovens in gas chromatographs, capillary columns, detectors and support systems, gas control system for atomic adsorptions, and many others. Wear-dependent items, such as septa on gas chromatograph injection systems, will be replaced as needed. The performance of instruments will be checked against known standards at the beginning of each working day or shift. Failure to achieve proper performance indicates a system problem, which will be addressed by laboratory personnel or by the manufacturer's service representative.

In addition, laboratory personnel or the manufacturer's service representative will service working systems according to a fixed schedule. A record of service and repairs, whether accomplished by laboratory personnel or by the manufacturer's service representative, will be maintained in a log book kept with each instrument.

## **3.7 Inspection/Acceptance of Supplies and Consumables**

Critical field supplies and consumables include the following:

Sample bottleware

- Decontamination fluids
- Personal protective equipment
- General sampling consumables (e.g., ice, plastic bags, paper towels, aluminum foil)

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For bottleware, the acceptance criteria will entail an inspection upon receipt of analytical testing to confirm the absence of cross-contamination and the presence of appropriate preservatives. For decontamination fluids, field staff will ensure that the fluids meet the necessary requirements for concentration and quality grade (e.g., reagent-grade methanol). Personal protective equipment will be inspected to confirm integrity and ensure that the appropriate sizes are available as required by sampling team members.

### **3.7.1 Laboratory Supplies**

The inspection and acceptance criteria for analytical reagents will be performed in accordance with the selected California-certified laboratory's SOPs.

## **3.8 Assessments and Response Actions**

The project team may conduct performance and systems audits of field and laboratory activities, as necessary. Following is a discussion of audits, corrective action, and reporting procedures.

### **3.8.1 Systems Audit**

A systems audit consists of the evaluation of key components of the measurement systems to determine their proper selection and use. When required by the EPA or alternative regulatory authority, systems audits are performed prior to or shortly after systems are operational. This audit includes a careful evaluation of field and laboratory QC procedures, which are explained below.

#### **Field Systems Audits**

Field systems audits are on-site audits that focus on data collection systems, using the appropriate SAP/QAPP as a reference. Specific activities vary with the scope of the audit, but can include a review of sample collection activities, decontamination practices, equipment calibration techniques and records, decontamination and equipment cleaning, background and training of personnel, sample containers and preservation techniques, and chain-of-custody procedures.

#### **Laboratory Systems Audit**

The laboratory systems audit is a review of laboratory operations to verify that the laboratory has the necessary facilities, equipment, staff, and procedures to generate acceptable data.

Specific activities vary with the scope of the audit, but can include a review of equipment suitability and maintenance/repair; SOPs; background and training of personnel; laboratory control charts and support systems; and QA samples, including performance evaluation samples, chain-of-custody procedures, data logs, data transfer, data reduction, and validation.

## **Sampling and Analysis Plan and Quality Assurance Project Plan**

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### **3.8.2 Performance Audits**

After systems are operational and generating data, a performance audit may be requested to determine the accuracy of the total measurement system(s) or component parts thereof. Similar to the systems audit, there are two types of performance audits, as explained below.

#### **Field Performance Audit**

Performance audits of sampling activities will be conducted using review of laboratory sample receipt forms.

An inspection for suitability of the samples for proper laboratory analysis will serve as the performance audit of the sample collection procedures. Insufficient sample volume for analysis, or improper preservation of samples, will be noted by the analytical laboratory. A preponderance of such reports of unsuitable samples will indicate that the sampling procedures are poor or unacceptable. Analytical results will be reviewed by the sampling project manager and the QA manager to assess the performance and adequacy of sample collection procedures.

Proper execution of sampling procedures will be audited by the sampling project manager and the QA manager. The sampling project manager and QA manager will audit these project operations on a regular basis over the life of the project through review of the field log book and audit forms, and through discussion with the field manager.

#### **Laboratory Performance Audits**

The project laboratories participate in a variety of federal and state programs that subject laboratories to stringent performance audits on a regular basis. QA policies and procedures currently in place at the laboratories, and actions that will be included in sampling activities to ensure QA, include the following:

- Inter-laboratory check samples
- Periodic audits
- Laboratory control samples analyzed at applicable analytical method frequencies
- Performance evaluation samples to be submitted to laboratories by the project team to each laboratory during major sampling events that use the particular laboratory

Laboratory performance in these areas will be monitored by the project team QA manager. If necessary, the project team QA manager will conduct an on-site audit of field operations or the analytical laboratory.

## **Sampling and Analysis Plan and Quality Assurance Project Plan**

### **3.8.3 Corrective Action for Measurement Systems**

When a problem situation arises regarding any significant impediment to the progress of the SAP during site characterization, corrective action will be implemented to identify the problem and its source. Appropriate documentation of this action will be recorded in the project file.

Personnel responsible for the initiation and approval of corrective action will be the laboratory QA manager (for corrective action at the laboratory) and the project team project manager (for corrective actions identified during field activities and/or during the data validation effort).

### **3.8.4 Quality Assurance Reporting Procedures**

Below are the QA reporting procedures that will be implemented for this project.

#### **Reporting Responsibility and Recordkeeping**

Comprehensive records will be maintained by the project team to provide evidence of QA activities. These records will include the following:

- Results of performance and systems audits
- Data validation summary
- QA problems and proposed corrective action
- Changes to the project documents

The proper maintenance of QA records is essential to provide support in any evidentiary proceedings. The original QA records will be kept in the QC manager's records.

Access to working files will be restricted to project personnel.

#### **Audit Reports**

Should audits be requested, the corresponding audit reports will be distributed to the following project personnel, as appropriate:

- Project Manager/Project Director
- Field Manager
- Laboratory QA/QC Manager



## **Sampling and Analysis Plan and Quality Assurance Project Plan**

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### **3.9 Data Reduction, Review, Verification, and Validation**

This section addresses the stages of data quality assessment after data have been received. It addresses data review, verification, and validation. It also sets procedures for evaluating the usability of data with respect to the DQOs set forth in Section 3.2.

#### **3.9.1 Data Reduction**

Raw analytical data generated in the laboratory are collected on printouts from the instruments and associated data system, generated electronically and stored in a laboratory information management system (LIMS), or manually recorded into bound notebooks. Analysts review data as they are generated to determine that the instruments are performing within specifications. This review includes calibration checks, surrogate recoveries, blank checks, retention time reproducibility, and other QC checks as specified in the laboratory's SOPs. If problems are noted during the analytical run, corrective action will be taken and documented.

Each analytical run is reviewed for completeness prior to interpretation and data reduction.

#### **3.9.2 Data Review**

Data review is an initial and relatively non-technical step of data assessment that primarily addresses issues of completeness and data handling integrity. In data review, the reviewer will ensure that all necessary reporting components have been included in laboratory reports, such as necessary fields (e.g., collection/analysis dates, units) and the presence of (but not implications of) QA/QC data components (e.g., LCS records, surrogate results).

#### **3.9.3 Data Verification and Validation**

Data verification is a more technical process than data review in that the core technical aspects of data quality (e.g., precision, accuracy) are evaluated through a review of the results of QA/QC measures, such as LCSs and surrogates.

Following interpretation and data reduction by an analyst, data are transferred to the LIMS either by direct data upload from the analytical data system or manually. The data are reviewed by the group leader or another analyst and recorded in the LIMS as being verified. The person performing the verification reviews all data, including QC information, prior to verifying the data. The laboratory will complete the appropriate forms summarizing the QC information and transfer copies of all raw data (e.g., instrument printouts, spectra, chromatograms) to the project management group for the final laboratory deliverable. This laboratory project manager will combine the information from the various analytical groups and the analytical reports from the LIMS into one package. This package will be reviewed by the laboratory project manager for

## **Sampling and Analysis Plan and Quality Assurance Project Plan**

conformance with SOPs and to ensure that all project QC goals have been met. Any analytical problems are discussed in the case narrative, which is also included with the data package deliverables. A Level 2 data deliverable will be required for this project.

Following data verification by the laboratory, data validation will be conducted on 100% of the laboratory data by an entity independent of the laboratory. The following level of validation will be performed:

- Stage 1: 100% of samples collected

If systematic errors with the laboratory data are identified, further validation may be necessary. Data validation may be performed on hard-copy data or electronically, as applicable. General compliance to the August 2014 National Functional Guidelines for Inorganic Data Review and the National Functional Guidelines for Superfund Method Organic Data Review (EPA 2014), and EPA Region 9 validation guidance will be used as the basis for the validation. The guidance documents provide structured approaches for the assignment of data qualifiers based on observations made in the data verification process, and will be used in conjunction with the specific EPA method criteria and the QA criteria set forth in the project-specific SAP.

### **3.9.4 Data Validation and Usability Determination**

Data verification is a technical process to evaluate data, but it does not answer the final question of the usability of the data and the implications of any departures from data expectations. The data validation process is designed to assign data qualifiers based on the data verification results, and provide a case-by-case review of data quality issues with respect to QAPP objectives to render a final assessment of data usability.

### **3.10 Data Evaluation Roles and Responsibilities**

The following components of data evaluation will be performed:

- Data reduction will be performed by the analytical laboratory
- Data review will be performed by both the laboratory and by the project team
- Data verification will be performed by the laboratory
- Data validation and usability determination will be performed by the project team

## Sampling and Analysis Plan and Quality Assurance Project Plan

### 3.11 Data Reporting

Laboratory reports will contain the following:

- **Case Narrative:** Description of sample types, tests performed, any problems encountered, corrective actions taken, and general comments.
- **Analytical Data:** Data are reported by sample or by test. Pertinent information, such as dates sampled, received, prepared, and extracted, will be included on each results page. The reporting limit and method detection limit for each analyte will also be recorded. In addition to a report saved as a pdf, the laboratory will provide an electronic data deliverable in a text format corresponding to each analytical report.
- **Laboratory Performance QC Information:** The results for all of the associated laboratory QC samples and practices will be reported (e.g., LCS, method blanks, surrogate recoveries).
- **Matrix-Specific QC Information:** Results of any sample duplicates, MSs, MSDs, or other project-specific QC measures that are requested will be reported.
- **Methodology:** The reference for the applied analytical methodology will be cited.

## Sampling and Analysis Plan and Quality Assurance Project Plan

### 4 REFERENCES

- County of San Diego, Department of Environmental Health. 2012. *Site Assessment and Mitigation Manual*. Updated June 21, 2012.
- Dudek. 2017. *Borrego Springs Subbasin, Monitoring Plan*. 21 August.
- DWR (California Department of Water Resources). 2016a. *Bulletin 118. Interim Update*. California Department of Water Resources. December 22, 2016.
- DWR. 2016b. *Best Management Practices for the Sustainable Groundwater Management of Groundwater – Monitoring Protocols, Standards, and Sites*. California Department of Water Resources, Sustainable Groundwater Management Program. December 2016.
- EPA (United States Environmental Protection Agency). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4)*. February 2006.
- EPA. 2014. *Contract Laboratory Program, National Functional Guidelines for Superfund Organic Data Review*, EPA 540-R-014-002, August 2014.
- USGS (United States Geological Survey). 2014. *National Field Manual for the Collection Water Quality Data, Techniques and Methods, Handbooks for Water-Resources Investigations*, Version 3.1. United States Geological Survey. Updated April 2014.

## Sampling and Analysis Plan and Quality Assurance Project Plan

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**APPENDIX A**  
*Example Groundwater Elevation  
Monitoring Field Form*



**SAN DIEGO COUNTY WELL MONITORING DATA SHEET  
BORREGO SPRINGS SUBBASIN  
GROUNDWATER GAUGING SHEET**

Date \_\_\_\_\_  
 Sampler: \_\_\_\_\_

State Well #	No Measurement	Questionable Measurement	Depth to Water	Groundwater Elevation	Previous DTW	Gauge Time	Well Box Type	Well Cap Type	Survey Point (Reference Point)	Comments

**Notes:**

*NO MEASUREMENT:* 0 Measurement discontinued 1. Pumping 2. Pump house Locked 3. Tape hung up 4. Can't get tape in casing 5. Unable to locate well 6. Well has been destroyed 7. Special 8. Casing leaky or wet 9. Temporarily inaccessible

*QUESTIONABLE MEASUREMENT:* 0 Caved or deepened 1. Pumping 2. Nearby pump operating 3. Casing leaky or wet 4. Pumped recently 5. Air or pressure gauge measurement 6. Other 7. Recharge operation at or nearby well 8. Oil in casing

*Notate depth in feet, tenths of feet, and/or hundredths of feet Do not notate in inches*



**APPENDIX B**  
*Example Groundwater Quality  
Monitoring Field Form*

**SAN DIEGO COUNTY LOW FLOW WELL MONITORING DATA SHEET**

DATE: \_\_\_\_\_

Project Name: <u>Borrego Springs Subbasin</u>					Project Address:				
Sampled by:					Project Number:				
Sampling Company:					Well GPS Latitude: _____				
Well ID:					Longitude: _____				
Borehole Diameter: _____ inches					Well Diameter: _____ inches				
Static Water Level (ft. btc): _____ Time _____					Referenced to: <u>Top of PVC Casing</u>				
Reference Point Elevation (ft. MSL):									
Total Well Depth (ft. btc) (WD):									
Meter type/ID: <u>Ultrameter YSI 556 YSI 550</u> ID: _____									
Water Level Indicator Type: <u>GeoSlope Indicator</u> ID: _____									
Decontamination Method: <u>Steam/High Pressure Wash</u> <u>3 Stage Rinse</u> <u>Other</u>									
Sampling Equipment: _____ Other: _____									
Purge Method: <u>Low Flow</u>									
Pump Depth (ft btc): _____					Date Pump Installed: _____				
Purge Rate: _____					Start Purge: _____				
Time	Temp (°C)	pH	Cond. (mS or µS)	Turbidity (NTUs)	D.O. (mg/L)	ORP (mV)	Depth to Water (ft btc)	Water Removed (ml)	Observations
Stabilization Parameters*	+/-3%	+/-0.2 units	+/-3-5%	+/-10%	+/-0.2 units	+/-20 mV			
Sampling Date:				Sampling Time:			Depth to Water:		
Sample I.D.:					Laboratory:				
Analyzed for:	Volume	Container	Filtered	Pres.	Parameters				
EB I.D. (if applicable): _____ Time _____					Duplicate I.D. (if applicable):				
Field Sheet Checked By:					License #:				
COMMENTS:									

\* 3 Consecutive Readings

**APPENDIX E2**  
*Borrego Metering Plan*

# **DRAFT**

## **GROUNDWATER EXTRACTION METERING PLAN BORREGO SPRINGS GROUNDWATER SUBBASIN**

*Prepared for*

### **Borrego Valley Groundwater Sustainability Agency**

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## **MARCH 2019**

**Groundwater Extraction Metering Plan**

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- A Groundwater Extraction Facility Registration Form
- B Example Data Submittal Format

## Groundwater Extraction Metering Plan

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## Groundwater Extraction Metering Plan

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### 1 INTRODUCTION

The Borrego Springs Groundwater Subbasin (Subbasin) of the Borrego Valley Groundwater Basin (BVGB) has been identified by the California Department of Water Resources (DWR) as subject to critical conditions of overdraft (DWR 2016). As such, in accordance with California's Sustainable Groundwater Management Act (SGMA), a Groundwater Sustainability Agency (GSA) has been formed to develop and implement a basin-specific Groundwater Sustainability Plan (GSP). The general purpose of the GSP is to facilitate a long-term groundwater withdrawal rate less than or equal to the sustainable yield of the Subbasin within the maximum 20-year implementation period mandated by SGMA.

This Groundwater Extraction Metering Plan (Metering Plan) is a foundational component of the GSP that will facilitate the reporting of groundwater extraction data. Collection and reporting of these data are integral to enable proactive and adaptive management of groundwater resources and documentation of seasonal fluctuation in water demand. Agricultural pumping was identified as one of the greatest sources of uncertainty in the Borrego Valley Hydrological Model (BVHM), because the groundwater use was indirectly estimated using potential evapotranspiration, crop coefficients, and irrigation efficiencies. Collecting metered data is one of the three primary recommendations proposed to improve the accuracy of the BVHM, which in turn improves the GSA's tools for adaptive management. Furthermore, the collection of metered pumping data is a key metric for evaluating the effectiveness of four out of the six projects and management actions being undertaken by the GSA (i.e., the water trading program, water conservation, pumping reduction program, and the voluntary fallowing of agricultural land). The GSA derives its authority to require groundwater extraction metering pursuant to the SGMA § 10731.

This plan has also been prepared consistent with Borrego Valley GSP Advisory Committee (AC) Policy Recommendation #1 – Questions #1 and #2 (AC Agenda and Minutes November 2017). AC Policy Recommendation #1 – Question #1 recommended meters to be installed on all wells with the exception of wells that use two acre-feet per year (AFY) (651,702 gallons/year) or less within the Subbasin.

AC Policy Recommendation #1 – Question #2 provided two options to the AC for consideration as follows:

Option 1: The GSA inspects and monitors/reads the meter on a monthly basis and ensures the accuracy of the data including meter calibration. The GSA would provide an annual statement setting forth the total extraction in gallons from each



## Groundwater Extraction Metering Plan

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well. The GSA will keep data confidential to the maximum extent allowed by law (California Govt. Code 6254(e)).

Option 2: The property owner (or third-party contractor acceptable to the GSA) monitors/reads the meter on a monthly basis. A third-party contractor acceptable to the GSA would inspect and read the meter on a semi-annual basis to verify the accuracy of data including meter calibration. On behalf of the property owner, the third-party contractor would provide an annual statement to the GSA with verification of the total extraction in gallons from each well and verification that each flow meter is calibrated to within factory acceptable limits. The GSA will keep data confidential to the maximum extent allowed by law (California Govt. Code 6254(e)).

Although the AC did reach consensus on requiring meters to be installed on all wells except those wells that use two AFY or less, consensus was not achieved for AC Policy Recommendation #1 – Questions #2 as indicated by Level 5 and 6 AC member votes. As such, that issue was returned to the Core Team without a recommendation as per the Borrego Valley GSP AC By-laws adopted and approved January 29, 2017. This Plan has been prepared under the presumption that the Core Team accepts both Option 1 and Option 2 presented in AC Policy Recommendation #1 – Question #2 as acceptable.

### 1.1 Applicability of the Metering Plan

An interim Monitoring Plan was prepared in support of the GSP, outlining the types of monitoring necessary to address the applicable DWR-designated SGMA sustainability indicators in the Subbasin (Dudek 2017). This Metering Plan serves to supplement the Monitoring Plan by outlining consistent groundwater extraction metering procedures required for all groundwater production wells in the Subbasin which pump in excess of two AFY. However, *de minimis* groundwater production wells that pump less than two AFY are exempt from the metering requirement defined herein pursuant to SGMA § 10721e.

Implementation and compliance with this Metering Plan will be mandatory for all non-*de minimis* wells in the Subbasin beginning 90 days from adoption of the GSP. The GSA may require metered data from any well located in the Subbasin if it is uncertain whether it qualifies as *de minimis* groundwater production.

This Metering Plan will be implemented to address the following:

- The GSA is currently relying on estimates of pumping, which is considered a source of uncertainty in the Subbasin's numeric groundwater model at this time. Initially these data

## Groundwater Extraction Metering Plan

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will be used to refine existing groundwater extraction estimates for non-de minimis groundwater production wells in the subbasin. Additionally, the data will be used to verify and refine the sustainable yield of the Subbasin.

- Groundwater extraction metering data will be integrated with other data being collected (i.e., groundwater level data) to track changing conditions in the Subbasin in order to evaluate the SGMA sustainability indicators: chronic lowering of groundwater levels, reductions in groundwater storage, and the potential for water quality impacts to municipal supply as groundwater levels decline.
- Groundwater extraction metering data will be used throughout the GSP implementation period to quantitatively track compliance with prescribed pumping allocations and reductions.

The Metering Plan outlines a procedure that will facilitate confidential collection and reporting of groundwater extraction data to the GSA, which will not be subject to public review pursuant to Government Code 6254(e).

**The Metering Plan has been modified and superseded by Section VI.A of the Judgment, whereby the parties will install, at their own expense, meters approved by the Watermaster that can electronically transmit a recording of the amount of groundwater pumped from the Basin and other data to Watermaster in real-time on a schedule determined by the Watermaster.**

## Groundwater Extraction Metering Plan

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## Groundwater Extraction Metering Plan

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### 2 METERING PLAN

This section describes the metering objectives and acceptable approaches, meter types and installation configurations, and meter maintenance and calibration requirements for routine groundwater extraction metering activities in the Subbasin.

#### 2.1 Metering Objectives

The purpose of this Metering Plan is to outline the procedures for the metering of all non-*de minimis* groundwater extraction wells (>2 AFY) within the Subbasin to enable proactive management of water resources. The GSA may request metered data from any well located in the Subbasin if it is uncertain whether it qualifies as *de minimis* groundwater production.

#### 2.2 Approach

All non-*de minimis* wells will be required to register with the GSA upon GSP adoption, which will include identification of flow meter type, San Diego County Assessor’s Parcel Number (APN) for each parcel served by each well and farm identification, golf course identification or other type of water use identification. Figure 1 illustrates an example of one well serving multiple parcels within a farm:

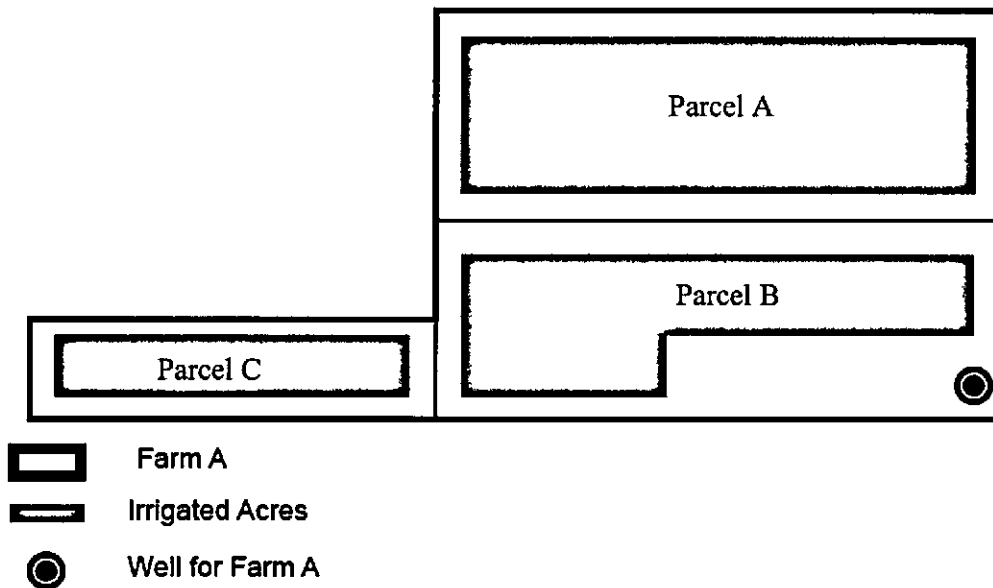


Figure 1. Example Documentation of Parcels Served by a Well for a Farm

## Groundwater Extraction Metering Plan

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Registration of non-*de minimis* production wells is achieved by submittal of the registration form to the GSA and is due within 90 day of GSP adoption. A copy of the registration form is provided as **Attachment A**, which specifies details for electronic submittal of the form. At the time of form submittal, the GSA will verify parcels served by each well and current area of irrigation based on aerial photography and GIS analysis.

Subsequent to registration, each applicable well owner that does not already have an appropriate flowmeter installed (as reported on registration form and verified by GSA) will be required to have one installed near the wellhead. The registrants will be required to install the flowmeter within 60 days of registration, or as determined appropriate by the GSA at time of GSP adoption. The meter is required to be read and recorded monthly and reported to the GSA annually. Registrants will be required to begin recording groundwater production immediately following installation. A third-party contractor acceptable to the GSA would inspect and read the meter on a semi-annual basis to verify the accuracy of data including meter calibration. An annual report will be required to be submitted to the GSA to demonstrate compliance with the Metering Plan.

### 2.3 Meters

Historically, basin-wide monitoring has included municipal reading of Borrego Water District Wells and San Diego County Major Use Permit readings for golf courses in the basin. Additional meters are required in the Subbasin to more accurately measure and document water usage.

Flow meters must be installed on existing production wells and should be installed at easily accessible above-ground portions of the well. Flow meters should be installed according to the meter's installation specification (e.g., correct upstream and downstream pipe length). Flow meters must include both an instantaneous flow rate and a totalizer recording the total volume of water extracted from the well. Appropriate meter types are described in the following subsections.

#### 2.3.1 Meter Types

Wells owners can select the brand of flow meter to be installed on their well(s); however, meters must be calibrated as described in Section 3 of this Metering Plan. The propeller-type flow meter is recommended for installation as part of the GSP. Propeller-type meters have been used throughout the Subbasin, and have proven to be a reliable mechanism for long term monitoring. Also, additional implementation of propeller type meters would ensure data comparability to previous historical data.

## Groundwater Extraction Metering Plan

### *Propeller Flow Meter:*

- Propeller type flow meters use mechanical parts to record production and/or measure flow rate.
- Commonly used in agriculture and municipal settings (majority of meters in Borrego Valley are propeller meters).
- Propeller meters must be sized based on expected flow rate and pipe diameter.
- Historically reliable for long-term use.
- May require maintenance, as bearing wear can occur from the internal propeller, and calibration is also periodically required.
- Future data collected would be of comparable accuracy to historically collected flow meter data.
- Flow meter accuracy is commonly plus or minus 2%.



*Figure 2. Example Propeller Type Flowmeter*

Source: McCrometer 2017

Additionally, Automated Meter Infrastructure (AMI) can be implemented to remotely report measurements. AMI can be implemented to minimize visits to the wellhead, and remote

## Groundwater Extraction Metering Plan

communication options include satellite and cellular connections. Power options for AMI can include grid, battery-only, and rechargeable solar power.



*Figure 3. Example Automated Meter Infrastructure*

Source: McCrometer 2017

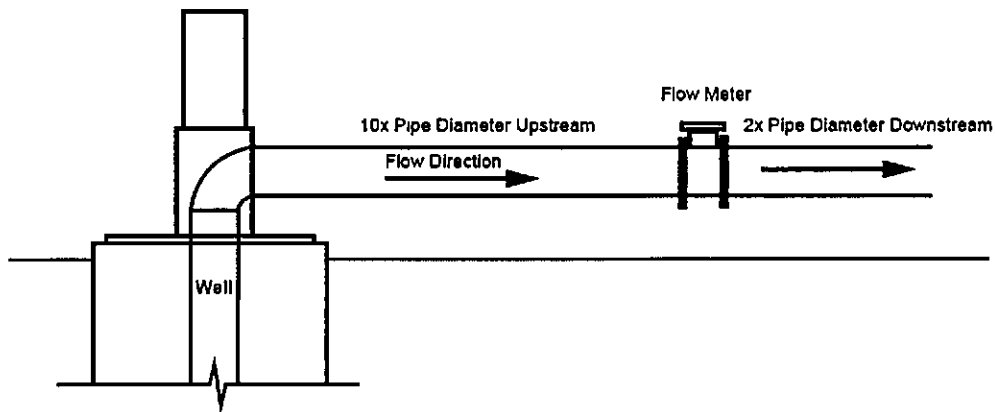
### 2.3.2 Typical Installation Configurations

Many wells in the Subbasin already have flow meters installed; however, many wells will require new flow meter installation, retrofits, or meter calibration. Installing each flow meter typically requires 4-8 hours, and must be performed by a licensed pump contractor. Well owners may have the option to allow installation of the flow meter through the GSA for a limited time with a subsidized program, or through an independent pump company at the expense of the well owner.

The meters must be installed in accordance with manufacturer's specifications. A typical installation configuration is depicted in Figure 4.



## Groundwater Extraction Metering Plan



*Figure 4. Typical Flowmeter Configuration*

### 2.3.3 Maintenance and Calibration Considerations

Propeller flow meters are considered to be reliable for long-term use; however, routine maintenance of the flow meter will be required, and will be the responsibility of the well owner. Calibration will be conducted as needed semi-annually for propeller type flow meters, and annual meter accuracy checks must be conducted by a GSA-approved vendor. Calibration specifications are presented in Section 3 of this Metering Plan.

## Groundwater Extraction Metering Plan

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## Groundwater Extraction Metering Plan

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### 3 GROUNDWATER METERING COMPLIANCE REQUIREMENTS

#### 3.1 Calibration and Validation

Proper calibration and verification is important for ensuring data quality, and necessary for meeting the objectives of the Metering Plan. Well owners are responsible for costs for installation (if needed), calibration, verification, and maintenance of meters. Under certain parameters, a flow meter may be deemed “commercial.” The County of San Diego, Department of Agriculture, Weights and Measures (AWM) considers a meter to be commercial if it is being used to determine a fee or penalty charged to pumpers, and the meter is owned by the property owner. AWM requires commercial meters to be tested and sealed at the AWM testing facility prior to installation, and to be retested every ten years.

The AWM testing facility has the capability of testing flow meters up to two inches in diameter. Most of the meters subject to the Metering Plan are larger than two inches, and therefore, cannot be tested at the AWM laboratory. In lieu of AWM facility testing, flow meter testing and calibration shall be conducted by the meter manufacturer in conformance with National Institute of Standards and Technology (NIST) Handbook 44, as referenced in California Code of Regulations, Title 4, Division 9 Weights and Measures Field Reference Manual (2018) Section 3.36 Water Meters. Based on the GSA’s review of existing, accessible meters in the Subbasin, most meters are manufactured by McCrometer, based in Hemet, California. McCrometer’s calibration Standard Operating Procedure for applicable meters has been reviewed by the GSA and determined to be compliant with above-referenced NIST standards. Therefore, McCrometer’s two California calibration facilities (Hemet and Porterville) are considered acceptable for meter calibration. Other meter manufacturers may also be acceptable for calibration procedures pending confirmation of NIST compliance.

#### *Initial Calibration/Validation of Existing Meters*

New meters will require a certificate of calibration which must be provided to the GSA and recorded. Existing meters in the Subbasin will need to be inspected and validated to ensure proper function and calibration. These activities must be conducted by a California-licensed pump contractor or GSA-approved vendor. This initial calibration and validation will be conducted at the beginning of the schedule of routine metering activities, and a certificate of calibration must be produced and recorded. Certificates of calibration for new and existing meters must be submitted with the initial semi-annual report (Section 3.4 of this Monitoring Plan).

## Groundwater Extraction Metering Plan

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### ***Routine Calibration/Validation***

Routine calibration checks (i.e., validation) must be conducted semi-annually. If variability exceeds 5% then manufacturer recalibration will be required. This typically involves removing the meter and having it factory calibrated. Routine validation can be conducted using either a temporary ultrasonic meter test to measure instantaneous flow rate, or other approved recalibration methods performed through professional services. Calibration can also include motor efficiency testing by the pump contractor or vendor to determine current efficiency and remaining useful life of the well motor. Replacing well motors when they become inefficient can save on electrical cost with the potential for regular maintenance resulting in cost savings to the pumper.

### **3.2 Meter Reads and Monthly Data Reporting**

Upon GSP adoption, meter reads must be recorded monthly and submitted to the GSA team electronically on an annual basis with third party validated reports for pumpers who elect to not have GSA staff perform the meter reads. Compliance with GSA meter reading requirements can be achieved by one of two approaches:

#### **3.2.1 Option 1 - GSA Performed Meter Reading**

Provide access for the GSA to perform monthly visual meter reading. Enrollment in this approach requires execution of the access agreement provided in **Attachment A** of this Metering Plan. Currently numerous groundwater flow meters within the Subbasin are visually read and documented on a monthly basis.

#### **3.2.2 Option 2 - Third-Party Contractor Performed Meter Reading**

The property owner (or third-party contractor acceptable to the GSA) monitors/reads the meter on a monthly basis. A third-party contractor acceptable to the GSA would inspect and read the meter on a semi-annual basis to verify the accuracy of data including meter calibration. On behalf of the property owner, the third-party contractor would provide an annual statement to the GSA. Third party contractors shall possess an appropriate license, including Professional Geologist, Professional Engineer, California Well Drilling License (C-57), or other applicable professional license approved by the GSA.

### **3.3 Annual Reporting**

Annual reports shall be submitted to the GSA on or before October 31<sup>st</sup> of each year. The reporting year will be defined as the water year from October 1<sup>st</sup> through September 30<sup>th</sup>. The water year is designated by the calendar year in which it ends.

## Groundwater Extraction Metering Plan

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Annual reports must contain the following:

- **Total Annual Water Use Per Well:** Tabulated results of monthly meter reads and cumulative annual water production amount.
- **Meter Calibration/Validation Documentation:** Semi-annual validation and annual calibration certificates produced by an appropriate pump or meter company.
- **Representative Parcel Numbers:** San Diego County APN for each parcel served by each well.
- **Farm Identification, if applicable:** Name of farm or farms served water by each well.
- **Meter Reading Method and Qualification:** Description of the meter reading method (e.g., visual read by Borrego Water District, remote automated reading infrastructure with confirmation by third party, etc.) and certification that the individual collecting that data meets the minimum qualifications of the GSA.

Annual reports shall be submitted electronically to the GSA in the required format. An example annual report template is provided as **Attachment B** to the Metering Plan which also specifies submittal details.

### 3.4 Data Confidentiality

To address concerns regarding the confidentiality of pumping data, the raw data will remain confidential pursuant to Government Code 6254(e). These data will be maintained for use by the GSA, and only publicly available as aggregate values by water use sector (i.e., Agriculture, Municipal, and Recreation).

### 3.5 Enforcement and Penalties

The GSA's enforcement of compliance with the Metering Plan is imperative to ensure effective implementation. Pump owners who fail to comply with the Metering Plan or who provide inaccurate data to the GSA will be subject to penalties. Specific enforcement and penalties will be outlined in a Fees and Penalties Plan to be approved by the GSA.

## Groundwater Extraction Metering Plan

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## Groundwater Extraction Metering Plan

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### 4 REFERENCES

Advisory Committee (AC) Agenda. 2017. Borrego Valley Groundwater Basin: Borrego Springs Subbasin. Sustainable Groundwater Management Act (SGMA). AC Meeting, November 27, 2017

Dudek. 2017. *Borrego Springs Subbasin, Draft Interim Monitoring Plan*. August 21, 2017.

DWR. 2016. *Best Management Practices for the Sustainable Groundwater Management of Groundwater – Monitoring Protocols, Standards, and Sites*. California Department of Water Resources, Sustainable Groundwater Management Program. December 2016.



## Groundwater Extraction Metering Plan

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**ATTACHMENT A**  
*Groundwater Extraction Facility  
Registration Form*

# Groundwater Extraction Facility Registration Form

## ***Owner Information***

Contact Name \_\_\_\_\_

Business Name \_\_\_\_\_

Farm/Entity \_\_\_\_\_

Address \_\_\_\_\_

City/State/Zip \_\_\_\_\_

Phone No. \_\_\_\_\_

Email Address \_\_\_\_\_

## ***Operator Information (if different than above)***

Contact Name \_\_\_\_\_

Business Name \_\_\_\_\_

Address \_\_\_\_\_

City/State/Zip \_\_\_\_\_

Phone No. \_\_\_\_\_

Email Address \_\_\_\_\_

## ***Well Information***

Owner's Well Name/No. \_\_\_\_\_

Well Location/Address \_\_\_\_\_

Public Land Survey Location; Township \_\_\_\_\_ Range \_\_\_\_\_ Section \_\_\_\_\_

GPS Coordinates; Latitude \_\_\_\_\_ Longitude \_\_\_\_\_

State Well No. (SWN) \_\_\_\_\_

State Well ID \_\_\_\_\_

## ***Additional Well Information***

County Well Permit No. \_\_\_\_\_

Date Drilled \_\_\_\_\_

Well Depth \_\_\_\_\_ feet

Casing Diameter \_\_\_\_\_ inches

Perforations \_\_\_\_\_ feet from ground surface

## **Groundwater Extraction Facility Registration Form**

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Motor Type: Submersible or Turbine *(circle one)*

Motor/Engine \_\_\_\_\_HP

Existing Water Meter: Yes or No *(circle one)*

Manufacturer of Water Meter \_\_\_\_\_

Water Meter Size \_\_\_\_\_ inches

Water Flow Meter (state what flowmeter reads in: acre-feet (AF), gallons, cubic feet (CF))

Serial No. of Water Meter \_\_\_\_\_

Electric Meter No. \_\_\_\_\_

Assessor's Parcel No. (APN) \_\_\_\_\_

***Hydrogeologic Data (If any of the below data are available, check box and please provide documentation.)***

- Driller Well Completion Report Available
- Groundwater Quality Data Available
- Groundwater Level Data Available
- Geologist Log Available
- Aquifer Test Data Available
- Geophysical (E-log) Available

### ***Well Water Use Type***

- Agricultural/Irrigation *(list number of acres and crop category(ies))* \_\_\_\_\_
- Stock Watering *(number and type of animals)* \_\_\_\_\_
- Domestic *(number of persons served)* \_\_\_\_\_
- Municipal or Industrial \_\_\_\_\_
- Other *(describe)*

## **Groundwater Extraction Facility Registration Form**

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### ***Property Access for Meter Readings and Groundwater Level Monitoring***

Please provide your printed name and signature to allow for monthly meter readings and approximately semi-annual groundwater level monitoring.

Contact information for property access notification:

Contact Name \_\_\_\_\_

Phone No. \_\_\_\_\_

Email Address \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_

Are additional active or inactive well located on the property? If so, provide number of well:

Number of Active Wells \_\_\_\_\_

Number of Inactive Wells \_\_\_\_\_

Please complete a separate Groundwater Extraction Facility Registration Form for each additional active well.

**ATTACHMENT B**  
*Example Data Submittal Format*